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CIVIL SERVICE EXAMINATIONS for architectural and structural steel draftsmen will be held on Jan. 9, 10 and 11, 1900, in any city in the United States where there is a board of examiners. The examination will be on the following subjects, which will be weighted as designated in the marking. Mathematics, ten; materials and construction, thirty; drawing and design, thirty; freehand, ornament and projection, twenty, and technical education and experience, ten. The minimum age limitation for entrance to this examination is 20 years. From the eligibles resulting from this examination certification will be made to the position of architectural and structural steel draftsman in the Bureau of Yards and Docks, Navy Department, in the Yards and Docks Department at Boston, Mass., and at League Island, Pa., the first two at a salary of $4 per day each and the last named at a salary of $4.50 per day. This examination is open to all citizens of the United States who comply with the requirements. Persons desiring to compete should at once apply to the United States Civil Service Commission, Washington, D. C., for application forms 304 and 375, which should be properly executed and promptly forwarded to the commission at Washington. The department has stated that it desires for these positions men who are proficient in structural steel work as applied to architectural construction.

A DAM ACROSS THE NIAGARA RIVER to regulate the levels of the Great Lakes and their connecting waterways is provided for in a bill which will be introduced in Congress by Representative John B. Corliss, of Michigan. The purpose of the bill is stated in its introductory paragraph as follows:

Be it enacted by the Senate and House of Representatives of the United States of America, in congress assembled, that there shall be constructed by the United States a regulating dam at the foot of Lake Erie, for the purpose of controlling the level of the lake and improving the harbors and waterways of Lake Erie, Detroit River, Lake St. Clair, and St. Clair River, at such point at the foot of Lake Erie or in the Niagara River, as may be hereafter determined by the United States board of engineers on deep waterways to be the most practicable and advantageous to commerce, taking into consideration all surveys, estimates and data then existing.

The bill provides that upon its passage the President shall take steps to secure the consent and co-operation of the Canadian government, and also that the sum of $800,000 shall be immediately available for carrying out the work. It is estimated that the dam will not cost more than $1,000,000 if built without locks. It is stated that this bill has been drafted under the directions of the United States Board of Engineers on Deep Waterways, and that this board in its coming report will recommend a dam that will raise the water level of Lake Erie from 2½ to 3 ft. The general proposition of damming the Niagara River was discussed in an address by Mr. Geo. Y. Wisner, reprinted in our issue of Nov. 23, 1893.

THE SO-CALLED CHISHOLM GAS PROCESS, which we discussed at length in our issue of Dec. 7, met with a setback in the application of its promoters for a franchise at Passaic, N. J., at the meeting of the city council on Dec. 18. The United Gas Improvement Co. sent a letter to the council offering to pay the expenses of a committee of three experts to visit San Francisco and investigate the Chisholm process there. They further offered that if two of the three experts should report that Dr. Chisholm's gas could be made, as he claims, at less than half the cost of the U. G. I. Co.'s gas, for equal heat and light value, then the U. G. I. Co. would agree to sell its gas in Passaic at 50 cts. per 1,000 cu. ft., would pay Dr. Chisholm's company $50,000 per year during the life of the patents, and would use his process in all their plants. In addition they would light Passaic's churches free, would pay off the $40,000 debt on its two hospitals, build a new $28,000 school house, and contribute $10,000 to its fire department. This remarkable proposition so weakened the support which Dr. Chisholm's application for a franchise had in the councils that a resolution to lay the subject over until the third week in January was carried by a vote of 6 to 4.

RECENT FIRE TESTS of fireproofing by the British Fire Prevention Committee comprise a test of a board and stud partition filled with slag wool, and of several forms of solid and paneled wooden doors. The partition was built of 3 x 3-in. studs, sill and cap, the studs being spaced 14 ins. apart. On the outside of the studs on both sides of the partition a 1⅛-in. mesh 1-32-in. thick wire netting was secured with iron staples. On top of the wire netting and covering the face of each stud was placed a 1-16-in. thick, 6-in. wide asbestos board. The space between the studs and the wire netting was filled with slag wool. Over all these was nailed a covering of ¾-in. tongued and grooved boarding. The fire was applied to one side of the partition for 45 minutes at a temperature running from 925°F. to 1,725°F. Fire broke through the partition in 28 minutes at a temperature of 1,365°F., and in 40 minutes, at a temperature of 1,450°F., the outside boarding was afire in several places. The points where the fire broke through were points where the slag wool had been imperfectly packed; elsewhere the outside boarding was not affected. The inside boarding was consumed and the studs and cap were charred part through. The committee calls attention to the evident necessity of carefully packing the slag wool filling in partitions of this construction. Two doors of identical construction except that one was American oak and the other Moulmein teak were tested side by side. These doors had the approximate dimensions of 3 ft. 3 ins. x 6 ft. x 9 ins., the fire was applied to one side only and the doors were hung to open toward the fire. The construction of the doors was as follows: Four panels 1⅞ ins. thick; styles and top rail 4 ins. wide; center and bottom rail 9 ins. wide.; panels tongued to styles and rails by 1x⅝-in. tongues; styles and rails same thickness as panels. Fire was applied to doors at a temperature gradually rising to 2,000°F. for one hour. In the oak door the flame came through at the top in 30 minutes, between panel and style in 40 minutes, at lock rail in 44 minutes. The panels fell outward from the fire in 55 minutes, and the remainder of the door fell outward in 59 minutes. In the teak door the flame came through at the top in 5 minutes, and in 58 minutes the door collapsed inward. Another test of a teak door of closely similar construction and dimensions showed the following results: Flame came through in 24 minutes, and was issuing at all joints in 60 minutes. In 65 minutes the door fell. The pine doors were ordinary paneled pine doors about 6½ x 2½ ft. in area, one being 1⅝ ins. thick and the other 1⅞ ins. thick. The test lasted 30 minutes with the temperature rising to 1,500°F. Flame broke through the 1⅝-in. door at 1,400°F. in 19 minutes, and the door was destroyed in 22 minutes. Flame broke through the 1⅞-in. door at 1,600°F. in 20 minutes, and the door collapsed in 26 minutes.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred near Allentown, Pa., on the Jersey Central R. R., on Dec. 13. A passenger train ran into the rear end of a coal train. Four persons were killed and a number were seriously injured.——A train of 16 cars and two locomotives on the Northern Pacific R. R. became uncontrollable on a grade at Kendrick Hill, Idaho, on Dec. 16, and was derailed, killing four trainmen and completely wrecking the train.

THE PENNSYLVANIA RAILWAY'S "PENSION DEPARTMENT" commences operations on Jan. 1, 1900. The plan provides for the retirement on that date of all officers and men employed by the railways east of Pittsburg and Erie who have attained the age of 70 years. A pension will be paid to the men equal to 1% for each year of continuous service of the average salaries of the ten last years. The plan also provides for the retirement of all officers and men between the ages of 65 and 69 years who have been 35 years in the service of the company and are physically disqualified; they will be pensioned on the same basis as the above. These pensions will be payable during the lives of these men; provided, that the aggregate annual payment does not exceed $300,000; if the total exceeds this sum a readjustment will be made on a lower percentage basis.

WIRELESS TELEGRAPHY, it is reported, will be tried by the Toledo & Ann Arbor R. R. as a means of communication across Lake Michigan, between Frankfort, Wis., and Menominee, Mich. The distance to be covered is about 83 miles. The railway company will attempt to keep this ferry open all winter, and, if the wireless telegraphy fails, a cable will be laid across the lake next year.

THE U. S. NAVAL OBSERVATORY, at Georgetown, D. C., is to be thoroughly reorganized, if a bill now before Congress becomes a law. The principal change proposed is to put the observatory in charge of a professional astronomer, who shall plan and systematize its work; as a substitute for the present plan of placing a naval officer in charge who is compelled to retire at the age of 62—just when most astronomers are at the height of their usefulness. The compilation of the national almanac would also be made a separate work under a skilled officer in charge; and a board of visitors would be appointed, made up of six professional astronomers of high standing and three prominent citizens. This board would make annual visits, report conditions and make recommendations as to the management of the observatory. The salaries fixed by the bill are as follows: Astronomical director, $6,000; director of nautical almanac, $5,000; first to fourth astronomers, $4,000, $3,600, $3,200 and $2,800; first to third assistant astronomers, $2,400, $2,200 and $2,000. The present naval observatory was established in 1830, under then Lieut. Goldsborough, U. S. N.

THE CONSOLIDATION OF SOME OF THE NAVAL bureaus under one head is the subject of a bill prepared by Secretary Long for submission to Congress. This bill would consolidate the Bureaus of Construction and Repairs, Steam Engineering and that of Equipment into one called the Bureau of Ships. In this new bureau there would be a division of construction and one of machinery. The Hydrographic office, now under the Bureau of Equipment, would be under the supervision of the Assistant Secretary of the Navy. The Chief of the Bureau of Ships would be selected from the line officers or naval constructors, not below the grade of Commander, and that of the two divisions named from the naval constructors and line officers having skill as engineers. The act would go into effect on July 1, 1902, when the present chiefs shall have retired.

AMERICAN EXPORTS TO CHINA, says the Treasury Bureau of Statistics, increased 40% in the year 1898, while the increase in total imports into China for that year was only 5%. The imports from the United States for 1898 amounted in value to 17,163,312 taels, as against 12,440,302 taels in 1897. In the same period those from England, our most important rival in Oriental trade, fell from 40,015,587 taels to 34,962,474 taels; while the importation from Europe also showed a slight reduction, with a total of 10,852,738 taels. Including the imports from Hong Kong, largely of European origin, and assuming that all of them are, the grand total of European products imported into China in 1898 was 146,376,946 Haikwan taels in value, as against 145,457,326 taels in 1897; this is a gain on the total for 1898 of less than 1%, while the United States gained nearly 40%. The principal imports into China from this country are cotton goods, kerosene oil, flour, provisions, railway material and engines, manufactures of iron and steel, manufactures of wood, and manufactured tobacco.

THE PHILADELPHIA COMMERCIAL MUSEUM is asking from Congress an appropriation of $200,000, which would be used as follows: To collect samples and data in foreign countries for the use of our manufacturers; to employ experts in foreign ports for the extension of American trade; and third, the publication and the free distribution of all the information gathered to every chamber of commerce and board of trade in the country. As showing the character of work now performed, Director William P. Wilson reported that in the week ending Dec. 2, taken as an example, the Museum received 92 special inquiries; of these 28 were from Argentina, Bavaria, Cape Colony, Chili, England, France, Germany, India, Italy, Mauritius, Mexico, Portugal, Prussia, Syria and Venezuela.

A BRICK CHIMNEY, 160 ft. high and 8½ ft. square at the base and 4½ ft. diameter at the top, was overthrown lately in St. Louis by the use of hydraulic jacks. The chimney belonged to the old Belcher sugar refinery, and it contained about 200,000 bricks. As described in the St. Louis "Globe-Democrat," the chimney was first undermined on one side, and three 10-ton hydraulic jacks were placed in position under the side. A hawser was then fastened about the chimney, 60 ft. from the ground, and ropes led from this hawser to crabs placed at a distance of about 100 ft. from the chimney. With eight men at each crab and men at the hydraulic jacks, the chimney was slightly lifted and pulled at the same time; the men at the jacks left their posts at the first warning crack, but those at the crabs continued their work until the chimney fell. The top of the chimney toppled over first and the base followed. The work was performed by P. W. Hassatt, contractor.

RICHARD BOYSE OSBORNE, C. E.

Richard Boyse Osborne, a prominent civil engineer of the older generation, died on Nov. 28, 1899, at Glenside, Pa. He was born on Nov. 3, 1815, in London, England, and was a direct descendant of Sir Thomas Osborne, of Kent, who was created first Duke of Leeds in the 16th century. His mother was the granddaughter of a sister of Gen. Hugh Mercer, one of Washington's favorite Generals, who gave up his life at Princeton for the Revolutionary cause.

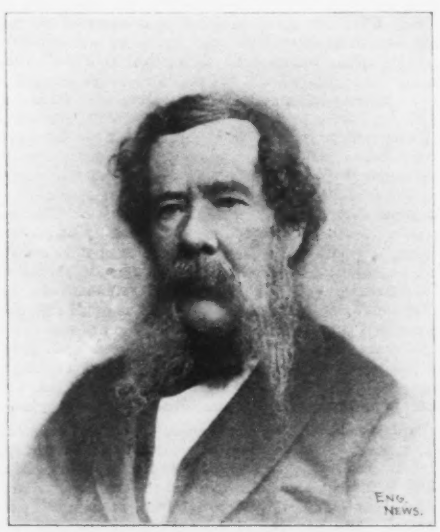
Richard B. Osborne was educated at Bannow and Waterford, Ireland, and Bath, England. In July, 1834, he landed in Canada, and after spending about a year there he went to Chicago with Townsend Gahan, and the two spent some months in town lot surveying. After a visit to St. Louis, Mr. Osborne, in 1838, entered the service of the Philadelphia & Reading R. R., where he had been preceded three years by his former schoolmate, Mr. G. A. Nicolls, who served that company 52 years. Mr. Osborne rose rapidly in his now chosen profession of civil engineering, and was Chief Engineer on the Philadelphia & Reading, the Mt. Carbon and Port Carbon railways until 1845; in this time he constructed a number of important bridges, tunnels and stations, completed the main line of the Reading and the Port Richmond Branch, and its coal wharves.

In March, 1845, he went to Ireland on a six months' leave of absence; but being offered the position of Engineer-in-Chief of the Waterford & Limerick Railway, he resigned from the Reading Co., and remained in charge of this Irish railway until 1850. In this latter service he introduced a number of important American inventions and ideas; including in these the American transit and methods of railway location, the Howe truss in bridge and roof construction; and, in July, 1846, the American 8-wheeled bogie truck under long passenger and box freight cars, to supplant the ordinary 4-wheeled English cars of both types. The opposition of connecting lines, which complained that the American second-class cars "were too comfortable," and thus injured the passenger traffic on the other lines, caused them to be later cut in two, and "long" cars were not again used in the United Kingdom until the introduction of the Pullman system a few years ago. Mr. Osborne was a friend of Mr. Howe, the inventor of the Howe truss, and by arrangement with him he patented the system in England, and designed and built the first Howe truss ever erected in Great Britain. Mr. Osborne also planned the first large Howe truss roof in America—for the old Philadelphia, Wilmington & Baltimore R. R. station, still standing on Broad St. and Washington Ave., in Philadelphia. This latter roof was planned at the request of the then Chief Engineer—the late Gen. Isaac R. Trimble, with the view of avoiding the usual supporting pillars. He also built the first iron Howe truss bridge ever constructed, and still standing on the main line of the Reading Railway, just above Manayunk; it is now supported by trestling to withstand the heavier rolling stock using it.

In 1850 Mr. Osborne spent six months on the Isthmus of Panama in the interest of the Graves, of Liverpool; and in 1851-2 he was engaged in examining and reporting upon the Catawissa R. R. In 1852 he commenced a work of far reaching importance to the public—the surveys and construction of the Camden & Atlantic Railway, now a part of the Pennsylvania system. Mr. Osborne also laid out and named Atlantic City; and, in June, 1879, in celebrating the 25th anniversary of the founding of "the City by the Sea," Mr. Osborne was selected, as the only one then living, of those actually connected with the building and laying out of the railway and the city, to make the historical address.

In 1852 he was also in charge of the Dauphin & Susquehanna Railway; and in 1854 he took charge of the Lebanon Valley R. R., which was opened to Harrisburg in 1858; he was connected at intervals with this latter road until 1863. From 1859 to 1870 he was professionally engaged in connection with the East Mahanoy, Danville & Northumberland, Shamokin & Northern, Jersey Shore, Pine Creek & State Line, Elmira & Williamsport and New York & Oswego Midland railways, and in the examination of bridge sites for the Baltimore & Ohio R. R., at Parkersburg and Bellaire. In 1870-71 he was Chief Engineer of the Western Maryland R. R. in its difficult construction over the mountains; and later he was engaged on surveys for the Tuckerton & Atlantic, Washington, Cincinnati & Ohio, Shenandoah Valley & Ohio, and Susquehanna & Delaware railways. In 1886 he was Consulting Engineer for the late Moncure Robinson, on his North and South Carolina lines. In 1882-3 he was also Engineer for North Atlantic City in closing an inlet on Brigantine Beach.

Mr. Osborne, by his experience, was well posted in railway law, and was frequently called as an expert before the courts of New Jersey and Pennsylvania. Among the more important special work of Mr. Osborne may be mentioned the following: The stone skew arch, on ellipsoidal curves—the first in this country, built over 6th St., in Reading, Pa.; the long-lived wooden Howe truss bridge over the Schuylkill, at Reading, burned during the railway riots of 1877; the Swatara brick arch bridge on the Lebanon Valley R. R.; the Pulpit Rock tunnel, at Port Clinton; and the coal-shipping wharves at Port Richmond. He was a voluminous writer on professional subjects; and published "Select Plans for Engineering Structures," "Treatise on the Merits of Narrow Gage Railroads," "Profesional Biography of Moncure Robinson," etc.; it is also claimed that he suggested and originated the "Lyons Tables," still used by engineers. He patented the Statistical Suspension Truss and the Elastic Arch Truss Bridge.



Richard Boyse Osborne.

In 1842, Mr. Osborne married Eliza, the youngest daughter of Major Bartholomew Graves, one time Prothonotary of Philadelphia. His brother, the late John H. Osborne, was also a civil engineer, and was associated with him on many works. Mr. R. B. Osborne was a Life Member of the Institute of Civil Engineers of Ireland, since 1856, and an active Member of the Engineers' Club of Philadelphia.

SOME OLD-TIME WATER WHEELS.

By Wm. Wallace Christie,† M. Am. Soc. M. E.

(With two-page plate.)

The earliest record of a machine for developing the power of moving water that I am able to find is the machine shown in Fig. 1, taken from an article by the late W. F. Durfee, published in "Cassier's Magazine" for March, 1899. The power of this open frame, undershot wheel was transmitted by means of a bent crank on one end of its shaft, which raised and lowered the pump rods in the well; unfortunately we have no information given as to its proper place in historical dates.

Bishop Ely, the British Embassador at Rome, describes as a curiosity "that which he saw at Lyons" in 1555:

> A saw mill, driven with an upright wheel, and the water that maketh it go is gathered into a narrow trough, which delivereth the same water to the wheel.
>
> This wheel hath a piece of timber put to the axle tree end, like the handle of a "brock" (a hand organ) and fastened to the end of the saw, which being turned with the force of the water, hoisteth up and down the saw, that it continually eateth in and the handle of the same is kept in a ringall of wood from severing.
>
> Also the timber lieth as it were upon a ladder, which is brought by little and little to the saw by another vice.

The first saw mill in England was put up near London by a Dutchman more than a century later.

Coming down now to more recent times and our own country, we have, in Fig. 2, an overshot wheel with a revolutionary record. It was used in a grist mill near the Orange, N. J., Water-Works Dam. It has arms of wood, placed edgewise. Grist mills operated by water wheels are very old, dating back in this country to about 1730, and this wheel is without doubt older than any of the others described in this article.

In New England the first water wheel is supposed to have been in use in Dorchester, Massachusetts, about 1628, for a grist mill. Barent Pieterse Koeymans built a water mill or grist mill near Albany on the Hudson River, New York State, between 1631 and 1636.

There was a water mill in the vicinity of Wall St., New York city, previous to 1661, the waste water of which passed to the North River through what is now Canal St., where the Dutch maidens did their weekly washing.

In 1649, a tract was published in London, England, entitled "A Perfect Description of Virginia," which states that they (Virginia people) had four wind mills, five water mills, to grind corn, besides many horse mills. Inventors have been fascinated with this subject, for 306 patents were granted in the United States up to the year 1857 for water wheels; the greatest number up to that time for any one subject. The first of these was issued to E. Frame Hubbie, of Middlebury, Vt.

The oldest mill seat in New Jersey was established at Athenia in 1734; this has been carefully traced and was known as Westervelt's Mill, and was used as a grist and saw mill.

Another oldtimer is a large overshot water mill at Ringwood, N. J., on Cooper & Hewitt's property, which was used in connection with iron forges as early as 1770. Not many years ago this same wheel was being used to churn milk.

Fig. 3 illustrates a saw mill wheel at Wyckoff, N. J., of the overshot type, with arms and rim of wood. The shaft and bearing are also of wood, the ends of the shaft being bound with iron. At the left can be seen a box-like pulley wheel which, by means of a small iron pinion on its shaft and the toothed rim on the water-wheel, gave the high speed which in other plants was obtained by means of a separate "flutter" wheel. At the right are the pulley, gear, etc., used to transmit the power from the main wheel directly to the vertical saw blade. This plant dates back to about 1770.

Sometime between 1770 and 1776, the Windham Forge, Stockholm, N. J., was established (Fig. 4). The name was originally Wingdam, finally corrupted to Windham. The forge is supposed to have been founded by Capt. Winans, and it was later operated by John O. Ford. It worked ores from the Ogden mines, now operated by Thos. A. Edison, and also ore from some other local mines. Miscellaneous forgings and iron blooms were the product of this forge. The last work done was anchor making.

This was one of many powers where three wheels were in operation to obtain three speeds without the necessity of belting down—an old example of "direct connection." One of the wheels is in ruins, shown in the foreground, with parts of the ore stamping devices; its diameter was 14 ft., face 5 ft., shaft, of wood, 24 ins. in diameter. Both this and the other large wheel are of the pitch-back type, and the diameter of the smaller of these wheels was 12 ft., face 7 ft. With its connection to a wood crosshead and a cylinder 5½ ft. in diameter, it makes a very complete illustration, if not the original of the first forced-draft plant in connection with iron-forge chimney fires.

The undershot flutter, or hammer wheel, was 8 ft. in diameter by 6 ft. face, built up of 3-in. rough hewn plank, spiked one across the other in two

†Paterson, N. J.

thicknesses. Its shaft was of rough hewn wood 3 ft. in diameter, with iron bearings. The old workmen told me that a shaft for this wheel was very difficult to find. It was of white oak, and its immense diameter, and the twisting strain brought upon it, made the obtaining of it the most difficult task to accomplish in the fitting-up of a large forge. The trip-hammer ruins, and the levers by which the water gate opening was controlled may be seen in the photograph.

Between 1770 and 1780 Stephen Personet started a mill at Cedar Grove, N. J., which has since been known as "Steve Allen's Bark Mill," where bark and snuff were ground for many years, the raw material being carted from Newark, N. J. The wheel was of the breast-wheel type, and has a gear in segments bolted to the outer rim of the wheel to furnish power to another shaft than its own. The water entered the wheel buckets at about the height of the wheel center.

Some parties locating in Belleville, N. J., about 1795, started a foundry, machine shop and smelt-

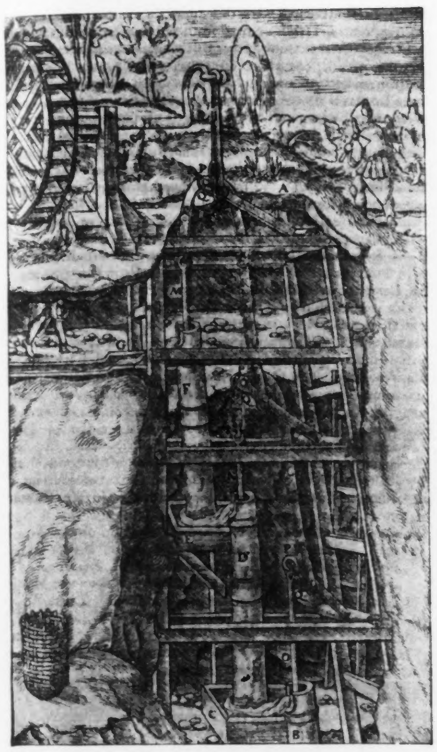


Fig. 1.—An Ancient Mine Pumping Plant.

ing works for copper, now known as Hinrich's Bros. Copper Mill. Fig. 6 shows the old wheel at these works. It is of the pitch-back type, with a shaft of wood 36 ins. square, with wrought-iron bands, and cast-iron gudgeon pins 10 ins. in diameter, and wooden arms. We notice, however, some advance over the previous wheels. The rim is cast iron, in segments, and there are iron hub-plates. The diameter of this wheel was 18 ft., its face was 13 ft.

Ryerson's forge, at Bloomingdale, N. J. (Figs. 7 to 9), was established about 1815, using ore which came from mines partly owned by Martin John Ryerson, at Ringwood, N. J. Fig. 7 shows the undershot flutter-wheel with shears, and the large wheel. Wooden shafts are in each, and the iron gudgeon pins in the ends of the shaft of the large wheel turn in iron bearings. The anvil is seen at the left of the shears in Fig. 8. There was a third wheel in this plant located beyond the building shown in Fig. 8.

Figs. 7 and 8 show both the large and flutter wheels, and also show very clearly a large separate wooden wheel used as a gear wheel, having a toothed rim bolted to its circumference. Outside of this wheel is a small gear which, by means of a pinion on the crank shaft, operated a shear to cut scrap or bar iron. The iron shaft with trips which operated the stamp, lies in the foreground in Fig. 7. Notice also the iron pipe used to supply air to the small forge at the left of the shear.

The third wheel at this plant, referred to above, had a wooden rim and spokes. By means of a crank on its shaft and an iron-bound wooden connecting rod, it drove a piston in an iron cylinder in the stone building, and furnished forced draft to the forge fires.

The trip hammer and its anvil are well shown by Fig. 9. The framing is of very heavy timber. The chain which supported the weight of the tongs holding the hot iron while being forged is in plain sight, as is also a large wooden shaft from the flutter-wheel, fitted with an iron dog which lifted the hammer beam once at every revolution of the shaft. Fig. 7 gives a better view of the beam which acted as a spring for the hammer beam, and of the flutter-wheel, hammer and anvil.

The shear used to cut up the scrap would seem to be a somewhat modern device, and may not be as old as the wheels.

Iron furnaces were also established in the vicinity of Lake Hopatcong, N. J., and Figs. 10 and 11 are views of the wheels at a forge located at the foot of the Morris Canal incline, about one mile from the D., L. & W. R. R. station.

This forge was probably established about 1760-70. The wheel shafts are of cast iron, turned at the bearings, and taken altogether they seem to be of later construction than 1770. In fact, they are of the latest type here shown, and hence may not be the original wheels. While other large wheels had a gear on the outer rim, this wheel has a small gear on the shaft. While other wheels were governed by a lever, this one has a wheel for that purpose, though a lever is used for the flutter-wheel, which in this case is an open-framed wheel. The water was brought to these wheels in sheet-iron flumes. The large wheel had cast-iron flanged plates with hubs at each side of the wheel for the iron shaft to pass through.

Fig. 12 is an overshot wheel 30 ft. in diameter by 3-ft. face, containing about 90 buckets set in iron-end brackets. The wheel was placed on a very substantial masonry foundation. It was located at Hudson (Claverack Landing), N. Y. The tail race emptied into the Hudson River. This wheel had wooden arms and an iron axle. It was built about 1820, and the entire plant is now a thing of the past. The water was brought from Underhill's Pond in a tube and penstock.

FIG. 12.—OVERSHOT WHEEL AT HUDSON, N. Y.

The oldest paper mill in New Jersey is now known as Kingsland's Lower Paper Mill, Delawanna. The works were established more than 100 years ago by John Bradbury. Fig. 13 shows the remains of the late-type pitch-back wheel, with wooden arms, and an iron shaft, with iron flange plates around it at each end.

The illustrations to this article, with two exceptions, are from negatives made by Mr. Vernon Royle, of Paterson, N. J., an amateur photographer, and President of John Royle & Sons.

EXPERIMENTS ON SEWAGE PURIFICATION AT THE LAWRENCE EXPERIMENT STATION DURING 1898.

For twelve consecutive years there have been carried on at Lawrence, Mass., an exhaustive series of investigations on the purification of sewage and water which have justly brought international fame to the Massachusetts State Board of Health, under whose direction the work has been conducted: The general supervision of this work has been under the direction of Mr. Hiram F. Mills, C. E., of Lawrence, from the start. The station work during 1898, and for some years previous, has been in the direct charge of Mr. Harry W. Clark, who is now the chemist of the board. The operations of the station for 1898, the eleventh year of its existence, are presented in detail in the latest report of the board, just made public.

Beginning with the year 1898, a septic sewage tank was put in operation, the effluent being treated on filter beds of different characteristics. The size of the tank is not given. The sewage remains in it from 24 to 36 hours, being drawn out as wanted for the filter beds, instead of flowing through continuously. The tank effluent shows a removal of 48% of albuminoid ammonia and 43% of carbonaceous matter, as indicated by the oxygen consumed from permanganate. Ordinary plate cultures show a diminution of 85% of the bacteria during the stay of the sewage in the tank. The bacteria in the effluent are nearly all facultative; that is, they can live either with or without the presence of oxygen. Whether other than ordinary plate cultures might be expected to give different quantitative bacterial results, the report does not state. The effluent contains a larger proportion of liquefying bacteria and the suspended matter is in a finer state than is shown by the crude sewage.

The septic effluent was applied during 1898, or parts of the year, to three different intermittent filters and to a contact filter bed. The contact bed is of much coarser material than the others, and has its outlets closed so the sewage will remain in contact with the filtering material for as long a period as may be desired, instead of flowing out through the underdrains as soon and as fast as it reaches them. This particular contact bed has sewage applied at hourly intervals for eight hours, beginning early in the morning, the bed becoming filled so the sewage just covers the surface in that time. After remaining filled for two hours the outlet is opened and the sewage "allowed to drain very slowly." The filtering material consists of 5 ft. of coke, all of which has passed a screen with a ¼-in. mesh, and most of which would be retained by a ⅛-in. mesh. This size of material prevents surface clogging, gives a larger percentage of voids and, together with the method of filling, brings all the material into use, air being drawn down to the bottom of the filter daily and the sewage being aerated to some extent as each dose passes rapidly down into the bed.

For the last seven months of the year the contact filter operated at the rate of 800,000 gallons per acre per day (for six days in the week) giving "a better appearing effluent than the intermittent filter, and one which contains less organic matter, as shown by the analyses, and only about one-half as many bacteria." The intermittent filter to which reference is made operated at the rate of 100,000 gallons a day for June, July and August, 165,000 for September and 200,000 gallons during the last three months of the year, giving an average daily rate, six days in the week, of about 150,000 gallons. Reduced to a practical basis of seven days in a week the comparative rates of the intermittent and contact filter are about 130,000 and 700,000 gallons per acre per day.*

The intermittent filter not only gave less favorable results than the contact filter, but it was very slow in setting up nitrification and did not do thoroughly satisfactory work after nitrification was established. This is not surprising, since it is well known that the septic effluent is inimical to nitrifying bacteria. The sand in this intermittent filter was 5 ft. deep, with an effective size of 0.26 mm. (0.01 in.) a size considered very favorable for ordinary intermittent filtration. In September, 1898, a second intermittent filter, of the same depth but having finer sand (0.17 mm.), was started. To this filter sewage was applied at a daily rate of 100,000 gallons an acre during September and October, 173,000 in November and 200,000 gallons in December, making an average of 143,000 gallons for the four months, or about 120,000 gallons per acre per day, when reduced to a seven-day basis. The resulting effluent was better than that from the coarser-grained intermittent filter, during its first four months of service. This is attributed to the slower passage of the sewage through the finer-grained filter and the consequent opportunity for deleterious gases to escape from the sewage while the latter remained on the surface of the bed, which averaged ten minutes for the fine and only a little over one minute for the coarse-grained or earlier bed. Still later in the year a third intermittent filter was started, the filter itself being a duplicate in every respect of the one first put in service, but having the septic sewage aerated before being applied to the filter. The results from this filter indicate an improvement in quality and a much higher rate of filtration than was obtained with the un-aerated sewage. This is as would be expected, both from the nature of the case and from the fact that the sewage from the English septic tanks is subjected to aeration before going to the filters.

Mr. Clark concludes his review of the experiments with the septic tank by expressing a belief that such tanks may be made relatively smaller than the English examples and need not be covered, as follows:

Our studies have also indicated that it is probable that a much smaller septic tank can be used, in proportion to the volume of sewage flowing, especially where this volume is large, than has been proposed abroad, for this reason: A sewage of ordinary age, that is, one which has traveled for any considerable distance in the sewers, will, when it reaches its point of disposal, be practically free from dissolved oxygen, all having been exhausted before reaching this point. If such a sewage is run into a properly built septic tank, no air will be carried in with it, and the length of time which it remains within the tank need be only long enough to allow a precipitation of the organic matters in suspension and the accumulation of the fats upon the surface of the sewage. These matters can remain in the tank for an indefinite time—being added to, of course, each day by the sewage flowing through—and, by the action of the bacteria of decomposition and putrefaction, a large percentage of the sludge will be slowly changed to the soluble form, and pass away to a large extent, perhaps, in the effluent of the tank. It seems to be doubtful if it is necessary to have this tank air-tight; it is also doubtful if it is necessary to exclude light, experiments made at Lawrence seeming to show that the action goes on as well in the presence of air over the surface of the sewage and with light as it does without air and without light. Of course, with an air-tight tank the gases can be prevented from escaping into the air until just before running upon the sewage filters, and at that time they can be taken care of, and thus prevented, perhaps, from making the tank and its surroundings a nuisance. It is also probable that higher rates of filtration of the tank effluent can be maintained than followed during 1898.

The principal object of the septic tank is to so alter the character of sewage that it may be applied to filter beds at a higher rate and with less outlay of labor in caring for the beds than would be possible otherwise. This is effected, chiefly, by removing the sludge, both organic and inorganic, and by so changing the character of such suspended matter as may pass through the tank as to reduce its powers of clogging the filter beds. The active agent in the septic process is supposed to be the anaerobic bacteria, or those working in the absence of oxygen. For some years before experiments with the septic tank were begun at Lawrence, various other means of reducing the quantity of sludge were tried, including chemical precipitation, simple sedimentation, straining, or rapid filtration through various materials.

Of the materials used for straining, or rapid filtration, coke seems to have been the most satisfactory. During the first nine months of 1898, sewage was passed at the rate of 1,000,000 gallons per acre per day (six days in the week) through 6 ins. of coke, the upper 1½ ins. of which "was fine coke breeze." This straining removed 48% of the organic matter in the sewage, including 73% of that originally in suspension. The strained sewage was applied intermittently at a daily rate of 320,000 gallons an acre (six days in the week) to a filter containing 5 ft. of sand having an effective size of 0.19 mm., which had been receiving sewage strained through coke for over three years previous to 1898. The result was "a well-purified effluent, without turbidity, with very little color and without odor," containing an average of only 85 bacteria per cu. cm., against monthly averages of from 698,000 to 2,448,000 in the original sewage and 82,000 to 970,000 in the strained sewage. Changes made in the composition of the strainer, during the latter part of the year, indicate that the use of coke somewhat coarser than breeze will permit of a higher rate of straining for the same depth and area of coke.

It is well known that the bulk of the work done by an intermittent filtration area is accomplished in the upper layers of the filter and that the finer the filtering material the lower the rate of filtration must be. The difficulty with coarse material is that the sewage passes through it too rapidly to give the necessary time for bacterial action. By closing the underdrains the sewage may be retained in the bed as long as is desired, but unless the material is quite coarse it will drain out slowly when the outlets are opened. If a sufficiently coarse-grained material, uniform in size, is used, the air spaces in the beds are materially increased, the chances for surface clogging diminished or removed, the whole depth of the bed may be quickly filled or drained, and every portion of its volume utilized. Accordingly, there has been gradually developed by various engineers and others in England a modified form of intermittent filtration, in which the beds are filled as rapidly as possible, allowed to stand full for a time and then drained as fast as may be. The object of the rapid filling is to draw air into the pores with the sewage; standing full gives the bacteria a chance to work; quick draining sucks air down through the whole body of filtering material. Such filters are called contact beds. Their size and rate of operation should really be determined by volume rather than area, and are so expressed quite commonly in England, although as a matter of convenience surface area and rate per acre are still largely used.

One of these contact beds has already been described in connection with the work of the septic tanks. That bed, as well as a number of others at Lawrence, is filled by intermittent dosing, instead of by one continuous dose, as in England. The material used at Lawrence for these filters has been cinders and coke, with an apparent tendency to use coarser material as the studies progressed. With cinders and coke the voids have approximated 55% of the volume of the bed, instead of 35 to 40% for intermittent filters. In general, these bacterial filters, as they are called in England, have given a fair degree of purification at Lawrence, with high rates of filtration. Further tests, with modifications in detail like those gradually being introduced, will enable one to speak more conclusively of the results that may be obtained by this method of treating sewage. The Lawrence experiments, and the tests abroad, both experimental and practical, indicate that there is much to be expected along these lines.

Studies of tannery, paper mill, creamery and other wastes were carried on during the year at Lawrence with promising results. A number of the large intermittent filters, having an area of one two-hundredth acre, and placed out doors, were continued in operation during the year. Three of these have been in use for eleven years, and during 1898 treated an average of from 19,300 to 60,500 gallons of sewage per acre per day (six days in the week) with a removal of from 99.99 to 99.15% of the bacteria and 98 to 89% of the albuminoid ammonia. Of seven of these large filters in use during the whole year, the lowest bacterial removal was 98.57%, while operating at an average rate of 70,700 gallons per acre (six days in the week). This filter was started on March 5, 1898. It removed 93% of the albuminoid ammonia in the applied sewage. The old filter mentioned above as having worked at the low rate of 19,300 gallons per day (or only less than 17,000 gallins per acre, seven days in the week) in composed of 60 ins.

of fine river silt of an effective size of 0.04 mm. (0.0016 in.), with two circular trenches, about 14 ins. wide and 12 ins. deep, of coarse sand of an effective size of 0.48 mm. The surface of these trenches is below the surface of the remainder of the filter and to them the sewage is applied. * * * The surface of the trenches has been raked 1 in. deep each week and spaded to a depth of 6 ins. on March 26 and Oct. 1.

The filters working at the higher rates are composed of coarser material.

*The results at Lawrence are expressed on the basis of the average daily amount of sewage applied for six instead of seven days per week, thus indicating a rate 14.2% higher than the actual.

THE LIQUEFACTION OF AIR.*

By Arthur L. Rice, Jun. M. Am. Soc. M. E.†

In 1884 Dewar, at the Royal Institution, showed that liquid air could be produced by the use of solid carbon dioxide and nitrous oxide as cooling agents, giving − 184° F. (− 120° C.), a compression to 200 atmospheres and subsequent expansion; the amount liquefied was about 5% of the air compressed. He also devised for holding liquid gases the vacuum flasks which bear his name. By this means the rate of evaporation of a liquid gas is reduced to 1-5 that in the open air; if the inner wall be coated with mercury to form a heat mirror, the evapora-

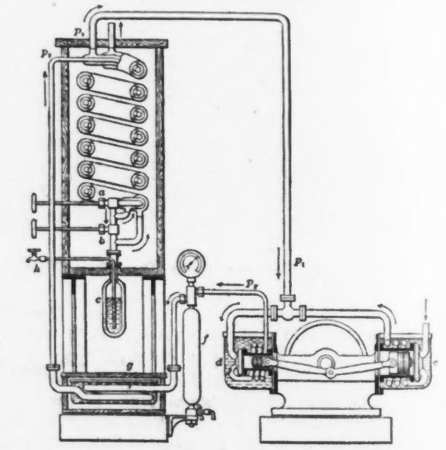


Fig. 1.—Air Liquefying Apparatus of Linde, 1898.

tion will be only 1-33 the free rate. These flasks were the means by which liquid gases were handled and kept in static form, until very recently.

Dewar at first used the Cailletet apparatus as altered by Wroblewski, but changed to that of Pictet, using, however, pumps to compress the gases previously made, and force them into the liquefying chamber; he used ethylene in place of carbon dioxide, placed the draw-off cock inside the cooling chamber, and, later, added the regenerative principle suggested by Siemens for cooling the chamber in the case of hydrogen liquefacton. Professor Dewar is the most extensive of the modern experimenters in the field of the liquefaction of gases; he first liquefied oxygen in large quantities and held it in liquid form in 1891, and a little later liquid nitrogen was produced. In 1895 he demonstrated that air in the liquid form could be frozen to a jelly-like solid by the expansion method, the jelly proving to be a mass of nitrogen with the liquid oxygen of the air contained in the interstices; this solid air melts instantly on contact with the atmosphere. In

*From a paper presented at the New York meeting of the American Society of Mechanical Engineers.

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1896, before the Chemical Society, the production of a jet of liquid hydrogen by means of the expansion of the cooled and compressed gas and the regenerative method of cooling the incoming gas was announced; by the use of this hydrogen jet, oxygen and air were frozen to a solid white mass.

Continuing this line of research, in May, 1898, Dewar was able to collect hydrogen in static condition, and to hold it in this form by the use of the Dewar bulbs at a temperature of − 396.4° F. (− 238° C.) only 65° F. above the absolute zero.

Although liquid air has received considerable attention from the investigators already mentioned, they have been particularly interested in the scientific investigation of the properties of the elementary gases. The workers in this particular field have been Tripler, Linde and Hampson, all of whom have been aiming at the simplification and cheapening of the production, so that the liquid may be made of use. All three have been working along the lines of a direct regenerative action, as suggested by Siemens. Dewar has also done work along this line, combined with cooling by a separate fluid, but in a smaller way, as would be expected in a chemical laboratory. The principle is this: a perfect gas expanding to do work loses heat; if this cooled gas be exhausted so as to jacket the pipe through which the incoming gas enters, it will cool that incoming gas; the process is cumulative without limit, if the machinery is frictionless and insulated against heat from the surrounding objects. Solvay built a machine on this principle, but was unable to get lower than − 139° F. (− 95° C.), on account of the heat due to the friction of the pistons and to conduction.

In a perfect gas no lowering of the temperature would result from lowering of the pressure by free expansion, but none of the so-called gases are perfect, and all are cooled somewhat by expansion through an orifice. Joule and Kelvin found that with air the fall of temperature is about 0.45° F. (¼° C.), for each atmosphere difference of pressure at the orifice, at ordinary temperatures, and that the effect increases as the temperature falls, because the gases are coming more nearly to the vaporous state. If, then, air be compressed to a high pressure and allowed to expand through a small orifice, it will become considerably cooled and may be used to cool the incoming air, which, in turn, will lose heat by expansion; the process may be carried on until some of the air, on or before leaving the orifice, is liquefied.

Tripler's English patents of 1891 seem to be the first specification of any definite machinery for thus liquefying air. Linde and Hampson did not come forward with a working apparatus until 1895, and, at that time, Tripler's apparatus was about perfected. The latest (1898) type of Linde's machinery is shown in Fig. 1. The fall of temperature, as previously stated, is proportional to the difference of pressures at the orifice, and this difference should, therefore, be large; the work required to compress the air again will depend upon the ratio of the pressures; i. e., upon the ratio of compression, and should be as small as possible. This necessitates that both pressures be high for the most economical working, hence Linde works his machine between 200 atmospheres and 16 atmospheres for all the air by expanding through the valve a; 1-5 is then expanded to 1 atmosphere through the valve b, so as to cool it still further, and about ¼ of this amount is condensed.

The expanded air is sent back in the outer pipes as shown, the part which is at 16 atmospheres to the compression pump, and the rest to the atmosphere. f is a separator and g a freezing bath, both being used to remove the moisture from the air; d is the compression pump, and e a pump for supplying at 16 atmospheres as much air as escapes at b. In the earlier form of the machine, none of the air was expanded below 50 atmospheres, and the air was cooled by a surface condenser supplied with water. With this apparatus, about 0.9 of a quart of liquid can be obtained per hour with the use of 3 HP., this being about 5% of the air handled; the first liquid will appear about two hours after starting up the machine.

Hampson's apparatus is somewhat simpler and more compact. Three helices are arranged in the form of concentric cylinders, and connected so that air is forced through them successively, beginning at the outside; expansion occurs at the lower end of the inside spiral, and the released air flows back along the outside of the three coils in a reverse direction and escapes to the atmosphere near the inlet. With this device Hampson claims to have condensed about 1.2 quarts of air per hour at an expenditure of 3.5 HP., using a pressure of 120 atmospheres expanded to 1, and getting 6.6% of the air handled as liquid; the liquefaction commences in 15 minutes from the time of starting.

Lennox, an assistant of Dewar, reports the making of 1 quart of liquid per hour by the cascade system with an expenditure of 3 HP., at a pressure of 300 atmospheres

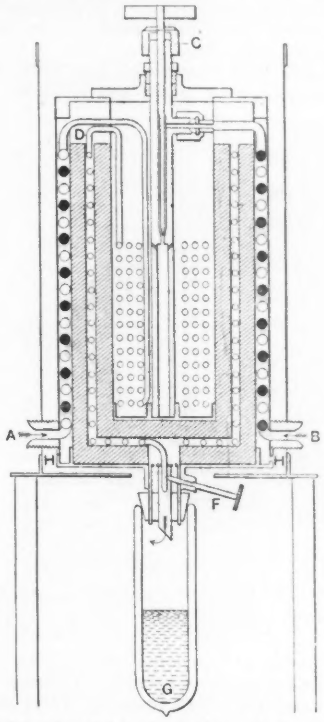

Fig. 2.—Air Liquefying Apparatus of Dewar, 1899.

expanded to 1. Dewar's latest apparatus is shown in Fig. 2. In this both regenerative action and cooling by carbon dioxide are employed; if air be drawn from steel cylinders at 200 atmospheres pressure and expanded to 1, the amount of air liquefied will be about 5% of that used, and the liquid will begin to flow in six minutes from the time of starting.

These achievements, though notable, seem petty when compared to the work of Mr. Tripler in producing gallons of the liquid, and handling it in ordinary tin cans with only a felt or air packing for protection from heat absorption. Mr. Tripler's apparatus* consists of a three-stage compressor drawing air directly from the atmosphere and driven by a steam engine. The air is taken first into the low-pressure cylinder, where it is compressed to 65 lbs. per sq. in.; it is then sent through an intercooler to reduce the temperature to that of the atmosphere, and taken into the intermediate-pressure cylinder; from that, at a pressure of 400 lbs., it is taken through a second intercooler to the high-pressure cylinder, where it is forced up to 2,000 to 2,500 lbs., and thence sent to the aftercooler to be reduced again to the temperature of the atmosphere. The air is passed through a separator to take out all moisture and then passes to storage tubes in which compressed air, not in the liquid form, may be kept. The liquefier is Mr. Tripler's special invention; this takes the air from the separator and, by expansion through a coil of pipe and a small orifice, cools it to a low temperature; it passes up around the coil of pipe, cooling the air inside and thus giving the regenerative action. The expansion valve is placed at a little distance above the bottom of the coil, so that some liquid air collects in the bottom of the coil, and thus serves to further cool the air as it comes to the expansion cock. The air which is to be drawn off collects in the liquefier just below the expansion valve, and may be drawn off at will. The expanded air escapes to the atmosphere after having been used to cool the coil of the liquefier. The capacity of the present plant is two to four gallons per hour, and the air will begin to liquefy in 15 minutes after starting up. No data are available as to the power used in the compression.

*See Eng. News, April 14, 1898.

The physical constants which have been determined with regard to the liquefied gases are given in the accompanying table, which was prepared by Mr. Walter Dickerson. It will be noted that the order of the liquefaction of the gases historically is almost exactly that of the descending critical temperatures; it is the attaining of a low temperature limit that has taken all the time and study that have been devoted to this matter. Some of the gases when in the liquid form are lighter, and some heavier than water, as shown by the values of specific gravity; of the constituents of air, nitrogen is lighter and oxygen is heavier; the mixture, containing 4-5 nitrogen and 1-5 oxygen, is a little lighter than water.

Professor Jacobus and Mr. Dickerson have found the latent heat of air at atmospheric pressure to be about 140 B. T. U., but this figure is stated as only a rough approximation. This is about the only value which has been determined with regard to air in the intermediate or vaporous state.

Any calculations as to the efficiency of liquid air as a fluid for a prime mover must necessarily be only approximate. The approximations can, however, be made on the right side, and the air given the benefit of the doubt. President Henry Morton has recently made some calculations regarding the maximum amount of power which could be obtained by the expansion of one pound of liquid air under certain circumstances. The same hypothesis which he used will be assumed and his figures adopted.

Suppose one pound of liquid air to be confined in a cylinder and heated to 70° F., then let it expand at 70° to atmospheric pressure, the expansion to be hyperbolic. It is not known what the volume of the air will be at 70° before expanding, but it is certain that its ratio of expansion will be less than it would be if expanding from the volume of the liquid at − 312° to the volume of the gas at 70° and atmospheric pressure; this ratio is something less than 800, hence we will call the ratio of expansion 800. The volume of one pound of air at 70° F. and atmospheric pressure is 13.36 cu. ft.

The work done in a hyperbolic expansion is:

$$W = p_2 \times v_2 \times \log_e R,$$

when

p_2 = final pressure per sq. ft. = 2,117 lbs.
v_2 = " volume = 13.36 cu. ft.

$$R = \frac{v_2}{v_1} = \text{Ratio of expansion.}$$

TABLE I.

Physical constants.

No. of line.	Substance.	Symbol.	Critical temperatures, degrees Cent.	Critical temperatures, degrees Fahr.	Critical pressure. Atmos.	Temp. of saturated vapor at atmos. pressure, degs. Cent.	Temp. of saturated vapor at atmos. pressure, degs. Fahr.	Freezing point, degrees Cent.	Freezing point, degrees Fahr.	Pressure at which freezing point determined, mm.	Density of gas.	Density of liquid at temperature given.	Color of liquid.
1	Water	H_2O	365	689	200	100	212	...	32	760	.....	1 at 0.4°C.	Colorless.
2	Hyd. selenide	H_2Se	185	365	91	− 41	− 41.8	− 68	− 90.4	...	40	....	"
3	Ammonia	NH_3	130	266	115	− 33	− 27	− 77	− 107	...	8.5	0.6364 at 0°C.	"
4	Propane	C_3H_8	97	206.6	44	− 45	− 49	Still liquid at	−151°C.	...	20.95	....	"
5	Acetylene	C_2H_2	37	98.6	..	− 85	− 121	− 81	− 113.8	950	12.97	....	"
6	Nitrous oxide	N_2O	35	96	75	− 89	− 128	− 115	− 175	760	21.99	....	"
7	Ethane	C_2H_6	34	93.2	50.2	− 93	− 135.4	Still liquid at	−151°C.	...	19.97	....	"
8	Carb. dioxide	CO_2	31	88	75	− 80	− 112	− 56	− 69	760	21.94	0.83 at 0°C.	"
9	Ozone	O_3	..	..	..	− 93	− 135.4	..	..	...	23.89	....	Dark blue, easily explod'd
10	Ethylene	C_2H_4	10	50	51.7	− 102	− 150	− 169	− 272	...	13.97	....	Colorless.
11	Methane	CH_4	− 81.8	− 115.2	54.9	− 164	− 263.4	− 185.8	− 302.4	80	7.98	0.415 at − 164°C.	"
12	Nitric oxide	NO	− 93.5	− 135	71.2	− 153.6	− 254	− 167	− 369	138	14.98	....	"
13	Oxygen	O_2	− 118.8	− 182	50.8	− 181.4	− 294.5	..	..	...	15.96	1.124 − 181.4° C.	Blue.
14	Argon	A	− 121	− 185.8	50.6	− 187	− 304.6	− 189.6	− 309.3	...	19.9	about 1.5 at − 187°C.	Colorless.
15	Car. monoxide	CO	− 139.5	− 219.1	35.5	− 190	− 310	− 207	− 340.6	100	13.96	....	"
16	Air	..	− 140	− 220	39	− 191.4	− 312.6	..	..	...	.....	0.933 at − 191.4° C.	Light blue.
17	Nitrogen	N_2	− 146	− 231	35	− 194.4	− 318	− 214	− 353.2	60	14.01	0.885 at − 194.4° C.	Colorless.
18	Hydrogen	H_2	− 234	− 389	20	− 243	− 405	..	..	...	1	....	"
19	Helium	He	..	..	..	Below − 264	− 443.2	..	..	...	2.02	....	....

$W = 2{,}117 \times 13.36 \times 6.685 = 188{,}000$ ft. lbs.

$\frac{188{,}000}{60 \times 33{,}000} = .095 =$ HP. per lb. of air used per hour, and $\frac{1}{.095} = 10.55$ lbs. of air per HP. per hour, if the terminal pressure equals the back pressure, no compression and no clearance being considered.

This result cannot, of course, be realized, for there are many sources of loss which cannot be avoided, and which will make this figure for the weight of air per horse-power hour much higher. However, even if it could be realized in actual practice, it is only just inside of the figure which has been obtained in our best steam engines under practical working conditions. In these figures the liquid is considered simply as a storage medium for energy, and no account is taken of the amount of heat necessary to develop or store the energy.

In order to get a comparative idea as to the relative values of liquid air and water for power storage, two similar cycles for water will be calculated, and comparative figures obtained.

The range of temperature in the cycle taken for air is from — 312° to 70° or 382°.

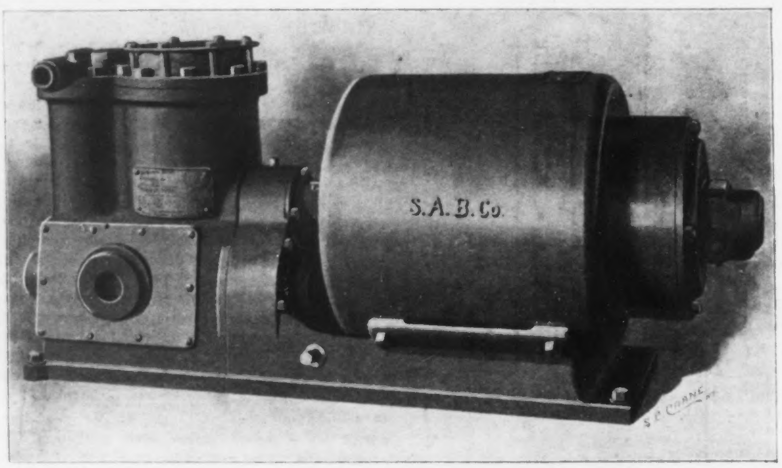

FIG. 1.—MOTOR-DRIVEN AIR COMPRESSOR OF 2 HP., BUILT BY THE STANDARD AIR BRAKE CO., 168 BROADWAY, N. Y.

Starting with water and heating it to 504° under 700 lbs. pressure absolute, and expanding it to 2 lbs. pressure absolute and 126° F., gives a range of temperature slightly less, viz., 378°. The ratio of expansion will be 254. This final volume of 1 lb. is 172 cu. ft., and considering the expansion to be hyperbolic, we have:

$W = 288 \times 173 \times 5.59 = 280{,}000$ ft. lbs.; $\frac{280{,}000}{60 \times 33{,}000} =$ 0.1415 HP. per pound of water used per hour, and $\frac{1}{.1415}$ $= 7.08$ lbs. of water per HP. per hour.

By heating the water to 546° under 1,000 lbs. pressure and expanding to atmospheric pressure the range of temperature would be still less, or about 334°.

The final volume would be 26.3 cu. ft.

Ratio of expansion $\frac{26.3}{.48} = 55$.

$W = 2{,}117 \times 26.3 \times 4.04 = 225{,}000$ ft. lbs.

$\frac{225{,}000}{60 \times 33{,}000} = .1139$ HP. per lb. of water used per hour.

$\frac{1}{.1139} = 8.8$ lbs. water per HP. per hour.

From these figures it will be seen that under the conditions assumed, water will give off from 20% to 50% more energy than liquid air, during expansion through equal temperature ranges. The possibility of the use of liquid air in a prime mover comes from the fact that the upper temperature limit for the range assumed is so low as compared with that for the steam. The upper limit for the air is at 70° F. or 531° absolute, and the possible thermal efficiency is $^{382}/_{531} = 0.72$; for the water the upper limit is 504° F., or 965° F., and the possible efficiency is $^{378}/_{965} = 0.39$. If the efficiency of the liquid is in any way comparable with that which can be gotten from steam in the steam engine, the efficiency of the air engine should be good. The cost of production of a pound of air would be much greater than that of a pound of steam, so that to be a commercial factor, the efficiency of the air engine would have to be much greater than that of the steam engine. Whether this can be accomplished, the future alone must decide.

As to other uses, refrigeration, medical cautery, prevention of chemical action, explosive compounds, reduction of resistance of conductors for electricity and use for prevention of the ill-effects of anaesthetics have been suggested, and others will doubtless develop as experiments are tried. It is only within a few months that the liquid could be obtained at a cost that allowed of trial of its properties for any except scientific purposes where no possible financial return was to be expected, and cost was a secondary consideration. With a large supply available, rapid development may be looked for, and new uses will be constantly discovered.

A SMALL MOTOR-DRIVEN AIR-COMPRESSOR.

The many and varied uses which are every day being found for compressed air have created a large demand for air compressors of small size, and simple enough to be operated without skilled attendance. The electric-motor-driven air-compressor which we describe below was originally designed for service in connection with air brakes on electric cars, but its simplicity of construction and efficiency of operation render it valuable for use in many other situations.

The motor and compressor are both substantially and compactly built, and are fastened together in such a way that they may be handled as a single machine. All wearing surfaces and all electrical parts are well protected from moisture and dirt, and the whole machine has a neat appearance, as may be seen in Fig. 1.

The compressor, of which a vertical longitudinal section is shown in Fig. 2, is connected to the motor through a reducing gear, the pinion on the motor shaft being made of raw-hide to reduce wear and prevent noise. The crank case is closed, except for a single vent, to allow for flow of air with changes of volume of the space under the pistons, and is intended to be partly filled with oil, which is dashed about by the cranks, so that the crank shaft bearings and the cylinders receive sufficient lubrication. When a raw-hide pinion is used, no oil is placed in the gear case, which, as will be seen, is separate from the crank case, but a small quantity of flake graphite is used. There is no tendency for the oil to work up above the pistons into the air compression space above, but rather the reverse.

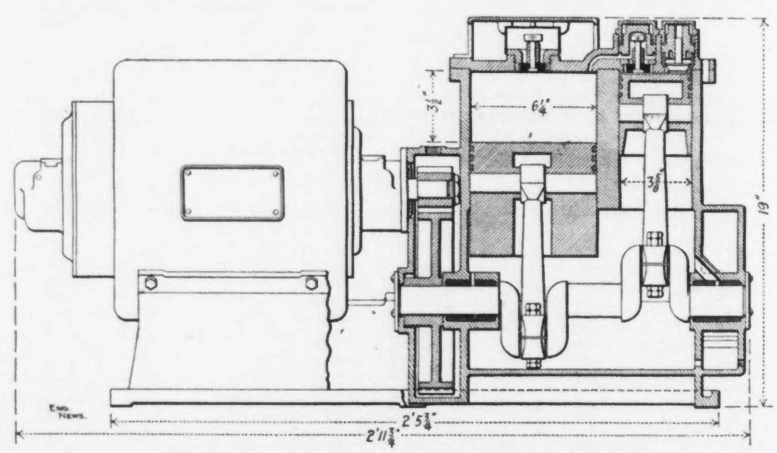

FIG. 2.—LONGITUDINAL VERTICAL SECTION OF AIR COMPRESSOR.

The compression is compound, the diameter of the low pressure cylinders being 6¼ ins., and that of the high pressure cylinder, 3⅝ ins., with a common stroke of 3½ ins. No intermediate receiver is employed between the cylinders, but the communicating passage is made as short and of as little volume as possible. The clearance space in either cylinder is a very small proportion of the whole displacement, which arrangement secures the greatest possible capacity with a given piston displacement. The advantages of compound compression, when an inter-cooling device is not used (which was hardly warranted by the capacity, 2 HP., and final pressure, 60 lbs. per sq. in., in the present case), are that a shorter length of joint must be kept tight, and a smaller clearance space filled at the final pressure than in a simple compressor. In this way there is less loss due to leakage, and less reduction of capacity due to air confined in the clearance space, both of which are important matters in the case of small machines.

Simple lift or clack valves are used, and are so arranged that they may be easily removed, together with their seats, when necessary. A large hood is secured to the top of the low pressure cylinder over the admission valve, and is packed with some light fibrous material, serving to prevent small particles of dirt or dust from entering the air passages.

The piston of the low pressure cylinder, as may be seen in the section, is made very heavy. This is evidently done in order to partially balance the high pressure piston while operating against the high pressure on the up stroke, and thus more evenly distribute the power required during a revolution. However, we deem this inadvisable, inasmuch, that if the piston travels at even a moderate speed, the inertia effect of a heavy reciprocating part would have a greater disturbing effect upon the speed than the unevenly-distributed pressure in the cylinders, besides causing the machine to pound upon its foundation, and thus produce a disagreeable and harmful vibration in the floor or car-body. The inertia of the rapidly revolving armature will be sufficient to take care of any great speed variation which might otherwise be due to unequally distributed pressure, which latter would be harmful in no other way.

In Fig. 3 are shown parts of two longitudinal sections of the electric motor, taken through the center of the shaft, the lower one being a vertical section and the upper one, horizontal. A transverse section on the line M M is shown at the right of the figure, and at the left one, on the line L L. The yoke of the magnets is a steel cylinder turned on the outside, so that it fits the bed plate, which is bored, thus insuring accurate alinement and doing away with planed surfaces. On the inside of the cylinder are two diametrically opposite T-shaped pole pieces C C, and the windings F F, concentric with the shaft, are so connected that these are consequent poles of the same polarity. The other pair of poles is formed by the inwardly projecting pieces E E, which are cast with circularg flanges fitting the ends of the cylinder at

J J. The two half-poles at one end of the motor, with the circular flange, are all in one piece, and, when removed, the field-coil at that end may also be taken out.

The self-oiling ring bearings are carried in cover-plates, which are bolted to the inwardly projecting poles. At the commutator end a metal ring is interposed between the cover-plate and the pole pieces. In this ring are openings for access to the brushes, the openings being usually closed by a circular steel band, provided with a clamp. By this construction, the motor is made practically dirt and dust proof, and presents a very neat appearance.

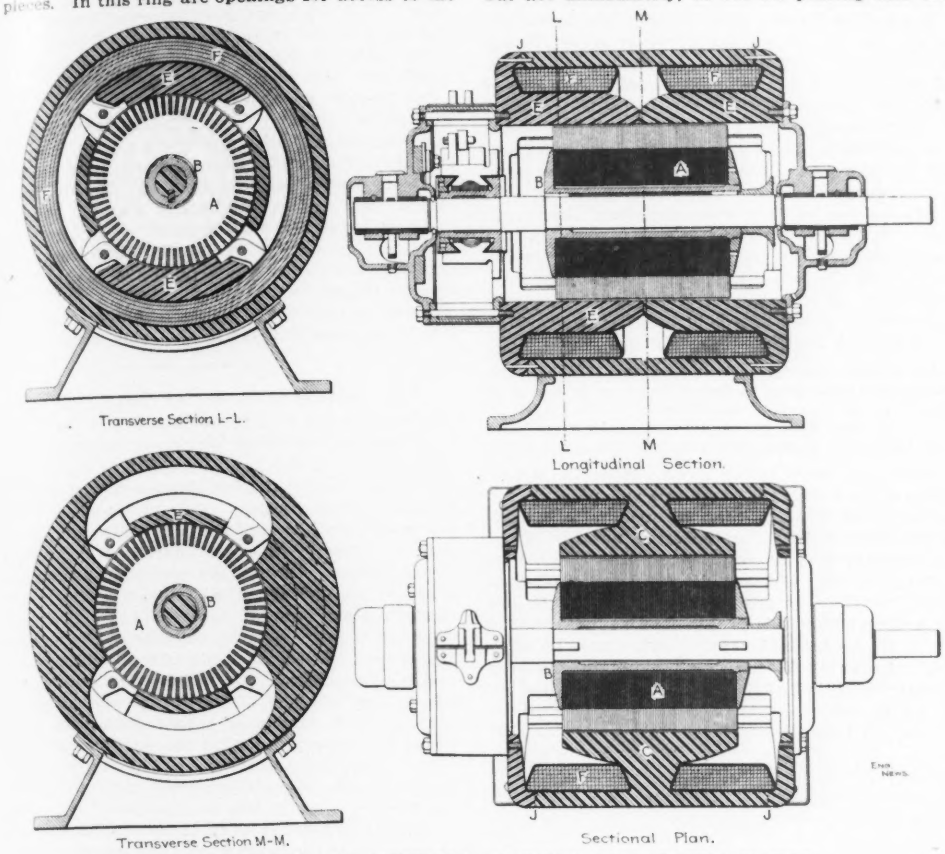

FIG. 3.—HORIZONTAL AND VERTICAL SECTIONS OF ELECTRIC MOTOR.

The field coils are of such a shape as to be easily and cheaply wound, and are well insulated and served with rope before being placed in position.

The armature is of the iron-clad drum-wound type. The core, A, is made up of soft steel stampings clamped together on the steel sleeve, B. The coils are separately wound on forms, taped with linen tape, and then placed in the slots, which are lined with mica troughs. The commutator segments are insulated with mica and clamped on a sleeve. The two carbon brushes are placed 90° apart on the upper side of the commutator, and the holders are attached to the ring, K.

The design of this motor is admirable, in that practically all the machine work required can be done on the lathe, and the turned fittings also insure perfect alinement. The special construction of the magnet frame allows the use of cast-iron cover plates, attached to the pole pieces, whereas in the usual multipolar construction some non-magnetic material would be necessary.

As the motor is series wound, it may be started with the full pressure on the mains, but it is usually desirable to use a rheostatic controller. One especially designed for use in connection with an air compressor is illustrated in Fig. 4. The main switch, which is provided with carbon points, is operated by the heavy spring at the left. The lower end of this spring rests on a piston, to the under side of which air from the supply pipes is admitted. This device is usually adjusted to open or close the switch with a range of pressure of 10 lbs. The contact arm of the rheostat is operated by the piston in the cylinder at the right. This rises slowly, cutting out resistance step by step as the air pressure increases, thus preventing too large a current at starting or racing of the motor at light loads. Whenever the circuit is broken, whether by the main switch or otherwise, a valve controlled by an electro-magnet allows the air to escape from under this piston, thus throwing in all the resistance. When the circuit is again closed, if there is a considerable pressure of air in the receiving vessels, the resistance is again cut out, but not immediately, as the air passing into the cylinder is throttled so that sufficient time is allowed for the motor to pick up speed without an excessive current, before the piston reaches the end of the stroke.

Where a very close regulation of the air pressure is desired, another controller is furnished, in which the regulating device is a metal diaphragm, similar to those used in steam gages.

The complete set which we have described is put on the market by the Standard Air Brake Co., of 168 Broadway, New York city. The motor is built by the Storey Motor & Tool Co., of Trenton, N. J.

VOTING BY MACHINERY.

We are indebted to Dr. R. H. Thurston, Director of Sibley College, Cornell University, for a copy of a report by the Finance Committee of the City Council of Ithaca, N. Y., of which committee Dr. Thurston is chairman, on the subject of the use of voting machines at the election on Nov. 7. The report is printed in full in the "Ithaca Democrat," of Nov. 23. Its conclusion is as follows:

Summarizing our conclusions, therefore, your Finance Committee would respectfully submit that:

(1) The voting machine is a simple, reliable, durable and convenient apparatus for its purpose.

(2) The machine compels the deposit of a perfect and accurate ballot, of the form chosen by the voter.

(3) It restricts the voter absolutely to the limits of the law and permits him freedom as absolute in voting within that limit.

(4) Blank and defective ballots, the usual fault of ordinary methods of voting, are entirely done away with and no man loses his vote through defect of the system, or fault of his own, if he votes at all. The disfranchised voter becomes unknown.

(5) Fraudulent voting is impossible as well as errors in voting.

(6) The vote cast is registered, vote by vote, with absolute accuracy and certainty.

(7) The result can be declared immediately upon the close of the polls, having been already completely counted.

(8) The cost of the system is so much less than that of the old method that the machines usually pay for themselves in from three to seven years.

The whole case may be summarized in a sentence: "The machines retain all the virtues and exclude all the vices of the old methods of balloting." Their use would be entirely justified, even though they involved a more costly, rather than a much less expensive system. Their adoption is looked upon by your committee as promoting good politics, good morals and good finance.

The committee quotes from the Rochester "Democrat and Chronicle" the following statement concerning the use of voting machines in New York State at the last election:

225 machines were used, 108 in Buffalo, 73 in Rochester and 26 in Utica, and the others in Ithaca, Albion, Canisteo and Winfield. Mishaps were reported to but seven of the 225 machines, of which three were due to "malicious vandalism and breakage by violence"—for which the law provides punishment if not a remedy at the moment—three came of misplacing of keys by election officers, delaying the opening of the poll; but in no case did the loss of a single vote result. All in all, the voting machine is one of the inventive triumphs of the age, and it is as sure in the near future to displace the printed ballot as steam has proven to be in putting out of date the stage coach and the packet-boat.

The committee also quotes the opinion of Prof. John E. Sweet past president of the American Society of Mechanical Engineers, as follows:

I have no hesitation in saying that I believe every object sought, so far as I have heard them presented, has been accomplished; that no other invention within my knowledge, of even a simple character, has been brought to a higher state of perfection with the experience and time this has had, and it is seldom that any invention has been so thoroughly constructed in its early stages. The invention is a completed one and the construction admirable. The invention is a notable one in its results and the simplicity of its mechanism. I have not been able to think of anything that the machine ought to do that it does not do, nor how it can be made to do that which it ought not, and of such of the voting machines as I know, and have heard, this is by far the best, and for those who want an honest vote and true returns, using this machine at the present time seems the only way.

A FIRE TEST OF A FIREPROOF CEILING was made at the testing plant of the British Fire Prevention Committee in London on July 26, 1899. The construction of the ceiling was as follows: The main members were 3 x 9-in. wood joists, spaced 19 ins. apart c. to c., and resting on brick walls 4½ ins. at each end. There were two joists spiked together in the center of the hut. At both sides at the end of each joist, and screwed thereto, was a slag wool slab, 1 in. thick, 5 ins. wide, and the full depth of the joist. On the top of the joists, and forming a floor, was ⅞-in. headed boarding, tongued and grooved, nailed with 2½-in. floor brads, two nails to each joist. One board in the middle of the floor was screwed down so as to be removed for inspection. Slag wool slabs 1¾ ins. thick (reduced to 1½ ins. thick when pressed into position), were fixed to the under-side of the joists, covering the entire area of the hut and projecting down the walls all round about 3 ins., secured to the joists with 3¼-in screws and washers. The screws were inserted in asbestos tubes, 1½ ins. long. The slag wool slabs comprised slag wool enclosed on both sides with galvanized wire netting of No. 19 gage and 1-in. mesh. The slabs were made so as to butt against each other at the double joists in center, and the whole of the slag wool ceiling was then covered with ⅞-in. tongued, grooved and headed boarding, nailed through the slabs to the joists with 4-in. wire nails. Round the walls of the hut a wood molding was fixed, forming a cornice and covering the slag wool which projected below the boarded ceiling. The space at the end of each joist was grouted in with fire-clay, and the space between joists on the set-off was filled in with brickwork. The test was a fire rising to 1,800° F. in one hour, followed by the application of a stream of water for two minutes. At the conclusion of the test the flooring over the ceiling was uninjured. With the exception of one small hole the joists were not burned.

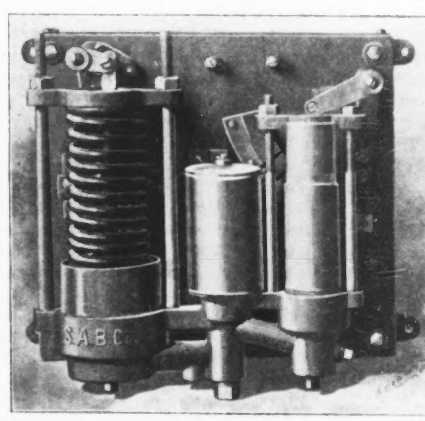

Fig. 4.—View of Automatic Controller for Motor-Driven Air Compressor.

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ADVERTISING RATES: 20 cents a line. Want notices, special rates, see page XXII. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.

The beneficial effect of water filtration upon the typhoid death rate of a city afflicted with polluted water is strikingly shown by figures given in the report of the Massachusetts State Board of Health for 1898. From 1887 to 1892, inclusive, the number of deaths from typhoid in the city of Lawrence ranged from 47 to 60 per annum, a rate per 10,000 of population of 11.44 to 13.44. The filter plant was put in operation in the latter part of 1893, and the typhoid deaths for that year fell to a total of 39 and a rate of 7.96 per 10,000. In 1894, the first full year the filter was in service, the deaths were 24 and the rate 4.75 per 10,000. There has been a steady diminution since, until in 1898 there were but eight deaths from typhoid fever in the city, giving a rate of 1.39 per 10,000 population.

The figure for 1898 is all the more significant because the operation of the filter was interfered with during the latter part of the year to allow reconstruction of the underdrainage system, the gravel around the underdrains and the underdrains themselves, beneath a part of the area, having become clogged with iron rust and crenothrix. Before this reconstruction was started, or up to Oct. 1, the filter had removed an average of 99.24 per cent. of the bacteria in the applied water. During the three months the filter was being disturbed the bacterial efficiency fell to 97 per cent., but notwithstanding this the number of deaths from typhoid, and the death rate per 10,000, was unprecedentedly low.

During the year 1898 some interesting studies were made on the removal of the bacillus coli communis from water. The presence of this organism in water gives rise to a suspicion that the latter has been contaminated by sewage, and, therefore, may contain typhoid fever germs, since both organisms have their origin in the human intestine. For the full year 1898, the water from the Merrimack River, at the inlet to the city filter, contained an average of 47 B. coli per cu. cm., the monthly average varying from 20 in May and June to 92 in August and September. Up to Oct. 1, 1898, 9 of 117 samples of water from the city filter, or 8 per cent., showed one colony, each, of B. coli, but never more than one. The reconstruction of the underdrains was accompanied by an increase in B. coli, the effluent from Oct. 1 to Dec. 31 showing the organism in 23 of 53 samples, or 40 per cent. Various tests with the small filters at the Lawrence experiment station, and the results from the city filter, indicate that water like that from the Merrimack River in which B. coli are found pretty frequently, cannot be filtered with safety through 4 ft. of sand at rates in excess of 2,500,000 gallons per acre per day; and that with a more highly polluted water a lower rate would be preferable. The Lawrence city filter was operated at the rate of only 1,500,000 gallons an acre. The low typhoid death rate in Lawrence in 1898 confirms the belief hitherto expressed that a filter with a high bacterial efficiency is a pretty sure safeguard against typhoid fever, and this is not shaken by the fact that the B. coli was found occasionally in the effluent before and frequently after the filter bed was disturbed. As the chemist to the board, Mr. H. W. Clark well says:

> We assume that for every typhoid bacillus in a polluted water there must be thousands of the B. coli, since the latter are found in the dejecta from all human beings and some animals, while typhoid bacillus comes only from persons who are ill with that particular disease.

Obviously there is far more reason for alarm when a few B. coli are found in a water that is not subjected to filtration than when found in the effluent from a filter, for the small number in the former case may at any time be accompanied by a large number of typhoid germs, against which there would be no protection, while a few B. coli in a filter effluent is pretty good assurance that there are no typhoid germs there, since the original number of B. coli must in all cases be far greater than that of the typhoid germs. Of course, if the B. coli in a filter effluent were to increase rapidly in number and frequency there would be good reason for believing that something was wrong with the filter, just as there would be if the number of bacteria, without regard to species, were to increase with rapidity.

Those interested in the recent attempted municipal ownership of street railways in Detroit will find a connected story of the movement in "Municipal Affairs" for September. The story is told by Prof. E. W. Bemis, who was employed on behalf of the city to estimate the value of the street railway franchises. While the movement as originally planned came to an end by a court decision to the effect that the city could not legally embark on an enterprise of such a character, it seems doubtful whether public opinion would have sustained the commission in its proposal to pay $8,000,000 for the value of the unexpired portions of the several franchises. A strong opposition to such an outlay was manifested in Detroit from the start, but of far more significance was the attitude of the daily press throughout the country. Paper after paper, in cities widely separated in distance and local traditions, looked askance or openly condemned the proposition to pay so many millions to get back franchises for which the city had received nothing at the start. However just or unjust this feeling may have been, it is nevertheless one that must be reckoned with in the movement for municipal ownership. It is to be noted that in Detroit and other American cities, as in so many English municipalities, there are thousands who are so urgent for municipal ownership that they are willing to swallow their indignation over the alleged extortion, and pay immense sums to wipe out unexpired franchises and secure municipal control of public service industries. While each case must be decided on its merits, any city having before it the question of paying heavily for unexpired franchises will do well to consider the opinions put forth by Mr. Bird S. Coler, Comptroller of the city of New York, at the recent meeting of the National Municipal League. These opinions, as summarized in the report of the meeting given in our issue of Nov. 23, were as follows:

> Mr. Coler said he would not for a moment advocate municipal ownership in cases where it would mean the purchase of existing franchises. Endless jobbery, and finally municipal bankruptcy, would follow the announcement of the fact that a city stood ready to pay such prices as might be fixed as the value of unexpired franchises.

Mr. Coler was in favor of municipal ownership, but would await the expiration of existing franchises where purchase of private works was necessary. This does not always seem practicable, especially where, as in the case of the Detroit railways, many of the franchises run from 10 to 25 years and some have no limits. The latter, Mr. Coler thought, could be terminated by the courts, as against public policy. The difficulties now being experienced with franchises already granted should teach municipalities to see that their future interests are guarded in granting all new franchises. For a number of years past the Massachusetts legislature has inserted in all the franchise-acts passed by it the provision that the works to be built by the recipients of the charters may be bought by the city at any time, but without any allowance for franchises, other than the actual expenses incurred in obtaining them.

In the death of Col. Julius W. Adams, the engineering profession in the United States loses one of its earliest and most prominent members, the last survivor of the twelve men who founded the American Society of Civil Engineers, and a Past President of that Society. Col. Adams was a typical example of the civil engineer of the past generation. These men had to start in their professional careers without the preliminary training given by modern technical schools, with their splendid equipment of teachers and apparatus; they had to depend for success upon their natural ability, and upon close study of the problems presented to them and the application of such methods in the solution as their own experience, or that of their associates taught them was best. These pioneer engineers did win success, however, and to them the present generation is largely indebted for the material progress which has made our country great among the nations of the earth.

Col. Adams had the advantages of some training at West Point, an institution that provided many of the early civil engineers of the United States. But his success was largely due to the fact that he was always a hard, steady and careful worker; he conscientiously studied all ruling conditions and details, and when his mind was made up he vigorously pushed his enterprise to completion. He was a forceful man; strong-minded and almost obstinate in his opinions; a firm and lasting friend, but a vigorous and hard-hitting antagonist when he honestly differed from the opinion of others, either professionally or otherwise. His retentive memory, even in his old age, made up in a great measure for the lack of that early training now considered so essential in starting upon a professional career. He read much, and had the rare faculty of remembering the valuable parts of his reading and of applying this knowledge when occasion demanded; and his record of over sixty years of almost continuous active professional work is in itself an index of the public appreciation of his engineering knowledge and experience, and of his personal ability. This period of years covers, in this country, the advance from horse railways and inclined planes to the wonderful railway equipment of the present day, and it is to be regretted that Col. Adams did not see fit to preserve in some lasting form his experiences during this eventful period in our national evolution. That all was not plain sailing among those pioneers in civil engineering is evident from a favorite remark of Col. Adams: "The chief art of life is to learn how best to remedy mistakes." Even with the present advancement in engineering theory and practice, this remark still holds good.

As an editor of this journal, for a time during its early and struggling days, we acknowledge our indebtedness to Col. Adams for the aid of his pen and his ripe experience; and for these reasons we personally join with all American engineers in paying tribute to him as one of the pioneers in the profession of engineering in the United States. The

FIG. 5.—BREAST-WHEEL
AT "STEVE ALLEN'S BARK MILL,"
CEDAR GROVE, N. J.

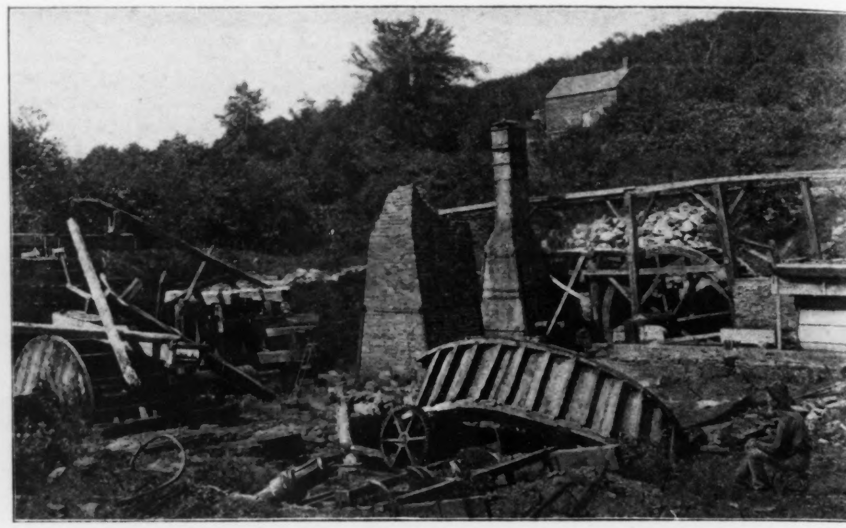
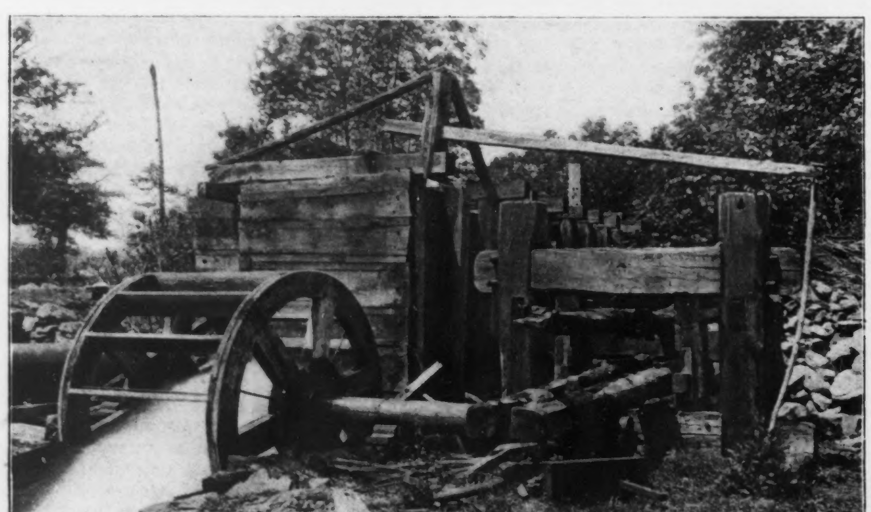


FIG. 4.—THE WINDHAM FORGE, STOCKHOLM, N. J.

FIG. 8.—NEA

FIG. 3.—RUINS OF A SAW MILL
AT WYCOFF, N. J.



FIGS. 10 AND 11.—OLD WATER-WHEELS AT FORGE, NEAR LAKE HOPATCONG, N. J.

FIG. 2.—OVERSHOT WHEEL
NEAR ORANGE, N. J., WATER-WORKS

FIG. 8.—NEAR VIEW OF WATER-WHEELS; RYERSON'S FORGE.

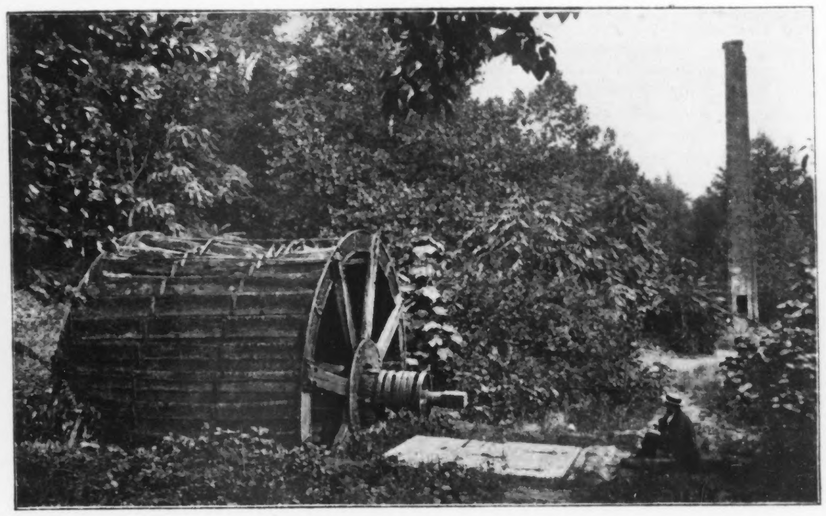


FIG. 6.—OLD WHEEL AT THE SOHO COPPER WORKS, NEAR BELLEVILLE, N. J.

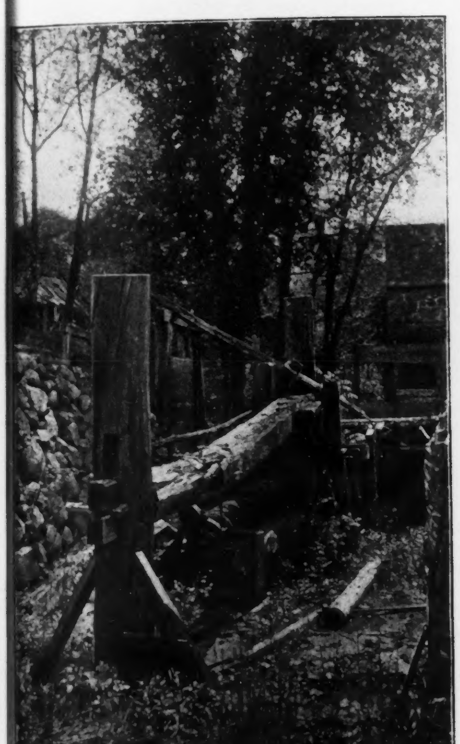


FIG. 9.—THE TRIP HAMMER AT RYERSON'S FORGE.

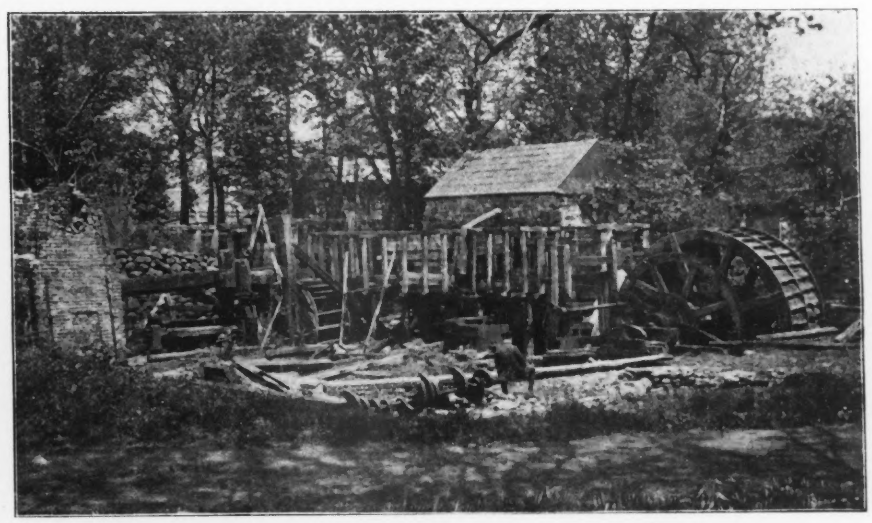


FIG. 7.—GENERAL VIEW OF RYERSON'S FORGE, BLOOMFIELD, N. J.

SOME OLD TIME WATER WHEELS IN NEW JERSEY.

FIG. 13.—WHEEL AT KINGSLAND'S LOWER PAPER MILL, DELAWANNA, N. J.

consolation remains to his friends that his was a long, useful and well-spent life; and a life which has played an important part in the engineering history of this country.

Since writing the note in our issue of Dec. 7 regarding the necessity of covering septic sewage tanks, we have received the full report of the experiments on sewage treatment at Manchester, Eng., recently completed by Messrs. Baldwin Latham, Percy F. Frankland and W. H. Perkin, Jr. The report states that "the composition of" the effluent from closed tanks, like those at Exeter, was "in all respects exactly similar to that of the effluent from the open tank" used in the experiment. Accordingly, the commission recommended that the tanks now employed for chemical treatment be utilized as septic tanks, without being covered. In our issue of Nov. 2, 1899, we noted the statement of the Lord Mayor of Leeds, to the effect that experimental open tanks there were giving results similar to closed tanks. This statement, together with an abstract of the Manchester report, which reached us soon after, formed a partial basis for the suggestions made in our issue of Dec. 7, that septic tanks need not be covered. The full Manchester report strongly tends to confirm this view. Further confirmation is also given by Mr. H. W. Clark, Chemist of the Massachusetts State Board of Health, in his report on the work of the Lawrence Experiment Station, for 1898, abstracted elsewhere in this issue.

The proposal to use the Manchester precipitation tanks for septic treatment, and the fact that similar tanks at Sutton (Surrey), Eng., are being turned into contact beds for sewage filtration by Mr. W. J. Dibbin, promise to simplify the sewage disposal problem of the future, owing to the apparent ease with which changes may be made from one system to another. Altogether, there is fair promise of material advance in sewage purification methods during the next few years, more especially in a simplification of methods or a reduction in the magnitude of the works required and expense involved.

The recent sale of the works of the Steelton Home Water Co., to the borough of Steelton, Pa., seems to have been attended with circumstances of more than local significance. The works were built in 1892 by the Steelton Water Co. The company states that it

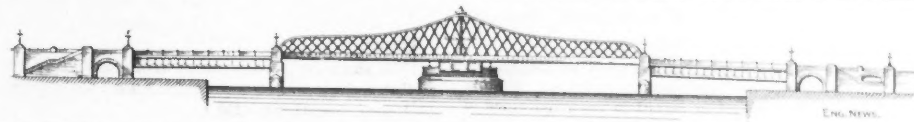
met with a fair degree of success, but under the growing desire for municipal ownership of public works, especially water, it became apparent of late years that this feeling might become unpleasant, and in order to avoid this it was thought advisable to sell, which was done, and under circumstances very much to the credit of both parties.

For some time past we have noted an apparent tendency for water companies to make terms of sale to cities without the opposition so commonly manifested in previous years. This, as well as the statement just quoted, indicates that water companies, at least, are realizing the strong current toward municipal ownership, and that some of them are prudent enough to come to terms and surrender their plants before controversies arise. Under such conditions, the chances are increased of conducting a sale on a fair "give and take basis," instead of having each side go to extremes in their demands, and leaving the price to be determined after a long struggle in the courts or before arbitrators. If nothing more than ill-feeling is saved by such a sale as that effected at Steelton the gain would be great, but where litigation and perhaps enabling legislation has to precede the transfer of works from private to public ownership, a large bill of expenses is sure to accumulate. As to the fairness of the price paid the company for the Steelton works, the facts in hand are insufficient to warrant an opinion. The borough assumed a 5 per cent. mortgage for $80,000, and paid the company $72,368 in addition. According to "The Manual of American Water-Works" for 1897, the works included Deane compound duplex pumps, with a capacity of 2,300,000 gallons; a 10,000,000-gallon distributing reservoir; 11 miles of mains, 76 fire hydrants and 600 taps. The company then had an authorized capital stock of $80,000, and the $80,000 of 5 per cent. bonds outstanding, already mentioned. Apparently, the contract for public service, which was at the rate of $2,600 a year, would have expired in 1902. It is commonly reported that franchises in Pennsylvania are perpetual, but we cannot vouch for the truth of the statement.

Mr. P. D. Wanner, Chairman of the Reading Foundry Co., of Reading, Pa., has been president of the Steelton Home Water Co. for a number of years past.

THE ARTISTIC SIDE OF BRIDGE DESIGN.

The subject of architectural beauty in engineering construction, as exemplified in some of the bridges in New York city, has been recently discussed editorially by the New York "Times." Its remarks are in many respects well considered and just; but it concludes with a rather sweeping condemnation of the American engineer for his lack of artistic feeling, describing him as a professional Goth and Vandal. We are as earnestly opposed as the editor of the "Times" to a somewhat brutal sacrifice of architectural appearance to the purely utilitarian object of safely carrying a load across a given opening; and we freely admit his contention that the selection of an American engineer of high professional standing to make a design for a bridge, gives no assurance that the resulting structure will possess any artistic merit. On the other hand, we by no means admit that the same thing is not true of other countries. One will not have to travel far in foreign lands to find bridge structures whose appearance is calculated to give the artistic beholder a pain.



THE THIRD AVENUE BRIDGE OVER THE HARLEM RIVER, AS BUILT TO CONFORM TO THE LAW CONCERNING NAVIGATION REQUIREMENTS.

Again, there are American engineers, as there are foreign engineers, who unite a knowledge of architectural requirements to their engineering attainments; and wherever an artistic design is demanded by the public, where the money to pay for it is forthcoming, and where those responsible for the work will select an engineer who has also proved his capabilities as an artist—there the results obtained will be equal, we are sure, to anything that is produced under similar conditions abroad. If proof of this statement is necessary, we need only refer to the numerous illustrations of American bridge structures of artistic merit which have appeared in this journal during the past half-dozen years.

The combination of the engineer and the architect in one man, or in one group of men, working in entire sympathy and harmony with each other's purposes, is sure to lead to good results. The attempt to reach these results, however, by setting an architect to work to decorate a structure which the engineer has designed sometimes leads to the worst possible eyesore.

An important bridge is a structure that is to be seen from a distance, if seen at all, as a whole; and the rules that apply to structures on shore are inapplicable. A bridge must depend for its artistic effect upon the lines of members which have an honest and important duty to perform; and any attempt to hide these lines by ornaments or deceive the beholder as to their nature and position would be ridiculous and false to every principle of art. This, however, has sometimes been done, as a result of some such division between the architect and the engineer, as we have outlined.

The fact that seems to us to need greatest emphasis, is that in order to secure a pleasing artistic effect, the main lines of the structure must be themselves of pleasing form, even at some sacrifice of economy. If this is not done no amount of decoration can save the appearance of the structure.

It follows from the above that when the main lines of the structure are fixed by other considerations, the task of creating a structure of really pleasing appearance may become almost or quite impossible. One of these conditions is the provision of drawspans. Take the Harlem River, for example, which carries an annual commerce exceeding that of the Suez Canal, a large amount of it in masted vessels. Here, a draw span, with wide openings on each side of the draw pier, is imperative, and the designing engineer must make the best of it. The "Times" refers to the new bridge over the Seine, in Paris, as an index of how European engineers treat such problems in artistic design; but the comparison is an unfair one. The Seine has comparatively high banks on either side, and the bridge floor may be practically on a level with the tops of these banks. No masted vessels navigate the Seine, no drawspan is required, and the small passenger steamers plying on it have hinged chimneys that permit a minimum of clearance under the bridges. With a continuous structure and an almost level roadway terminating on broad streets or parkways at each end, all the conditions are present to permit the design of bridge structures of great beauty. European engineers, of course, take advantage of these conditions, and are enabled to do so effectively through the fact that they have more money at their disposal for bridge construction in cities than is usually allotted by American municipal authorities. The abuse of this privilege and the waste of this money in trivial and frivolous ornamentation is also sometimes apparent; as in the case of the Bonn bridge across the Rhine, commented on in our issue of April 20, 1899. In this case, the structural lines of the bridge are very good, and the general effect is pleasing when viewed from a distance; but the portal of the bridge and the toll-house and other constructions upon its approaches were loaded down with silly and meaningless decorations which detracted from instead of adding to the dignity of the main structure.

THE THIRD AVENUE BRIDGE, AS IT MIGHT HAVE BEEN DESIGNED WITHOUT LEGAL LIMITATIONS.

Returning to our contention that the main outlines of a bridge are the chief factor in determining its architectural merit, and that the requirement of a drawspan makes a design on pleasing lines well-nigh impossible, we may take as an illustration the Third Avenue Bridge, designed by Mr. Thos. C. Clarke, Past-President, Am. Soc. C. E. We show herewith, from our issue of Sept. 15, 1893, a view of this bridge as actually constructed; and also a sketch which Mr. Clarke has kindly furnished to us as a rough example of what could be done in the design of a more pleasing structure for this site, if the requirement of a drawspan and wide opening were not present. As Mr. Clarke has remarked, the task of designing an artistic bridge with a long drawspan in it, is one which would have stumped Leonardo da Vinci himself.

LETTERS TO THE EDITOR.

Balancing Compass Survey Notes.

Sir: In the recent communication in your columns, entitled "The Balancing and Adjustment of Compass-Survey Notes," the statement is made that in the text-books of surveying no method is given for correcting the lengths of the sides of a closed field.

In Raymond's "Plane Surveying," on p. 167, in connection with an example, the following simple method is given for finding not only the corrected lengths, but also the corrected bearings:

The lengths and bearings are now inconsistent with the balanced L's and M's, and should be corrected to be consistent. This is done in this example for the first course only. The tangent of the bearing is $\frac{M}{L}$, hence write the log. M and subtract the log. L and get log. tan. Above log. M write the log. sin., and, subtracting up, get log. length.

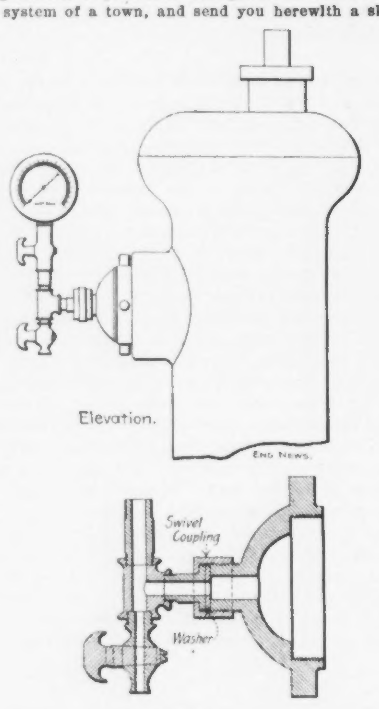
This method has the advantage of logarithmic solution.

Yours respectfully, E. R. Cary.

Rensselaer Polytechnic Institute, Troy, N. Y.
Dec. 14, 1899.

Another Device for Attaching Pressure Gages to Hydrants.

Sir: In your issue of Oct. 12 you gave an illustration of a device for taking pressures of hydrants. I fully agree with all that is said in regard to the importance of keeping records of pressures throughout the entire waterworks system of a town, and send you herewith a sketch



Device for Attaching Pressure Gages to Fire Hydrants.

of a device which is in use by this company. It was devised by John Stagg, Chief Engineer of the Paterson Fire Department.

It is a very simple and effective apparatus, and with the drawings needs no detailed description. It can be attached to the hydrant without the use of a wrench. The gage, by means of a swivel joint, can always be maintained in a vertical position. It seems to me that this is a far simpler apparatus than the one previously referred to.

Respectfully yours, J. Waldo Smith,
Engineer and Superintendent,
The Passaic Water Co.

Paterson, N. J., Nov. 23, 1899.

The Design of Washers for Timber Frame-Work.

Sir: Can you give me the necessary information for economically and correctly designing cast and wrought-iron washers for the ends of tension rods in combination trusses? I am frequently called upon to design such trusses and so far I have been unable to find any data upon the subject.

The principle I have followed, however, is to have sufficient area of bearing on the timber to prevent crushing across the grain when the strain is at right angles to the member. When the strain is not at right angles to the member, such as the rafter of an ordinary roof truss, I have found the normal component and then provided sufficient bearing to prevent crushing as before.

These calculations, however, give such large results that I am inclined to believe there must be some other way of designing the washers, since the standard sizes of round cast-iron washers as used by various bridge companies, and the standard plate washers as manufactured for the trade, have so much less area for any particular size of rod. For example: A 1½-in. rod has an area at the root of the thread of 1.29 sq. ins. Allowing 15,000 lbs. per sq. in. for tension, the rod would safely sustain a strain of 19,350 lbs. Allowing 280 lbs. per sq. in. as the safe resistance to crushing across the grain for Georgia yellow pine, a washer would be required having a net area of 69.1 sq. ins., or a gross area of 71 sq. ins., allowing 1.92 sq. ins. for the rod hole. A plate 8½ ins. square has an area of 72¼ sq. ins., and would, therefore, be ample.

Referring to the catalogues of the Hoopes & Townsend Co., of Philadelphia, Pa., and of J. Edward Ogden, of New York city, I find that they both give the diameter of round cast washers for a 1½-in. rod as 6 ins.; their plate washers for the same size of rod 6 × 6 ins. These washers would, therefore, have a net area of only 26.2 sq. ins. and 34 sq. ins., respectively, as against 69.1 sq. ins. required by the above calculation. Thanking you in advance for any information you may be able to give me on this subject, I am Yours respectfully, K. A. W.

Newark, N. J., Dec. 12, 1899.

(We shall be glad to hear from our readers regarding their practice in such cases as our correspondent mentions.—Ed.)

A Proposed Code for Open Holes for Bolts in Structural Iron Work.

Sir: I send herewith a print of a proposed "bolt code," which has met with favor among those who have examined it. Everyone who has to do with the preparation or other use of drawings has noticed how unsightly and ragged an otherwise neat -looking- drawing is made to appear by the use of bolt notices. It is also a common experience in the erection of structures to find that the field bolts are often fewer than the number required, because of the omission of the bolt notices. With a view of correcting some of these troubles the writer proposes a code for open holes for bolts. It is simply the excellent

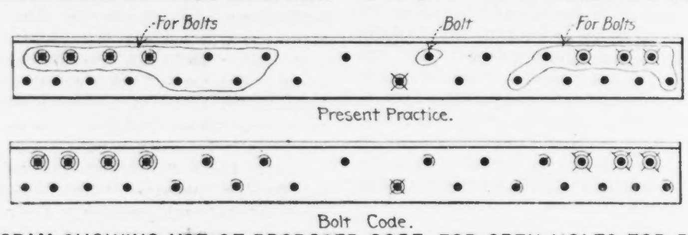


DIAGRAM SHOWING USE OF PROPOSED CODE FOR OPEN HOLES FOR BOLTS.

Osborn code with the letter B on its signs. This code has been shown to a number of persons whose duty it is to get out the field rivets and bolts, and they are very much in favor of its adoption on account of its simplicity, as there is nothing new to learn. Some have thought that at the beginning there might be a slight confusion by confounding the bolt sign for plain open holes with the Osborn sign for holes "countersunk far side." In actual practice, however, the position of the open hole, in nine cases out of ten, will show to the shop-man whether the hole is a countersunk or for bolts. With the use of good prints of good drawings, made to a respectable scale, there need no more confusion arise in using this bolt code than arises in the use of the Osborn code for riveted work.

Yours truly, William G. Miller,
Pittsburg, Pa., Oct. 30, 1899. Civil Engineer.

Concrete Docks for the Illinois Steel Co.—Correction.

Sir: I am pleased at the excellence of the illustrations of the article in your issue of Dec. 14, and from the many inquiries which have been made I learn that the article was looked for with interest by many engineers. There are some unfortunate mistakes, however, which should be corrected for the sake of an accurate record of the work.

(1) The cuts labeled Fig. 2 and Fig. 5 are transposed, the one shown as Fig. 5 on p. 380 being properly Fig. 2, and belonging on p. 378. The titles are in the right places, but the cuts are misplaced. In line 26 of column 2, p. 378, Fig. 2 should be changed to read "Fig. 5;" and in line 8 of column 3, p. 379, "Fig. 5" should be changed to read "Fig. 2." But even this will not correct the titles.

(2) Fig. 3 is a general view of the concrete dock, and does not show a Page car dumping the backfilling. The title you give to this cut belongs to a photograph which you evidently did not use.

(3) The contractors for both pieces of work were the Hausler & Lutz Towing & Dock Co., with John H. Jones as sub-contractor for the masonry.

(4) On p. 378, column 1, line 11; the old anchor rods were 1½ ins. diameter, and not 1¾ ins.

(5) On p. 378, column 3, line 12 from the bottom; the timbers were 10 × 14 ins., and not 19 × 14 ins.

(6) On p. 379, column 3, line 10, the word "but" implies that this wall is of a different concrete, whereas the proportions are already correctly given in column 3 of p. 378.

Yours very truly, Victor Windett.
Illinois Steel Co., South Chicago, Ill., Dec. 16, 1899.

Carbonated Cement.

Sir: An invention which has attracted considerable attention and in which I have taken great interest, owing to my former close connection with the cement industry in Germany, has recently been patented by Mr. H. J. Livingston, of Baltimore, Md., who is a competent authority in all matters connected with cement manufacture. I have carefully investigated this process and find it is chemically unassailable, and I venture to think that it begins a new era in the manipulating, if not in the manufacture, of Portland cement.

Assuming that all other ingredients are in proper proportion we know that the higher cement is in Ca O the stronger it is, but at the same time it is more expensive to make and more treacherous. Neutralizing the Ca O in cement has therefore been always sought for and the benefits of such a result fully explained by standard authorities as Le Chatelier and Michaelis. But while all agreed on its advantages, no cheap and efficient means of realizing these were available until Mr. Livingston's investigations disclosed the fact that the union of carbon and calcium oxide, under ordinary conditions impossible, could be effected by the introduction of a small but sharply-defined quantity of hydro-carbon, say about 1% on any lime hydrate added to the cement.

A sample of German cement, and for comparison a sample of the same with carbon and 80% of dry lime hydrate, have been experimented on for two years, the first nine months in water and the remainder of the time in the open air. Even with this high percentage of added lime, much above what the inventor recommends, the diminution of strength is very small in the second sample. But a similar trial with 125% of added lime gave corresponding results. Beyond the latter figure it seemed impossible to go, the limit of added lime having been reached.

It may be noted at this point that Portland cement is not always reliable if it contains over 62% of lime, but by the process I describe 66% to 68% may be used safely, also thereby ensuring the advantages enumerated further on, for a summary of the experiments showed that the best results were obtained with from 15% to 25% of added hydrate. If, as the inventor proposes, these figures be accepted, but preferring, as my own judgment endorses, the 25% addition, then a cement results which, though slow setting, will, neat, equal or overtake the Portland on which it is based in about six weeks. A 15 months' test with an inferior Portland shows that the neat Portland is cracking badly, while that with the 25% addition is as sound as the best Portland and is harder than the neat cement on which it is based. But with three of sand it gets ahead of Portland and three of sand in about three weeks, and will keep gaining longer than if it had the ordinary percentage of lime.

The following advantages may be justly claimed for cement treated as proposed:

(1) It is cheaper than ordinary Portland.

(2) It is stronger than ordinary Portland and cracks less.

(3) It is much more adhesive.

(4) It is more plastic and very easy to trowel, a quality which will commend it to all workmen.

(5) Gypsum is not required in the original Portland; a great advantage when we consider that many cements have already too much $S\ O_3$ in their composition without adding more. Color is good blue; and

(6) Setting is slower than ordinary Portland. In addition I suggest that makers might send their clinker at gravel or sand rates to a convenient distributing point, where good lime is cheap, and grind and mix there. In many cases there would be great saving in railway haul, particularly to distant points. Clinker could be imported often from Germany freight free and profitably manufactured into carbonated cement at ports on this side, competing with the ordinary domestic Portland more successfully than hitherto.

By preference two inexpensive materials, coke and sugar, are used. Apparently a sub-carbonic acid is formed as soon as the mixing water is added, rapidly becoming carbonic acid, and the lime is efficiently neutralized. The term carbonated cement is scarcely a misnomer, for it is a compound of Portland cement with the materials of a carbonate.

The advantages of this discovery, when applied in sea water, sewers, etc., cannot be overestimated; there is no lime for acid to attack.

The same process is also applicable to slag cement and to natural hydraulic cements, but the consideration of this is at present unnecessary for "the greater includes the less." It need only be observed that the proportions will, with these materials, require modification.

There is no adulteration in this process. The extra lime is burnt in another kiln instead of being as usual burnt free or uncombined in the cement kiln. In either case the mode of burning is immaterial. The carbon again is added at once instead of being absorbed slowly from the atmosphere. A proportion of 2% of SO_3 or its equivalents is a somewhat high figure for Portland cement, and so is 3% of Mg O.—1-12% of either of these factors is enough for reliable sea work. For those manufacturers who have to contend against an excess of these ingredients the new process offers considerable aid, for they have only to dilute their cement with the hydrate from calcite, as proposed, and the percentage of sulphur and magnesia is at once reduced. Very truly yours,

Baltimore, Md., Dec. 11, 1899. Theodore Zwermann.

JULIUS WALKER ADAMS, HON. M. AM. SOC. C. E.

Col. Julius W. Adams, Past President of the American Society of Civil Engineers, and one of the oldest and most prominent civil engineers of this country, died at his home, in Brooklyn, N. Y., on Dec. 13, from old age.

Julius Walker Adams was born in Boston, Mass., Oct. 18, 1812; he was of Huguenot and Puritan stock, and belonged to the famous family of that name, which played so prominent a part in making the early history of the United States. He was educated in the public schools and academies of New England, and was especially proficient in mathematics. At the age of 18 he was appointed to the U. S. Military Academy at West Point, and remained there two years. Immediately upon leaving the Academy he began work as a surveyor; but he really commenced his professional career in the drafting-room of the Paterson & Hudson River Ry., one of the earliest railways in the country, and operated at that time by horse-power. In 1833 he was appointed Assistant Engineer of the Stonington & Providence R. R.; he held this position until 1835, and was then, for a year, an Assistant Engineer on the Norwich & Worcester R. R.

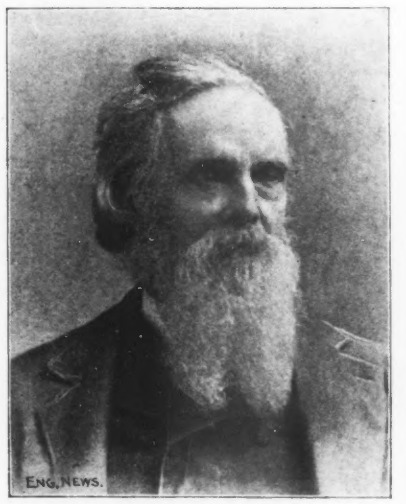
After this period Mr. Adams was practically continuously engaged in active engineering work, as is shown by the following brief summary of positions held: 1836-1838, Chief Engineer, Lawrenceburg & Indianapolis R. R.; 1838-41, Division Engineer, Western R. R. of Massachusetts; 1841-44, Chief Engineer, Mohawk & Hudson R. R. The last-named line connected Albany and Schenectady, and was operated by inclined planes when he took charge. It was by his influence that this system was abolished and steam power substituted. In 1844-45 he was the Resident Engineer in the construction of a stone dry dock in the U. S. Navy Yard in Brooklyn; and in 1845-46 he was Resident Engineer on the Boston Water-Works. From 1846 to 1849 Mr. Adams was Superintending Engineer on the Central Division of the New York & Erie R. R.; and during this period he constructed the Cascade and Starucca stone-arched viaducts. In 1849-54 he was Chief Engineer of the Lexington & Danville Division of the Kentucky Central R. R.; 1854-55, Chief Engineer Memphis & Ohio R. R.; 1855-60, Engineer in Charge of the construction of the Brooklyn drainage system; 1860-61, Chief Engineer of the New Haven Water Works; 1861-66, Chief Engineer Hudson River bridge, at Albany.

For about three years Col. Adams was engaged in literary work and in private business; but in 1869 he was made Chief Engineer of the Board of City Works of Brooklyn and held this office until 1878. In the latter year he was appointed Consulting Engineer to the Board of Public Works of New York city, and remained in that position until 1889. For some years thereafter he was a Director in the Panama Railway Co.

Though the positions thus outlined were practically continuous over nearly 60 years, Col. Adams found time in his busy life to perform a large amount of other work; in designing systems of water-works and sewerage, and in acting as Consulting Engineer to the Tehuantepec Isthmian Canal project, in the interests of which he visited and reported upon the water-ways of Europe.

At the outbreak of the Civil War Col. Adams was one of the first to answer the call to arms, and became the commander of the 1st Regt. Long Island Volunteers, afterwards the famous 69th New York Volunteers. He took part in several important engagements, but having been too free in his comments upon the methods of Gen. McClellan, he was made to feel the resentment of this commander, and he resigned his commission to again engage in professional work. During the Draft Riots of 1863, in New York city, Col. Adams was in command of troops stationed in Printing House Square to protect the "Tribune" office.

To Col. Adams the people of New York and Brooklyn are in a considerable measure indebted for the Brooklyn Bridge. Living as he did for many years in that city, he early recognized the necessity for such a structure, and, in 1855 he made plans for a bridge, and at his suggestion a company was formed which eventually resulted in the erection of the present suspension bridge. Col. Adams was one of the original twelve incorporators and founders of the American Society of Civil Engineers, on Nov. 5, 1852; and was the last to survive of these incorporators. He was elected President of the Society on Nov. 5, 1872, and re-



Julius W. Adams

elected on Nov. 3, 1873: on Oct. 26, 1888, Col. Adams was made an Honorary Member of the Society along with the late Maj.-Gen. George S. Greene, who had also been Past President in 1875-77, and was one of the two then surviving original members.

Col. Adams had a decided artistic bent. He occasionally contributed designs in bridge and architectural competitions, and was very generally successful. He owned a large and well-selected library, and was a frequent contributor of short articles and editorials to the technical press. In 1852 he was the editor of "Appleton's Mechanics Magazine and Engineers' Journal," published by D. Appleton & Co., and in 1881 he was for a time editor of Engineering News. He had a very retentive memory, and though he kept no diary, he could at any time, even very late in life, accurately recall the incidents and dates of occurrences in his professional life and enter into minute details of engineering works with which he had been connected.

Col. Adams was married in 1835, and one of his sons, Julius W. Adams, Jr., graduated from West Point on June 24, 1861; became a Captain in the 4th Infantry, U. S. A.; and died, on Nov. 15, 1865, as the ultimate result of a severe wound received at the Battle of Gaines' Mill. Another son became a Civil Engineer, and was long resident in Central America. A daughter and a grandson, Julius W. Adams 3d, survive him.

CAR FAMINES AND RAILWAY TERMINALS.

One of the most significant comments, in connection with the enormous movement of freight on all the principal railroads of the country this year, was the remark of the President of one of the great Western lines, that the chief limitation to the freight movement was "not a lack of cars, but a lack of facilities for unloading them."

At the time this President spoke, the news despatches were reporting interesting facts on which his statement was based. In Boston it was said that 1,000 cars of freight, chiefly grain, were waiting in and near the city to be loaded into steamships for Europe. At Jersey City a still greater blockade was reported.

It is obvious that the insufficiency of cars or of terminal facilities is due to fluctuations from month to month in the volume of freight moving; but why cannot this be provided for. For a general answer, it may be said that at the large cities land is so costly that a railroad company cannot afford to buy additional ground unless the volume of business promises to keep it well occupied. But the heavy freight movement usually continues through only about four months out of the twelve. The question, then, why any particular railroad does not buy more land or put up more storehouses or grain elevators is a comparatively simple problem of first cost and of probable profit.

The practice of using cars as storehouses usually begins as rate cutting begins, when business is dull. Often, as in the case on the roads bringing anthracite coal to New York harbor, cars may be allowed to stand in the yard loaded, without any loss whatever. If one road is getting a large share of the export grain business, while another road is getting but little, and has cars standing idle, it is the most natural thing in the world for the latter road to give free storage in cars to get a share of the trade. Moreover, the roads sometimes virtually compel themselves to use cars as storehouses. If a contract has been made to supply a certain number of ships monthly with grain cargoes, it may often happen that the cars will arrive at the elevator too soon, or the arrival of the ship to load be delayed, and the capacity of the elevator therefore be overtaxed. The usual free movement will be clogged, and a long line of waiting cars is the result. To use the cars for storage is the only method of escape. Competition between rival roads also results in frequent wastes at the Western as well as Eastern terminals. A hundred side tracks in Nebraska will hold, say, 1,000 cars, and if the Nebraska road has not sufficient cars (as is generally the case), the Eastern road which first sends out 1,000 cars to wait on those side tracks until the shipper and the market agree is the road which eventually gets the business.

The universal custom of borrowing cars has helped along the car-storehouse evil. To provide for through shipments without the expense of reloading, all of the railroads are constantly lending their cars to other roads; and payment is made by mileage alone; so that a borrowed car may be subjected to any number of days' delay with practically no responsibility. It is always easy enough to lend other people's property, and if a New York road, for instance, gives a grain merchant $1,000 worth of free storage in an Illinois road's cars, no penalty is ever inflicted.

The losses under the present system are thus plain. But when the alternative of larger terminals is considered, difficulties at once arise on that side. The cost of any given unit of yard service is hard to calculate. The main items are the interest on the first cost of the land, the expenses of switching locomotives, and the wages of the yardmaster, foremen, and brakemen. It would be easy enough to make an arbitrary charge per car, unloaded or loaded, based on the gross annual cost, but often it would be found that the freight would not stand such a charge; and it is sometimes legitimate to omit the terminal charge when business is dull, or under the stress of competition. A grain elevator, like those at Buffalo, will make a fat income in a good year, but, in the case of an elevator costing a million dollars, the loss in dull times is considerable, and desperate measures may be warranted for the securing of business. In common with other railroad facilities, yards are used to their full capacity only about four months in the year. This being the case, who can calculate what shall be a proper charge per car for bulk freight?

Demurrage (called by the railroads "car service") is the nearest approach that we have in actual business to a basis of the value of freight-yard service. The ordinary rate is $1 per car per day, after, say, two days beyond arrival; or, in the case of export freight, perhaps four days, or longer. But the actual value of this car service may fluctuate greatly. It may go down to zero when cars are plenty. At such times the yardmaster often can actually save money by letting a car stand on the team track, rather than switch it out and send it back West, for in switching it out he has to disturb a lot of other cars on the same track. On the other hand, a car may, in a busy season, be well worth $5 to $10 a day to its owner. The customs of the demurrage bureaus illustrate the value of the land required for a railroad terminal at a large city. The charge made to the consignee goes to the owner of the yard, not to the owner of the car, unless the same company be the owner of both. As car service is now managed, this rule is usually warranted by the conditions, although it is by no means just for the Western car-owner to go entirely without compensation when his car is detained at an Eastern terminal. In a discussion among railroad officers not long ago concerning the equitability of the one-dollar rate for demurrage on cars, there was much objection to a proposition to raise the rate to two dollars; and yet a manager who delivers large quantities of freight at New York harbor, and who had no sufficient terminal yard room, said that he would gladly pay $2 per car per day if he could get additional terminal ground at a convenient point on Manhattan Island. At the same time this manager had, no doubt, numerous stations on the line of his road where the land would cost practically nothing. In the face of such conditions as these, the fixing of a uniform rate for terminal charges is impossible.

These are some of the conditions connected with railroad terminals proper. When we come to consider New York city, we have a separate and complicated problem. All railroad people are familiar with the "arbitrary" of 3 cts. per 100 lbs. for lighterage. When grain rates have been at their lowest, say 10 cts. per 100 lbs. from Chicago to New York, 30% of this charge had to be taken out for the service performed on the water in New York harbor (not over ten miles), and this really had to be borne by the nearly 1,000 miles of railroad participating in the transportation from Chicago. The gross rate, 10 cts., had to be made to meet competition at Chicago, perhaps that of the Chesapeake & Ohio, or of a line to New Orleans, and so, of course, the Lake Shore & Michigan Southern, although not reaching within 400 miles of New York, had to stand its share, for unless the lighterage were made free to the shipper, the freight could not be secured. In the case of a shipment from Buffalo (of grain brought to that point by lake vessels) this 3 cts. of lighterage may have to be taken out of a gross through rate of 6 cts., or even 5, and when, as has happened within the last four years, grain is carried by rail from Buffalo to New York at 2.75 cts. a bushel, or 4.6 cts. per 100 lbs., lighterage and terminals become a problem almost insoluble. If we allow even 1 ct. (instead of 3, the regular charge) for carrying the grain to the ocean steamers, the amount left for the railroad is 3.6 cts. per 100 lbs. for over 400 miles. A rate of 3.6 cts. per 100 lbs. equals 1.6 mills per ton per mile, this result being reached by taking the distance over the New York Central. With everybody asserting that a rate of 2 mills per ton per mile is the extreme minimum of reasonable freight transportation, how much of this Buffalo-New York rate can go for switching, for delays to cars, and for interest on the yard during the months when it is half idle?—New York "Evening Post."

THE CONSTRUCTION OF THE RUTLAND-CANADIAN RAILROAD.

One of the longest lines of railway now under construction in the eastern part of the United States will extend from Burlington, Vt., northward through the Lake Champlain islands, to Rouse's Point, N. Y., and Noyan Junction, Que., on the Canada Atlantic Railway. The work is being done by the Rutland-Canadian Railroad Co., to connect the Rutland and the Ogdensburgh & Lake Champlain railways. The interests building the new road control the two old ones just named, and also a line of steamers running from Ogdensburgh, N. Y., through the Great Lakes. The total length of the new line will be about 47 miles. It is expected that it will be ready for summer traffic, next year.

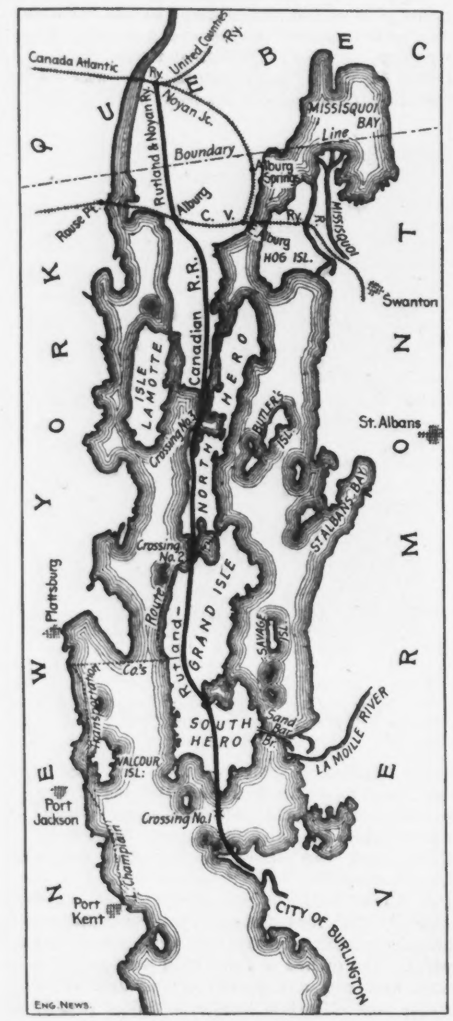
As is shown by the accompanying map, the greater part of the line extends through Lake Champlain and its islands. What the map does not indicate, however, is the scenic features of this new route from New England to the West. Besides the natural charms of the adjacent lake and its islands, the traveler over this road will have many unsurpassed views of the broad waters of Lake Champlain, with the Adirondacks in the distance.

The alinement and grade of the new road are easy, the maximum grade going north being 0.7%, and going south, 0.57%, while the maximum curve is 1.30°. The maximum cut and fill (land) are about 22 ft. each, except for one short stretch, where the cut is 30 ft. The most marked features of construction are the lake crossings, which are to be rubble embankment. Going north from Burlington the first crossing is from Colchester Point to Allen's Point, about 3¼ miles of rather light fill, the maximum depth of the lake at low water being about 9 ft. The second crossing is through water slightly deeper, and is about ½ mile in length, extending from Tromp's Point to Bow Arrow Point, and connecting South Hero and North Hero islands. The deepest water of all is encountered at the third crossing, from Pelot's Point, on North Hero, to Point of Tongue, the southern extremity of a long peninsula, extending from Canada down into the lake. The southern part of this peninsula forms the town of Alburgh, Vt. The water here has an average depth of about 20 ft., for ¾ of a mile, there being about 600 ft. of fill at the south end in 28 ft. of low water, and a maximum fill of 40 ft.

All the crossings are located on curves, wholly or partially, in order to avoid deep water. Each will have a draw-span at its respective lake channel. Heavy rock is being used for the fills, as far as possible.

Eleven Barnhart and Bucyrus steam shovels and 19 locomotives and trains, mostly standard gage, are used on the work. One of the Bucyrus shovels weighs about 85 tons, being the largest size made by the Bucyrus Co.

The contractor for the whole work is the firm of O'Brien & Sheehan, 253 Broadway, New York



Map Showing Location of the Rutland—Canadian R. R.
J. W. Burke, Chief Engineer.

city. The Chief Engineer is Mr. John W. Burke, 45 Broadway, New York city, and South Hero, Vt. Messrs. L. A. Bostwick, Geo. R. Olney, J. S. Lhoyd, Hamilton Lindsay, Geo. B. Boggs and G. L. Mattice are serving as resident engineers. Mr. R. W. Leonard of Montreal was Consulting Engineer on location.

The three draw spans, each 196 ft., three fixed spans, each 150 ft., and one fixed span of 80 ft., were designed by Mr. Chas. F. Stowell, M. Am. Soc. C. E., Albany, N. Y. All but the short span are riveted steel trusses, and built by the Edge Moor Bridge Works, Wilmington, Del. The short span is a plate girder bridge, built by the Rochester Bridge & Iron Works, of Rochester, N. Y.

All of the truss bridges on the road are of the riveted lattice type, and the draw spans present some features of novelty. The tops of the ties being only 6 ft. above high water mark, and 5 ft. above the top of the masonry, some ingenuity was required to get all the machinery at the pivot pier for a draw of this length and weight into so limited a space. This was finally accomplished by dispensing entirely with the customary drum and fastening the upper track of the wheel circle directly to the bottom of the chords and floor beams.

The draws are so designed as to act as center-bearing while turning, but rim-bearing when a load comes on the bridge.

The devices for working the signals, the latches, the end supports and the turntable are all interlocked, so that they can only be moved in proper sequence. Thus when the draw is closed the only machinery that can be moved is the signal apparatus, operating home and distant signals at both ends of the bridge. When this is thrown to danger the latch lever is released and the latches can be drawn. The drawing of the latches unlocks the end supports (rollers) which may then be removed, lifting the ends of the rails at the same time. Not until this is done is it possible to swing the bridge. Each of these operations, in addition to releasing the next one, locks the preceding, so that to return the bridge to its former position, all the operations must be performed in the reverse order, the last one being the throwing of the signals to safety, which cannot be done until everything else has been performed, and which locks them all in their proper positions. On account of their infrequent use the draws are designed to be operated by hand.

All the bridges on the road are built of acid open hearth steel of an unusally high grade, which was furnished by the Phoenix Iron Co., of Phoenixville, Pa., and the Central Iron & Steel Co., of Brazil, Ind. The bridges were designed according to the best modern practice, and proportioned to carry two 136-ton locomotives, followed by 4,000 lbs. per ft., with very moderate unit stresses.

We are indebted to Mr. Burke for information and aid given in connection with the preparation of this article, and also to Mr. R. T. McKeever, General Passenger Agent of the Rutland Railroad Co., Rutland, Vt., for courtesies extended. We are also indebted to Mr. Stowell for notes regarding the bridges.

TRACK THROWING CAR; PENNSYLVANIA R. R.

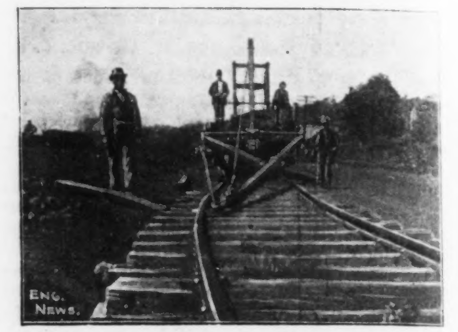


Fig. 1.—Track-Throwing Car on the Pennsylvania Lines.
David C. Creese, Inventor.

The operation of throwing or shifting railway track to a new position or alinement is usually slow and laborious work, requiring the services of a large gang of men, and involving much additional work in preparing the track for throwing and putting it in shape when in its new position. The accompanying illustrations represent a device for doing this work by mechanical power, and by means of which, it is claimed, work can be done in half an hour which would occupy men with bars ten hours. Fig. 1 shows the car ready for work, and Fig. 2 shows the details of construction.

The apparatus is fitted to the rear end of a flat car, on the floor of which is a hand hoist carried by a timber frame attached to a vertical post or gin pole (A), which is supported by iron braces bolted to the floor of the car. At the top of the post is a 12-in. pulley. To opposite corners of the car frame are attached the bull pole (B) and the bull-pole brace (C). The former is 30 ft. long, 9 x 9 ins. section for 14 ft. at the middle and tapering towards the ends. About 14 ft. from the outer end is a collar to which is fitted the end of the brace timber (C). The end of the pole carries a 14-in. wheel, and has attachments for the ¾-in.

wire cable and for the 1½-in. hog rod (D). This rod is attached to the same corner of the car as the bull-pole brace, and is in three sections, the middle one being connected to the outer one by a pin joint, and to the inner one by a turnbuckle 3 ft. 6 ins. long. The bull-pole brace is a 17-ft. timber, the outer end of which has a tongue attached to the collar on the bull-pole The bull-pole can be attached to either side of the car, and the car is heavily weighted with steel rails.

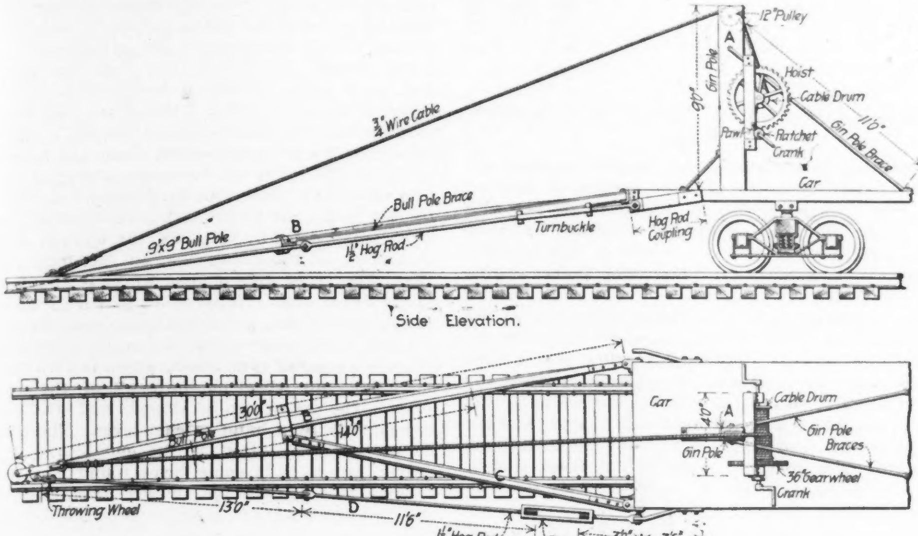


FIG. 2.—DETAILS OF TRACK-THROWING CAR.

In operation, the track behind the car is thrown out in the usual way to the desired amount, and the bull-pole set so that its wheel will bear against the web of the outer rail, the position being adjusted by the brace and the hog rod. The ballast is also shoveled away from the ends of the ties, but not between them, and as the car is hauled over the track its pole displaces or throws the track. The distance to which the track is thrown or shifted may be from 6 to 36 ins. When not at work the pole is raised clear of the track by means of the hoisting crab. It can be used on main track without breaking or disturbing the rail joints. The device was first tested in the yards of the Pennsylvania Lines at Conway's, O., throwing track 12 ins. for a length of 1,000 ft. In another test at New Brighton, Pa., the track was thrown 38 ins. without removing any of the ballast.

The machine was invented by Mr. David C. Creese, P. O. Box 612, New Brighton, Pa., and has been tried experimentally on the Pennsylvania lines. The inventor, who is a carpenter employed on the Pennsylvania Lines West of Pittsburg, states that he conceived the idea when engaged in pile-driving work, when after driving one row of piles it was necessary to wait some hours for the section men to throw the track over before the pile driver could start to work on the next row. Further particulars may be obtained from the inventor, or from H. C. Evert & Co., Park Building, Pittsburg, Pa.

A NEW AUTOMATIC BUCKET FOR DUMPING CONCRETE UNDER WATER.

The accompanying illustrations show two views of a new design of bucket for dumping concrete under water which is now being employed in constructing the foundations for the City Island Bridge in New York city. This bucket is the design of Mr. John F. O'Rourke, M. Am. Soc. C. E., of 44 Broadway, New York, the constructor for the foundation work. Open caisson foundations are being employed, and the bucket has shown a capacity of 200 cu. yds. of concrete deposited in place at the bottoms of the caissons in 24 hours. A study of the illustrations show the construction and principle of operation quite clearly.

Fig. 1 shows the bucket closed to carry its load of concrete. It is rectangular in form, with flap doors at the top while the bottom is left open. The timber frame at the bottom gives the bucket a wide bearing when it rests on the soft deposited concrete and prevents it from sinking into and cutting up the concrete. For holding the concrete in the bucket there are two interior flap doors, which, when closed, form a V-shaped interior hopper bottom, and, when open, swing back against the sides of the shell, and leave the bucket open its full bottom dimensions. The doors are held closed by the chains attached to the bail, which is held by the key or pin shown just above the chain connections to the bail. When filled the bucket is swung clear of the ground, and the pin or key is pulled out, leaving the pull of the load on the bail to hold the doors closed. In this condition the basket is swung over the spot where it is desired to deposit its load, and then lowered until it reaches the bottom. As the bucket comes to rest, the load of concrete on the doors pulls on the chains, and this pull, aided by the weight of the bail, which is purposely made very heavy, causes the bail to slide down into the position shown by Fig. 2, and also causes the door to swing open as shown. As the doors swing open they tend to force the water out of the shell, while the shutter attached to the door closes the curved slots in which the pins at the ends of the doors slide back and forth. As soon as the doors have swung clear open, the latches on the bail catch, as shown in Fig. 2, and hold the bail from sliding up until the latches are released by hand.

Fig. 1.—View of Bucket Closed.

Fig. 2.—View of Bucket Open.

BUCKET FOR AUTOMATICALLY DUMPING CONCRETE UNDER WATER.
John F. O'Rourke, M. Am. Soc. C. E., New York, N. Y., Designer.

An obvious advantage of this bucket for depositing concrete under water is that it does not let the material fall through the water, and that it operates to shut out the water from the load until it is finally in position. It operates automatically without the use of a tripping rope, gives the largest possible discharge opening for the size of the bucket, and is simple in construction. The discharge of the load is effected simply by raising the bucket free from it. This bucket has been patented by its designer.

THE DARIEN SHIP CANAL PROJECT, now being reinvestigated by the Isthmian Canal Commission, was intended to connect the Gulf of Darien with the Gulf of Panama, by canalizing one of the tributaries of the Atrato River. The route was first surveyed in 1854, and the straight distance between the bays was found to be 39 miles; but the plans included a 5-mile tunnel for ships. Routes in this neighborhod have been examined and reported upon by Trautwine, Porter, Michler and Selfridge; and the purpose of the present commission is to examine carefully these, among all other proposed routes, before coming to ultimate conclusions.

THE WHITE NILE is being obstructed by floating weeds, says Mr. W. Willcocks, Director of the Cairo Water-Works. This obstruction, called "sudd," is brought down from Lake Uganda and Lake Albert in such quantity as to threaten to choke up the White Nile altogether. Since 1840, what was then a stream over 1,300 ft. wide and 16½ ft. deep, is well-nigh obliterated for a distance of 155 miles. Mr. Willcocks recommends thath this sudd be removed from the Bahr Loràf and a wide channel be thus opened into the Victoria Nile. At a cost of about $3,000,000, he says that the Victoria Nile supply could be brought directly into Egypt and made to increase the summer supply and advance the date of overflow.

THE "LITTLE CROSSING" 80-FT. STONE ARCH bridge, built in 1813 on the old National Road, near Frostburg, Md., is still standing, intact though neglected. It crosses the Castleman River, and is a semicircular arch rising nearly 50 ft. above the stream. Mr. James P. Gaffney, C. E., writing to the Baltimore "Sun," says that the bridge, with span and approaches, is 307 ft. long by 34 ft. wide. It was designed and built by David Shriver, Jr., some time in 1813, and it is constructed in rubble masonry of a very excellent quality. Mr. Gaffney pleads for the preservation of this monument of early state engineering and says that $1,000 would completely renovate it.

THE WORLD'S GOLD AND SILVER PRODUCTION, for the calendar year 1898, is given in the annual report of the Director of the U. S. Mint. The total gold production is put down at 13,904,363 ozs. fine, valued at $287,428,600.

This is an increase of about $50,000,000 over 1897, and shows a continuance of the annual increase apparent for the last decade; in 1887 the total value mined was $105,-774,900. As a gold-producing country South Africa ranks first, with $79,213,935 in value; Australia and the United States come next with $64,860,800 and $64,463,000 respectively. The total silver production was 165,295,572 ozs. fine; to which Mexico contributed 56,738,000 ozs, commercially valued at $33,475,400, and the United States mined 54,438,000 ozs., valued at $32,118,400; in the latter country the lead ores gave 31,000,000 ozs. of the product. In the arts and manufactures, last year, $65,000,000 in gold, and silver of the commercial value of $20,200,000 were consumed; this is a value increase over the preceding year of $6,000,000 in gold, and $1,400,000 in silver.

A NEW STAGE FOR MASONS, in shaft lining, has been successfully tried in the Saint Etienne collieries, in France. Brick was being used for lining this shaft, and the platform for the workmen was arranged as follows: The clear diameter of the shaft was 12.3 ft., and the circular stage used had a diameter of 11.97 ft., and was made with two hinged flaps at the side and a notch for holding a 3.28-ft. pipe for ventilating the bottom working. This stage was suspended from four pieces of rail, built into the upper part of the shaft, by four 50-ft. lengths of chain, followed by a differential pulley-block with 50 ft. of chain, and a bottom length of 10 ft. of chain. Each tackle was tested to 2 tons, or 8 tons in all, while the total weight was 1.8 tons, with 1 ton represented by the stage itself. This stage was shifted by four men, one at each tackle; and during this operation these men were chained together by safety belts. The stage was held in position by four bolts shot into holes left in the brickwork. The time saved by this arrangement was figured at 10 days for each 98.4 ft. of shaft; or, about two months in the total depth of 590 ft. The cost of the four differential blocks was about $210, while the saving, as compared with fixed staging, was nearly $3.60 per foot of shaft.

BOOK REVIEWS.

BUILDING AND ENGINEERING TRADES DIRECTORY, 1899-1900. Containing complete and accurate lists, properly classified and indexed, of contractors and builders, and also of manufacturers and dealers in all materials, apparatus and appliances used in the construction, furnishing and equipment of modern buildings and in engineering projects, and all others identified with these interests in Boston, and in the Metropolitan District. Supplemented by the official lists of the building exchanges, together with the architects and engineers of New England. Boston: F. W. Dodge, publisher. Cloth; 9 × 6 ins.; pp. 273. $2.00.

The title leaves little to be said regarding the scope and purpose of this publication, other than to say that it seems to carry out the expressed intentions of its publisher.

CALIFORNIA MINES AND MINERALS.—Published by the California Miners' Association, under the direction of Edward H. Benjamin, Secretary, for the California Meeting of the American Institute of Mining Engineers. San Francisco, Cal. 1899. Cloth; 8¾ × 5¾ ins.; pp. 450; illustrated.

This handsome volume, issued as a souvenir of the visit of the American Institute of Mining Engineers to California, is a very thorough exhibit of the mineral wealth of that state and the methods of its development. The contents include more or less extended papers by experts, treating of the following main subjects: The mineral industry of California, dredging for gold, electric power on the Pacific coast, California petroleum and asphalt, mining and reducing methods and machinery, detailed descriptions of chief mining districts, the California Miners' Association, the State Mining Bureau, etc. These papers are very profusely illustrated, and the whole makes an exceedingly useful book of reference.

PRIMERA REUNION DEL CONGRESO CIENTIFICO LATINO-AMERICANO, celebrada en Buenos-Aires del 10 al 20 Abril de 1898. Por iniciativa de la Sociedad Cientifica Argentina, y bajo el patronato del Excmo. Sr. Presidente de la Republica Argentina, Dr. D. Jose Evaristo Uriburu, y de los excmos. Sres. Ministros de Justicia, Culto e Instruccion Publica, Dr. D. Luis Belaustequi y de Relaciones Exteriores Dr. D. Amancio Alcorta. I., Organizacion y resultados generales del Congreso. IV., Trabajos de la 3d Seccion (Ciencias Medicas). Buenos-Aires, Argentina. Paper; 10 × 6¾ ins.; pp. I., 133; IV., 768; diagrams.

The first volume gives a list of the officers and members, and the business transacted and the division of subjects proposed for discussion; the topics including such interesting subjects as international railways and pan-American postal exchange, the port of Buenos Aires, international telegraphing of time, study of the ocean bed, etc Volume IV. gives a number of medical papers presented to the Congress, having especial bearing upon Latin-American conditions.

ENGINEERING RULES AND INSTRUCTIONS; NORTHERN PACIFIC RY.—By E. H. McHenry, M. Am. Soc. C. E., Chief Engineer. New York: Engineering News Publishing Co. Cloth; 3½ × 6 ins.; pp. 74, with folding plates. 50 cts.

Under the title "Rules for Railway Location and Construction" we published in our issues of April 20 and 27 last, the very complete instructions prepared by Mr. E. H. McHenry, for the guidance of the engineers in the employ of the Northern Pacific Co. on surveys and construction. As we said at the time, this is really one of the most practical and up-to-date treatises on railway location that has appeared for many years. To meet numerous requests from those who desired the articles in a form convenient for reference, they have been reprinted (together with other material in the book relating to methods of accounting which was omitted in the publication in Engineering News), and bound in convenient pocket-book form. The material in the book is classified under the heads of Organization, Location, Surveys and Construction, Track and Ballast, Bridges and Culverts, Accounting, and Supplies.

A GASOLINE HOISTING ENGINE AT A MEXICAN MINE.

A class of work to which gasoline engines are now being quite extensively applied is that of operating hoisting plants. We illustrate herewith a combination gas engine and double drum hoist manufactured by the Weber Gas & Gasoline Engine Co., of Kansas City, Mo. The Weber engine is of the four-cycle, single cylinder, center crank type, with two heavy overhung flywheels on the crank shaft. Direct-acting, tool-steel poppet valves are used, and are driven by gearing, which runs in a closed oil chamber. A governor controls the admission of gas to the cylinder, according to the load on the engine, giving a full charge at each stroke when the engine is working at its full capacity. The governor is under the direct control of the operator, who can instantaneously regulate the speed of the engine.

The valve gear consists of a gun-metal pinion keyed to the crank shaft, which meshes into a spur wheel supported on a steel center pin. On each side of the spur wheel are pivoted steel anti-friction rollers, which act rotatively on levers which are pivoted at their lower ends to the housing. The center pins, roller pins, rollers and levers are all case-hardened to prevent wear. This valve gear is all incased in a dust-proof housing, to protect the gear and also to carry the oil for lubrication, so that the whole valve gear runs in oil. The exhaust valve rod enters the housing near its top, and the end of it is acted on by the reciprocating motion of the upper end of the levers, imparting action to the valves. The governor acts on the gas valve and is of the "hit-and-miss" type. Until the engine attains its normal speed, the governor continues to open the gas valve, but when the normal speed is reached, it misses a collar on the valve rod, so that the gas valve is not opened. When the speed falls below the normal, the governor will again open the gas valve, admitting gas as often as is necessary to carry the load.

The speed of the engine and hoist is regulated at will by the operator, who stands within reach of the speeder lever, which is connected to a moving part of the governor, changing its contact action on the collar, and as a result the number of impulses is varied and the engine caused to run fast or slow.

The igniter may be of the incandescent tube type (heated by a Bunsen burner) or electric spark type. It is claimed that this is the only gas engine in which the point of ignition is altered while the engine is in operation, this change being made in accordance with the speed of the engine. Greater economy in fuel, and certainty of firing the charges promptly are claimed to be thus secured. Water circulation is maintained in jackets surrounding the cylinder, cylinder head and valve chamber. The ordinary working speed of the engine is 100 revolutions per minute, with a maximum of 190 revolutions.

The drums are of cast iron, with steel shafts, and each drum is driven by friction clutches, keyed to the shaft. Fig. 1 shows the toggle-joint arrangement for the clutch mechanism, by means of which all end thrust on the shaft and bearings is eliminated. The clutch consists of four cast-iron shoes (A), lined with hard maple (B). These operate in grooves on the disk plate (C), the power being transmitted by links (D), through the lateral movement of the sleeve (E), on the drum shaft (F). The large driven gear wheel is also keyed to the drum shaft. A shrouded pinion on the end of the crank shaft drives the large spur wheel on the axle of the inner drum, and on the axle of this drum is a smaller spur wheel, which in turn drives a similar spur wheel on the shaft of the outer drum. The drums can be stopped and started independently by a hand ratchet lever. The clutch handles may be fitted at the end of the drum shafts, but it is in some cases found more convenient to assemble the levers operating the clutches and brakes in a sector frame on the platform at the side of the engine.

The brakes are of the band type, with bands nearly encircling the brake surface on the drums. The bands are contracted by powerful latch-handle levers, and are capable of holding the load at any point of lowering or raising. Post brakes with wooden shoes are used on the larger hoists.

A number of these plants have been put in use for mine hoists. The largest of these is shown in Fig. 2. It has a 40-HP. engine and is in use at the Santa Maria de la Paz mine in Mexico. It is placed in a tunnel in the mine and operates two cages in a double compartment shaft, each drum hoisting 33,000 lbs. per hour, with a lift of 1,312 ft. The base plate is 17½ × 9½ ft., made in two pieces for convenience in casting and erection. The cylinder is 15 × 23 ins., and there are two flywheels, 72 ins. diameter, weighing 2,200 lbs. each. The speed of hoisting is about 280 to 350 ft. per minute, and the cages carry 1,800 to 3,500 lbs. each. The total weight of this hoisting plant is 25,600 lbs.

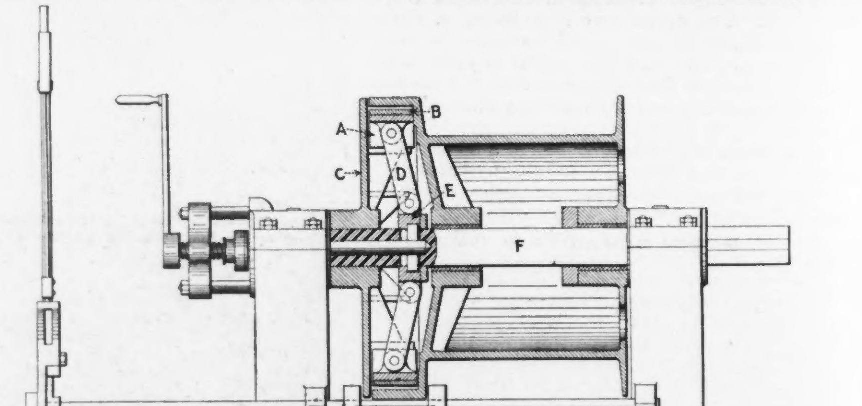


FIG. 1.—CLUTCH MECHANISM OF WEBER GASOLINE HOISTING ENGINE.

The engine was tested before shipment, and ran idle continuously for 10 hours at 100 revolutions per minute with a consumption of 6 gallons of 74° gasoline. It developed 48 brake HP. on a continuous run of 10 hours, with a consumption of 48 gallons, while on 24.3 brake HP. on a run of the same duration, the consumption was 29 gallons. According to these tests the consumption of gasoline is nearly proportionate to the work done. The tank system for water circulation for cylinder jacket and valve chamber is employed with this engine, and with a continuous 40-HP. load, the evaporation of water was 22 gallons for the day's run and overnight. In the location where this hoist is employed water is very scarce and costly, so that this slight water consumption enables the engine to work where it would be impossible to work a steam engine.

The engine is started by compressed air from a receiver, which is charged by a small air compressor driven by the engine.

POOLING OF LOCOMOTIVES.*

By M. E. Wells.†

Men must have regular rest, while engines need only repairs. Is there any argument why a locomotive should lie in the roundhouse longer than is necessary to make these repairs? The arguments are rather on the other side, for, if the boiler does not need washing, it is an actual detriment for it to cool down. We have, all around us, examples of almost continuous service of other classes of engines. Why are locomotives any exception to this rule? What would the world have thought had the engineers of the battleship "Oregon" insisted that their engines needed rest, on its trip of a year ago? Another case I am familiar with is the hoisting and mill engines of the celebrated Homestake mines at Lead City, S. Dak. The mill engines run continuously, and only have steam shut off every 15 days, when they are stopped for a few hours in order that the gold may be cleaned off the plates in the mill.

The pool with which I am familiar includes both freight and passenger runs, and is by no means an experiment, having been in successful operation since August, 1893. In it there are used eight-wheel, ten-wheel, mogul and consolidation locomotives. There are also fast trains, slow trains, work and local trains, and all these runs are pooled, the crews being run first in, first out, while the engines are put on the different trains to the best advantage to the company. There are 52 crews, 41 being in the freight pool and 11 in the passenger pool. To keep these crews going requires an average of 30 engines in freight service and 7 in passenger service. But if necessity demands it, the engines of one pool are used in the other. Here will be noted a saving of 15 engines over the old system of regular engines, and, counting the average value of an engine at $10,000, makes a saving of $150,000 in the amount invested in machinery.

In the pool, as we have it, each engine is equipped with headlight and signal oil cans, and the necessary tools in locked boxes, the keys being kept on a large board in the foreman's office. All that an engineman transfers from one engine to another is an oiler, a supply can for engine oil, a tallow pot and a torch, all these being marked with his number. The crew is called about an hour and a half before time to leave the roundhouse. When called, they know what train they get, and where they go; but the engine they are to have they only learn on reaching the foreman's office, where they receive the keys to the boxes. The engineman goes at once to the oil house, gets his cans, goes directly to the engine, and proceeds to fill all cups, and oils and inspects the engine. While the engineman is thus engaged, the fireman is lighting the lights, if at night, filling the lubricator, getting the signals ready, if any are to be carried, and wiping the windows and the inside of the cab.

On coming in, while the engineman is looking the engine over for his work report, the fireman is filling the headlight, cab and signal lights. The three cans and the torch, previously described, are turned in at the oil house, and the crew goes home and stays there until called again. This is the simple statement of the working of our pool. I will now take up more specifically some of the methods followed in the different branches, beginning with what is, to my mind, the best point in the system, viz., the engine inspection.

An engineman comes into a division point and puts his engine on the clinker pit track. Before turning it over to the hostler, he goes over it carefully, examines all bearings, and inspects it as thoroughly as can be done by getting around on the outside, and reports all work that he finds to be done. The engine is coaled, sanded, the tank filled, the fire knocked, and then placed in the roundhouse. While in the roundhouse, over a pit, an inspector goes over this engine carefully and thoroughly. While this is being done the boilermakers are inspecting the boiler, flues, grates, ash pan and front end. The man who regularly packs truck and driving boxes, looks over all packing to see that it is not settling away from the journals. The time he now spends in watching the packing and keeping it in shape, he used to spend in packing hot boxes; but it is much pleasanter for him, and more profitable for the company, to keep the packing in good shape than it is to pack the hot boxes. And all this advantage is reaped with a reduction in the cost; for while the wages of the truck packer remain the same, the company is saving oil, and, what is a greater advantage, saving delays on the road. An official report for August, 1899, showing an engine mileage of 299,205 miles, has but two engine delays from hot boxes—one of 23 minutes for a hot driving box, and one of 30 minutes for a hot engine truck.

But to return to our inspection. When all work reported is done, the engine is ready for another trip. Let me say here that the engines are always placed in the roundhouse, over a pit, for the inspectors. No amount of "hurry up" from the dispatcher varies the rule. The most economical place for an engine to die or break down is in the roundhouse (it is expensive when it happens on the road), and a little wait for an engine is better than an engine failure on the road. I do not intend to criticise the engineman's inspection under the old system; but his inspection is usually made when the engine is covered with dust and oil in summer and with ice in winter, and he could not be expected to find a great many defects that could be more readily found when the engine is in the roundhouse and cleaned. I have said that engines and conditions are very similar the country over, and I think you will agree with me that human nature is pretty much the same whereever you find it. Engineers are run very hard sometimes, in rushes of business, both in the pool and out of it; and when an engineer has been on his engine for 18, 20 and sometimes 24 hours without rest, he is not competent to do a good job of inspection. In rushes of business, he cannot go to the roundhouse for his more careful inspection, for the caller is after him before he has had the rest that he should have, and he goes down and goes out, often on a "hurry up" order, when something about his engine is not as it should be.

No matter how thorough any one inspection may be, three inspections are better than one. Another point worthy of consideration is that the engine stands in two different positions under the three separate inspections, and what might be hidden by counterbalances and other moving parts, in one piston, would more than likely be exposed in the other. The incoming engineman is made to be careful in his inspection; for if the roundhouse inspector finds anything that the engineman should have found, the latter is checked up on it. The engineman who goes out on this engine also inspects it; and if he finds anything not O. K., both the incoming engineman and the inspector are checked. I can give you a good idea of the efficiency of the roundhouse inspector's work by enumerating some of the defects he is continually finding that would result in serious break-downs on the road: Cracked driving and side rods, eccentric cams, straps and blades, transmitting blades, wheels, rod straps and frames. This is about as thorough an inspection as it is possible to give an engine between trips; and in refutation of the argument that an engineman can inspect his engine better than anyone else, the result here is a great decrease in break-downs and engine failures, arguing conclusively for the system of inspection followed by this pool. The same official report, previously quoted, shows but five other engine delays for the month of August, 1899, none of which could be traced to poor inspection. They are due to engine not steaming, broken spring hanger, broken valve stem, injector not working, failure of air pump. The entire report shows but these seven engine delays for 218,520 engine miles, or one delay for every 31,218 engine miles; while the best showing for the same month, on a non-pooled division, was 16,472 engine miles to one delay. This, in my opinion, can be credited to nothing but the careful system of inspection carried on under the pool.

To keep an account of the coal consumption by each engine crew, the tanks are filled to a uniform height. An engineer receives the engine with a full tank of coal; and when he leaves it, he makes a ticket in blank; the hostler fills the tank to the regulation height, and fills in the ticket with the amount it takes.

Under the pool system, the fireman does not go to the roundhouse and put in three or four hours cleaning his engine, nor does the engineman go down and pack the throttle and cab glands, clean the headlight, put in lubricator glasses, or do the numberless little things that he used to do under the old system of regular engines.

In arguments against the pool system, a great deal of stress is placed on the assertion of great increase in

*Abstract of a paper discussed at the meeting of the Western Railway Club, Chicago, Nov. 21.

†Locomotive engineman, B. & M. R. R., Lincoln, Neb.

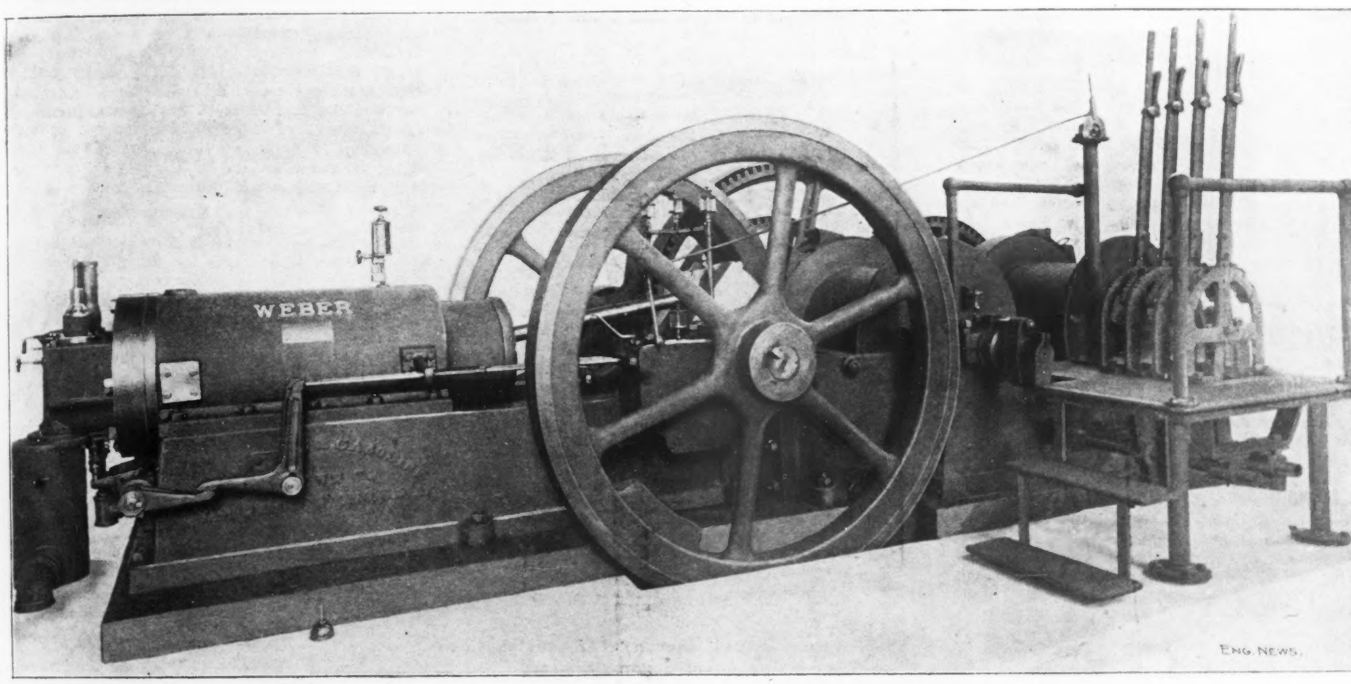


FIG. 2.—GASOLINE HOISTING ENGINE AT THE SANTA MARIA MINE, MEXICO.
Weber Gas & Gasoline Engine Co., Kansas City, Mo., Builders.

roundhouse work and running repairs. A little analysis, in detail, of this subject shows that the increase in expense is not so very great. Take, for example, the cleaning of headlights. In the pool I have described, there are 37 engines. A man can clean a headlight easily in 30 minutes. To clean the 37 would require 18½ hours; and if they are cleaned every two weeks, here would be 37 hours per month it would cost to clean headlights. The packing of throttle stem and cab glands and the putting in of water and lubricator glasses is done by the machinists and their helpers, and it is hard to discover that there is any additional expense in this line. Of course, the salary of the engine inspector is extra, but our decrease in engine delays and failures on the road is worth many times this expense to the company.

In the matter of oil records, the division where the pool is in operation makes a showing for August, 1899, of 70.02 miles per pint of valve oil, as against an average of 74.3 miles per pint of valve oil on three other divisions where the pool is not in operation. On engine oil it is 67.25 against 63.89; in one case the showing being against, and in the other in favor of the pool. What I wish especially to show is that there is no great difference either way, and that there is no argument against the pool in these figures.

In the matter of coal, the showing is in favor of the pool:

	Lbs. of Coal per 100 Ton-Miles. Freight.	Passenger.
Pool division	20.70	29.80
Regular engines	24.00	33.00

Engine crews make about 3,500 miles per month, and, of course, with regular engines, the engines would make about this mileage. Here are figures showing the mileage made by some pool engines in one month: 7,688, 7,228, 7,316, 6,014, 5,648, 5,702. I wish to speak especially of the mileage recently made by a passenger engine in one month, and this record is being kept up from month to month as a steady work. This engines doubles a division, making 333 miles per day. This it did for 20 consecutive days, when it lost one trip for repairs, and then went back on the run for the rest of the month. This shows a mileage for this engine during the month of 9,657 miles.

Discussion.

The discussion of the above paper developed a very general sentiment in favor of the pooling system. It was agreed, however, that the systematic inspection described by the author was a necessity to economical and satisfactory results. It was also developed that while the engine crews do not have regular engines, they do have regular runs, so that they are familiar with the road over which they have to go. With reference to the continuous running of locomotives, Mr. G. W. Rhodes stated on one division of the Burlington road, locomotives now make a round trip of 339 miles without going to the roundhouse, and the motive power necessary to keep the trains moving was thus reduced one-half. Two of these engines are now making 10,170 miles per month each.

THE FRICTION OF STEAM PACKINGS.*

By Chas. Henry Benjamin, M. Am. Soc. C. E.†

It is generally conceded that one of the most serious frictional losses in engines and pumps is that due to the rubbing of piston and valve-rods in their stuffing-boxes, and that this loss varies with the kind of packing employed, the steam pressure, and the judgment of the engineer. The writer is not aware, however, that any experiments have been described which would show the extent of this loss and the law of its variation.

The experiments described in this paper were made at the laboratories of the Case School by senior students, under the direction of the writer. The apparatus used was constructed by Mr. E. O. Lieghley, of the Class of '98, and a few experiments made by him. During the past year, Mr. G. S. Beckwith, of the Class of '99, made a large number of tests with different varieties of packing, and the results seemed of such interest as to justify their presentation to this society.

The general character of the apparatus is shown in Fig. 1. It consists of a cast-iron cylinder, 6 × 13 ins. inside, fitted at each end with a cover and stuffing-box, suitable for a 2-in. rod. The proportions of the gland, etc., were taken from those of a well-known engine. The rod was given a reciprocating motion by means of a slotted cross-head and crank; a pulley on the crank was connected by a belt with the pulley of a transmitting dynamometer; steam was admitted to the cylinder by the vertical pipe shown in the figure, and the water of condensation was drained off from time to time at the bottom.

A steam gage attached to the cylinder showed the internal pressure at each instant. The adjusting nuts of the glands were usually tightened only by the fingers, but when a wrench was used, it was turned by a spring balance and the turning moment noted.

The travel of the rod was 4.25 ins., and the usual speed about 200 revolutions per minute, giving a piston speed of about 140 ft. per minute. Seventeen different varieties of packing were tested, made by nine different manufacturers. The materials present were rubber, asbestos, cotton, flax or hemp, lead, mica, graphite and paraffin. No metallic packings, strictly so called, were tried.

The following brief description will show the general characteristics of each variety:

1. Square, ring, ⅝-in. layers of canvas and rubber, saturated with graphite and oil.
2. Sectional, ring, ⅝-in.; composition similar to No. 1; each ring consists of an inner and outer cone, fitting together, and so wedged under pressure as to fit tightly to rod and box.
3. Similar in shape and composition to No. 1.
4. Metal face packing; alternate soft and metallic rings; metallic rings contain lead band, backed by rubber and flax, the whole wound with cotton braid.
5. Two kinds: (a) A sleeve composed of woven flax, rubber and canvas; (b) a spiral packing of woven flax backed with rubber.
6. Spiral, square, ⅝-in.; alternate layers of rubber and canvas.
7. Spiral, square, ½-in.; layers of canvas and rubber, saturated with graphite and oil.
8. Similar to No. 7, but of a different make.
9. Spiral, square, ½-in.; composed of rubber and asbestos compound, with elastic rubber inset; slightly impregnated with graphite.
10. Spiral, circular, ⅝-in.; red rubber core, wound with layers of rubber and flax, and coated with graphite.
11. Spiral, round, ½-in.; two wedged-shaped strands of woven flax in center, and two strands of canvas, the whole surrounded by a woven cover saturated with graphite and oil. There seemed to be also some paraffin present.

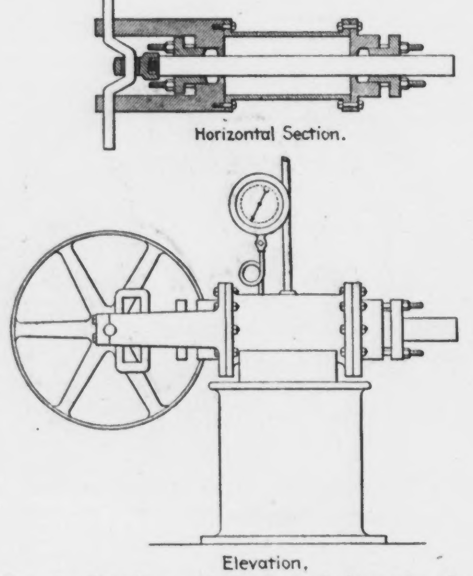


Fig. 1.—Elevation and Section of Apparatus for Testing Friction of Steam Packings.

12. Spiral, round, ½-in.; a rubber core, around which are braided three thicknesses of hemp or flax, soaked in oil; the whole coated with paraffin.
13. Spiral, round, ½-in.; a rubber core, surrounded with layers of woven cloth and rubber, impregnated with ground mica.
14. Square, ½-in.; pump packing; alternate layers of canvas and rubber; no lubricant.
15. Square, ½-in.; similar to preceding, but having a rubber back about ⅛-in. thick.
16. Square, ½-in.; alternate layers of rubber and canvas; no lubricant.
17. Spiral, square, ½-in.; woven flax, soaked in oil.

As at first constructed, the gland was adapted for packing ⅝-in. thick. The flat ring and sectional packings of this size, such as Nos. 1, 2, and 3, worked well, but it was found that no spiral packing ⅝-in. thick would coil easily around a 2-in. rod. Accordingly, the box was bushed, and a new gland made to accommodate ½-in. packing.

In cutting and inserting each kind of packing, careful attention was paid to the accompanying directions, and an endeavor was made to insure the most favorable conditions. It was not practicable to make endurance tests, but each packing was allowed to remain in the box long enough to get into fair working order.

The routine of each trial was about as follows: The apparatus was first tested empty of packing to determine friction. The packing was then inserted and adjusted in each end, according to directions, and the steam turned on. The very least pressure which would prevent leakage was used on the gland nuts. The packing was then tested under various steam pressures, each run lasting from 15 to 40 minutes. The nuts were then tightened to various pressures, and other sets of readings taken. Cylinder oil was next applied to the rod, the only lubrication in the tests so far having been that contained in the packing itself. Finally, a last run was made with the boxes empty, as at first. A Flather recording dynamometer was used on a few of the runs, so as to determine the nature of the variations in power. The majority of the tests were made with a Webber box-gear dynamometer, readings being taken at short intervals and averaged.

Table I. gives a summary of the results, showing the average horse-power consumed by each packing box at varying pressures, and, for purposes of comparison, the power at 50 lbs. pressure of steam. The friction of the machine has been deducted.

Table II. shows the effect of tightening the gland nuts on the friction of the packing and also the effect of oiling the rod. In most of the experiments detailed in Table I. the nuts were tightened with the fingers only, and then just enough to prevent leakage, and no lubricant was used except that incorporated in the packing itself. With some of the dry rubber packings it was necessary to use oil from the first. A good quality of cylinder oil was applied.

The effect of varying the steam pressures was determined and it was found that the friction varies with the pressure in approximately straight line ratios in many of the cases.

General Conclusions.

1. That the softer rubber and graphite packings, which are self-adjusting and self-lubricating, as in Nos. 2, 3, 7, 8 and 171, consume less power than the harder varieties. No. 17, the old braided flax style, gave very good results.
2. That oiling the rod will reduce the friction with any packing.
3. That there is almost no limit to the loss caused by the injudicious use of the monkey-wrench.
4. That the power loss varies almost directly with the steam pressure in the harder varieties, while it is approximately constant with the softer kinds.

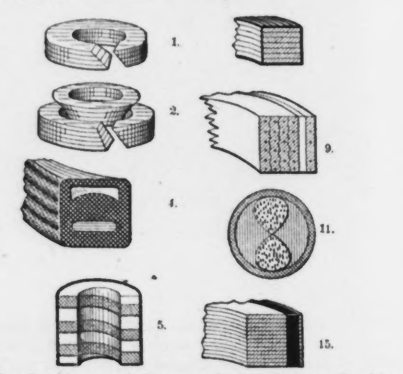


Fig. 2.—Sections of Some of the Steam Packings Tested.

The diameter of rod used—2 ins.—would be appropriate for engines of from 50 to 100 HP. The piston speed was about 140 ft. per minute in the experiments, and the horse-power varied from .036 to .400 at 50 lbs. steam pressure, with a safe average for the softer class of packings of .07 HP.

At a piston speed of 600 ft. per minute, the same friction would give a loss of from .154 to 1.71 with a working average of 0.30 HP., at a mean steam pressure of 50 lbs.

It is the intention of the writer to make a series of tests with water packings, and also to try some of the standard forms of metallic packings. He would be glad of any criticisms and suggestions from builders and users of pumps and engines, in regard to any further experiments.

TABLE I.

Kind of packing.	No. of trials.	Total time of run, mins.	Av'ge HP. consumed by each box.	HP. consumed, 50 lbs. pressure.	Remarks on Leakage.	Remarks on Working.
1	5	22	0.091	0.085	Moderate.	
2	8	40	.049	.048	Slight;	easily adjstd.
3	5	25	.037	.036	Considerable.	
4	5	25	.159	.176	Badly.	
5	5	25	.095	.081	Badly;	oiling nec'sry.
6	5	25	.368	.400	Moderate.	
7	5	25	.067	.067	None;	easily adjusted
8	5	25	.082	.082	Slight;	very satisfcty.
9	3	15	.200	.182	Moderate.	
10	3	..	.275	....	Excessive.	
11	5	25	.157	.172	Moderate.	
12	5	25	.266	.330	Moderate.	
13	5	25	.162	.230	None;	oiling nec'sry.
14	5	25	.176	.276	Moderate;	oiling nec.
15	5	25	.233	.255	None;	diff. to adjust.
16	5	25	.292	.210	None;	oiling nec'sry.
17	5	25	.128	.084	None.	

TABLE II.

Kind of packing.	HP. consumed by each box when pressure was applied to gland nuts by a 7-in. wrench. 5 lbs.	8 lbs.	10 lbs.	12 lbs.	14 lbs.	16 lbs.	HP. before and after oiling rod. Dry.	Oiled.
1	0.120	.....	0.136	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	.....	.....	0.055	0.021
4	.....	.248	.....	.303	.....	.390	.154	.123
5	.....	.220	.....	.....	.....	.....	....	....
6	.....	.348	.430	.....	.....	.....	.323	.194
7	.....	.126	.228	.260	.330	.340	.067	.053
8	.....	.363	.500	.535	.520	.533	.533	.236
9	.....	.666	....	....	....	....	.666	.636
11	.....	.405	.454	....	....	....	.454	.176
12	.....	.161	.242	.359	.454	....	.454	.122
13	.....	.317	.394	.582	....	....	....	....
15	.....	.526	....	....	....	....	....	....
16	.....	.327	.860	....	....	....	....	....
17	.....	.198	.277	.380	....	....	....	....

*A paper presented at the New York meeting of the American Society of Mechanical Engineers.

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