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THE POLLUTION OF THE PASSAIC RIVER is to be studied anew by a third commission. The eight members of this commission have just been appointed by Mr. Foster M. Voorhees, Acting Governor of New Jersey, under an act passed by the state legislature of 1897, providing for a state commission to consider the subject of the pollution of the rivers and streams of New Jersey. While the act is general in character, the popular conception of it seems to be that it is intended to be applied to the Passaic River only, and all of the eight commissioners reside in cities or towns affected by the Passaic River problem. The commisioners are to receive not over $1,000 per year for their services, and may expend $25,000 in their work, subject to the approval of the governor of the state. The expenses of the commission are to be apportioned among the communities benefited. The members of the commission are as follows: Messrs. Wm. T. Hunt, Editor of the Newark "Sunday Call," and H. C. H. Herold, President of the Newark Board of Health; Chas. W. Fuller, City Attorney of Bayonne; Jas. A. Exton, M. D., of Arlington; Wm. Kent, M. Am. Soc. M. E., Associate Editor of Engineering News, of Passaic; Elias J. Marsh, M. D., and John Hinchliffe, Mayor, of Paterson; and Chas. F. Harrington, of Bergen Co.

MUNICIPAL OWNERSHIP OF WATER-WORKS continues to make rapid headway. On July 31 the plant of the Duluth Gas & Water Co. was formally transferred to the city of Duluth, thus ending the long struggle described in our issues of Dec. 16, 1897, Jan. 20 and May 5, 1898. At Des Moines, Ia., the people vote on Aug. 29 on buying the plant of the Des Moines Water-Works Co., formal agreements for the purchase having been made between the officials of the city and company. The Great Falls Water-Works Co., of Great Falls, Mont., has just accepted the city's offer of $375,000 for its plant. Several other places have recently changed to or voted for municipal ownership, while Indianapolis, Denver, Los Angeles, Pasadena, Cal., Cripple Creek, Col., Fulton, N. Y., and many other places, big and little, have the subject under discussion.

WORK ON THE MASSENA CANAL, says the Watertown, N. Y., "Standard," is rapidly progressing. Seven steam shovels are at work on the ridge near the St. Lawrence, and two of these Vulcan shovels have a capacity of 1,000 to 1,500 cu. yds. per day of 10 hours. Cableways are being put up for Vivian scrapers and for transporting material, the latter is a 2½-in. steel cable stretched from two towers across the Grasse River, and capable of carrying a 10-ton bucket.

HIGHER SPEED IN NEW BATTLESHIPS was decided upon on Aug. 9 by the Naval Board of Construction. But the board opposed making new designs for these ships, and recommended that bids be opened on Sept. 1, as originally proposed. This action is taken in the hope that the builders will submit plans and bids for faster ships, and the Cramps and the Newport News shipyard have already promised to send in such bids. Engineer-in-Chief Melville dissents from the recommendation of the board, and sends in plans of engines for speeds of 17 and 18 knots; but for the latter speed he wants 600 tons additional displacement if the 1,200 ton coal capacity and 6,300 knot steaming radius are to be preserved. The inherent danger in increasing speed without proper increase in displacement will be a crowding of machinery and a continuance of unsufferable heat conditions in the fire and engine rooms.

THE TORPEDO BOAT "MACKENZIE," built at Hillman's shipyard in Philadelphia, on Aug. 5, made 23 knots on its builder's trial trip. The contract speed was 20 knots. But a boiler tube blew out on her return trip and four men were seriously burned. On the same day the torpedo boat destroyer "Farragut," a 30-knot boat, made a preliminary trial at San Francisco. She was built at the Union Iron Works, and with 3,000-HP. developed out of her 5,800-HP. contract power, she made 26 knots.

THE COST OF LARGE CALIBER AMMUNITION, in the present war is very great. A 13-in. gun, firing a projectile weighing 1,100 lbs., consumes 550 lbs. of brown prismatic powder, costing from 30 to 33 cts. per pound. At the lower price the powder for a single discharge costs $165. The common 13-in. shell is said to cost $116.63; but the armor-piercing projectile costs $418. To these items musts be added cartridge-bags, primers, freight, etc., amounting to about $15; or, $296.63 for the shell discharge, and $588 for the discharge of an armor-piercing projectile. As the 13-in. gun can be discharged about 25 times in an hour, the work of one gun for an hour may cost the government about $15,000. The 8-in. gun costs about $65 for each shot; the 5-in. rapid-fire costs $33; the 6-in. breech-loading shot costs about $40, $14 being for the powder; and each round of a Hotchkiss 6-pdr. gun is estimated to cost $5.70, and a 1-pdr., $1.12. Whitehead torpedoes cost $2,500 each, and a Howell torpedo, $2,200.

ONE FLOATING DOCK, instead of two, will be purchased by Commodore Endicott, Chief of the Bureau of Yards and Docks, for immediate use in Southern waters. This order was issued since peace representations were made, and negotiations have been concluded for towing the Perth Amboy dock, of 2,300 tons capacity, to Key West.

A COALING STATION WILL BE ESTABLISHED by the Navy Department at the U. S. Naval Station, New London, Conn., and bids have been asked for the work. The specifications call for the erection of coal pockets or sheds with a capacity for about 10,000 tons of bituminous coal on a basis of 45 cu. ft. per ton. The plans contemplate the receipt of coal by rail over an extension now being built through the station, and also by water, suitable coal handling and conveying apparatus being provided for rapidly unloading or loading vessels or lighters. Only the most approved and substantial methods and construction will be used.

GREAT ACTIVITY IN SHIPBUILDING is expected to follow the end of the present war. As a result of the number of vessels impressed into the government service, many steamers are now being built to replace them. Wm. Cramp & Son are building a steel twin-screw steamship, 360 ft. long, for the New York and Cuban Mail Steamship Co., and four steel steamships, each 280 ft. long, for the American Mail Steamship Co. At Chester, Pa., two steel steamships, each 260 ft. long, are being built for the Old Dominion Line; Harlan & Hollingsworth, of Wilmington, Del., is constructing a 274-ft. steel steamer for the Merchants' and Miners' Transportation Co., of Baltimore; and at Newport News, three new Morgan liners, two new Cromwell liners and two new Pacific Mail steamships are on the ways.

THE THREE 2,500 HP. GENERATORS and steam engines constructed by the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., for the Metropolitan Electric Supply Co., of London, England, were inspected on July 30 by a large number of engineers. Each of these machines include a marine-type, vertical-cross compound engine of 2,500 HP. and a direct connected 2,000-HP. 500-volt two-phase generator, with a revolving armature. The engines are capable of operating at speeds between 116 and 145 revolutions per minute.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred Aug. 8 on the New York, New Haven & Hartford R. R., at Canton Junction, Mass. A special mail express, composed of four cars, jumped the track while running at a high rate of speed, owing to the breaking of a bolt in the cross beam of a siding switch. Three postal clerks were killed and seven were injured.

THE HAMBURG-AMERICAN LINER, "Fuerst Bismarck," has made a new record, from New York to Cherbourg, of 6 d. 13 h. 50 m. This beats her previous best record by about one hour. The "Bismarck" held the Southampton eastward record for four years. It was taken from her in September, 1897, by the "St. Louis," which made the trip in 6d. 10h. 14m., and the Southampton record is now held by the "Kaiser Wilhelm der Grosse," at 5 d. 17 h. 8 m., made in November, 1897.

AMERICAN EXHIBITORS at the Paris Exposition will, if present indications continue, make a creditable showing. Already applications have been received from over 600, and the 150,000 sq. ft. allotted to the United States will undoubtedly prove too small, and a request will be made for a total of 500,000 sq. ft. So far, ten electrical companies alone have asked for 75,000 sq. ft. The prominence given to the United States by the present war has had its effect abroad, and it is expected that little trouble will be experienced in obtaining the extra space.

ARMOR-PLATE BANK-VAULTS are being built by the Carnegie Co. for the Union Trust Co., of Pittsburg, and the Philadelphia Saving Fund Society. The steel vault of the Union Trust Co. will be built of single 6-in. plates, with an 8-in. plate, weighing 46,150 lbs. and 234 x 114 ins., in the front. This front plate will be reinforced by a rolled steel plate 6½ in. thick and weighing 38,200 lbs. The door will be circular, 86 in. diameter and 3 ins. thick at center, and 6 ins. thick on the edges, ground to a gas-tight fit. The clear space within the vault will be 18½ x 16½ ft. and 9½ ft. high. No bolts are used in joining the plates, as the work is machined out and dovetailed so as to form a solid box resting on a masonry foundation. This is said to be the first use of solid armorplate for this purpose as a substitute for the usual laminated steel construction.

THE PHILADELPHIA STORM OF AUG. 3 eclipsed all previous records. The rainfall record was 5.48 in. in 1 h. 50 m., and a boy and horse were killed by lightning. A man was drowned in a cellar in a sudden and enormous inrush of water from the street.

A STEEL VERTICAL LIFT BRIDGE, with steel towers 213 ft. high, has been built by French engineers, at Bizerte, Tunis, over the entrance to Lake Bizerte. The span is not noted, but the bridge is lifted by cables and pulleys, by a 6-HP. engine, in 40 seconds.

ALUMINUM HORSESHOES have been tested in the Russian cavalry and seem to prove satisfactory. It is reported that they wear out less rapidly and are less affected by mud and moisture than the ordinary shoe. The difference in weight is 2½ oz. per shoe.

A TELEGRAPH LINE FROM CAIRO to Cape Town, in Africa, is talked of, with Mr. Cecil Rhodes as chief promoter. The proposed route would be from Fort Salisbury to the Zambezi, near Tete; thence to Zomba and along the west coast of Lake Nyassa to Karonga and Lake Tanganyika. At the latter point it would be necessary to lay a cable to the head of the lake; or, obtain the permission of Germany or the Congo State to run an overland line through that territory. A telegraph line is now said to extend as far north as Lake Tanganyika; and from Cairo south it almost reaches the site of old Khartoum, or the junction of the Nile and the Athara.

THE CONSERVATOIRE DES ARTS ET METIERS, on June 24, celebrated the centennial of its installation in the old priory of Saint-Martin des Champs, in Paris. Descartes is credited with first conceiving the idea of a museum of models for the use of artisans; but the French Convention, on Oct. 11, 1794, realized this idea by a decree then issued; and on June 10, 1798, the Conservatoire was definitely organized and installed in its present building. The decree called for the collection of machines, models, tools, designs, and books of all kinds relating to the arts and manufactures, and the construction and uses of these machines, tools, etc., were also to be made plain. Free lectures are given here upon the application of science to the industrial arts, upon mechanics, chemistry, industrial economy, descriptive geometry, industrial legislation, agriculture, etc. Original research is here conducted under the ablest men obtainable, and the scientific library now numbers 40,000 volumes. The building itself is a beautiful structure of the 11th, 12th and 13th centuries.

THE FRANKLIN TUNNEL, now under construction on the Valley Railway terminating on the Bay of San Francisco, will be 5,600 ft. long. Work was commenced on the approaches in December, 1897, under the Engineer, Mr. A. S. Riffle. This tunnel, named after Franklin canyon close by, is 22 miles from Point Richmond, the terminus of the Valley Railway, and the road now being built will connect at Stockton with the present line of the Valley road. This road will require five tunnels through the Coast Range of mountains, one at Point Richmond, 825 ft.; a curved tunnel of 1,100 ft. at Pinole, and two others of 1,300 ft. and 300 ft., besides the Franklin tunnel. The contractors for the latter work are Foley Bros. & Muir, of St. Paul, Minn., and the estimated cost is about $400,000. The work is being pushed from both ends, at the present rate of 6 ft. daily on the eastern end and 8 to 12 ft. daily at the west. The tunnel lies about 400 ft. below the summit of the ridge pierced.

COVERED STORAGE ROOM FOR RAW MATERIAL; YOUNGSTOWN BRIDGE CO.

The advantages to be gained in the cheapness and comfort of handling and in the ease of marking and laying out the various rolled shapes used in bridge work has led a few bridge companies to build covered storage yards for their raw material. In the accompanying view such a covered space, forming a part of the main truss shop of the Youngstown Bridge Co., of Youngstown, O., is shown quite clearly, with the assorted piles of angles, Z-bars and other shapes fully protected from the rain and snow. The view also shows some features of the overhead trolley construction and the heating arrangements for these shops, which, as we have previously noted, were entirely rebuilt last winter. The advantages to be gained by so fully protecting the material from the weather are not confined to economy in labor and time in handling the material at the bridge shop. Recent investigations have shown that the durability of paint is very materially increased by having the metal free from corrosion and perfectly clean when the paint is applied. These conditions are much more likely to prevail if the material is protected from the weather from the first, than if the manufacturer is depended upon to clean thoroughly in the rush of work all metal work to which paint is applied before shipment.

INTERIOR OF MAIN TRUSS SHOP OF THE YOUNGSTOWN BRIDGE CO., SHOWING RAW MATERIAL STORED UNDER COVER.

THE NEW WATER-WORKS INTAKE TUNNEL FOR CLEVELAND, OHIO.

(With single-page plate.)

The longest water-works intake tunnel yet attempted in the world, so far as we know, is now being constructed at Cleveland, O., beneath Lake Erie. It will be 26,000 ft. in length, 9 ft. in diameter, in the clear, have an estimated daily capacity of 170,000,000 gallons, and will terminate at an intake crib in water 49 ft. deep, located as shown by Fig. 1. On June 17, 1898, when a member of the editorial staff of this journal visited the work, the shore shaft and one temporary lake shaft had been sunk and about 8,500 ft. of tunnel had been driven, besides which the second temporary shaft was down about 98 ft. below the water level and the permanent steel intake crib had been launched and was being finished preparatory to being towed to and sunk in place. This article, however, describes the work up to July 31, as noted further on.

Thus far the work has progressed without more than the minor incidents to be expected on all such jobs, with the exception of two explosions in the tunnel and the encountering of bad material in the shaft of temporary crib No. 2, as described further on. Mr. M. W. Kingsley, M. Am. Soc. C. E., Superintendent of the Water-Works, is the chief engineer of the work, and Mr. C. F. Schulz is first assistant engineer.

Before proceeding to describe the new tunnel and accessories a few words may be said regarding the old works and the report recommending the improvements now in progress.

The Original Tunnels and the Expert's Report.

The present water supply of Cleveland is taken from the lake at a point 6,006 ft. from the shore, although the tunnels are somewhat longer, through two intake tunnels, as shown on the map, Fig. 1. The first tunnel built was 5 ft. in diameter and 6,662 ft. long. Later this tunnel was extended for 2,580 ft., from the shore to the pump wells, the diameter being 5½ ft. and 6 ft. About 1890 a second tunnel was completed, leading from the old intake crib to the main pumping station. The diameter of this tunnel is 7 ft. and its length is 9,200 ft., including the shore end.*

The combined capacity of the two old tunnels is placed by Mr. Kingsley as at least 120,000,000 gallons, at all stages of the lake. By lowering the pumps and the conduits connecting with them it is expected that 150,000,000 gallons per day can be drawn through these tunnels, even after they are extended as a single tunnel of large diameter, as recommended in the report mentioned below.

Early in 1896 a commission composed of Messrs. Rudolph Hering, G. H. Benzenberg and Desmond FitzGerald, Ms. Am. Soc. C. E., reported on improvements in the water supply and sewerage systems of Cleveland. They recommended that water should be drawn from a new intake crib about four miles from the shore, through an extension of the present tunnel; that intercepting sewers should be built to convey the sewage some ten miles, measured along the shore, from the water-works intake; and that a flushing tunnel be built to dilute the water of the Cuyahoga River. This report was approved, except in some details, by Messrs. M. E. Rawson, Chief City Engineer, and M. W. Kingsley, M. Am. Soc. C. E., Superintendent of the Water-Works. Mr. Kingsley advised the construction of an independent tunnel from the proposed intake to a new pumping station on the opposite side of the city, as is being done. Instead of a submerged intake crib, as recommended by the commission, the projecting structure shown by the accompanying drawings is to be used. The intercepting sewer, it may be added, is now well under way, but the flushing tunnel has not been started, which delay accords with the suggestions of both Mr. Hering and Mr. Kingsley.

*A detailed description of the Cleveland water-works from their start to the close of 1877, including the construction of the first tunnel, was published in Engineering News for April 26, May 3 and 10, and June 14, 1879. Subsequent articles on various phases of these works were published in our issues of April 23, 1881; March 19, 1892; April 5, 1894; and Feb. 20, 1896, the latter being an abstract of an expert's report on the new supply.

The Shore Shaft.

The work of driving and lining the tunnel is to be carried on finally from four shafts, a shore and inlet shaft, respectively, and two temporary shafts, thus giving six headings. The shore shaft was completed Dec. 18, 1896. Its dimensions and general character are shown by Fig. 2. It was sunk some 60 ft. by the use of a cast-iron shoe and ordinary excavation, the shoe having a cutting edge and the curb being loaded as found necessary. Steel cylinders of ¼-in. plate were riveted on the shoe and then on each other as it sank, and a brick wall built up inside the cylinder, as shown. After the shaft had been carried down as far as was deemed practicable by this means, a pilot shaft about 6 ft. sq., lined with heavy oak sheathing, was sunk to the level of the bottom of the sump. This shaft was then enlarged by sections and the brick lining put in from the bottom upwards until some 10 or 12 ft. from the cast-iron shoe. The weight of the curbing caused it to sink down, bending all supports placed under it, until it rested on the lower wall. The two walls not coinciding perfectly, the latter was rebuilt, after an air lock had been placed in the upper section. The location of the two temporary cribs is shown in Fig. 1. The cribs are very solidly built of timber, in pentagonal form, having outer sides 54 ft. in length. The first course consists of 12 × 12-in. timber framing, upon which is a solid floor of two courses of 12 × 12-in. timbers, with 3 × 12-in. plank, laid flatwise and calked, between them. All four courses are of pine, drift-bolted vertically and horizontally, besides which many screw bolts were used. The outer and inner walls of the crib and an intermediate wall are of hemlock timbers for 40 ft. above the pine bottom just described, and of pine for the next 16 ft., or to the floor line, the timbers being of 12 × 12-in. stuff. Vertical drift-bolting is used freely in these walls and proper bracing is also employed. A plan of the crib at the floor line and a cross section of the superstructure are shown by Fig. 3. The corners of the cribs for a distance of 14 ft. below the floor line are protected by ¼-in. steel plates and there is a 3-ft. band of the same material around the cribs at the water line to protect the cribs from the action of moving ice. The construction of the cribs was begun on shore and finished inside the breakwater after launching them.

The Temporary Cribs and Shafts.

The temporary shafts are 8 ft. in diameter inside and are in 43 ft. of water. Only the one nearest the shore has yet been completed. For about 25 ft. above the top of the ring of the tunnel the shaft is lined with 12½ ins. of brick. Next comes a cast-iron cylinder with a 1¾-in. shell and inside flanged and bolted joints, lined with 4 ins. of brick. The upper 9 ft. of the shaft is of steel. This shaft was sunk in much the same way as the shore shaft, the shell having the flange on its lowest section omitted to form a cutting edge'

Difficulties at Temporary Shaft No. 2.

At the second temporary crib the sinking of the shaft has met with delays, which can be best described by quoting from a letter to this journal written by Mr. Schulz, First Assistant Engineer, which brings the account down to July 31:

Work proper on this shaft was begun on Jan. 14, 1898, and by Jan. 25 eight cylinders were bolted together, making the total length of the shaft 72 ft., 18 ft. of which had been forced into the lake bottom, the upper 8 or 9 ft. being sand, while below that was soft blue clay. The ninth cylinder was then added, having first been converted into an air lock by bolting to the end flanges heads or diaphragms having a door each and made of steel plates stiffened with channel irons. The shaft was then ready to have an air pressure applied to complete the lower part under pressure. Before this the water had been pumped out and the shaft found to be perfectly dry.

The work was now delayed, because the air compressor for this crib had not arrived, and after it did arrive (on

Feb. 3) the ice in the lake prevented its being taken out until Feb. 11, when it was set up and connected with the shaft ready to put on the pressure. Digging was resumed in the shaft Feb. 18. During this time, i. e., from Jan. 25 to Feb. 18, or 23 days, this shaft, in order to prevent its settling further, had been held in timber clamps, which were secured to the wall enclosing the well of the crib. There had been a strong movement of ice in the lake at different times from Feb. 1 to 10, which shook and jarred the crib considerably, and the shaft being held in the clamps, this shaking and jarring was communicated to it, so that it worked down into the clay bottom about 3¾ ft. farther. It, however, remained perfectly dry during all this time.

On Feb. 21, the cast-iron shaft, now 81 ft. long, was in its proper position and embedded for 25 ft. in the lake bottom, with 3 ft. excavated below the cutting edge, ready for the masons to build the brick lining, consisting of three rings of brickwork, making a wall 12½ ins. thick. The air pressure was now put on, 18 lbs. per sq. in. being maintained, and the masons were sent in at 11 p. m. About an hour later a little water was observed to be trickling in through what seemed to be a vein of sand about 6 ft. wide and a few inches thick. The flow of water gradually increased, so that by 2 a. m. there were about 18 ins. of water in the shaft and the men were compelled to quit work. As no provision had been made for taking care of or pumping out any water, the shaft slowly filled up, there being 11½ ft. of water in it at 8 a. m., although the air pressure had been increased to 25 lbs.

The contractors decided to order two more cylinders and to force the shaft 18 ft. farther into the clay before again attempting to put in any brickwork. While these were being made, the air pressure was let off from the shaft, and the water in the shaft then rose to the lake level, indicating that the water had forced its way down on the outside of the shaft, or through some cracks in the clay extending from the bottom of the shaft to the bottom of the lake.

The tenth cylinder was delivered on March 10 and put in position on the following day. The water was then removed from the shaft and excavating commenced. It was found that the clay, also some sand and gravel, extended up in the shaft to about 9 ft. above the cutting edge. The shaft settled about 4 ft. on the second day after resuming operations. On the following day the eleventh cylinder was bolted on, making a total length of shaft of 90 ft. Excavating was then continued, the material being soft clay. Subsequently two cracks were discovered in the cast-iron cylinders, one in the second cylinder and one in the third cylinder from below. Both cracks were immediately under the top flange of these cylinders and extended a little more than one-fourth way around. The water now came in quite fast through these cracks, and also around sides of cylinders from below, which finally compelled the men to leave the shaft and allow it to fill again with water. The work was delayed on two other occasions, first by gas and water bursting up from below, and again by water coming in under the cutting edge of the shaft. Both times the shaft was allowed to fill up with water.

Permission was finally given the contractor to add a third extra cylinder, making twelve in all, or 108 ft. total, and to drive the shaft a few feet deeper than was originally planned in order to get into better ground for driving the tunnel. (The invert of the tunnel here was to have been 105 ft. below datum.—Ed.) In order to secure the cracked cylinders the top flange of the first and the bottom flange of the fourth cylinder were connected by rods about 18 ft. long, passing through the flanges of the two cracked cylinders and drawn up tight with nuts on both ends. The cracks were also calked with lead and a brick wall 8 ins. thick built inside the two cracked cylinders, the brickwork being laid in Portland cement mortar and thoroughly grouted. While this work was being done 40 lbs. pressure were maintained in the shaft. After this work had been completed and the clay again dug out to the cutting edge, on July 20, the air was allowed to exhaust from the shaft in order to sink it farther down, settling it 4 ins. in about one hour and then stopping. Air pressure was then again applied, the water pumped out and excavating continued until 3 ft. below the cutting edge had been taken out, when the air was again let off, the shaft sinking 21 ins. this time, but filling with water in a few hours.

After the water had been removed an examination showed that another cylinder had been cracked during this operation, being the sixth one from below; the crack being in the same relative position with the others. This is now being calked and secured by rods. This shaft is now, July 31, 108 ft. long and extends from 12 ft. above lake level, or 10 ft. above city datum line, to 52 ft. below the bottom of the lake.

It is our opinion that the most trouble has been caused by the leakage through the cracks in the cylinders, rather than by water following down outside the shaft and coming in under the cutting edge; and we were at first inclined to the belief that these cracks were due to the heavy strains produced in the shaft while it was held in the clamps and the crib was jarred and shaken by the moving ice. Against this theory, however, is the fact that the shaft was perfectly dry during all the time that work was suspended and for four days after it was resumed, and that the cracks themselves were not discovered until about 26 days later. This third crack occurring during the operation of forcing the shaft down indicates that the cause is to be sought in the ground through which it is being sunk.

When the tunnel is completed it will be arched over at the two temporary shafts. The shafts will then be filled with puddled clay to a depth of 20 ft. and for the remaining depth to the lake bottom with earth. All obstructions to navigation to a depth of 35 ft. below the water line will then be removed.

The Steel Intake Crib.

The permanent steel crib has an outside diameter of 100 ft. and a central well 50 ft. in diameter. A section of the crib is shown by Fig. 4, and two views of it under construction by Figs. 5 and 6. It has an octagonal pine timber bottom, 4½ ft thick, the lower course being a frame and the three upper ones being solid, all the timber being 12 × 12 ins., except the outer ones, which are 12 × 18 ins. Radial partitions divide the crib into 24 water-tight bulkheads. The rings and partitions are of ⅜-in. steel plates, in 6-ft. courses, reinforced by angles at the joints and also at intervals along the radial plates. The rings are bolted to the timber bottom and also braced against it, triangular-shaped plates with angles bolted to their longer sides serving as braces. In each compartment and course there is one strut between bulkheads, and one tie piece between braces, all of angle iron, the struts being formed of two channels bolted together and to vertical gusset plates inserted at the top of each vertical joint in the bulkheads, four angles being used at these joints. All joints are riveted. The twelve inlet ports are designed to admit water to the shaft and tunnel at eight times the rated capacity of the latter, allowing a velocity of 4 ft. per sec. through the tunnel.

The metal work of the crib is painted with three coats of lead and oil, the first and third coats being of red lead and the second of white lead. Analyses of the lead were made from time to time to make sure that only pure lead was being furnished.

The timber bottom of the steel crib was constructed on land and the steel work started there after which the structure was launched to the breakwater and work continued until it was ready to be towed to and sunk in place. Fig. 5 shows the crib at the breakwater and Fig. 6 shows it in place.

The intake shaft will be about 10 ft. in diameter. As proposed, the first 18 ft. of the shaft, above the top of the tunnel lining, will be lined with a 16¾-in. brick wall. For the next 60 ft. the lining will be of 2-in. cast-iron cylinders, each 10 ft. in length, 4 ins. of brick being built inside this cylinder and carried on to the top of the shaft through the upper 30 ft. of steel cylinders. All the metal sections have inside flanged and bolted joints.

The Lake Tunnel.

The tunnel, as already stated, is 9 ft. in diameter in the clear, and is lined with three courses of shale brick, laid in mortar composed of one part of natural hydraulic cement and two parts clean sharp lake sand.

The grade line of the tunnel was designed to start at an elevation of 105 ft. below city datum at the shore shaft and also at the two temporary shafts, and to start at an elevation of 109 ft. below city datum at the inlet shaft. The tunnel is being built with a very slight up grade from each shaft so as to cause any water that may be encountered to flow towards the shafts. There will be three summits in the tunnel, not exceeding 2 ft. high each, which will be at the points where the different headings will meet. It is calculated that the air which will be entrapped at these summits will be absorbed by the water, as it will be under a pressure of about 43 lbs. when the tunnel is full of water.

Compressed air under an average pressure of about 20 lbs. is being used in building the tunnel, the locks being placed as already stated above in describing the shafts, except that the lock near the shore shaft has been moved out about 3,700 ft. beneath the lake. This lock is of boiler iron, 5½ × 17 ft., built into brickwork. The two locks at the next shaft are of greater length than the first one, so as to admit three instead of two construction cars. They are built of brick, with steel diaphragms, bolted together. The air supply is 4 ins. in diameter. The tunnel beyond the lock is ventilated by taking the air required for locking in and out through a 2½-in. pipe leading from the face of the work to the lock. A special air lock (of 6-in. wrought-iron pipe) is used to send rails, pipe and similar supplies into the portion of the tunnel under pressure, thus diminishing the waste of air caused by operating the large lock. The tunnel is lighted by incandescent lamps. The cars for sending in supplies and hauling out the excavated material are drawn by mules.

The tunnel excavation has been carried on by the ordinary methods employed for such work, except for a few feet at the scene of the accident. The material encountered has been mainly a stiff blue clay, in layers of ½-in. to some 6 or 8 ins. thick, with very thin layers of quicksand between them.

Accidents in the Tunnel.

Occasionally small pockets of gas were found, but the gas gave no trouble until, on May 11, a large amount of gas was encountered which gave rise to an explosion, from the effects of which eight men died subsequently. A mass of clay fell into the heading in advance of the brickwork, completely filling it for a length of 17 ft., the lining having been carried to a point 6,281 ft. from the shore shaft. At this point there was some 50 ft. of clay above the excavation. The cave-in extended up 20 ft., leaving about 30 ft. of solid material between its top and the lake bottom. The contractor requested permission to change the course of the tunnel, but this being denied work was resumed on June 13. The fallen material being loose, it was decided to hold it in place, while inserting the lining, by means of a steel cylinder. This was built up to the diameter of the outside of the brickwork with 18 × 24 × ¼-in. steel plates, bent to shape, with 3 × 3-in. angles riveted on each edge by means of ⅝-in. rivets, 3 ins. c. to c. The angles of the adjoining plates were fastened together with ⅝-in. machine bolts, five in each longitudinal and six in each circumferential joint, making 102 bolts in each ring of 17 segments. When the writer visited the tunnel this work was well under way and it was expected that twelve rings, or a length of 18 ft., would suffice to pass through the fallen material. Under date of July 31 Mr. Schulz sent us the following additional information regarding this break in the tunnel, as well as a description of a second break, which occurred on July 11, or just two months later:

Eighteen feet of steel plate did pass through the fallen material and work was then carried forward in the usual way, except that shorter drifts were made, as the clay was quite poor, containing a large mixture of dry quicksand. Since the explosion on May 11, the contractors had changed their method of ventilation so as not to depend altogether on locking through the air-lock for exhausting the air from the face, but had extended a branch of the exhaust pipe through the air-lock, which was constantly blowing off air, and it was thought that this would prevent any re-occurrence of any accident from gas explosion. On July 11, however, while the masons were at work, another explosion occurred, which killed eleven men, or every one at the face of the work, the only men escaping being a mule driver and the locktender, who were both at the air-lock about 2,850 feet from where the explosion occurred. The tunnel had been completed to 6,541 ft., or 260 ft. beyond the point where the first explosion occurred. What caused it is not known; the electric lights were not extinguished, except for a distance of 700 ft. back from the face, the wires being torn down and the lamps broken in this part. The tunnel was not injured in any way, although a brick bulkhead 4¾ ft. thick, built across the tunnel at 6,200 ft. from the shore shaft, or 340 ft. from the face of the work, was completely demolished, the whole mass being buried about 120 ft., carrying floor and tracks before it for this distance. A temporary bulkhead has been built in the tunnel at the face and work stopped for the present.

Instrumental Work in Locating the Tunnel and Cribs.

The following description of this part of the work was prepared for this journal by Mr. Schulz:

To reproduce the direction of the line in the tunnel as established on the surface, two plumb lines were suspended in the shore shaft, lined in with the transit on top, the bobs being steadied in oil, and the line was then produced in the tunnel by a transit set up about 50 ft. from these two lines and ranged in until the three points were in perfect alinement. The line was then marked by files on iron hooks, driven into the roof of the tunnel every 100 ft. The shaft not being vertical, the two plumb lines could only be placed about 2½ ft. apart. As this gave too short a base line by which to build the tunnel for any great distance, a 6-in. tube was driven from the surface down through the roof of the tunnel at a point 65 ft. from the shaft. The operation of plumbing down and producing the line in the tunnel was then repeated at three different times, with one plumb line in the shaft and one in the tube, giving a base line 65 ft. long. As the transit work interferes considerably with the transportation of spoil and material, the line was then very satisfactorily produced as the work progressed, for 400 or 500 feet, by stretching a fine line, 200 ft. long, always using the last two hooks as a range, and then checking the work with the transit. The grade of each section built is given with a straight edge and carpenter's level, and checked with the instrument once a week, or every 90 or 100 ft.

The intake protection crib is located 18,040 ft. from the breakwater light, bearing N. 32¼° W. This point was selected as complying with the recommendations of the sanitary commission to place the intake west of the river, and as not being too far west to make it impracticable to build the tunnel to a pumping station three miles east of the river. After this point had been determined, the line of tunnel was marked on the grounds of the proposed pumping station by a series of stakes. A base line, 3,800 ft. long, was then measured on the U. S. breakwater, west of the river, which runs parallel with the lake shore at a distance of about 3,000 ft. from it.

The positions of prominent points, such as the center of the old intake crib, center of Detroit St., school house, steam exhaust pipe of Society for Savings Building, breakwater light and center of shaft No. 1 (shore shaft) were then established, by triangulations, from this base line, to be used in determining the proposed positions of the different cribs by means of angles observed with a sextant.

In placing the two temporary cribs more attention was paid to locating their centers exactly on the line of the tunnel, so as to make it possible to build the tunnel in a straight line, than to have them any exact distance out from shore.

To determine the right location of the first temporary crib, which was to be 11,600 ft. distant from shaft No. 1, pound stakes, i. e., stakes about 65 ft. long used by fishermen, were driven in the lake on the line of the tunnel; one 100 and one 200 ft. from the proposed center of the crib. To determine the location of the first stake a fisherman's pound stake driver, equipped with a steam hammer and its own motive power, was run over the proposed line of tunnel as nearly as could be judged, and the position located approximately with a sextant, an anchor with buoy attached being thrown overboard the moment that the two objects, subtending the angle at which the sextant had been set, coincided. Four anchors, each about 300 ft. from this buoy and at right angles to each other, were then dropped and the stake driver was then, by means of lines attached to these anchors, hauled back and forth in the vicinity of the buoy until it was brought into the exact position as nearly as could be determined with the sextant. A stake was then driven and checked by an observer on shore stationed with a transit on the line of the tunnel, as previously marked, and who could plainly see the stake after it was driven and the driver removed to one side.

It was found that the stake was 0° 4' 25" south of the tunnel line, this angle corresponding to a distance of 16.5 feet; a second stake was then driven 16.5 ft. north of the first stake, and again checked with the transit on shore and found to be exactly on the line of the tunnel. A third stake was then driven on the line of tunnel at a distance of 100 ft. from the second stake, in order to have a range for the location of the crib in case it should be impossible (which proved to be the case) to see the shore when the crib was being placed in position.

The second temporary crib was located in the same way. After these cribs were sunk and built up their exact position was also determined; to be used as a basis in placing the intake protection crib.

Before the intake crib was taken out another base line was measured on the railroad right of way, on the east side of the river, commencing at the intersection of this line with the tunnel line and going westward 3,636.94 ft. By means of this base line the positions of the first and second temporary cribs and the old intake crib were determined independently of the west side base line and found to agree very closely, i. e., the distance from shaft No. 1 to center of crib No. 1, by the west side base line, was 11,613.1 ft.; by the east side base line it was 11,611.8.

As the distance determined with the east side base line was obtained more directly, this was adopted as being the more correct one and was used in calculating the angle for the proper location of the intake crib.

To determine this angle the distance from the old intake crib to temporary crib No. 2 was calculated, as well as the proposed distance, on the line of the tunnel, from crib No. 2 to the intake crib, and the included angle being known, the proposed angle at the new intake crib between crib No. 2 and the old intake crib was then determined. Before this crib was taken out three stakes were driven on the line of the tunnel, the same as for the temporary cribs. Four ship's anchors for hauling and holding the crib in exact position were then placed in the lake, two being placed parallel to the line of tunnel and two perpendicular to this line, at the proposed center of shaft in this crib; each anchor was about 350 ft. distant from this point.

The crib was taken out early in the morning on July 1, and was sunk by 10.20 a. m. The crib was controlled by five lines, two leading from one anchor to opposite sides of the crib so that it could be swung around as well as hauled back and forth, the object being to have the landing point directly towards shore. After the crib was secured to the anchors the lines were hove taut to hold it in position so that the proposed center of the shaft to be sunk from this crib should be exactly on the line of the tunnel and also the right distance away, this distance being determined and controlled by constant observations made with the sextant, stationed over this point.

The 24 4-in. gates to the compartments were then opened, care being taken to have the crib go down in a level position. When within about a foot of the bottom the crib began to surge to the southwest a little and touched bottom before it could be brought back to line, so that the proposed center of shaft was afterwards found to be 19 ins. south of the tunnel line. This point can, however, be shifted somewhat, so that this divergence is of no consequence practically. The crib was also found to be 8 ins. out of level in 100 ft. (its diameter), which accounts for 5 ins. of this 19 ins. divergence. Up to July 27 about 12,000 tons of stone had been thrown into the crib, and about 1,500 tons of large rip-rap stone had been placed around it.

After the crib had been filled with stone to its full height of ten courses, or 60 ft., as now built up, and when about 6,000 tons of rip-rap have been placed around it, it will be leveled by means of the eleventh course. A parapet 7 ft. high will then be added and a house 44½ ft. sq. be built in the center of the crib. It will probably be the middle or end of September before this will be accomplished.

Quantities and Contractors.

The estimated quantities in the steel and wooden cribs were as follows:

	Crib.	
	Steel.	Wooden.
Pine timber, ft. B. M.	284,319	404,166
Hemlock timber	......	480,000
Oak timber	1,120	8,774
Pine lumber, rough, ft. B. M.	20,696	19,800
Pine lumber, planed and matched	11,600	15,500
Steel plates, angle beams, etc., lbs.	*2,861,288	......
Cast iron, lbs	17,610	......
Drift bolts, lbs	14,314	54,695
Spikes	952	......
Screw bolts	11,426	14,250
Concrete, cu. yds	785	......
Stone filling, cords	2,640	1,390
Rip-rap, tons	3,000	5,500

*Including machine bolts.

The tunnel and four shafts will contain the following estimated quantities: Excavation, 95,515 cu. yds.; brick, 15,785,000; steel, 91,400 lbs.; cast iron, 549,000 lbs.

All the work was let to Cleveland contractors, as follows: Steel crib, the Van Dorn Iron Works, for $137,393; wooden crib No. 1, L. P. & J. A Smith, $50,000; wooden crib No. 2, T. H. Garland, $44,445; tunnel and shafts, W. J. Gawne, $524,190; total, $756,038. Mr. J. J. McReynolds has been associated with Mr. Gawne in the tunnel work and the Schaller & Schniglau Co., of Chicago, are carrying on the work from the two temporary cribs, including both shafts and the tunnel work extending therefrom, but the city recognizes Mr. Gawne only as connected with it.

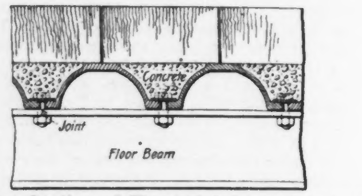
Up to July 22 progress at the three tunnel headings had been made as follows: 6,541 ft. had been completed from the shore shaft westerly; 1,392 ft. from temporary crib No. 1, easterly; and 1,429 ft. from the same crib westerly; making a total of 9,362 ft.

We are indebted to Mr. Kingsley for information and blue prints used in preparing this article, and also to the several contractors for courtesies extended to our representative. We are also indebted to both Mr. Kingsley and Mr. Schulz for a revision and several important additions to the article, especially with a view of noting changes and progress made since our representative visited the work. The additions by Mr. Schulz are properly accredited to him wherever inserted.

WOOD BLOCK PAVEMENT ON THE SUSPENSION BRIDGE OF AVIGNON, FRANCE.

M. Armand describes in the "Annales des Ponts et Chaussees," for the first quarter of 1898, the repaving with wooden blocks of the suspension bridge over the Rhone, at Avignon. This bridge is 743 ft. long, in three spans, and was built in 1843, and rebuilt and stiffened in 1887-89. The floor, however, was still made of wood, with transverse planks laid on longitudinal stringers; and with the extensive use of the bridge and the dryness of the climate this floor was constantly under repair, to the great annoyance of passengers over it.

It was determined to take advantage of the more rigid structure by laying a pavement of



Part Cross-Section of Floor of Avignon Suspension Bridge.

wooden blocks; but a solid foundation was requisite for this purpose, and the vibration of the bridge was liable to disintegrate concrete as ordinarily laid. At first, a floor of steel plates riveted to iron cross I-beams was suggested, and on this were to be laid the wooden blocks, imbedded in bitumen and the joints filled with cement. This type of pavement would have cost about $7.27 per sq. yd.; as based upon 38 francs per 100 kilos. for steel, and 14 francs per sq. meter for the wood pavement. But it was found difficult to put down this floor without interrupting the traffic, and for this and for other reasons a new plan was adopted in November, 1897, which permitted the use of beton.

Stamped steel troughs were used, weighing 25 lbs. to the yard, and these were laid parallel to the axis of the bridge and bolted to the transverse floor beams, which were ordinary I-beams. A thin iron strip laid in the bottom of the trough formed by the meeting of two of the shapes tightly closed the space between them and served to hold the heads of the bolts. The cross-beams were spaced 4 ft. apart on centers. The space between the troughs was now filled with beton to the level of the top; upon this foundation were laid wooden blocks 8 ins. deep, with bitumen poured in the joints to a certain height and the joint then finished with cement mortar. This pavement was covered with fine gravel and opened to traffic 48 hours after its completion. The whole work was completed between Oct. 18 and Nov. 14, 1897.

The advantages gained are—the very considerable decrease in the cost of maintenance, the increased comfort to users of the bridge, and the removal of the danger of fire. The total cost of replacing the floor was $3,192; but the annual repair account was formerly $1,200, and the repairs to the present floor, including a fund to replace pavement when worn out, should not exceed $900 per annum.

STANDARD METHODS OF TESTING PAVING BRICK.*

By Arthur N. Talbot, M. Am. Soc. C. E.†

The extensive use of brick for street paving purposes in our interior cities has made the adoption of standard methods of testing paving brick a matter of interest alike to engineers and manufacturers. The present diversity of practice does not permit an accurate understanding of the requirements of any set of specifications.

To make a durable pavement, brick must have, to the requisite degree, toughness and hardness, strength, and imperviability to liquids. Acceptable methods of testing paving brick must be easy and convenient to make and must give similar results when repeated, and the apparatus must be easily and cheaply duplicated anywhere. Such tests must determine the qualities of the brick, must distinguish soft from hard, and brittle from tough, and must do justice to both large and small brick.

*Slightly condensed from "The Technograph," of the University of Illinois.

†Professor of Municipal and Sanitary Engineering, University of Illinois.

The test commonly used to determine toughness and hardness is known as the rattler test, or impact and abrasion test. Abrasion machines are unsatisfactory, because they do not include a test of the impact effect. The rattler test gives the impact and abrasion effect, but there is such a great variation in size of rattler, in speed and duration of test, and in the amount and kind of foundry shot used that the adoption of a uniform method and uniform conditions becomes a matter of great importance.

Two societies have had under consideration for three or four years the matter of standard tests of paving brick—

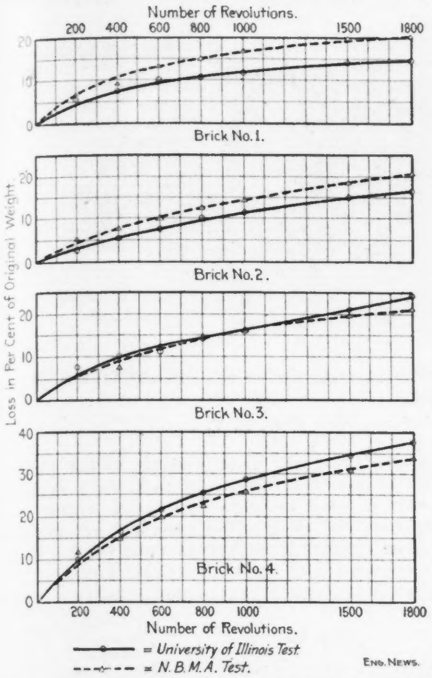


Fig. 1.—Rattler Losses of Paving Brick; Comparison of Results by Standard Methods of the University of Illinois and the National Brick Makers' Association.

By Prof. Arthur N. Talbot, Champaign, Ill.

the Illinois Society of Engineers and Surveyors and the National Brick Manufacturers' Association. The committee of the National Brick Manufacturers' Association, known as the Commission on Paving Brick Tests, made a very comprehensive set of tests and secured a large amount of valuable data.* Their work is certainly a valuable contribution to engineering literature. A recommendation of the Commission, adopted by the Association, was that the rattler test be made the principal test, and that it be made without foundry shot; i. e., with a charge of brick alone. Among the specifications adopted are the following: That the standard rattler shall be 28 ins. in diameter and 20 ins., long, but that machines having diameters between 26 and 30 ins. and lengths from 18 to 24 ins. may be used; that the cross section of the barrel shall be a regular polygon of from 12 to 16 sides; that the shaft shall not extend through the chamber; that the charge shall consist of a number of brick of one kind nearest equal in bulk to 15% of the bulk of the rattling chamber; that the per cent. of loss of weight be determined for 1,800 revolutions at a speed of 30 revs. per min.; and that the average of two distinct and complete tests made on separate charges of brick shall be used as the official result.

The efforts of the Illinois Society of Engineers and Surveyors have been to secure the adoption of some standard form and amount of foundry shot which may easily be exactly duplicated and which will give the proper relation between the impact and the abrasion effect, in place of the miscellaneous foundry scrap so commonly used. Favorable consideration has been given to the shot used by the writer in the Laboratory of Applied Mechanics of the University of Illinois, in tests made for the Department of Public Works of Chicago, and known as the University of Illinois standard. This standard shot consists of cast-iron blocks of two sizes, a larger size, 2½ × 3⅛ × 5¼ ins., with edges rounded to ½-in. radius, weighing about 8 lbs. each, and a smaller size, 1 × 1½ × 2½ ins., with rounded edges, weighing about 1 lb. each. After experimenting with various mixtures, a mixture of even parts of large and small blocks was chosen. A large proportion of 8-lb. shot gives too great impact action and a smaller proportion gives too little. From 7 to 10% of the volume of the rattling chamber may be occupied by the shot. For the 24 × 36-in. rattler, 150 lbs. of 8-lb. shot and 150 lbs. of 1-lb. shot makes a good charge.

An advantage in the use of the iron mixture is that a few bricks or several may be tested without affecting the conditions materially. Thus, for the charge and size of rattler above mentioned, from 5 to 14 bricks may be tested at one time and the percentage of loss will remain nearly constant. This method easily distinguishes soft and brittle brick, and is fair to large as well as to small brick. The writer is of the opinion that the use of a standard amount of a standard form of cast-iron shot such as that used in the tests at the University of Illinois and mixed in such proportions as to give a proper relation between the impact and the abrasion action offers the best method of making the rattler test on the score of convenience, fairness, ease of securing standard material, detection of soft brick and measurement of toughness and ability to stand both impact and abrasion. The National Brick Manufacturers' Association Commission abandoned the use of cast-iron shot on the ground that the impact effect exceeded the abrasion effect; that the wear and tear on the rattler was prohibitory; and that the results did not give a good characteristic curve. It is to be regretted that this decision was reached on such a meager data and that a second form of foundry shot was not used. With the shot herein described, the abrasion effect is sufficiently marked, the wear on the machine is not excessive, and the characteristic curves are regular and uniform, as shown by the curves illustrated in this article.

However, the general adoption of a uniform method of testing paving brick is of such importance to engineers and manufacturers that the particular method selected is not essential, provided it fulfils the requirement of uniformity, fairness and thoroughness. If the National Brick Manufacturers' Association standard is satisfactory in these respects, the writer is quite willing to aid in securing its general adoption. The objections made to this method are that it requires a large number of brick for the test, too many to detect lack of uniformity if averages be taken; that a slight decrease in the number of brick below the number required to make 15% of the volume will seriously affect the results of the test; and that the method will not sufficiently distinguish soft and brittle brick. The last objection, if found to be true, would show a serious defect in the method.

To find whether the rattler test of the National Brick Manufacturers' Association does sufficiently distinguish differences in texture of brick known to be different in character, and also to compare the results of this method with those obtained with the standard cast-iron shot of the University of Illinois, a series of tests was made in the Laboratory of Applied Mechanics.

Four kinds of brick were used. Brick No. 1 was a repressed shale paver, 2½ × 3⅞ × 8⅛ ins., selected from the product of one of the best known manufactories, and an excellent brick. Brick No. 2 was also a repressed shale paver of excellent qualities, 2⅞ × 3⅞ × 9¼ ins. Brick No. 3 was a surface clay brick, well burned and a good article, 2⅛ × 3⅝ × 7⅝ ins. It may be said, however, that its structure, appearance and wear, and also its life in pavement under ordinary conditions, go to show that it is inferior to Bricks Nos. 1 and 2. Brick No. 4 may be ranked as a high-grade sewer brick or building brick, 2⅛ × 3⅞ × 7⅝ ins. All were selected by the makers, and as the individual bricks were weighed during the tests, their uniformity is known from the data collected. The absorption test gave the following amounts in 48 hours, only rattled brick being used for the test: Brick No. 1, 0.5%; Brick No. 2, 2.2%; Brick No. 3, 3%; Brick No. 4, 4.7%.

The rattler used was the 24 × 36-in. rattler of the Laboratory of Applied Mechanics of the University of Illinois. A movable partition allowed this to be shortened to 18 ins. Although this diameter is 2 ins. less than the minimum allowed by the Manufacturers' recommendation, the variation will not affect the comparison in this discussion.

Each make of brick was tested by the Manufacturers' test; i. e., without foundry shot and with a charge of brick equal in volume to 15% of the volume of the rattler. Experiments were made both with the full length rattler and with a length of 18 ins. The speed was about 30 revs. per min.

Each make of brick was also tested with the form of shot known as the University of Illinois standard cast-iron blocks. For the full rattler, 150 lbs. of the large and 150 lbs. of the small shot were used, and for the 18-in. length, one half of this amount. The speed was about 20 revs. per min. Twelve bricks were used in the full rattler and six in the half length.

The brick were weighed at the end of 200, 400, 600, 800, 1,000, 1,500 and 1,800 revolutions. The results have been plotted and are shown in the diagram, Fig. 1, the abscissas representing the number of revolutions and the ordinates the per cent. of loss in terms of the original weight. It will be noted that the curves, now generally called characteristic curves, are quite similar, and that the Manufacturers' curve is above the Illinois curve in Brick No. 1 and Brick No. 2, crosses it in Brick No. 3, and is below it in Brick No. 4. To make a comparison of the two methods, the diagram shown in Fig. 2 was constructed. The loss of Brick No. 1 was taken as unity, and the losses of the others were expressed in terms of this and plotted as shown.

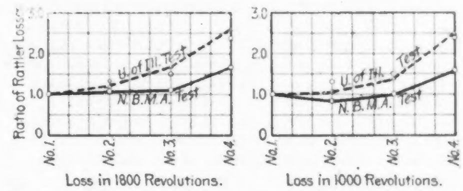


Fig. 2.—Ratio of Rattler Losses to Loss of Brick No. 1 Compared with Ratio of Reciprocals of the Moduli of Rupture.

The ratios of the reciprocals of the moduli of rupture of the different makes to that of Brick No. 1 are shown by the points enclosed in squares.

Two things may be seen from Fig. 2: (1) The Manufacturers' test makes Brick No. 3 as good as No. 1 and No. 2, when, as has been stated, it is manifestly inferior. (2) The loss in Brick No. 4, which is unfit for pavement, is much less distinctly marked in the Manufacturers' test than in the Illinois test.

If these conclusions are borne out with other makes of brick, the Manufacturers' test has serious defects. It does not sufficiently distinguish between hard and tough brick and soft and brittle brick. A satisfactory method of testing paving brick must show the difference between bricks of the nature of No. 1 and No. 2, and such as No. 3, and will make a more marked distinction between bricks like No. 4 and hard and tough bricks.

The ratios of the reciprocals of the moduli of rupture of the different makes to that of Brick No. 1 are shown in Fig. 2 by the points enclosed in squares. It will be seen that these ratios increase much as the ratios of rattler loss by the Illinois standard. The values of the moduli of rupture were the averages of five brick, and there was no great variation in individual cases.

The tests described above were verified partly by repetition and partly by comparison with results obtained with the same brick heretofore, and it is thought they are representative of the makes of brick used. It may be added that in the Manufacturers' test, a charge of soft brick soon broke, and thereafter the loss was much lighter. In general, the im-

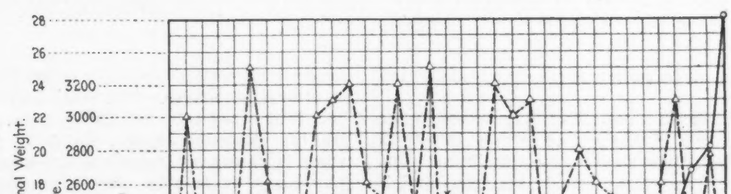


FIG. 3.—RESULTS OF TESTS OF 35 MAKES OF PAVING BRICKS.

*See Eng. News, May 6, 1897, for a very full abstract of this report, with editorial comments.—Ed.

pact effect of the test was insufficient to test the toughness of the brick. The results are quite different from those anticipated by the writer.

While the tests described are not extensive enough to warrant rejecting the standard method of the National Brick Manufacturers' Association, they show that the method should not be adopted without further investigation. It is hoped that engineers having opportunities to make such tests will contribute to the general knowledge of the subject. If these results shall prove to be representative, the method of using a charge of brick alone cannot properly be adopted as a standard by engineers.

The recommendation of the National Brick Manufacturers' Association abandoning the absorption test and not recommending the cross-bending test will not be acceptable to engineers. It is true that the limit of absorption has frequently been placed too low, that overburned brick are as bad as underburned, and that uniformity of brick is more important than low absorption. With a moderately low limit, as 3 or 4%, and a definite time of say 48 hours, brick which pass the rattler requirement but which have high absorptive qualities would be cut out. The cross-bending test adds another precaution. The results are indicative of shearing and crushing strength—qualities which are necessary in a pavement having heavy traffic. It takes the place of the crushing test, which is difficult to make.

As a matter of interest on the topic of tests of paving brick, the diagram, Fig. 3, is presented. The data are from tests made in the Laboratory of Applied Mechanics of the University of Illinois, on thirty-five makes of paving brick from Ohio, Indiana, Illinois, Iowa and Missouri. They are plotted in the order of loss by the rattler test, the different properties of the same brick being shown on the same vertical line. These may be said to be picked brick, and among them are the best paving brick of the country. It will be seen that while there is a considerable variation in the modulus of rupture, in a general way the value decreases as the rattler loss increases.

THE SIMS-DUDLEY PNEUMATIC GUN.

The present war is affording an excellent opportunity to test in actual service the many new forms of weapons which have been brought forward during recent years. Some of these types are proving very successful; one in particular, the Sims-Dudley pneumatic gun, owing to its adoption by the Cuban insurgents, previous to the declaration of war, and later by the Rough Riders, has received considerable notice in the daily press. Generally it is spoken of as a dynamite gun, but it is really a pneumatic or compressed air gun throwing shells filled with high explosives.

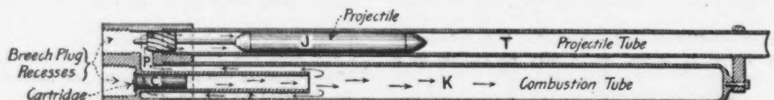


FIG. 2.—DIAGRAM ILLUSTRATING THE PRINCIPLE OF THE SIMS-DUDLEY PNEUMATIC GUN.

The accompanying cut, Fig. 1, represents the gun in its latest form, such as is now in use in Cuba. In Fig. 1 it is shown ready for firing. The extreme simplicity of the gun is apparent and is largely responsible for the good work it has already done. The upper or projectile tube is made of a combination metal having a tensile strength of about 75,000 lbs. per sq. in. and is about 14 ft. long, with a smooth bore about 2½ ins. in diameter. Just below is what is termed the combustion or firing tube, which is a strong steel tube 7 ft. long and 4½ ins. in diameter. The breech block is a steel casting into which the projectile and firing tubes are screwed. It has a suitable passage connecting the tubes and a swinging back upon which are mounted two segmental screw breech closing blocks. These are swung into place and locked by turning a lever much the same as with ordinary breech-loading ordnance. The tubes are mounted upon trunnions with a seator and hand wheel for elevating. The limber is built of sheet steel and angles, thus making a light and strong mounting.

The principle upon which the gun operates is to start the projectile without shock and to increase its velocity through the whole length of its passage through the long tube. This permits the use of shells containing high explosives. To fire the gun the breech block is unlocked by turning the hand lever, the cartridge, really a large blank shell, resembling a shot-gun shell, but about 6 or 7 ins. long, and containing 7 to 9 oz. of smokeless powder, is thrust into the shell chamber of the lower tube, Fig. 2. The projectile seen lying on the ground in Fig. 1 is then placed in the projectile tube, the breech closed and locked, and the gun is ready to be sighted and fired, which is done by pulling a lanyard in the ordinary way. This permits the firing pin, previously drawn back, to fly forward under the action of a spring and strike the fulminate cap of the cartridge. The large volume of gas immediately issuing from the cartridge C, Fig. 2, fills the combustion tube K, compressing the air contained. This air, now under considerable pressure, at once rushes through the passage in the breech block P and forces the projectile J out of the tube T. The powder charge is proportioned so that the pressure produced is sufficient to give the projectile a velocity which will insure an effective range while producing little noise or smoke. As the gun is at present constructed, the range varies from 2,600 to 3,600 yds.

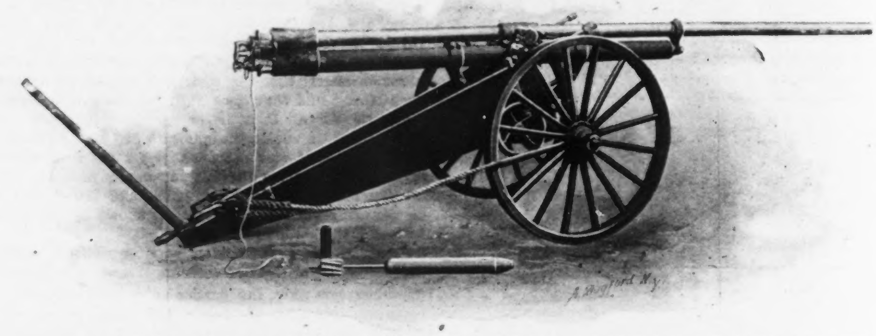


FIG. 1.—SIMS-DUDLEY PNEUMATIC GUN READY FOR USE, SHOWING PROJECTILE AND CARTRIDGE.
Sims-Dudley Defense Co., Makers, New York, N. Y.

The projectile, Fig. 3, is simply a light casing containing the explosive gelatine and the mechanical fuse, and is provided with an aluminum spiral on an extension at the rear end, which produces the rotation necessary to keep the projectile in a straight course. The main portion C, Fig. 3, is a thin brass tube 2½ ins. in diameter, containing the explosive charge, which so far has been what is known as Nobel's gelatine, a tough jelly-like mass containing nitro-glycerine and nitro-cotton, a mixture that does not explode as easily as dynamite but produces a much more destructive explosion; H is a conical brass head containing the time fuse which can be arranged to explode the charge after any given interval. This fuse ignites the fulminate of mercury in M, which explodes a small amount of gun-cotton in the metal case G, and the explosion of this sets off the main charge. To prevent accidental explosion in the gun or during transportation, the fuse head H is provided with a small wind vane and a screw, not shown in the illustration, which confines the firing device. After the projectile has left the gun, this vane whirls around, loosens the screw and falls off before it has traveled more than 200 ft. The complete projectile is 36 ins. long and weights when loaded 11¼ lbs., the casing weighing 7½ lbs. and the charge 4 lbs.

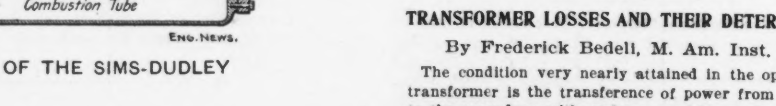


FIG. 3.—DIAGRAM SECTION OF EXPLOSIVE PROJECTILE.

It is possible, with a squad of about six men, to continually operate the gun at the rate of about five shots per minute, or 20 lbs. of the highest form of explosive known could thus be thrown each minute into the ranks of an advancing enemy without being seen or heard. The effect of the heavy explosions, each of which would be fully as destructive as a 6-in. shell can be imagined. The destructive effect of the explosive gelatine used is several times as great as that of the powder ordinarily used in shells, to fire which requires heavy artillery. In fact, such shells can only be used in siege operations, owing to the difficulty in transporting guns and ammunition.

The following table gives some further data in connection with these penumatic guns:

Dimensions, Weights, Range, Etc., of the 2½-in. Caliber Gun.

		Type of gun. Three-tube, light.	Type of gun. Two-tube, heavy.
Cartridge.			
Length		3 ins.	6 to 7 ins.
Amount of smokeless powder		3½ ozs.	7 " 9 ozs.
Gun.			
Weight	Gun alone	250 lbs.	480 lbs.
	Heaviest piece	150 "	310 "
	Carriage, complete	450 "	564 "
	Carriage wheels	120 "	150 "
	Gun complete, on carriage	700 "	1,044 "
	Naval mount	400 "	400 "
	Gun complete, on naval mount	650 "	880 "
Length	Projectile tube in gun	9 ft.	13½ ft.
	Gun,* on carriage, over all	12 "	16 "
	Gun,* naval m'nt, " "	10 "	14 "
Range of gun in yds.		1,750	2,600†

*Gun complete. †2,600 to 3,600 yds.

TRANSFORMER LOSSES AND THEIR DETERMINATION.*

By Frederick Bedell, M. Am. Inst. E. E.†

The condition very nearly attained in the operation of a transformer is the transference of power from the primary to the secondary without loss, a raising or lowering of the voltage in the ratio of the secondary turns (S_2) to the primary turns (S_1), and a corresponding decrease or increase in the current in the ratio of S_1 to S_2. As an example, let $S_1 = 10\ S_2$ in a 20-K-W. transformer. The condition nearly attained is

Primary watts	= 20,000	Secondary watts	= 20,000
" volts	= 1,000	" volts	= 100
" amperes	= 20	" amperes	= 200

In reality we have in the secondary an amount less than the above, as 19,200 watts, 98 volts, 196 amperes.

We accordingly have the following losses:

Lost watts; lost volts; lost amperes. The first determines the efficiency; the second, the regulation; the third, determines the magnetizing current.

The lost watts are due to hysteresis, eddy currents, and copper losses both primary and secondary.

The lost volts are due to copper drop (which is proportional to copper loss) and reactance drop due to magnetic leakage.

The lost amperes (magnetizing current) consists of two components, $I\mu$ the exciting component which takes no power, and an energy component I_h at right angles to it.

The hysteresis loss in watts is

$$\text{Vol. } \eta\ n\ B^{1.6}\ 10^{-7};$$

*Read before the Electrical Society, Cornell University, Ithaca, N. Y., May 4, 1898, and printed in the Sibley Journal of Engineering.

†Assistant Professor of Physics, Cornell University, Ithaca, N. Y.

where the volume is in cu. cms., n is the number of cycles per second, and B the number of C. G. S. lines per sq. cm. The hysteresis coefficient η varies with the grade of iron, being about 0.002 for good iron. This and the following formula are due to Steinmetz.

The eddy current loss in watts is

$$\text{Vol. } \gamma \, (d \; n \; B)^2 \; 10^{-21};$$

where d is the thickness of laminations expressed in mils. The eddy current coefficent γ is the conductance of the iron (the reciprocal of the resistance in ohms per cu. cm.) and is about equal to 10^5. In this case, eddy loss in watts equals

$$\text{Vol. } (d \; n \; B)^2 \; 10^{-16}.$$

It is not possible to calculate the eddy current loss with a high degree of accuracy; this, however, is not essential inasmuch as it is but a small part of the total loss.

If R_1 I_1 and E_1 are the resistance the current and the electromotive force of the primary, and R_2 I_2 and E_2 the resistance, current and electromotive force of the secondary, the copper drop in per cent. is

$$\frac{R_1 \, I_1}{E_1} + \frac{R_2 \, I_2}{E_2}.$$

In lighting transformers of the best makes this constitutes almost all the voltage drop, the reactance drop being comparatively ineffective.

The two components of the magnetizing current are

Power component, I_h = watts core loss $\div$ E_1.

$$\text{Exciting component, } I_\mu = .707 \frac{10}{4\pi} \frac{B \; l}{S_1 \mu}.$$

Here l is the length of the magnetc circuit in cms.; μ is the permeability and has a value of about 2,000. The total magnetizing current is

$$I_0 = \sqrt{I_h^2 + I_\mu^2}.$$

The formulæ given above may be used for calculating the lost watts, volts and amperes.

In transformer testing, the magnetizing current and the core loss (including both hysteresis and eddy currents) are found by ammeter and wattmeter measurements made on the low potential coil at normal voltage, the high potential coil being on open circuit.

Measurements with wattmeter and voltmeter on the high potential coil with normal current, the low potential coil being short-circuited, give directly the copper loss and impedance drop. The copper loss divided by the current gives copper drop. The reactance drop is

$$\sqrt{(\text{impedance drop})^2 - (\text{copper drop})^2}.$$

If we let x be per cent. reactance drop and i_μ per cent. exciting current, we have for lighting transformers:

$$\text{Effective reactance drop} = 100 - \sqrt{10{,}000 - x^2 - 2 \, x \, i_\mu}.$$

The total drip or "regulation" is the sum of the copper drop and the effective reactance drop.

For power transformers, if cos θ represents the power factor of the load:

$$\text{Effective reactance drop} = 100 - \sqrt{10{,}000 - x^2 - 200 \, x \sin \theta}.$$

To determine the eddy current loss in watts, the core loss must be measured at two frequencies. Let W' be total core loss at normal voltage E', and frequency n'. At a lower frequency n'' and a lower voltage

$$E'' = \frac{n''}{n'} E',$$

let the core loss be W''. We may compute the watts eddy current loss at the highest frequency (n') and normal voltage by the formula

$$\text{Watts eddy currents} = \frac{W' - \frac{n'}{n''} W''}{1 - \frac{n''}{n'}}.$$

If the electromotive-force wave at the two frequencies is essentially different, this may be taken into account as follows: Let the form factor (f) be the ratio (see Bedell's "The Principles of the Transformer," p. 312 et seq.) of the average to the virtual value. (For a sine wave this is .9). The core loss W'' at the lower frequency is to be measured at a voltage

$$E'' = \frac{n'' \; f''}{n' \; f''} E'.$$

The eddy current loss in watts at the higher frequency n' and normal voltage is

$$\frac{\frac{n''}{n'} W' - W''}{\frac{n''}{n'} - \left(\frac{E''}{E'}\right)^2}$$

This formula is exact; neglecting the difference in shape of the electromotive force-waves (i. e., assuming f' = f''), this reduces to the formula first given.

The efficiencies may be computed quickly and accurately by the following table (devised as a time-saver), in which c_2 is the copper loss at full load expressed as per cent. of output, h_2 is core loss as per cent. of full load output, and t is time:

Fraction of load.	Losses as per cent. of output — Copper.	Core.	Total, t.	$\frac{t^2}{100}$	Efficiency.
5/4	5/4 c_2 = ...	4/5 h_2 = ...	....	....	....
1	c_2 = ...	h_2 = ...	....	....	....
3/4	3/4 c_2 = ...	4/3 h_2 = ...	....	....	....
1/2	1/2 c_2 = ...	2 h_2 = ...	....	....	....
1/4	1/4 c_2 = ...	4 h_2 = ...	....	....	....
1/10	1/10 c_2 = ...	10 h_2 = ...	....	....	....

$$\text{Efficiency} = 100 + \frac{t^2}{100} - t.$$

The all-day efficiency, assuming that the transformer is on full load for x hours each day and idle the remainder of the time, is

$$\text{All day efficiency} = \frac{100}{100 + c_2 + \frac{24}{x} h_2}.$$

This method for computing efficiency, and also the formula for the experimental determination of eddy current losses and for effective reactance drop in lighting and power transformers are here given for the first time.

(The following example, also by Dr. Bedell, will illustrate the use of the foregoing.—Ed.)

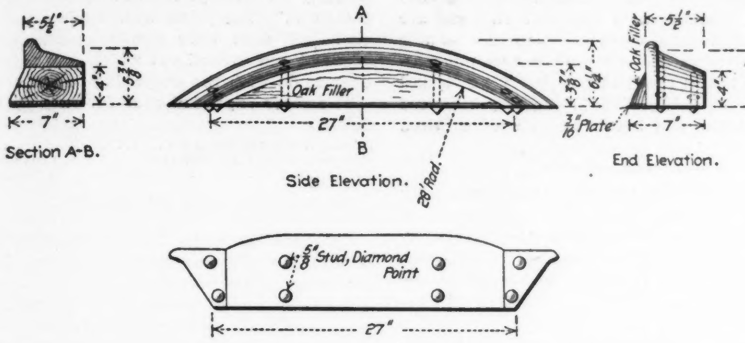
2-K-W. transformer. Copper loss = 48 watts. Core loss = 30 watts.

$$c_2 = 2.4. \quad h_2 = 1.5.$$

Fraction of load.	Losses as per cent. of output — Copper.	Core.	Total, t.	$\frac{t^2}{100}$	Efficiency.
5/4	5/4 c_2 = 3.0	4/5 h_2 = 1.2	4.2	0.18	95.98
1	c_2 = 2.4	h_2 = 1.5	3.9	.15	96.25
3/4	3/4 c_2 = 1.8	4/3 h_2 = 2.0	3.8	.14	96.34
1/2	1/2 c_2 = 1.2	2 h_2 = 3.0	4.2	.18	95.98
1/4	1/4 c_2 = .6	4 h_2 = 6.0	6.6	.44	93.84
1/10	1/10 c_2 = .24	10 h_2 = 15.	15.24	2.32	87.08

$$\text{Efficiency} = 100 + \frac{t^2}{100} - t.$$

$$\text{All-day efficiency} = \frac{100}{100 + c_2 + 4.8 \, h_2} = 91.24.$$



THE "BURLINGTON" CAR AND ENGINE REPLACER.
Henry Miller, Asst. Supt., C., B. & K. C. Ry., Inventor.

A NEW RERAILING DEVICE.

Car replacers or wrecking frogs, for replacing derailed car and engine wheels upon the track, form a somewhat important feature of the minor part of railway equipment, and a great variety of these devices are in use. The accompanying illustration represents the replacer which has been adopted as the standard rerailing device of the Burlington railway system, the special feature of which is that it is very simple in design and is made from scrap at the railway shops.

It consists mainly of a segment of the discarded tire of a locomotive driving wheel, the tread being beveled and the flange turned down to some extent. The space under this piece of tire is filled in with a wooden block, the bottom of which is protected by an iron plate 7 ins. wide, made of 3-16-in. scrap tank iron. The plate, block and tire are secured together by eight ⅝-in. steel rivets, which have countersunk heads in the tire, and diamond points projecting ¾-in. below the plate. These points act as spurs to prevent the replacer from slipping when in use. The smaller size is 27 ins. long, 5⅜ ins. high over the tread, and 6¼ ins. over the flange. The larger size is 32 ins. long, and 6⅞ to 7¼ ins. high.

This device is styled the "Burlington" replacer, and is the invention of Mr. Henry Miller, of Hannibal, Mo., who is Assistant Superintendent of the St. L., K. & N. W. R. R., and the C., B. & K. C. Ry. (Burlington system). We are indebted to Mr. Miller for a blue print and description of this rerailer.

A BELGIAN GAS-LEAK DETECTOR.

U. S. Consul Morris, of Ghent, describes a method in use in that city for detecting gas-leaks, which he describes as follows in the "Consular Reports," for June, 1898:

The outfit consist of a large hand drill or auger, several hollow tubes or pipes of the requisite length, a few corks fitted with quills through the center, a bottle of or-palladium, and a few bits of white paper. The tubes must be long enough to enter the ground to a point about 15 to 20 ins. above the main and to project above the street pavement a sufficient distance for observation, say 3 to 4 ft. They may be iron, such as common interior gas pipe, or, better still, brass, which is lighter to carry and more convenient to handle.

Several paving blocks are first removed for a space of about two yards immediately over the gas main, and holes are bored in the soil with the drill, care being taken to thoroughly loosen the earth and extract as much as possible. In each of these holes a piece of the hollow piping is planted. It should not be rammed down too deep, so as to be too near or below the gas main, or to become clogged with dirt. On the upper exposed end one of the corks is placed, with the quill in the center, running up and down parallel to the pipe. A small piece of the white paper is dipped in the or-palladium and pushed into the open quill. Twenty or thirty such detectors are put in position at one time. If a leak exists within, say, two yards of any of them, the effect of the escaping gas will be evident upon the paper, rendered sensitive by the reagent, and it will at once turn black. The effect of the action of the gas upon the detector first placed in position will be evident before the last one of a row of 20 is set up. It is a common sight to see two or three men in the streets of Ghent making experiments in this manner for the detection of leaks. Indeed, the gas company causes regular tests to be made in turn in all the streets of the city. The loss by leakage is now said not to exceed more than 3%.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Steam Rollers Not a Street Obstruction.

A steam roller, while being properly used in repairing a street, is not such an obstruction or defect in the street as will render the city liable for injuries inflicted by a horse frightened by such machine. Lane v. City of Lewiston (Me.), 39 Atlantic Rep., 999.

Electric Light Plant Not a Public Necessity.

Under the laws of North Carolina prohibiting municipalities from contracting debts or laying taxes, except for necessary expenses, unless by a majority vote of the qualified voters, such city having general powers only, cannot issue bonds for the erection of an electric light plant for lighting its streets, as such plant is not a "necessary expense," without legislative authority to submit the proposition to the voters and a ratification by a majority of such voters. Mayo v. Town of Washington (N. C.), 29 Southeastern Rep., 343.

Freight Rates and State Laws.

A state enactment, or regulations made under authority thereof, establishing rates of transportation by the railroad, that will not admit of the carrier earning such compensation as, under all the circumstances, is just to it and to the public, would deprive such carrier of its property without due process of law, and deny to it the equal protection of the laws, and would therefore be repugnant to the Constitution of the United States. Smyth v. Ames (Sup. Ct. U. S.), 18 S. C. Rep., 418.

When Objections to Improvements are Too Late.

After street improvements are completed, a landowner cannot object to assessments for the same on the ground that the contract was let to one whose bid was slightly more than that of another; although the law requires the contract to be let to the "best bidder." City of Bloomington v. Phelps (Ind.), 49 Northeastern Rep., 581.

Liability for Making Gas Connections.

Where a gas company insisted upon making all gas connections, between house mains and pipes, and assumed that duty, it was bound to exercise due care in performing it. A provision on the back of an application to furnish one with gas, exempting the company from damages from an explosion from the use of gas has no application where the explosion was caused by the imperfect closing of the gas main by the employees of the company when no gas was being used in the house. Bastian v. Keystone Gas Co. (N. Y.), 50 N. Y. Supp. Rep., 537.

Contractor Bound by Certificate.

Under a contract providing for compensation at a fixed price per cubic yard of earth moved, the amount due to be certified by the general manager of the railroad company month by month, such certificate is conclusive, in the absence of fraud, mistake or gross carelessness, to prevent the contractor after completing the work from asserting a claim for extra compensation for alleged overhauls. Breyman v. Ann Arbor R. Co. (U. S. Cir. Ct.), 85 Federal Rep., 579.

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ADVERTISING RATES: 20 cents per line. Want notices, special rates, see page 18. Rates for standing advertisements sent on request. Changes in standing advertisements must be received by Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

It seems that, after all, Spain has given unwilling, but very convincing testimony as to the manner in which the battleship "Maine" was destroyed in Havana harbor. At the time of that catastrophe Spanish officials loudly insisted that the cause was an internal explosion of one or more magazines, the result of "carelessness and a notorious lack of discipline on the American ships." But the board of officers appointed to report upon the result of our gun-fire upon the ships of Admiral Cervera, sunk in the Santiago fight, incidentally find a valuable object lesson in the appearance of these ships that has a direct bearing upon the destruction of the "Maine." Three of the four Spanish warships were blown up by their own magazines, and one of them had every magazine exploded, with all its torpedoes in addition. But as compared with the wreck of the "Maine," there was no upheaval of the keel and little bulging of the plates except in the immediate vicinity of the point of impact; the effect of the explosion was nearly always upward, the protective deck was sometimes lifted, but, except for the springing of a few plates, the hulls were intact. In other words, the evidence gathered from the wrecks of these Spanish warships, that in armor and guns were practically superior to the "Maine," conclusively shows that the latter ship was sunk by an external explosion, however brought about.

Another most valuable object lesson afforded by these ships is the terribly destructive effect of the smaller projectiles of the secondary batteries, as handled by American sailors. The fight started at a range of 6,000 yds., and narrowed down to about 1,000 yds. at the closest point. But one ship, the "Infanta Maria Theresa," was struck by 12-in. or 13-in. shot, and only two of these landed on the ill-fated warship. The "Christobal Colon," which kept out of range most of the time, was struck six times by 8, 6 and 5-in. projectiles; the "Vizcaya," with 10 and 12-in. armor, was hit with larger projectiles fourteen times, and by 6-pdrs. eleven times; the "Infanta Maria Theresa," as before mentioned, was pierced twice by 12 or 13-in. shot, and by one 8-in. shell; but the "Almirante Oquendo," of the same class as the last two, was hit four times by 8-in. shell, three times by 4-in. and twice by 6-in. projectiles, and 42 times by 6-pdrs. But in all cases, except the "Colon," it was the fire of the secondary batteries that wrought the greatest havoc and practically destroyed them. By this fire the decks were swept and men were driven from the guns; the explosion of shells fired the ships, and on the "Theresa" cut the water-mains, so that the fire could not be extinguished. The structure above the armor belts was torn into shreds; and though it cannot now be definitely determined whether fire on board or shells exploded the torpedoes, and some of the magazines, it is evident that the deadly rain of small shells kept the Spaniards from working their guns or from taking measures to preserve themselves and their ships from fire. The moral of this sea-fight is that modern ships and modern guns are only really formidable when the men that handle the ships and guns are not only brave, but also skilled in the use of these war-tools. What would happen when the antagonists are equally balanced in these qualities can better be guessed at than described.

Three of the Spanish warships were practically destroyed by fire started by the explosion of American shells, and the wisdom of reducing to a minimum the woodwork aboard our vessels and fireproofing that which must be used becomes apparent. Eight of the gunboats authorized in 1893 and 1895, were fitted with wood made fireproof by a simple and satisfactory process, which consisted in withdrawing all sap and moisture from the wood, in a vacuum, and then filling the pores with phosphate of ammonia. Wood so treated will only char and will not shrink, but objection was made that such wood was heavier, and not quite as strong as untreated wood, and that it was difficult to work and had a tendency to absorb and retain moisture. It was also complained that paint did not stick to it very well and the contained chemicals had a corrosive effect upon metal in contact, and spoiled the clothes of officers contained in drawers made of it. These are serious charges, and in January of this year a board of naval officers, convened for the purpose of reporting upon fireproof wood, voted in favor of discontinuing its use. But Naval Constructor Hichborn, who made a minority report in favor of wood thus treated, says that the greater number of these charges are false. Fireproofed wood is used in many of the costly large buildings now being erected, and there is little trouble in working or painting it; and for ships' use, especially in decks, its non-shrinking qualities are invaluable. Its increased weight is of comparatively little importance, and the additional cost adds but a few thousands of dollars to the millions invested in a battleship. The terrible experience in the Santiago fight, added to the almost forgotten destruction by fire of the Chinese ships in the Yalu River combat, have brought about a decided revision of the finding of the late board, in this connection, and the order has already gone out so to protect at least the wooden decks of the new battleships. The lesson taught at Santiago is that fire and smoke will drive the bravest men from their guns and make impossible any efficient defense against hostile attack. In other words, if modern ships and guns are to be successfully employed against modern gun-fire, it is of the greatest importance that all internal fittings be made fireproof. If there are any valid objections against present processes of fireproofing Yankee inventive skill should eliminate them.

THE INVESTIGATION OF THE NEW YORK STATE CANALS.

The report of the Commission appointed by Gov. Frank S. Black to investigate the work done upon the New York State canals under the $9,000,000 appropriation, which is abstracted elsewhere in this issue, is a document which does credit to its authors. The predictions that the Commission would present a "white-washing" report, for the sake of the political and commercial interests involved, have not been fulfilled. The arraignment by the Commission of those responsible for the loss of over a million dollars to the State of New York is temperate and judicial in its tone, but the facts are set forth with a fearless straightforwardness that is most convincing.

Let us briefly sum up the story of the New York canal improvement, as it is told in the Commission's report:

The State Engineer's estimate of its cost given to the Constitutional Convention in 1894 was $11,573,000, and was "little more than a guess." This was cut down to $9,000,000 by the advocates of canal improvement, apparently for no better reason than the fear that this was as large a sum as the people of the state could be induced to approve by a popular vote. It was hoped that by omitting all work not absolutely necessary, this sum might suffice. When it came to making plans and specifications, however, there seems to have been absolutely no attempt to "cut the cast according to the cloth." The plans were made exactly as if an unlimited sum were available, and works were planned and carried out which had nothing whatever to do with the deepening of the canals.

The sums expended thus far may be divided as follows:

Advertising for proposals		$92,321
Superintendent's Inspectors	$178,969	
Engineering	812,000	
Total for engineering and inspection		$990,969
Paid to and due contractors		7,937,903

Of these amounts, the Commission finds that at least $80,000 was improperly expended for advertising. The inspection carried on under the Superintendent of Public Works appears to have been needlessly extravagant; $41,514 was paid to the force of inspectors during the ceven months of open navigation in 1897, when work on the contracts was practically at a standstill. During the present year $98,922 has been paid to inspectors appointed without civil service examinations, and apparently for other reasons than their ability and fitness.

Of the engineering expenses, $272,000 was for preliminary surveys, on the basis of which the estimates and bidding sheets were made up and contracts were let, and this work the Commission finds to have been necessary. The survey did not accomplish, however, what it should have. No study was bestowed on special conditions, and the contracts were let without provision for meeting these conditions. Contract 4 on the Middle Division (the Jordan level) is an example. The contract price, according to the engineer's estimate, was $154,471; but up to May 1, 1898, it had cost $581,879.

Of the $272,000 for preliminary surveys named above, $50,391 is for plans for a pneumatic lift lock at Lockport, and special improvements at Cohoes, which were unwarranted and improper.

Turning now to the total of $7,937,903 represented by work done on the contracts, the Commission finds that not less than $1,000,000 has been improperly expended. The contractors have benefited through the improper classification of earth as rock; through the making of unbalanced bids for work, through unwarranted payments for material overhauled, in which case embankment price was added to excavation price. "More than half of the total amount of cost of embankment was improperly paid for material overhauled and wasted"; and finally, through allowances for "extra work." Up to June 1, the engineers had returned $824,821 as extra work; but the actual quantity is much greater. Besides the above, it is stated that $30,810 was spent in Syracuse, on work which had nothing to do with canal deepening, and elaborate plans ware made for expending $100,000 to benefit the milling interests at Lockport.

As one reads the instances of extravagance and illegal expenditure set forth in detail in the Commission's report, the conclusion is inevitable that their estimate of $1,000,000 as the amount which the contractors have received in excess of their just dues, is a conservative figure. When the unnecessary expenditures on advertising, engineering and inspection are also taken into account, it seems probable that the total sum of which the state has been robbed will reach a million and a-half or more, or about one-sixth of the total amount which the taxpayers of the state borrowed for the purpose of deepening the canals. The most hardened defender of the old-time maxim that "to the victor belongs the spoils," must agree that so great a proportion of "pickings and stealings" cannot be justified.

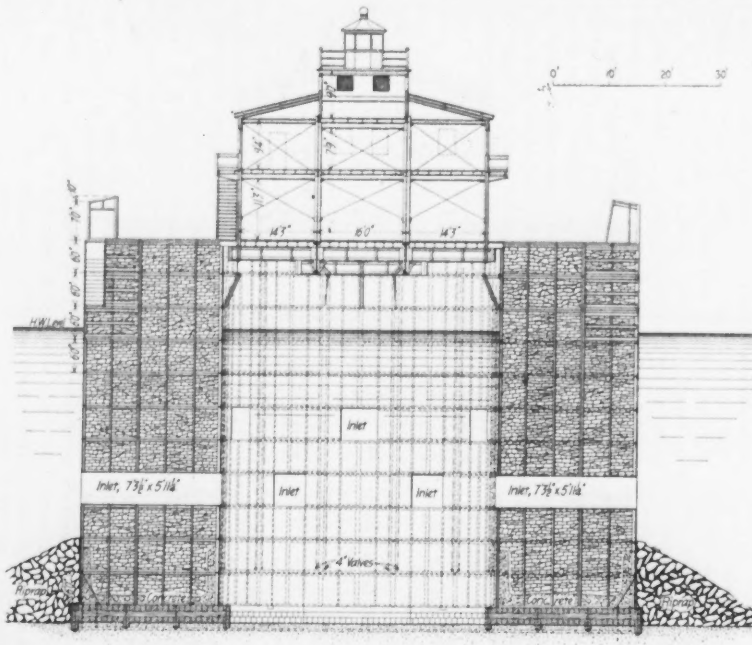


FIG. 4. SECTION OF STEEL INTAKE CRIB.

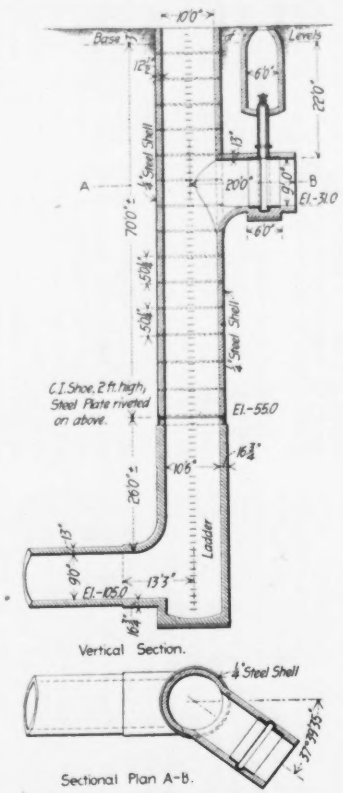


FIG. 2. SHORE SHAFT FOR NEW LAKE TUNNEL.

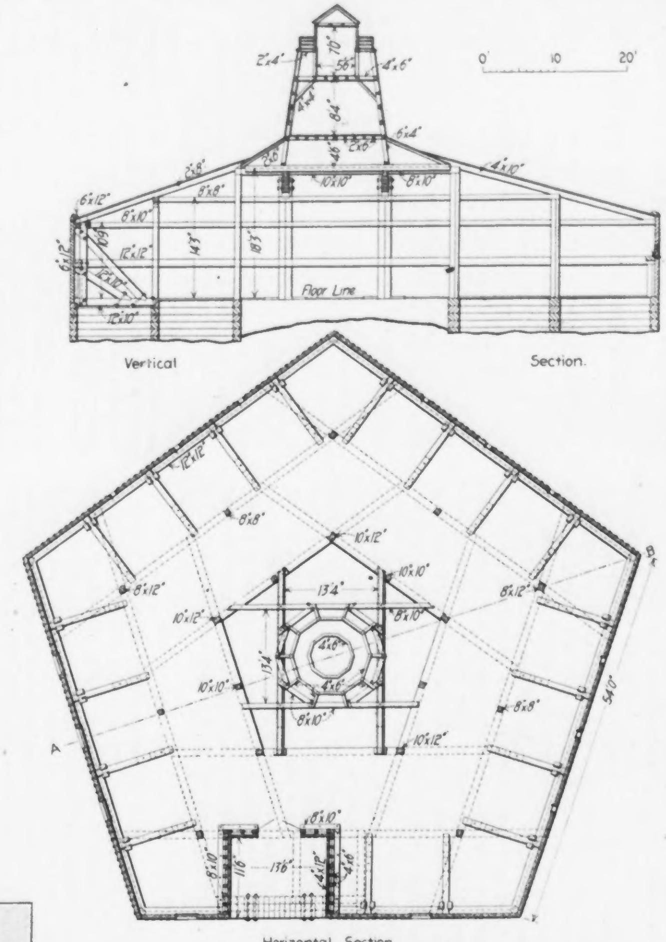


FIG. 3. SUPERSTRUCTURE OF TEMPORARY CRIBS.

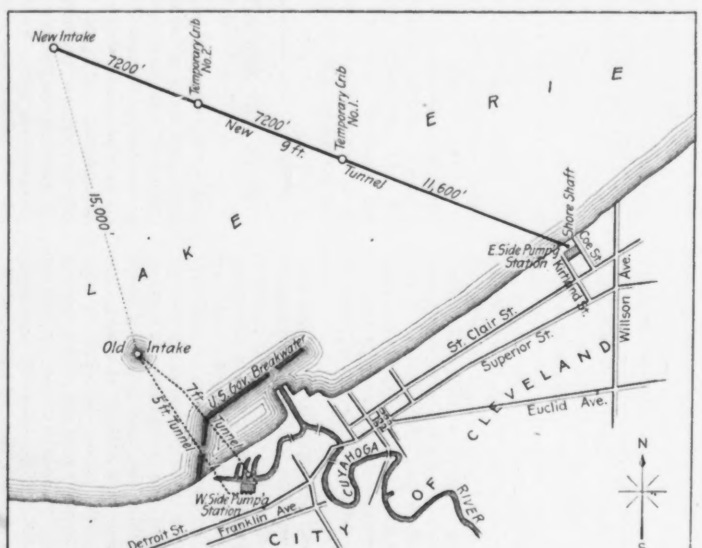


FIG. 1. MAP SHOWING LOCATION OF OLD AND NEW TUNNELS.

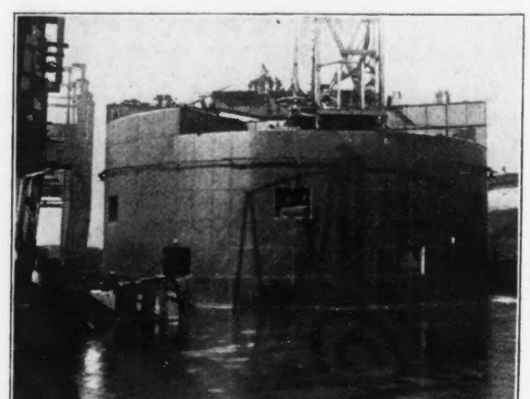


FIG. 5. STEEL INTAKE CRIB, APRIL 26, 1898; FIRST EIGHT COURSES COMPLETED.

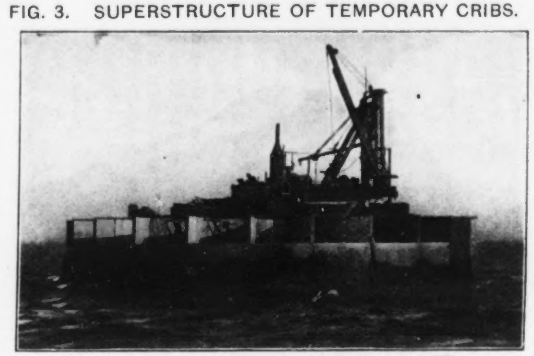


FIG. 6. STEEL INTAKE CRIB IN PLACE, JULY 9, 1898.

NEW WATER-WORKS INTAKE TUNNEL, CLEVELAND, O.

M. W. Kingsley, M. Am. Soc. C. E., Superintendent.

The action of the Governor in calling upon the legal authorities to take steps for the immediate prosecution of those responsible for the misappropriation of public funds and the misuse of public trusts deserves the warm approbation of all good citizens. It is just such corruption of public office for private gain as this investigation has laid bare that has brought the once great Spanish nation to the depths of humiliation and defeat. The American people must effectually punish such exhibitions of official corruption and malfeasance as the Canal Commission has uncovered, if they would preserve their own nation from a decay and degeneration similar to that which has eaten out the vitality of Spain.

We have it on excellent authority that one of the men who was seeking to reap a rich harvest from the canal fund, but who found the way blocked by an honest and incorruptible public official of high rank, swore with a great oath that he would give five thousand dollars to get this faithful guardian of the public treasury into the North Woods; and would guarantee that he would never be seen again alive. Surely, when matters have come to this pass it is time the people of the state should arouse themselves to the dangers that menace their government. No political influence, no considerations of personal favor should stand in the way of the detection, conviction and punishment of those who have robbed the state or been false to their trust.

We have thus far heartily commended the Commission's report; but when we turn to its recommendations as to the future work upon the canals, we are obliged to take issue with it. While the Commission was made up of non-partisans from a political standpoint, it was made up of men who are without exception known as "canal men," and it advises the completion of the canal improvement with no question whatever as to whether the work will be worth what it will cost in the benefit of commerce. Instead, the Commission brings forward the well-worn old fallacy that because the canals in the days of their prosperity paid into the state treasury a large amount above their cost, the state should not hesitate to pay out for their improvement the whole of this surplus. Not one of the able business men composing the Commission conducts his private business on such a principle. If a machine becomes obsolete in type, no longer able to produce goods in competition with newer and more modern devices, it never pays to make extensive repairs upon it, unless it appears that after these repairs are made, it will be able to compete with other machines and return to the owner a profit on the amount spent.

The conviction is growing upon all intelligent students of transportation economics that all such barge canals as those of New York state are obsolete machines; and that no such small improvement as that which the state has now undertaken can restore to them their traffic and prevent their abandonment in the early future. The Commission estimates that $15,616,000 additional will be needed to complete the deepening of the canals to the extent contemplated by the law of 1895; but how is that fund to be obtained? The people of New York who were assured three years ago that $9,000,000 would do a certain piece of work are now told, after they have furnished this sum, that about two and one-half times as much will be required! Are they likely to throw good money after bad? Because they have borrowed nine millions, and dropped one or two of them into dishonest pockets and the rest into the mud of the canals, is no sign that they will consent to borrow fifteen or sixteen millions more to meet a similar fate.

Further, for more than two years to come, there is no way in which New York can obtain further sums for canal improvement, except by direct appropriation by the legislature from funds in the treasury. It is now too late to submit a proposal for the issue of bonds to popular approval at the election next November. In November, 1899, certain constitutional amendments have to be voted upon and no bond proposal can be submitted to the people. Thus it will not be before November, 1900, that any proposition to issue further bonds for canal improvements can be submitted to the people. But by that time the falling off in canal traffic is likely to reach such proportions that the dullest cannot fail to comprehend that the day of the old barge canal is past.

Freight cars of 60,000 to 100,000 lbs. capacity hauled by modern powerful locomotives, are cheaper and more efficient machines for handling freight.

By 1900, moreover, the project for deep waterways from the Great Lakes to the Atlantic, on which the United States is now spending nearly a half-million in preliminary surveys, will probably have taken such shape that we shall at least know something of the cost of such new avenues for traffic, and whether their construction would be a paying venture. It goes without saying that if any such work is to be carried out, all money expended on permantnt improvements on the Erie Canal is practically thrown away. It may be said with truth that the chances are very small that the Government will undertake so vast a work as a ship canal from the Lakes to tidewater promises to be. The possibility, however, is bound to have more or less influence on public opinion; and there is also the possibility that in place of the ship canal the Government may take up the more modest, but much more promising project for a barge canal of large size over the Erie Canal route.

Taking all these conditions into consideration, the chances that the people of New York can be persuaded to approve the expenditure of some $16,000,000 more upon the canal deepening seems to us extremely remote. We are aware that the influences which favor the canal appropriations are very strong. The political leaders of both parties see large opportunities in them for strengthening whichever party happens to be in power. The commercial interests favor the canals, from force of habit. It has so long been dinned into people's ears that the canals are an essential factor in the commercial prominence of New York, Buffalo and the cities along the line of the canals throughout the state, that people have come to accept it without question. Time, however, will change all these influences. The politicians are likely, in the next two years, to learn more of the real temper of the people concerning the canal improvements. Those who defend the commercial importance of the canals are becoming wiser as the canal commerce dwindles, and New York's cities continue to flourish and grow. It seems to us very unlikely, therefore, that the recommendation of the Commission for the further improvement of New York's canals will ever be carried out.

LETTERS TO THE EDITOR.

Temperature and Sensible Heat.

Sir: As your editor who wrote the answer to Mr. Gould's letter in to-day's issue seems to be a little hazy on the generally accepted meaning of sensible heat, it might be well for him to look the matter up in standard works on thermodynamics. He can find the term as used by Rontgen in Du Bois's translation of his Thermodynamics, ed. 1880, bottom p. 379; and its relation to the temperature in the equation at the top of page 376. L. F. R.

Philadelphia, Pa., July 28, 1898.

(The writer of the review of Mr. Gould's book does not admit that he is hazy on the meaning of the term "sensible heat," but confesses that he is somewhat surprised to find the extent to which the inaccuracy of using this term to mean "heat of the liquid" has crept into the literature of thermodynamics. It is a good example of the too common practice of scientific writers to take a term from the ordinary language of the people and give to it a new and restricted meaning. Mr. Gould's book, p. 9, says "Temperature and sensible heat are generally considered as synonymous terms." Why should they not be? "Sensible" means perceptible by the senses, and heat that is perceptible by the senses is what is commonly called temperature. The temperature of water at the boiling point is 212° F. This is its sensible heat. The heat units in 1 lb., measured above 0°, are 212.9 B. T. U. The 0.9 B. T. U. excess of this "heat of the liquid" above the figure representing the temperature is not "sensible," and therefore it is inaccurate to call the 212.9 B. T. U. sensible heat. Heat of the liquid is a much better name for it. —Ed.)

Spacing Stiffeners in Plate Girders.

Sir: I notice in your issues of May 19, June 9 and July 7 letters on the subject of "Spacing Stiffeners in Plate Girders," and an allusion to my paper read before the American Society of Civil Engineers in 1885, on "Specifications for Iron Bridges." History repeats itself, and Mr. Beach seems to have worked out the problem on much the same lines as I did myself. So far as the question of I-beams or girders without stiffeners is concerned, there appears to be no dispute.

When I went to Altoona on the Pennsylvania R. R. in 1860, fresh from the Rensselaer Polytechnic Institute, I found in use on that road plate girder bridges, 50 and 60 ft. long, or longer, and 4 to 5 ft. deep, having only 3-16-in. webs, with vertical stiffeners of cast iron, placed on each side and bolted together through the web by three bolts, these being the only connection. The stiffeners hugged well up under the flanges of the girder and were spaced at intervals equal the depth of the girder, more or less. These bridges were, without question, the best and stiffest type of structure on the road, were considered in every way the most reliable, and were carrying with safety any load that could, with the then existing rolling stock, be placed upon them. Some of them may be still in use on branch roads.

When, however, I came to design such structures and applied Rankine's rule for vertical web, "considering that the shearing stress at the neutral axis is equivalent to a pull and a thrust of equal intensity, inclined opposite ways at 45°, and that the vertical web tends to give way by buckling under the thrust," I found to my surprise that these bridges ought to have been utter failures, and, according to Rankine, should have doubled up and departed this life.

The matter gave me considerable study, in the course of which I made a model of a girder with a thin paper web, something similar to the one I send you, only larger, and I found at once that the web did not resist by compression and give way by buckling, but by tension. I made diagonal slits in the web, as you see in this model, converging downwards towards the center. These being in the line of tension did not affect the strength in any way, as you may see by placing this model on supports at the ends, with the proper flange, as marked, up, and applying a heavy weight. When, however, I reversed the girder, with the other flange up, making these slits or cuts converge upward towards the center and placing the web in a condition that it could not resist by tension, the absolute weakness of the girder was at once apparent, and if much load were placed on it, it would break down, the web buckling up under compression. It was upon this practical solution of the problem that I formed my theory of the computation of web and stiffeners, which I stated in my paper, and which for thin webs I still maintain. If one will only give the matter a few moments thought and develop the plate girder from the open truss by increasing certain members to an infinite number, the result ought to be self-evident.

If there are no stiffeners, Rankine's rule holds good and the case is one of a lattice girder with an infinite number of lattice pieces forming a continuous web. Stiffeners in girders could, of course, be placed inclined instead of vertical, except for practical convenience in construction.

The increased thickness of web adopted in later years has not been due to theory but entirely to practical considerations, principally that of deterioration and rusting of the metal in thin sheets from the action of the coal-smoke of engines, and also to increase the bearing surface for rivets. Webs riveted in between angles have, of course, a great resistance merely from the hold which the angles have on them like the jaws of a vise, and in the early days there was not as much attention paid to the bearing surface of rivets as now. Shearing was the only matter considered. In those early days, also, engines burned wood, and coal-smoke with its sulphur fumes did not exist in any quantity.

When one comes to the use of a thick web and proposes to use it for all it is worth, the problem naturally becomes more complicated. A certain portion may be included in the flanges of the girder and often is by those economically inclined; perhaps a portion with the stiffeners; and then, if thick enough, it may also resist by compression as well as by tension, approximating to a girder without stiffeners. For my own part, I would prefer to make my calculations on the theory I have indicated, and having obtained the minimum dimensions for parts, then increase them as practical considerations from my experience, questions of wear and tear, etc., would make advisable.

Yours very truly,

Jos. M. Wilson, M. Am. Soc. C. E.

Philadelphia, Pa., July 19, 1898.

(The general appearance of the model sent by Mr. Wilson is shown quite clearly in the accompanying engravings made from photographs taken in the office of Engineering News. These photographs show the model girder loaded in the two ways suggested by Mr. Wilson. Fig. 1 is a view of the model placed with the slits in the web converging downward and loaded with a block of type metal, weighing $1\frac{1}{4}$ lbs. It will be noticed that the slits are drawn tight and that the web between each pair of stiffeners is tight and smooth. With the same load placed on the opposite flange of the model; that is, with the slits converging upward, the appearance is as shown by Fig. 2. In this view it will be seen that the slits are sprung apart and that the web is buckled between the stiffeners its entire length. The action of the girder with the two methods of loading described corresponds to the description given in Mr. Wilson's letter, and is a remarkably graphic and convincing proof of his statements.—Ed.)

Sir: Permit me to make a few, somewhat belated, comments on a communication in your issue of July 7th. "Practical Bridge Builder" is pleased to take me to task for what he considers a violation of the ethics of criticism, in my failing to point out more explicitly wherein a previous correspondent has erred in his so-called "theory" for the spacing of stiffeners, but, instead, contenting myself by calling attention to a few easily accessible references on the subject.

While I quite agree with this second writer in that, generally speaking, "the burden of proof rests upon the critic," I must submit, that the critic, in this instance, is none other than the original author, on whose side he has seen fit to arraign himself. From what the former terms a "theory;" but what must be regarded a conjecture, pure and simple, unless proved otherwise; he has ventured to draw conclusions, utterly at variance with certain incontrovertible principles of mechanics, without adducing a single argument in their support. It requires but little familiarity with the subject to recognize that each and every one of his six conclusions is untenable. But until something tangible is presented in their support, it is not worth the time or space to enter upon a detailed discussion to prove that the assumed analogy between a plate girder and a Pratt truss cannot possibly exist.

Unless "Practical Bridge Builder" can himself offer something more substantial in behalf of the Pratt truss "theory," than the account of his observations on the behavior of the web at the end of a certain plate girder, his views, too, will fail to impress sensibly on a thoughtful reader. What he has cited in that connection would go equally far towards proving a plate girder bridge similar to a Fink truss, a Bollman truss, or in fact any number of equally remarkable analogies. As a critic of what is generally regarded as sound theory, let him take to heart his own counsel.

Though seemingly superfluous, it may not be amiss to state that, before attempting to prove the analogy of a plate girder to any other form of construction, it is incumbent upon the critic—whether theorist or self-styled "practical" man—either to submit a formal refutation of the generally accepted theory of the distribution of stress in web plates, or to show that his own theory is merely an extension of the same. Nothing less than this can reasonably be expected to carry conviction, or is, in fact, deserving of serious consideration.

Passing over certain inaccuracies in my critics reference to my former communication, which are patent to anyone, I have only to defend myself against the carelessly thrown out charge, that in my reference to the spacing indicated in the sketch accompanying the original communication, I have presumed to state, or even to intimate, that your correspondent's guess was wrong, because slightly different from my own. That what I did write does not admit of this absurd construction will be shown to any reader who can recognize the broad distinction between a matter of empiricism (in the sense of experience, not experiment), and a matter of guess.

To sum up, experience in the case of hundreds, probably thousands of girders, has shown that if the stiffeners are placed at intervals not exceeding the unsupported depth (inside of flange angles) of the web, security against buckling is assured, provided that the bearing requirements of flange rivets are fully met. Toward the ends of a girder, the intervals are frequently reduced in a purely arbitrary fashion. That this is not necessary is attested by the record of the numerous girders designed after Cooper's specifications, which embody no such requirement. It goes without saying, that for girders of very great depth, the rule named must be modified in the case of thin webs, according to individual judgment, to ensure their better alinement. The proper size of stiffeners can be computed only at the supports. The sizes of the intermediate ones are absolutely beyond the reach of theory.

With apologies for trespassing on your space to this extent, in a matter that can have but little interest to the general reader, I am

Very respectfully, E. M.

Philadelphia, Pa., July 23, 1898.

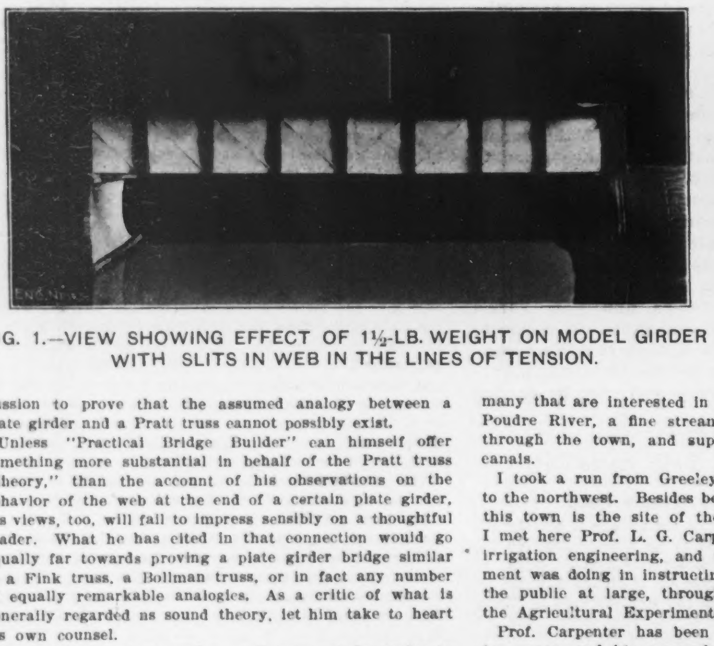


FIG. 1.—VIEW SHOWING EFFECT OF 1½-LB. WEIGHT ON MODEL GIRDER WITH SLITS IN WEB IN THE LINES OF TENSION.

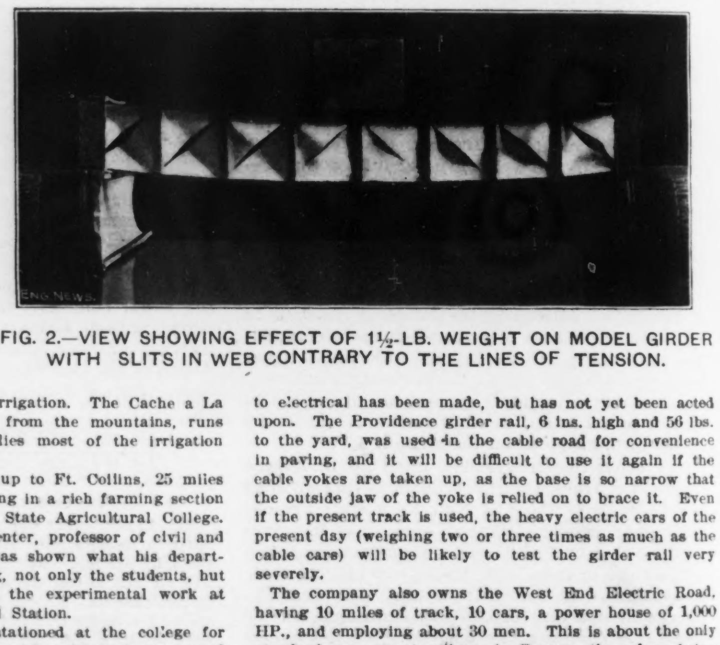


FIG. 2.—VIEW SHOWING EFFECT OF 1½-LB. WEIGHT ON MODEL GIRDER WITH SLITS IN WEB CONTRARY TO THE LINES OF TENSION.

Notes of an Engineer in Colorado.

Sir: The readers of Engineering News may be interested in a brief description of what the writer saw in a recent trip through the principal towns of Colorado. I entered the state from the north, traveling over the Union Pacific Ry. to Denver, thence over the Denver & Rio Grande standard-gage line to Grand Junction, and from there over the Rio Grande Western through Utah to my home at Salt Lake City.

From Cheyenne, Wyo., southward for about 40 miles there is no industry or agriculture but stock raising. Between Pierce and Eaton the first irrigated lands are reached, and thence all the way to Denver one has an ocular demonstration of the benefits of irrigation.

Greeley, 54 miles from Cheyenne and 52 miles from Denver, was the birthplace of the art of irrigation for the English-speaking people of Colorado. The town was laid out in 1870 by a colony under the fostering care of Horace Greeley. With but little experience in farming, and none in irrigation, these colonists went to work with a will, and, despite many failures at first, they have succeeded in establishing a colony that is pointed to as a model by many that are interested in irrigation. The Cache a La Poudre River, a fine stream from the mountains, runs through the town, and supplies most of the irrigation canals.

I took a run from Greeley up to Ft. Collins, 25 miles to the northwest. Besides being in a rich farming section this town is the site of the State Agricultural College. I met here Prof. L. G. Carpenter, professor of civil and irrigation engineering, and was shown what his department was doing in instructing, not only the students, but the public at large, through the experimental work at the Agricultural Experimental Station.

Prof. Carpenter has been stationed at the college for ten years, and his researches and writings have caused him to become well known abroad as well as in this country, wherever an interest is taken in irrigation. For the 300 to 350 students per year coming to the Agricultural College, there are four courses of four years each open. The only degree given for any of the courses is that of Bachelor of Science, though special degrees are given for post-graduate work. Over one-half of all the graduates are from the engineering course. Male students in all the courses devote one-third of their sophomore year to surveying, with field practice in compass and level work. Naturally a large amount of time in the civil engineering course is given to irrigation.

The civil engineering department has a building to itself. On the first floor are the office and library of the professor of engineering, the drafting room and also a room for carrying on the work of the irrigation engineering section of the Agricultural Experimental Station. This station is intimately connected with and under the same governing board as the college. In the basement are the physical and hydraulic laboratories. The hydraulic laboratory has tanks and a set of suspended scales, weighing to 5,000 lbs., for ascertaining very closely the amount of water flowing through orifices and over weirs.

The Department has Colorado, Lallie and Fteley current meters, the latter with an electrical recording attachment, and also a long-distance, electrical, self-recording water-level instrument, made by Richard Freres of Paris, by which the change in elevation of a water surface miles away in the mountains is recorded at the station.

As meteorology is an important factor in irrigation, instruction in this is given also, and a complete set of instruments, many of them imported, is in daily use. This includes self-recording thermometers, barometers, psychrometers, anemometers, pluviometers, actinometers, statoscope, soil thermometers, evaporation tanks, etc.

The Mechanical Engineering Department of the college has a large two-story building of its own, which is completely equipped for instruction and for manual training.

Denver.—This city has one of the best systems of street railways in the country, considering the great extent of territory covered. The total value of all the lines is about $4,000,000. The Denver City Railway Co. was the pioneer in street car matters, and its first horse car lines were built over 20 years ago. In 1889 most of the main lines were changed to the cable system. This was just before electric roads were proved to be a commercial success, and many hundreds of thousands of dollars in first cost, as well as excessive expenses in operation, could have been saved if electrical propulsion had been perfected a year or two earlier. The company has 30 miles of cable tracks (15 miles of double tracks) operated by six different cables running out of its power house at 18th and Lawrence Sts. The longest of these cables is the West Laramie, 32,000 ft. long. The plant at the power house has about 1,600 HP., while about 85 cars are run and 350 men employed. Though much inferior to the electric lines in economy and service, the cable line plant here represents a high type of engineering skill. More miles of cable railway are probably operated from this power station than any other single one in the world. A brief account of the plant and tests of its efficiency by the constructing engineer was given in Engineering News of Aug. 17, 1893, p. 130.

The company's system was sold under foreclosure after the panic of 1893-4 for $500,000. Something like $3,000,000 had been invested in it. An application to the city council for a franchise allowing the cable system to be changed to electrical has been made, but has not yet been acted upon. The Providence girder rail, 6 ins. high and 56 lbs. to the yard, was used in the cable road for convenience in paving, and it will be difficult to use it again if the cable yokes are taken up, as the base is so narrow that the outside jaw of the yoke is relied on to brace it. Even if the present track is used, the heavy electric cars of the present day (weighing two or three times as much as the cable cars) will be likely to test the girder rail very severely.

The company also owns the West End Electric Road, having 10 miles of track, 10 cars, a power house of 1,000 HP., and employing about 30 men. This is about the only standard-gage street railway in Denver—the others being 3½-ft. gage. The company also operates 4¾ miles of its old-time horse lines. On the cable road the cars run 11,000 car miles daily, on the electric 1,000, and on the horse track 175. The total number of passengers carried during 1897, including the transfers, was 9,000,000, and the car mileage was 2,000,000 miles.

The Denver Consolidated Tramway Co., now much the largest of the street railway companies, is an interesting example of the results of energy and good management. The Denver Tramway Co. was organized in 1888 to build a cable railway system. Franchises were secured and construction proceeded with that year, notwithstanding the vigorous opposition of the pioneer company, which had before had a monopoly of street railway privileges. All the money was furnished by local capitalists.

The cable system included 18 miles of track, costing about $40,000 per mile. The company soon decided that electric roads were the best, and all the additions have been of that system. In 1893 the 18 miles of cable line were converted into electric road, the cable conduit, etc., being left in. It is stated that about $25,000 per mile would have been saved if electrical propulsion had been so perfected as to allow of it at the start. The power house was built at the corner of Broadway and Colfax Ave., the center of the system and in the then resident district, and was a large building with handsome exterior. Cotton ropes were used in the place of cog gearing, on account of the objections to noise in this locality. The building has been abandoned, and the machinery used for other purposes where possible. The system as now consolidated includes 58½ miles of track in double track, 36 miles of single track and 4½ miles of sidings, etc., or 99 miles in all. It operates about 75 cars daily, and 18,000,000 passengers were carried in the first 10 months of 1897. It is found that there is a saving of about 6 cts. per car mile over the cable road, notwithstanding the great increase in the size of the cars, and as to freedom from stoppage, flexibility under very great variations of traffic and general convenience, the electric roads are found to be decidedly the best.

The old cable cars weighed 6,500 lbs., and carried 40 passengers; the new electric cars with motors weigh 16,000 lbs., and hold 100. Both the General Electric and the Westinghouse systems of electricity and motors are used, the latter ranging from 10 to 35 HP. The company has lately begun tearing up its old cable tracks to replace them with rails on ties. In forming the cable conduit the bottom part only was made of concrete, the sides being of plank stretching from yoke to yoke. On account of this, which was looked on as a penny-wise method at the time, the loss will be much less than if the entire conduit had been of concrete, as in the Denver City and other cable roads. The boards are considerably rotted, but still serviceable at the end of ten years. The yokes are broken off in pieces by sledge-hammers and used as old iron, the part imbedded in the concrete being allowed to remain. In the new track in the paving districts "T" rails 6 ins. high and weighing 72 lbs. are used. 30-ft. lengths rolled at Pueblo were first used, but more lately 62-ft. lengths, coming from the Johnson Co., Lorain, O., have been used. About five miles of the track had been replaced with heavy rails up to May of this year. Creosoted ties, 6 × 8 × 6, coming from the Michigan Pipe Works, at Bay City, Mich., and costing 94 cts. each, delivered, are used. The Servis tie-plate has also been adopted. The old cable road rails are only 35 lbs. weight. In the paving district all street car companies have to pave between the rails and for 2 ft. each side. This company spent about $80,000 in 1897 on such work, much of it re-paving.

In addition to the roads named, the Colfax Electric Railway has 11 miles of single track (east of the city limits); the Denver, Lakewood & Golden Ry. Co. has nearly 4 miles of electric road in the city, and the 34th Ave. line has 1½ miles of track, which are operated in one direction by horse-power and on the return by gravity—carrying the horse. There are altogether about 155 miles of street railway track in the city and suburbs.

In good weather nearly all of Denver's streets are in good condition, but before paving began in 1890 the business streets were miserable in very wet weather. There have been over 14 miles of pavement laid, all but about 10% being asphalt. The sandstone paving is confined to the down-town district.

Denver's sewer system has also nearly all been built since 1890, and is now quite complete, containing 224 miles of sewers.

Denver has become a very important manufacturing center during the past few years, and as the cost of living is now as low as in the East, one of the most important factors in the relative cost of manufacturing in the West is thus eliminated. Iron works, and especially works for the manufacture of machinery used in mining, milling and smelting, have a very extensive trade in the mountain regions. The manufacturing district lies principally along the Platte River, for a distance of about 9 miles. The Omaha & Grant, the Globe and the Boston & Colorado smelters, all at the north end of this district, give employment to nearly 1,500 men. In this locality are also the great Jersey shops of the Union Pacific Ry. Co, leased on May 1 to the Union Pacific, Denver & Gulf. Besides its own work, the U. P., D. & G. does a great deal of custom work at these shops, including much for the Union Pacific.

At present only about 230 men are employed in the machine and engine shops and 150 in the car building department here. The track for a heavy electric crane was provided in constructing the machine shop, but this was never put in (thus saving about $5,000), and instead air-lifts of about two tons capacity are used. These prove to be more rapid and to make a great saving of time in handling all small pieces. A 15-HP. Thompson-Houston motor is used for operating the transfer table, and by having call signals provided for the operator at one corner of the building he is not required to be at the table all day, but gets in three or four hours' work at a lathe.

The roundhouse was formerly lighted by electricity, but it was found that the stationary lights were not at all suited for inspecting the parts of an engine, and if carried around for this purpose many were broken. They were taken out and the regular engineer's oil lamp is now used, with 8 large oil bracket lamps placed around the walls for general lighting. By this means $300 per month is saved, two electric light dynamos and an engine being left idle. The omission of the overhead crane left room at one end of the overhead tramway to fit up a tool room.

Three steel viaducts connect the main part of the city with that west of the So. Platte River, crossing over the numerous railroad tracks along the river bottoms. Two of these, on 16th St. and on West Larimer St., were built by the Denver City Cable Ry. Co. The first of these is about 3,000 ft. long, the last considerably more. The 14th St. viaduct, now being built by the city, will be about 3,500 ft. long.

In the engineering profession I found that business had been extremely quiet for several years past—beginning with the panic of 1893—but that it has lately been picking up. Many engineers who had their own offices during the better days gave them up, and either attempted working on a salary or else moved to other parts of the state or the country.

Prices of living, merchandise, etc., have come down in Denver the past few years, until it now more nearly resembles an Eastern city than any other in the West; and with penny papers and other evidences of Yankee economy it must make the old-timer who returns here feel somewhat pensive when he remembers the scorn with which anything less than 10 to 25 cts. was formerly regarded.

All municipal improvements in Denver are built under charge of the Board of Public Works, the engineering staff making the surveys, as well as plans for new structures. The duties of the city engineer's office are mostly confined to street and lot lines and grades.

The state engineer's office is a very important one in Colorado, having control not only of irrigation, but of many state public works. Mr. John E. Fields is the present incumbent. For the administration of the irrigation laws, the state is divided into six natural drainage divisions, each in charge of a superintendent, and these into 69 districts, each in charge of a commissioner. All the streams of the state used for irrigation are regularly gaged. There are many volunteer observers of gages, but some are paid about $5 per month. The state engineer's department carries this along in conjunction with the hydrographic department of the U. S. Geological Survey, the former paying the salaries and the latter the expenses. One deputy is in the field all the time, making the rounds of the principal gaging stations about once a month. The last legislature made no appropriation for public works such as have been constructed under supervision of this department, but it is likely that the next one will provide for further expenditures. W. P. H.

Salt Lake City, Utah, July 1, 1898.

THE NEW YORK STATE CANAL INQUIRY.

In March last Gov. Black appointed a special commission to investigate and report upon the work already done in enlarging and improving the Erie, Champlain and Oswego canals, in the State of New York, under the provisions of Chapter 79 of the Laws of 1895; whether the contracts were properly made and whether the money paid out was properly expended; the proportion of work done and that still to be done; and the amount of money in excess of the appropriation of $9,000,000 still required to complete the proposed enlargement and improvement. The commission submitted its report to the Governor on July 30, and though the detailed evidence is not yet accessible a brief summary of the report proper is here given.

The commission secured the services of Mr. Abel E. Blackmar, of New York, as counsel, and appointed Mr. Edward P. North, Vice-President American Society of Civil Engineers, as consulting engineer, and Mr. Lyman E. Cooley, of Chicago, as advisory engineer. The report commences with a brief sketch of the Erie canal system and makes the following statement of the actual condition of the work on the several canals at the present date:

Location.		Work, miles. Completed.	Incomplete.	Not contracted.
Erie Canal	Eastern Division..	26.56	27.99	51.687
	Middle Division ..	23.18	73.61	None.
	Western Division..	3.45	112.40	31.81
	Total	53.19	214.00	83.497
Champlain Canal		5.886	24.03	36.11
Oswego Canal		6.63	6.73	24.11
Grand total		65.706	244.76	141.017

The commission notes that it is impossible to give the exact condition of the work done under these contracts, though its engineers report that the quality of the work performed is generally good and is an improvement upon that usually done upon our canals. As to the features of the work, the conditions as they developed were most unfavorable, and required a high degree of skill and moral strength to meet them; the pressure for haste resulted in demoralized and disorganized execution, and influences hereditary in canal work had to be combatted. As a general thing the contract prices were reasonable and as low as could be expected; there was actual competition between the bidders, and in a great many of the contracts there is nothing to condemn. The actual amount of money expended for the enlargement and improvement of the canals to July 28, 1898, was as follows:

Disinfectants	$6,684.93
Advertising	92,320.70
Inspectors	178,969.43
Engineering expenses	812,000.00
Paid to contractors	7,106,722.77
Continuing work on suspended contract No. 3	35,555.19
Total	$8,233,253.02

Under the law of 1895 not less than 10% of the amount due the contractor is to be retained by the state until the completion of the work, and including unpaid drafts amounting to $35,092.37, the apparent free balance out of the $9,000,000 appropriated is only $25,556.25. The item of disinfectants refers to the treatment of certain sewage-contaminated material excavated in the City of Buffalo.

In regard to advertising, the report states that the total amount thus expended upon the first 32 contracts was $74,978.50, an average of $2,343.08 for each contract. No attention was paid to the amount involved in the contract, and in one case the cost of advertising was 23% of the engineer's estimate of the total cost of the work, while in another case this cost was as low as one-third of one per cent. of the engineer's estimate. In later advertisements the superintendent's requirements were omitted and several contracts were grouped in one advertisement with the result that 49 contracts were advertised for $17,342.20, or an average of $353.92 each. The commission concludes from the evidence submitted that an average expenditure of $150 each would have properly advertised these contracts, and that $80,170.70 was improperly expended in this direction.

The report shows that while $38,532.80 was paid to inspectors during the season of closed navigation, and when work was being done, the sum of $41,514.19 was expended in paying these officials during the season of open navigation when work on the contracts had substantially ceased. The commission is of the opinion that a portion of the expense of maintaining this force of inspectors during the open season was useless, and therefore improper.

As no sufficient data existed in the engineer's office for the making of the estimates, maps, plans and specifications required by law, an expensive preliminary survey was absolutely necessary, and the commission deemed this expenditure requisite and proper. But a sum amounting to $49,391.32 was charged to these surveys and actually paid to experts for plans, etc., of lift locks at Lockport and Cohoes. While the employment of skilled and special engineering assistance is deemed generally proper, in such cases, the commission finds that the improvement contemplated by them was unauthorized and could not be legally made under Chapter 19 of the Laws of 1895, and this large expense was therefore improper. It was also deemed unnecessary to obtain complete working plans of three separate devices before choosing between them. The nature of the work required a large expenditure for engineerig services; but the complexity of the specifications, say engineers North and Cooley, has unnecessarily increased this cost.

For the purpose of making the contracts the canal was divided into contract sections, varying in length from .67 to 22.07 miles. The contractor bid upon the quantities estimated by the engineers, and upon the specifications, maps and plans accompanying the quantity sheets. In comparing bids these quantities were multiplied by the prices submitted, and the lowest total obtained the contract. If the quantity sheet does not represent with reasonable accuracy the actual amount of work to be done; or if the specifications admit of uncertainty of classification between the several items; or if the plans are indefinite, or made in the alternative; this method affords an opportunity for excessive final cost, unbalanced bids, improper classification and other abuses. The commission finds that, notwithstanding the large amount expended on the preliminary surveys, the quantity sheets, plans and specifications lack accuracy and definiteness. So far, the actual cost of the work let has exceeded the contract price by 9.84%; and the total cost of the work for which contracts have been let, including the estimated cost of those incomplete, will exceed the contract price by 69.08%. As early as July, 1896, it was evident to the State Engineer and to the Superintendent of Public Works that the cost of the work, as shown by the notes and measurements of the engineers, would far exceed $9,000,000. An attempt was then made to reduce the estimates by cutting out everything that did not seem to them to be absolutely necessary to obtain the result primarily aimed at in the statute. But this mutilation of the quantity sheets did not render the work unnecessary, and as the improvement progressed much of the work cut out reappears in an increase of quantities over the preliminary estimates. For example, the slope wall estimated for and bid upon amounted to 543,779 cu. yds.; while up to May 1, 1898, 425,-916 cu. yds. of such wall had been built and it was then estimated that 432,839 cu. yds. more would be required to complete these contracts. The preliminary estimate of vertical wall was 106,353 cu. yds.; on June 1, 1898, 168,735 cu. yds. of this wall had been built, and the revised estimate called for 110,326 cu. yds. to complete the contracts.

The value of the preliminary estimates was also greatly impaired by the fact that they were made without reference to the specifications, and were in fact made before there were any specifications. The assistant engineers classified and defined rock and earth as each saw fit in making the original soundings and estimates, and the quantity sheets were prepared accordingly. When the specifications were afterwards made these terms, rock and earth, were given a technical and arbitrary meaning, and no revision of quantities was or could be made owing to lack of sufficient data. The specifications classed as rock, hard-pan which "could not be plowed," and the meaning of the term "embankment" was also changed in the specifications after the computation of quantities in the preliminary surveys. The following table shows a comparison of quantities as shown on the bidding sheets with the quantities of work actually performed:

	Cu. yds.
Rock in quantity sheets	550,183
Allowed to contractors to May 1, 1898.	740,068
Estimated amount to be excavated, May 1.......	253,501
Embankment in quantity sheets	729,374
Allowed to contractors to May 1	1,167,849
Estimated amount remaining, May 1.	615,145

This disparity is partly due to improper classification; and another source of error was inexcusable carelessness in omitting quantities actually returned and inserting a nominal small quantity of 70 or 100 cu. yds. into the bidding sheets; in another case 5,000 cu. yds., estimated, was set down as 500 cu. yds. The report deals at length with the discrepancies in excavation, which showed an excess of from 10.77 to 35.09% over the preliminary estimates. On contracts in the cities of Utica and Syracuse the improvement was made by both lowering the bottom and raising the banks, and here the preliminary estimates were 1,532,370 cu. yds., while the work actually done and that estimated to complete calls for 2,171,724 cu. yds., an increase of 41.72%. On these contracts the material was procured from outside the prism, during the navigation season, and before there was any excavation from the canal. All this material was taken from borrow pits and paid for as excavation; and that hauled over 1,000 ft. was paid for as embankment in addition. The reason given for this course was that the material in the prism was an unknown quantity; could not be used in winter as it was frozen, and the silt could not be separated from the harder material. The commission disagrees with this position and believes that the course pursued was a wasteful departure from the original intent of the contract and specifications which called for the use of proper excavated material upon the banks. On some sections there were extravagant returns made for mucking, or removing all vegetable matter to the depth of 6 ins. on the outside slopes of embankments.

The earth and rock classification, as before mentioned, was very faulty, both for the reasons already given and because the specifications confided this classification to the three resident engineers, who in this case had supervision over about 152 miles of canal. Personal examination in all cases was absolutely impossible, and anything like accurate work would have required more engineers. The average of all accepted bids for dry excavation of earth was 28.8 cts. per cu. yd.; the average for all accepted bids for dry excavation of rock was $1.42 per cu. yd. The report then takes up the three divisions separately, and by individual cases shows a great uncertainty and frequent and arbitrary reclassification of earth and rock. Space available forbids going into this interesting detail, and the same may be said for the detail of the embankment returns.

Under the head of extra, or additional work, we find that to June 1, 1898, work valued at $824,820.88 was done under special agreement, outside of the contracts, showing the insufficiency of the preliminary investigation. A large amount of this work was not contemplated by either party and was thus not within the contract itself. Some of this extra work, though admitted as useful and necessary, was paid for as excavation, slope wall, etc., under the contract prices, and only swells the quantities under the contract and does not appear in the work done by special agreement. "Extra work" was also largely done from force account with 10% added for profit to the contractor; and many claims exist for work done without special directions. Other work was performed which was not properly part of the improvement prescribed by law, and in some cases a free gift of material belonging to the state was improperly made to the contractors. In concluding their report the commission expresses the opinion that not less than $1,000,000 in all was improperly expended in the manner here pointed out.

In its estimate of total cost of the work, done and to be done, the commission submits the following statement:

Expended on contracts (approximately).....	$7,867,924.36
To be expended to complete contracts	4,731,600.00
Total	$12,599,524.36
Estimated for work to be let	8,900,000.00
Total cost of completed work	$21,499,524.36

In other words, 36.6% only of the entire work is finished. The $13,651,000 estimated to complete the work does not include engineering, and 10% should be added thereto. This estimate does include, however, the pneumatic locks at Cohoes and Lockport, the change of line at Newark and the improvement at Little Falls. But the commission does not recommend the pneumatic lifts at Lockport and Cohoes, and if the locks at these points are left as at present, the estimate would be decreased by $2,100,000. The engineers, Messrs. North and Cooley, with the approval of the commission, recommend certain changes in the location of the canal, which, if sanctioned by the legislature, would further diminish the estimated cost of completion.

It is only just to the State Engineer's Department to say that the estimates of 1896, based upon the preliminary surveys, put the cost of the improvement at at least $13,500,000, not including engineering, advertising or inspection. This estimate was improperly cut down to $9,000,000 to meet seeming demands, and upon this revision the work was let. As the work progressed it became evident that the official estimate was too small and another was made amounting to about $16,000,000. The State Superintendent of Public Works also committed the grievous error of letting contracts after it was apparent that the money remaining available was totally insufficient to complete these contracts. This has left long stretches of the canal in an incomplete condition and has involved the state in serious questions of liability to contractors.

The commission finds that the force allowed the State Engineer is not adequate to the performance of all the duties of his department. The State Engineer himself is a member of various boards and has many duties to perform outside of canal improvement. The present dual system in the management of canal affairs is also objectionable and is inherently vicious. It throws the responsibility upon two departments, those of the State Engineer and Surveyor and the Superintendent of Public Works, which have separate functions to perform, but are so interwoven as to make it extremely difficult to fix responsibility in case of negligence or wrongdoing. The commission recommends that the authority and responsibility be vested in one department, and that either the Superintendent of Public Works be given power to maintain a sufficient engineering force and take all the responsibility; or, that the State Engineer be intrusted with the business management of the canals and the entire responsibility of maintenance, repair and improvement. The last suggestion would involve the abolition of the Department of Public Works; and the first would duplicate the engineering force to a great extent and largely increase the cost. In any event, before further work is done there should be a more accurate study of the conditions, a revision of the specifications and the preparation of adequate quantity sheets for all work still to be performed. In conclusion, the commission recommends the continuation of the improvement on the lines contemplated to final completion, with such changes as have been suggested and that may be sanctioned by the legislature.

The entire cost of Erie canal system, up to 1895, is $102,345,123. The state has received from these canals, up to 1882, when tolls were abolished, $134,648,900; and these canals have thus much more than repaid the entire cost of construction, maintenance and repairs, up to Oct. 1, 1885. The report is dated at Albany, N. Y., on July 30, 1898, and is signed by the following commissioners: George Clinton, Chairman; Franklin Edson, Secretary; Smith M. Weed, Darwin R. James, Frank Brainard, A. Foster Higgins and William Mc-Echron, Commissioners.

SEISMIC AND OCEANIC NOISES.

In the April issue of the "Monthly Weather Review," Mr. Samuel W. Kain, of the Natural History Society of St. John, N. B., and others, write of the mysterious "booming" noises often heard at sea and near the coasts. These sounds seem to be frequent off the coast of Nova Scotia; they resemble the distant boom of cannon, and they alarm and drive away schools of fish. Sometimes, as at Gannet Rock light-house, the sound is as sharp as the report of a 24-pdr. cannon, fired 40 yds. from the building, accompanied by a shaking of the ground. The same noises are frequently reported from the Bay of Fundy.

Mr. Kain says that while these sounds have generally been attributed to some form of earth disturbance, and are thus termed seismic noises, it is by no means certain that they may not often have an entirely different origin. The salt water drum-fish (Pogonias Chromis) is common on the Atlantic coast, and a large drum-fish will give out a sound that may be heard a long distance. As the sound is refracted into a nearly horizontal direction on its emergence from a level water surface, it may seem to come from a great distance, when it is really near at hand or under the vessel. There may be other fish of great size that can give forth louder sounds, and this may account for their variety. On the other hand, Mr. Kain believes that some of these oceanic noises defy all attempts at rational explanation.

Prof. Alexander Agassiz says that the large drum-fish attains a length of more than 4 ft., but he cannot satisfactorily explain how the "drumming" is produced. Cuvier observes that it may depend on the air-bladder, though this has no direct communication with the open air; De Kay supposes it "to be occasioned by strong compression of the expanded phraryngeal teeth upon each other." Prof. Agassiz, from frequent examinations of the structure of the fish, is fairly satisfied that it is made in the air-bladder itself; that the vibrations are produced by the air being forced by strong muscular contractions through a narrow opening, from one large cavity—the air-bladder—to another cavity, that of the lateral horn. The sound itself, says Dr. Mitchell, most resembles the tap of a drum, and it is so loud that when many of the fish are gathered together it can be heard "several hundred yards from the water."

Prof. Wm. F. Ganong, of Northampton, Mass., writes to Mr. Kain and says that he cannot accept the drum-fish theory. He has heard the sounds from hills one-quarter mile from the sea, and they were too great in volume to be made by any number of fish. Mr. Kain is inclined to conclude that these sounds originate from different sources; some undoubtedly come from drum-fish; others are due to the heavy thud of breakers on cliffs; others to the cracking of rocks in ledges, such as light-houses frequently stand upon, and others still are occasionally due to genuine earthquakes occurring at the bottom of near oceans. In the latter connection it is well to remember that there are eight or ten well-defined regions on the North American continent within each of which there is a so-called center of seismic disturbance. There is no reason why similar centers should not exist under the ocean; and the great solitary waves occasionally reported by vessels sailing between Newfoundland and New York may sometimes be due to earthquake shock, as similar waves in the Pacific are known to have been caused by earth disturbance.

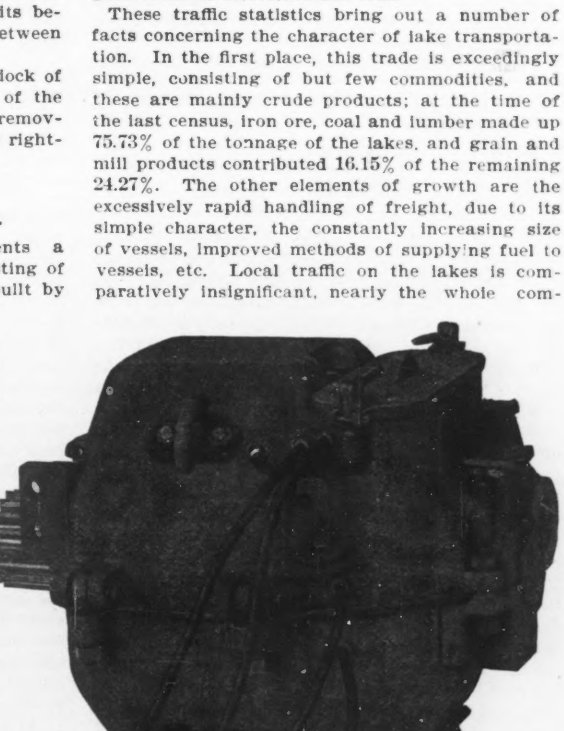
AN ELECTRIC MOTOR FOR NARROW GAGE RAILWAYS.

We illustrate in the accompanying cut a new type of electric motor designed for narrow gage railway service with a minimum gage of one metre (39¼ ins.). In outward appearance this new motor resembles the motors for standard gage. It is built by the General Electric Co., of Schenectady, N. Y., for comparatively heavy service, such as is encountered in city and suburban traffic where the load carried at times is considerable and the speed moderate. The motor is designed for 500 volts and other regular electric railway conditions, and is rated at 37 HP. on a basis of a maximum temperature rise not exceeding 75° C. in the winding of field or armature after a full load run of one hour, provided the temperature of the surrounding air does not exceed 25° C. It weighs alone 1,865 lbs., and together with gear and gear case 2,150 lbs.

The magnet frame is cast in two parts, each containing two pole pieces bolted on from the outside. The upper half also has heavy lugs which are fitted with bearings for the car axle, upon which the motor rests, and other small lugs to which is bolted the suspension bar. The armature bearings are also bolted to this part of the frame. The bottom half can be lowered and the armature, commutator and bearing exposed for examination or repair.

The armature bearings are lined with 3-16-in. Babbitt metal swaged and bored to size. On the commutator end the bearing is 2⅝ × 6 5-16-ins., and the pinion end 3 × 7⅞-ins. All bearings are amply lubricated, are easily accessible and are designed to keep oil and grease away from armature and fields. The four wire-wound field coils surrounding the pole pieces are insulated with asbestos, are carefully wrapped with tape and cloth for insulation and protection, and are tested when in place with 5,000 volts alternating current between coil and field frame. The armature core is 14½ ins. in diameter and 6½ ins. in breadth, with 33 slots. The winding is "barrel-type," there being 3 coils in each slot. These are insulated and taped to form one coil for convenience in repairs. The coils are held in place in the slots by tinned steel wire wound around and soldered so as to form bands. The coil terminals are brought down and soldered directly to commutator segments. The commutator is 10 ins. in diameter and has 99 hard-drawn copper segments 4⅜ ins. long with a wearing depth of 1 in. The best grades of mica is used in its construction, and when completed it is tested with 5,000 volts between segments and shell and 500 volts between segments.

The brush-holders are mounted upon a block of treated wood attached to the upper part of the field frame, and are readily accessible by removing the hand-hole plate seen in the upper right-hand portion of Fig. 1.



A 37-HP. ELECTRIC MOTOR FOR NARROW GAGE RAILWAYS.

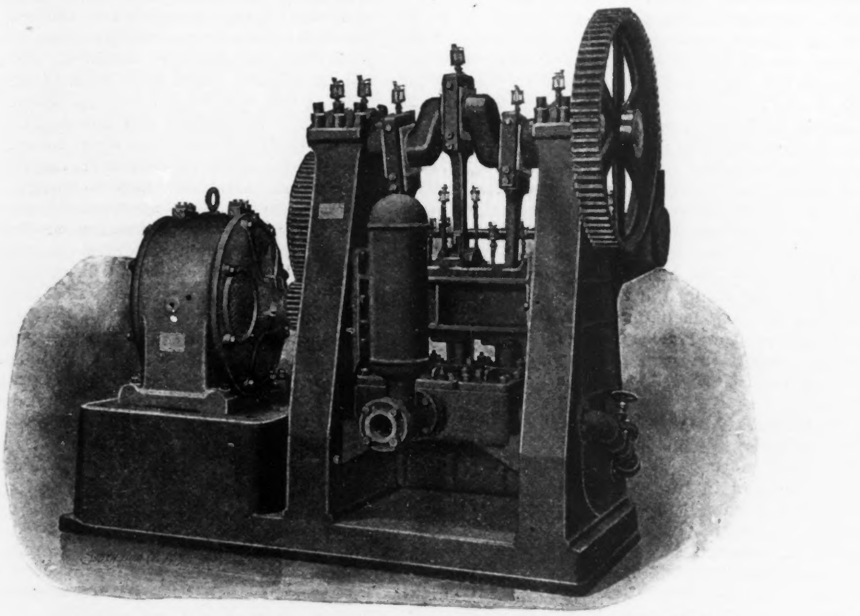


FIG. 1.—A WESTINGHOUSE THREE-PHASE MOTOR GEARED TO A GOULDS TRIPLEX PUMP.

AN ELECTRICAL PUMPING EQUIPMENT.

The illustration given herewith represents a combination electric pumping outfit, consisting of a type "C" three-phase induction motor built by the Westinghouse Electric & Mfg. Co., Pittsburg, Pa., and a vertical "Triplex" mining pump constructed by the Goulds Manufacturing Co., 16 Murray St., New York city. Such equipments are intended for use where the source of power is somewhat remote from the pump, and the pump here illustrated is designed for high pressures and has a capacity of from 60 to 150 gallons per minute to an elevation as high as 1,400 ft.

The motor is of the well-known "Tesla" type, and is built for circuits using 7,200, 3,600 or 3,000 alternations per second. It consists of a stationary part, known as the primary, permanently connected to the transmission circuits, which may be of any length, and a rotating secondary which is entirely disconnected from the primary, and consists of a series of thin steel disks, or laminae, mounted upon a suitable cast-iron spider. The disks have all around their outside square slots, and into these are slipped insulated copper bars which are connected at their ends to heavy copper rings. The revolving part is as solid and as free from liability to accident as an ordinary pulley wheel. This type of motor is especially remarkable in its simplicity. It possesses no commutator brushes, or collector rings and, consequently, requires very little attention. In addition it has a high commercial efficiency, a high power factor, and close speed regulation.

Starting up is accomplished by means of a double throw switch mounted upon a cast-iron case containing two auto-converters. These converters are connected across the circuit and are constructed to deliver a low electro-motive force to the motor. After starting the switch is thrown over and the motor is thus put directly on the main circuit. The starter may be some distance from the motor, for instance in mine pumping, it may be placed in the engine-room and the pump anywhere in the mine.

STATISTICS OF COMMERCE ON THE GREAT LAKES.

The Bureau of Statistics, of the U. S. Treasury Department, has issued an exceedingly interesting report upon the growth of traffic on the Great Lakes. It is practically the first comprehensive investigation of this subject since 1889, and the figures here gathered by Mr. George G. Tunell, of Chicago, are correspondingly valuable. For most useful purposes the report itself must be studied in all its detail, but some general figures are here given to illustrate this phenomenal growth in traffic, and to explain some of the reasons for it.

The astonishing development of the iron mines of the Lake Superior region, during the last 15 years, is very largely responsible for the enormous growth of traffic through the St. Mary's Falls Canal, and, in fact, throughout the Lake system. This development practically commenced in 1880, with but 677,073 tons of ore moved out of Lake Superior in the season; in 1895 the shipment of ore amounted to over 8,000,000 tons, or about one-half of the total of 16,806,781 tons passing the canal in that season. In 1897 the movement of ore exceeded all previous records and amounted to 10,633,715 net tons, with lumber, grain, flour and coal forming the other main items in an aggregate trade of 17,619,933 net tons.

These traffic statistics bring out a number of facts concerning the character of lake transportation. In the first place, this trade is exceedingly simple, consisting of but few commodities, and these are mainly crude products; at the time of the last census, iron ore, coal and lumber made up 75.73% of the tonnage of the lakes, and grain and mill products contributed 16.15% of the remaining 24.27%. The other elements of growth are the excessively rapid handling of freight, due to its simple character, the constantly increasing size of vessels, improved methods of supplying fuel to vessels, etc. Local traffic on the lakes is comparatively insignificant, nearly the whole commerce moving from one end of the system to the other; and a conspicuous feature is great preponderance of east-bound over west-bound freight. In 1890 the total east-bound commerce through the Detroit River in American vessels was 15,670,156 net tons, as compared with a west-bound trade of 6,080,757 net tons; and this difference is more apparent still in the St. Mary's Canal.

The average registered tonnage of vessels has been constantly increasing; in 1870 the average tonnage of vessels passing the St. Mary's Canal was about 375 tons; in 1880 it was about 495 tons; in 1890, 800 tons, and in 1896 it was 926 tons. This statement, however, does not give a fair idea of the actual growth in the tonnage of vessels, as that of sailing vessels is about the same, and the tonnage of steamers shows no remarkable change until 1887. In 1886, the average gross tonnage of steamers was 269 tons; in 1891 it was 759 tons, and in 1897 it was 1,437 tons; or an increase of 534% in average tonnage in 12 years. The latest steamer building, for the Bessemer Steamship Co., is 475 ft. long over all, 50 ft. beam, and 29 ft. deep, and she will carry 6,500 to 6,750 gross tons on a mean draft of 17 ft. Mr. Tunell compares these dimensions with the two largest ocean steamers afloat, as follows:

	Bessemer steamer, ft.	"Kaiser Wilhelm der Grosse," ft.	"Oceanic," ft.
Length over all	475	648	704
Length on keel	455	...	685
Beam	50	66	68
Depth	29	43	46

In the matter of depth of hull, the shallowness of the lakes is responsible for the above disparity.

Steam is very rapidly supplanting sails on the Great Lakes; in 1864 there were 624 steamers, aggregating 144,117 gross tons, and 1,855 sailing vessels, of 293,978 gross tons. In 1897 the sailing vessels aggregated 334,104 gross tons; while there were 1,775 steamers aggregating 977,235 tons, and 101 barges of a total of 60,783 tons. In other words, while the number of vessels has changed but little since 1864—2,543 against 2,-869—their total tonnage has increased from 438,-095 to 1,372,122 gross tons.

In regard to freight rates, the tendency has been steadily downward. This is shown in a general summary of results, from 1887 to 1896, inclusive, which is condensed as follows:

per ton. The cost of stripping the mine averages about the same; so that the aggregate cost of mining may be placed at less than 10 cts. per gross ton.

The cars used are especially designed for this ore traffic, and the expensive terminals are solely planned with a view to cheap handling of the ore. At some of these shipping ports the docks are built as high as 57.6 ft. above the water; and the ore-trains run upon them, dump the ore into pockets holding from 65 to 186 tons each, and from these pockets iron chutes lead directly to the holds of the vessels brought alongside the dock. Very little manual labor is required in this loading; though the ore has to be trimmed in the hold of the vessel at a cost of 2½ cts. per ton. The ore-receiving docks are similarly equipped with labor-saving devices. The chief item is the cost of shoveling the ore in the holds of vessels into the buckets; this charge amounts to 9 cts. per ton, and to this is added a dock charge of 5 cts., making 14 cts. per gross ton for the total expense of discharging iron ore. This ore, once in the buckets, is raised from the hold, carried back 350 ft. on the dock, and dumped, at a total cost of from 1 to 1½ cts. per ton, including labor, depreciation of plant, interest and fuel. Most of the ore is now loaded directly into cars and carried to furnaces located from 60 to 475 miles from the Lake Erie ports.

These improved loading and receiving docks are also partially responsible for the low transportation rates on the lakes; for instead of a vessel losing days in taking on and discharging cargo, this work is now done in a few hours. With the finely comminuted ores of the Mesabi ranges, which do not run so rapidly down the chutes as the hard and lumpy ores, 2,500 tons of ore can be put aboard a vessel in 70 minutes. At Two Harbors, 3,028 tons of hard ore were loaded in 70 minutes; and vessels frequently load and depart with a cargo of 3,500 to 4,000 tons within two hours of the time they reach port. With the appliances now in use for unloading, at the best docks, the largest vessels are unloaded in from 12 to 14 hours. At the new dock at Conneaut, O., to be operated in connection with the Bessemer Steamship Co. and the Pittsburg, Bessemer & Lake Erie Ry., it is expected that the largest vessels will be regularly unloaded in 10 hours; and it is hoped that in all but special cases this time will be reduced to 7 hours. The new plant is equipped with 12 "legs," one over each hatch in the vessel; and with all legs at work the capacity of the plant will be 900 to 1,000 tons per hour; or 7 hours for unloading a 6,000-ton ship. Owing to this perfection of transportation facilities, during the navigation season of 1896, large quantities of ore were carried from the head of Lake Superior to the lower lake ports, a distance of 889 miles, for 60 cts. per gross ton, or the equivalent of a ton-mile charge of only 0.67 mill. This low rate was even reduced to 50 cts. per ton for some weeks in 1897, or a ton-mile rate of 0.56 mill. During the early spring of 1895, red hematite ore of Bessemer quality was delivered at Cleveland for $2.80 per ton; in the summer and autumn of 1896, the price of this ore varied from $4.00 to $4.25, and in 1897 it was as low as $2.00 to $2.50. The influence of low rates is shown by the fact that if the lake rate per ton-mile were 3 mills, which may be taken as the lowest rate that a railway could afford, the transportation charge from Duluth to Cleveland would be $2.54 per ton, or more than the traffic could bear. A table of the ore-shipping docks on the Great Lakes shows that the length of dock, in one case, is as much as 2,304 ft., with a width of 52 ft.; this dock, that of the Duluth, Missabi & Northern Railway, at Duluth, is 53 ft. 8½ ins. above the water, has 384 pockets, and an ore capacity of 57,600 tons. There are 21 of these docks on Lakes Superior and Michigan.

General Summary of Freight Business from 1887 to 1896, Inclusive.

Season.	Total, ton-mile.	Total cost, transportation.	Cost per ton-mile, mills.	Average distance carried, miles.	—Value of craft— American.	Canadian.	Carried by Canadian vessels, %.
1887...........	4,458,544,804	$10,075,153	2.3	811.4	$17,684,550	$2,089,400	7.0
1890...........	7,207,299,415	9,472,215	1.3	797.2	27,857,700	1,777,800	3.5
1895...........	12,502,548,892	14,238,758	1.14	830.0	40,858,800	2,037,000	3.75
1896...........	13,582,641,886	13,511,615	.99	836.4	43,006,200	2,135,300	4.0

The total estimated value of freight passing through the St. Mary's Canal alone has increased from $79,031,757 in 1887, to $195,146,842 in 1896. In this time the bulk of freight passing the same waterway rose from 5,494,649 net tons to 16,239,-061 in 1896, and to 18,982,755 net tons in 1897.

The report enters largely into the flour and grain traffic; but while this is very important, the iron ore industry, as affecting lake transportation, is more generally interesting. The enormous amount of ore annually transported first arrests attention. In the navigation season of 1897, 10,633,715 net tons, out of a total of 18,982,755 tons passing through the St. Mary's Canal, were iron ore; and for the same year the total shipments of iron ore by lake from all the lake ports aggregated 13,681,-522 tons. This means that approximately two-thirds of all the iron ore consumed by the blast furnaces of the country passes over the waters of the lakes in its way from the mines to the furnaces. The excellent quality of the Lake Superior ore and the cheapness of its extraction has made this change in the sources of iron ore supply in 15 years. In mining, the steam shovel is largely used to dig it and load it onto cars. During one day, in 1896, three steam shovels, working 14 hours each, dug and raised 10,700 gross tons, or 428 car loads of ore, from the Oliver mine, of the Mesabi range. Cars holding 25 tons each are being continually loaded from the ore-bed at the rate of 2½ minutes per car; and the largest shovel has loaded as much as 5,825 tons, or 233 cars, in 10 hours. This shovel weighs 90 tons, has a hoisting capacity of 200 HP., and is equipped with a 2½-cu. yd dipper and loads 5 to 6 tons at each swing. The estimated average cost of loading ore into the cars from the bed of the mine is considerably less than 5 cts.

The coal traffic on the Lakes is important as furnishing the great bulk of the west-bound traffic; about 9,000,000 tons being shipped from the ports of Lakes Erie and Ontario in 1896. This trade from Buffalo, in 1873, amounted to only 570,443 tons, while that port shipped 2,400,068 tons of anthracite coal in 1896. The bituminous coal comes mainly from Cleveland, nearly 2,000,000 tons being shipped from that port in 1896. The chief western distributing points are Chicago, Milwaukee, Duluth and Superior, in the order named, but with Chicago handling two-thirds of the total. As with iron-ore, the handling of coal made necessary the development of facilities. The anthracite coal is usually loaded from pockets, and 5,127 net tons of this coal were lately put aboard the "Zenith City," at Buffalo, in 4 hours. In the loading of soft coal, however, very great innovations have been made. Until recently soft coal was shoveled, at a great cost, from cars to buckets, and then swung onto the ships by derricks; the loading is now done at the best docks by car-dumping machines, one of which, at Cleveland, loaded into a ship 5,176 tons of coal in 10 h. 30 m., at a total cost of $13, or ¼ ct. per ton. Coal is now generally unloaded by the self-filling clam-shell or grab-bucket. In the best type a speed of three trips per minute is guaranteed, with an average load of one gross ton; it is also guaranteed that the total cost of removing cargo and delivering it in the yard shall not exceed 5 cts. per ton for the entire cargo. At one of the Milwaukee yards, two vessels, whose cargoes aggregated 7,776 tons commenced discharging at 8 a. m. and were ready to leave at 8 p. m. For handling soft coal, a special form of "grate" has been devised. Coal rates are exceedingly low, owing to the scarcity of west-bound freight. The average of daily rates for 1896 was 24 cts. per net ton, from Buffalo to Duluth, or about ¼ mill per ton-mile.

Owing to the enormous drafts made during half a century upon the forests of Michigan, Wisconsin and Minnesota, the once seemingly inexhaustible timber supply of these regions is failing, and the lumber business on the lakes is waning. The lake shipment of lumber, from Saginaw River points alone, has steadily fallen from nearly 660 million feet, in 1885, to less than 90 million feet in 1897.

ANNUAL CONVENTION OF THE LEAGUE OF AMERICAN MUNICIPALITIES.

The second annual meeting of this association was held at Detroit, Mich., Aug. 1 to 4, and there was a very large attendance. The association is composed of cities, as corporations, which send numerous delegates and representatives. The attendance, therefore, included mayors, aldermen, public officers and a certain proportion of "politicians." In all, about 1,500 delegates were present, and the meetings were well attended. Owing to some hitch in the arrangements and the fact that the printed programs omitted to say where the meetings were to be held, the morning session of Aug. 1 was practically omitted, and the first regular session was called to order about 2.30 p. m. by the President, Mr. John MacVicar, Mayor of Des Moines, Ia.

Rev. C. L. Arnold opened the proceedings with prayer, after which the report of the Secretary was presented. In this it was stated that most of the work of the year had been in the direction of increasing the membership, and that in spite of certain interested antagonism, 72 cities are now members of the league. One of the most important departments is the bureau of information, which has issued three bulletins and answered 300 special enquiries, while a library of several hundred volumes has been collected. The report stated that, contrary to the requirements of the constitution, the Secretary had expended a large proportion of the receipts, without formal sanction, but that this had been necessary under the conditions. The receipts were $2,280, of which $590 was turned over to the Treasurer. The report of the Treasurer was then presented, and showed receipts of $590 and expenditures of $586.

Hon. H. S. Pingree, Governor of the State of Michigan, then delivered a short address of welcome, in which he pointed out that one of the most difficult and most important problems in municipal government is that of inducing the so-called "best citizens" to be something more than fault finders. He also favored trips by city officials to inspect the work and methods of other cities, and in this he is no doubt right, provided that these trips are not the mere junketing outings of aldermanic bodies and others which are somewhat too common, and are simply a means of wasting city funds.

The subject of "Garbage Disposal" was then opened by Mr. F. A. Walker, President of the Council of Trenton,

N. J., who prefaced his paper by the remark that it had purposely been made short, as he thought the best results of the convention would be obtained by an extensive discussion rather than by the presentation of the experience or opinions of one individual. He referred to the two systems of disposal by incineration and reduction, his own experience having been with the former, for the benefit of public health. At Trenton, a contractor is paid $6,000 per year for collecting and destroying the garbage (exclusive of night soil), the material being taken to a Dixon crematory, which has been in use for 2½ years, and has only cost $50 for repairs. It costs 30 cts. per ton for cremation alone. Night soil is carried five or six miles out by small contractors, who deal directly with the householders, while another contractor takes dead animals to a soap factory. Whatever system is used, should, in his opinion, be owned and operated by the city, as it is a matter of public necessity, and the collection should also be done by the city and not by contractors.

Mr. C. A. Collier, Mayor of Atlanta, Ga., said that all garbage, night soil, decayed fruit and vegetables, dead animals, etc., etc., is destroyed in a Dixon crematory four miles from the city. While this is thorough in operation, it is an expensive system, but nevertheless the city is quite satisfied, feeling justified in spending the money on behalf of the public health. The population is about 100,000, and the sanitary department expends $140,000 per year, which is considered money well spent.

Mr. F. B. Farnsworth, Mayor of New Haven, Conn., said that his city had an old-fashioned system of disposal which is not uncommon in the smaller cities. It lets contracts for the collection of garbage to men who have tracts of land and raise hogs, and what is not eaten by the hogs serves to fertilize the ground. The garbage includes nothing but kitchen refuse. He thought this system to be "good enough." The great trouble is to get the collecting properly done, as good men will not stay at this sort of work. At Worcester, Mass., a similar system is in force, but is under the supervision of the Superintendent of the Poor Farm, all the wagons, horses, etc., being owned by the city. One man is hired for each team, and with him goes one of the inmates. The garbage is utilized on the farm, as manure and food for hogs.

Mr. L. P. Whelan, Chairman of Council of Richmond, Ind., said the system of collecting by contract was not satisfactory, and this work had, therefore, been put in charge of the Health Officer. Garbage, night soil and refuse of every kind is carted to an Engle crematory near the river bank, in the middle of the city, natural gas being used for fuel. He did not think it well to insist upon the use of metal cans, as in winter the stuff freezes in the cans, which are damaged by the men breaking it loose for dumping.

Mr. Smith, of Moline, Ill., stated that in that city the collection of garbage is done under the supervision of the City Marshal. Mr. Hart, of New Orleans, referred to the trouble over the garbage contracts in that city, which has been fully described in Engineering News.

Mr. W. C. Maybury, Mayor of Detroit, said that his city has made a three-year contract at $50,000 a year, for collecting the garbage and delivering it on cars, which carry it out 15 or 20 miles to a reduction plant. It has happened that the contractors have done their work faithfully and well, but in view of the probabilities of carelessness and the evil results to public health which might attend such carelessness, he thought the city ought to do the garbage collecting. He argued that this formed an important part of the city's work in performing its duty to the health of its citizens, and that the responsibility should not be shifted to a contractor.

The meeting then adjourned, and the members proceeded to view an exhibition of throwing fire streams from a water tower and from the fire-boat on the river.

In the evening Mr. James A. Lavery, of Poughkeepsie, President of the Labor Federation of the State of New York, delivered an address on "The Relation of Municipalities to Organized Labor."

On Tuesday morning, Aug. 2, there was a reception by the Board of Education at the new Central High School, after which the regular meeting was held, the first subject taken up being "Administration by Boards, Single-Headed Commissions or Council Committees." Mr. W. E. Young, Mayor of Akron, O., favored the second plan, with one man at the head of each department, for water supply, fire protection, charity, etc. Mr. F. V. Evans, Mayor of Birmingham, Ala., strongly approved of the third plan, taking the view that the people's representatives should themselves attend to the affairs of their municipal government, and not delegate their authority or responsibility to boards or commissions.

An address on "Municipal Liberty, or Local Self-Government," was then delivered by Prof. Frank Parsons, of the University of Kansas. He did not approve of municipal affairs being so much under the control of the state legislatures, but thought each city ought to be allowed to govern itself without such general regulation. The comprehensive scheme of government suggested by him included municipal ownership of municipal industries, the initiative and referendum, and woman suffrage.

The afternoon session was opened by a discussion on "The Regulation of Saloons," in which most of the speakers presented liberal ideas, and denounced many of the present systems of restrictive regulation. The subject of "Street Paving" was then taken up, and Mr. R. J. Saltsman, Mayor of Erie, Pa., stated that asphalt and brick are now mainly used, on a concrete foundation, which is found to be superior to rolled gravel. The cost of asphalt is now $1.83 per sq. yd., with a five years' guarantee. Tramps are put to work cleaning the streets. Prof. Bemis, of the Kansas Agricultural College, gave an address on municipal ownership for electric lighting plants, and presented arguments and figures in favor of this system.

In the evening there was an entertainment at Belle Isle Park.

At the morning meeting on Aug 3 there was a large attendance, and the first subject taken up was "The Remuneration to Cities for Franchise Rights in, Over and Under Public Streets and Alleys." There was but little discussion, however. One of the speakers spoke strongly in regard to the point that improvement in municipal affairs can be secured only by citizens taking an active part in such affairs and not leaving them to politicians, who are financially interested.

The subject of "Public Water Supplies" was then opened by an address by Mr. James K. McGuire, Mayor of Syracuse, N. Y. This address described the growth of the present water supply system of that city, which is taken from Lake Skaneateles and flows by gravity to the city. Under corporate ownership, the distribution system was extended only on those streets where a remunerative return was assured, but very much better results have been obtained during the eight years of municipal ownership. Credit was given to Mr. Wm. R. Hill, M. Am. Soc. C. E., Chief Engineer, for his work in connection with this system, and for the introduction of day labor and the eight-hour day, which systems have been in use since Jan. 1, 1896. Mr. George Hillyer, President of the Water Board of Atlanta, Ga., then described the water-works of that city, where the water is forced up 500 ft. from the Chattahoochee River to a reservoir holding 30 days' supply, or 185,000,000 gallons. He strongly advocated the use of reservoirs of 20 to 40 days' capacity, especially where the water has to be filtered, as it facilitates the work of filtration. The most important part of his address was that in relation to the use of meters, the adoption of this system having reduced the fuel consumption and the pumpage to an enormous extent, and the pressure is now sufficient for fire purposes. The city is paid for about 57% of the amount consumed, and the maximum water rate is 10 cts. per 1,000 gallons. The consumer pays for the meter, and the city puts it in and keeps it in order. He favored mechanical filtration, as used at Atlanta.

Mr. M. H. Levagood, Mayor of Elyria, O., then exhibited a sample of the water supply of Painesville, O. There is a sand beach on the lake, kept clean by the wash of the waves, and in this a trench 800 ft. long was dug and filled with clean, sharp sand. The water percolates into this trench and flows through it to a cistern or tank, from which is drawn the supply for 7,400 people. The system has been in use for some years, and has cost practically nothing for repairs.

After the roll-call by cities the meeting adjourned. In the afternoon there was a boat ride on the river.

The morning session of Aug. 4 was devoted to a consideration of "Municipal Ownership of Public Service Industries," all the speakers favoring such ownership. Mr. Samuel F. Jones, Mayor of Toledo, O., read an address in which he referred to the various enterprises conducted by the city of Glascow, and pointed out that while people at large are patriotic enough to sacrifice position, health and life in time of war, they are lacking in that peace patriotism which would lead them to some self-sacrifice in the interests of their cities and their fellow-citizens. Mr. F. G. Pierce, Mayor of Marshalltown, Ia., and Mr. J. A. Johnson, of Fargo, N. Dak., also delivered addresses, taking the same general view.

In the course of the lengthy and animated discussion, one member asked how cities could acquire enterprises for which franchises have already been granted, without enormous expenses, which must be met by special taxation, general taxation or bonds. In answer to this, a delegate from Elwood, Ind., said that as the water company in that city did not give good service and could not be induced to sell out, the city built its own plant, and with such successful results that it is now arranging to build an electric lighting plant, raising the money by a tax of 8 cts. per $100. Prof. Parsons, of Kansas, said that at Springfield, Ill., a local lighting company was found which charged $150 per arc lamp. Of this amount, $60 is for the cost of lighting, and the balance is for interest, etc., and a sinking fund, so that in a few years, when the original investment has been paid, the plant will revert to the city without any further change.

Mr. Greene, formerly Mayor of Binghamton, N. Y., said that it should be borne in mind that a water or lighting company is in a legitimate business, and should be dealt with fairly and on a business basis, not as a criminal. He thought that even municipal ownership would be a failure without the civil service system and the exclusion of party politics. He thought every municipality should report to the state legislature, and after some further discussion a resolution was adopted in favor of such a plan, with a uniform system of accounting, while the resolution also provided that corporations conducting municipal enterprises should be required to report in a similar way. Prof. Bemis thought that a state legislature ought to have power to authorize a municipality to exceed its limit of debt, provided that the issue of bonds is for an existing plant as an asset, but in such case the charges must be sufficient to pay the interest and also form a sinking fund. Such a system is already in force in Massachusetts.

The afternoon session differed materially from the previous part of the meeting, the "politician" element being more in evidence, and the character of the proceedings somewhat resembling those of a ward meeting. The first business was the presentation of a report by the auditing committee, censuring the Secretary somewhat sharply for unbusinesslike methods and for not complying with the requirements of the constitution in regard to the conduct of the financial affairs. After a long and hot discussion this report was adopted, as were certain amendments to the constitution, by which the powers of the secretary are materially curtailed.

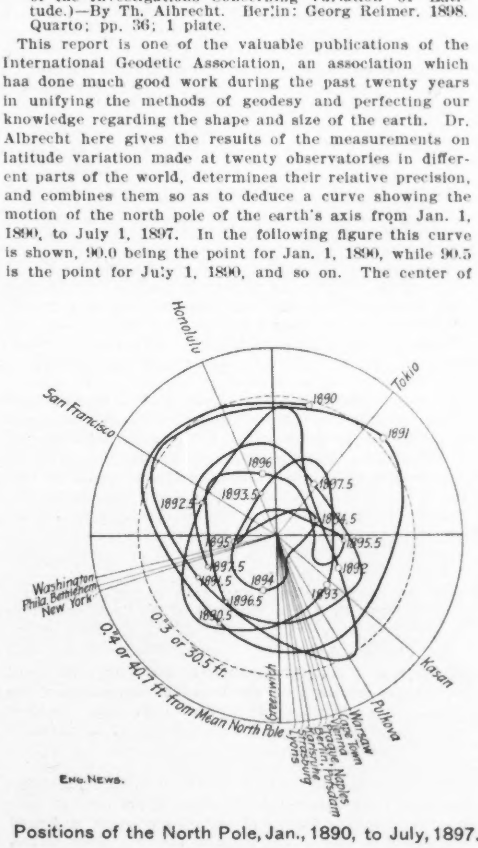
The election of officers resulted as follows: President, Samuel L. Black, Mayor of Columbus, O.; Vice-President, W. C. Maybury, Mayor of Detroit, Mich.; Treasurer, M. Taylor, Mayor of Bridgeport, Conn.; Secretary, B. F. Gilkison, New York city. It was also voted that the next meeting should be held at Syracuse, N. Y.

The exhibitors were few, and comprised the following firms: Dixon Garbage Crematory Co., Toledo, O.; Seagrave & Co., Columbus, O. (fire ladders and trucks); U. S. Voting Machine Co., Jamestown, N. Y.; International Street Sweeping Machine Co., Dayton, O.; Welsbach Light Co., New York, N. Y.; and the Atlas Cement Co., New York. The DeCarlie automatic compressed air catchbasin cleaner was also exhibited.

BOOK REVIEWS.

BERICHT UEBER DEN STAND DER ERFORSCHUNG DER BREITENVARIATION. (Report on the Status of the Investigations Concerning Variation of Latitude.)—By Th. Albrecht. Berlin: Georg Reimer. 1898. Quarto; pp. 36; 1 plate.

This report is one of the valuable publications of the International Geodetic Association, an association which has done much good work during the past twenty years in unifying the methods of geodesy and perfecting our knowledge regarding the shape and size of the earth. Dr. Albrecht here gives the results of the measurements on latitude variation made at twenty observatories in different parts of the world, determines their relative precision, and combines them so as to deduce a curve showing the motion of the north pole of the earth's axis from Jan. 1, 1890, to July 1, 1897. In the following figure this curve is shown, 90.0 being the point for Jan. 1, 1890, while 90.5 is the point for July 1, 1890, and so on. The center of



Positions of the North Pole, Jan., 1890, to July, 1897.

the figure is the mean position of the north pole for the 7½ years under consideration. In 1890 the pole made about seven-eighths of a circuit around its mean position; in 1891, but little more than three-fourths of a circuit, while in 1892 nearly the entire revolution was effected. The two circles drawn at 0.3 and 0.4 seconds of latitude from the mean pole give the scale of the figure, the radii of these circles being 30.5 and 40.7 ft., respectively. It should be noted that the north pole, which may be defined as the north end of the earth's axis, does not really move, since the axis remains parallel to itself throughout the year, but it is the earth which moves with respect to the axis; it is more convenient, however, to speak of the pole as in motion and the figure shows its path relative to the earth surface.

The practical consequence of this strange phenomenon is to cause a continual variation in the observed latitudes of all points of the earth's surface, for latitude expresses the angular distance from a point to the equator, and of course the equator moves with the pole, the plane of the equator being always perpendicular to the axis. For example, suppose that a certain point in our office had the latitude 40° 42' 58.93" on Jan. 1, 1891; if observations had been taken throughout the year it would have been found that this slowly decreased until in August it became about 40° 42' 58.41", and that an increase then followed until at the beginning of 1892 the observed latitude became about 40° 42' 58.67". It is thus seen that decimals of a second in astronomical latitudes do not have the precision which was formerly attributed to them.

The lines radiating from the center of the figure show the directions to the cities whose observatories furnished the data for deriving the curve. Of course, all these directions are south. The large number of observatories taking part in the work indicates the importance of the subject to astronomers and geodesists. The observations at Honolulu were conducted simultaneously by the International Association and by the U. S. Coast and Geodetic Survey from June, 1891, to July, 1892; simultaneously others were made by the Naval Observatory at Washington and by the Coast Survey at Rockville, Md. Those at New York were made at the observatory of Columbia University in 1893 and 1894. The most extensive series made in the United States is that conducted by Prof. C. L. Doolittle at the observatory of Lehigh University, in Bethlehem, Pa., which covers nearly four years. All these observations of latitude are made by the zenith telescope method. The curve given in the figure is the most probable one, derived by Dr. Albrecht from a discussion of all the records, and its degree of precision may be inferred from his conclusion that the probable error of location of a point of the curve is about 0.03" of arc, which corresponds closely to 3 ft. in distance.

Dr. Albrecht does not discuss the theory of the motion of the pole or give the equation of its path. We understand, however, that this has been done through the analysis of Prof. Chandler, of Harvard University. It is established that the pole makes a circuit around a certain center in 428 days, and that this center at the same time makes a circuit around the mean position in 365 days. The combined effect of these two motions is to cause the period of rotation to vary between 422 and 434 days and the distance of the actual from the mean pole to range from 16 to 36 ft. Whether this theory explains fully the curious path of the pole in 1895, when the motion appears to be reversed in direction, we are unable to state.

THEORY AND CALCULATION OF CANTILEVER BRIDGES.—By R. M. Wilcox, Ph. B., Instructor in Civil Engineering, Lehigh University. New York: D. Van Nostrand Co. Pasteboard; 3¾ × 9 ins.; pp. 108; illustrated; 50 cts.

This volume is published to replace the original No. 25, "Theory and Calculation of Continuous Bridges," by Prof. Mansfield Merriman, of "Van Nostrand's Science Series." The change of name and scope of the volume was considered advisable from the fact that the continuous girder has gone entirely out of use, except for swing bridges, and the cantilever bridge has taken its place. The book is divided into three chapters, the first of which is a brief history of cantilever bridge building, with short references to the larger structures of this type constructed in Europe and America. Chapter II. treats of the theory of the cantilever and the calculation of of strains under the conditions of loading common in highway structures, and Chapter III. is devoted to a similar consideration of railway cantilever bridges. The book is clearly written and provides a very handy little treatise on the subject which it covers.

HOW TO BUILD FIREPROOF AND SLOW-BURNING.—By Francis C. Moore, President of the Continental Fire Insurance Co. Author of "How to Build a House, etc." Continental Print. New York. Pamph.; 5¾ × 8¼ ins.; pp. 74, + 20. 10 cts.

Mr. Moore is the representative of the New York Board of Fire Underwriters, on the Board of Examiners of the Building Department of New York city. His pamphlet contains many interesting and valuable hints in regard to fireproof and slow-burning construction, together with a considerable number of statements which are based on insufficient information and are calculated to do harm rather than good. We commented editorially in our issue of June 30 on Mr. Moore's defence of cast-iron columns, and need only say here that he continues to advocate them in this book. He also betrays his well-known prejudices against concrete floor constructions, steel rivets, which he declares "are dangerous and should never be used, unless of a very superior quality," and curtain walls. He seems to think that the curtain wall as ordinarily used with steel skeleton construction is not thick enough to confine the heat in case fire occurs and prevent the ignition of adjacent buildings; but he gives no facts in support of this view, and we believe he would find it difficult to do so.

When Mr. Moore turns to matters more strictly in the field of fire protection, however, he lays down some sound principles, and his little book may be profitably studied by any engineer who will be careful to distinguish what is really sound and valuable from that which is based on prejudice and misinformation. Some of his suggestions, such as that of a glass floor for dynamo rooms, are novel and interesting.

WORKINGMEN'S INSURANCE.—By William Franklin Willoughby, United States Department of Labor. New York: Thomas Y. Crowell & Co. Cloth; 5½ × 8 ins.; pp. 386; tables: $1.75.

That this book might prove of great practical interest and value to some of our readers will be evident when it is stated that acording to its author workingmen's insurance abroad has developed very largely from the unsatisfactory working of laws relating to employers' liability. Such laws have proved inadequate for modern industrial conditions, both in the opinion of many employers of labor, of the laborers, and of legislators. Mr. Willoughby describes clearly and concisely what has been accomplished in the way of workingmen's insurance both in European countries and the United States. Both voluntary and compulsory insurance have been tried abroad, the former most notably in Germany. Some of the countries which neither make insurance compulsory nor provide it by governmental agencies have done much in the way of regulating private voluntary insurance. In the United States most of the attempts at workingmen's insurance described by the author are railway relief associations. Some space is also given to trade associations. The kinds of insurance described in this book are accident, sickness, old age and invalidity, and to a less extent life insurance proper. A few pages are devoted to insurance against lack of employment. One of the best chapters in the book is a critical discussion of the whole subject presented in the form of conclusions. Strange to say, the volume is without an index, a serious omission.

PROGRESS IN TIMBER PHYSICS.—Influence of Size on Test Results, and Distribution of Moisture. Circular No. 18, U. S. Department of Agriculture, Division of Forestry. B. E. Fernow, Chief of Division. Paper; 11¼ × 9¼ ins.; pp. 20; diagrams.

This circular gives the detailed results of experiments conducted by Prof. J. B. Johnson, of Washington University, and Mr. S. T. Neely, C. E., under the heads indicated in the title. The most important conclusions may be stated briefly as follows:

1. A difference in strength values derived from a few specimens of the same kind of wood, up to 10% for coniferous wood and to 15% for hard woods, cannot be considered a difference of practical importance; such differences cannot be relied upon as furnishing a criterion of the quality of the material. 2. The size of the test piece does not in itself influence strength values (except in compression endwise when the size is less than a cube). 3. Small test pieces judiciously selected furnish a better statement of average values of a species than tests on large beams and columns in small numbers. 4. A large series of tests on small pieces will give practically the same result as such a series on large beams and columns, hence there is no need of finding a coefficient with which to relate the results of the former to construction members. 5. The influence of moisture on strength appears even greater than the former tests and statements from this division have indicated. The most important discovery of all, worked out by Mr. S. T. Neely, may be stated as follows: The strength of beams at elastic limit is equal to the strength of the material in compression, and the strength of beams at rupture can, it appears, be directly calculated from the compression strength; the relation of compression strength to the breaking load of a beam is capable of mathematical expression.

PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—Forty-sixth Meeting, held at Detroit, Mich., August, 1897. Published by the Permanent Secretary. Salem, Mass. 8vo.; paper; 80, 499.

This volume contains, in addition to a list of officers, members and fellows, the Constitution of the Association, very brief abstracts of some of the scientific papers read at the Detroit meeting, and titles of the others, the addresses of the several vice-presidents of the Association before their respective sections, and the address of the retiring president, Dr. Theodore Gill. The latter was a memorial address on the life and work of Edward Drinker Cope, the distinguished naturalist, who had been elected to preside at the Detroit meeting, but who died a few months before. The titles of the addresses of the vice-presidents before the several sections are as follows: Section A—Mathematics and Astronomy. W. W. Beaman: "A Chapter in the History of Mathematics." Section B—Physics. Carl Barus: "Long-Range Temperature and Pressure Variables in Physics." Section C—Chemistry. William P. Mason: "Expert Testimony." Section D—Mechanical Science and Engineering. John Galbraith: "The Groundwork of Dynamics." Section E—Geology and Geography. I. C. White: "The Pittsburg Coal Bed." Section F—Zoology. L. O. Howard: "The Spread of Land Species by the Agency of Man; with Especial Reference to Insects." Section G—Botany. George F. Atkinson: "Experimental Morphology." Section H—Anthropology. W. J. McGee: "The Science of Humanity." Section I—Social and Economic Science. Richard T. Colburn: "Improvident Civilization."

It may be of interest to note the relative space given in this volume to the proceedings of the several sections, as follows: A—Mathematics and Astronomy, 62 pages. B—Physics, 30 pages. C—Chemistry, 27 pages. D—Mechanical Science and Engineering, 25 pages. E—Geology and Geography, 24 pages. F—Zoology, 38 pages. G—Botany, 44 pages. H—Anthropology, 102 pages. I—Social and Economic Science, 68 pages. Some of the statistics of the Association are also instructive. Its jubilee of the 50th anniversary will be held in Boston this year. The membership in 1897 was 1,610, the lowest figure since 1880. In 1883 the membership was 2,033, and from that date until 1896 it fluctuated between 2,054 (in 1891) and 1,802 (in 1896). The attendance at the Detroit meeting was 283, the lowest figure since 1879, when it was 256. There is abundant evidence in these figures that the Association is not filling the place that it should. In fact, for many years it has shown symptoms of decay. One cause, no doubt, is the wretched system of publication of its proceedings, of which this volume is one of the worst examples. Few of the addresses, which occupy the greater bulk of the volume, are of any permanent importance, and the rest of the book is scarcely worth garret-room. The society is about entering on a new regime, however. It has organized a committee on "Policy of the Association," which is expected to devise ways and means not only of preventing the death of the Association, but of infusing into it new life and making it creditable to American science and scientific men.

THE MINERAL INDUSTRY.—Its Statistics, Technology and Trade in the United States and Other Countries to the End of 1897.—Edited by Richard P. Rothwell, Editor of the "Engineering and Mining Journal." Vol. VI., supplementing volumes I. to V. The Scientific Publishing Co., New York and London. 8vo.; cloth; pp. 903; $5.

The sixth annual volume of "Mineral Industry" is a worthy companion of its five predecessors. It resembles them in being a most extensive collection of the statistics of about 100 different mineral substances, with brief statements concerning the location of their principal sources of supply, the history, the business prospects and the mineral and metallurgical development of each branch of the industry. It contains also a great number of articles on special subjects related to the mining industry, written by specialists in these subjects. We give the titles and the names of the writers of some of the principal writers below:

"Calcium Carbide and Acetylene," by Alfred H. Cowles; "The Manufacture of Hydraulic Cement in the United States," by Frederick H. Lewis; "Progress in Electro-Chemistry in 1897," by H. Borns; "Clay Ballast—Its Methods of Manufacture and Cost," by H. Foster Bain; "The By-Product Coke Oven," by W. H. Blauvelt; "Cyaniding Telluride Ores," by Philip Argall; "Gold Mining in South Africa," by E. D. Chester; "The Quicksilver Industry of Italy," by Vincente Spirek; "The Rare Elements," by L. M. Dennis; "Slate," by H. L. J. Warren; "Tunnel Rights Under the United States Mining Law," by R. W. Raymond; "Progress in Ore Dressing in 1897," by Robert H. Richards; "Fatal Accidents in Coal Mining in the United States and Canada," by Frederick L. Hoffman.

The volume contains a very complete index, containing, it is said, over 16,000 titles. We are informed that "Mineral Industry" was recently awarded a gold medal by the French De La Societe D'Encouragement Pour L'Industrie Nationale in testimony of the service which it is considered to have rendered in the promotion of industry in France.

DIRECTORY TO THE IRON AND STEEL WORKS OF THE UNITED STATES.—Embracing a Full List of all the Blast Furnaces, Rolling Mills, Steel Works, Rail Mills, Structural Mills, Plate and Sheet Mills, Tinplate Works, Steel-Casting Works, Wire-Rod and Wire Mills, Cut-Nail Works, Wire-Nail and Horse-Nail Works, Bolt, Nut and Rivet Works, Chain Works, Stamping Works, Bridgebuilding and Shipbuilding Works, Car-Axle, Car-Wheel and Carbuilding Works, Locomotive Works, Malleable Iron Works, Tube Works, Pipe Works, and Forges and Bloomaries. To which is added a complete list of the Iron and Steel Works of Canada and Mexico. 14th edition; corrected to April 1, 1898. The American Iron and Steel Association, 261 So. 4th St., Philadelphia. Cloth; 8vo.; pp. 380; $7.

The Directory of Iron and Steel Works is published every two years. The present edition is much larger and more complete than any of the earlier editions. The long sub-title above gives a general idea of its contents. The names and location of the works are given, arranged by geographical districts and alphabetically, followed usually by a description of their character, capacity and products, with the names of the principal officers. The iron and steel works of the country have a splendid organization for collecting statistical information, and the present directory is a credit both to Mr. Swank, the secretary and general manager of the Association, and to the whole American iron trade. We notice that two of the steel works, the Midvale and the Black Diamond, following their custom of previous years, have declined to furnish any information for the directory. Their action is odd, to say the least.

REGULARIZATION DU MOUVEMENT DANS LES MACHINES.—Par L. Lecornu. Ingenieur en Chef des Mines. (Encyclopedie Scientifique des Aide Memoire.) Gauthier-Villars et Fils, Paris. Paper; 4½ × 7½ ins.; pp. 217; 3 francs.

The theory of regulators of movement in machines, or governors, as they are usually called in English, is one of unusual difficulty to students. The present work may clear up some of the difficulties for those who can read French and who enjoy wrestling with equations in calculus. It is divided into two parts. The first treats of the theory of governors with indirect action, and is borrowed from the work of M. Leaute and put in accessible form. The second, or governors with direct action, is drawn from a memoir of M. Lecornu, for which he received the Fourneyron prize of the Academie of Sciences in 1895. The theory of governors, interesting in itself, leads to conclusions of practical value, for from it are formulated rules which should be followed by builders of machines in order to insure them a regular speed.