ENGINEERING NEWS AND AMERICAN RAILWAY JOURNAL.

VOL. XLII. No. 6.

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THE NEW HARBOR WORKS at Montevideo, Uruguay, are to cost about $15,000,000 and provide for a depth of water of about 30 ft. Complete plans of the work have been forwarded to the United States by Minister Finch, and are on file in the Bureau of Foreign Commerce in the State Department at Washington, where they may be inspected by interested parties. We learn from other sources that the government will guarantee the payment for the work, and that an unusual opportunity is presented to American contractors and capitalists.

WATER PIPE, for the extension of the water-works of Odessa, Russia, was first awarded to a Russian firm, says U. S. Consul T. E. Heenan, of that city. This contract was later cancelled by the city authorities and it was then awarded to an American firm. The French Ambassador at St. Petersburg requested the Russian government to annul this American contract and give it to a French firm, on the ground that "the close relationship existing between Russia and France entitled them to favors of this kind." The Governor of Odessa was instructed to investigate; but he reported that the city refused to change its arrangements, as it was well satisfied with the American contract. The specifications also called for a certain shape and quality of pipe which the French did not have and could not make. When the French Ambassador asked that these specifications be changed, his request was again refused, on the ground that the best engineering skill favored the American shape.

BIDS FOR THE LEAGUE ISLAND TIMBER DRY-dock were opened at the Navy Department on Aug. 5. The cost was fixed by Congress at "not exceeding $825,000." The bids were as follows: Farrell & Hopper, New York, $1,182,600; McGaw & Roosevelt, Philadelphia, $1,220,000; McIlvain-Unkelfer Co., Pittsburg, $1,143,569; Curtis & Driscoll, Springfield, Mass., $750,000; George Pierce, Bangor, Me., 949,973; Atlantic, Gulf & Pacific Co., New York, 749,000, and $3.50 per sq. ft. for steel approaches; Dagnon-MacLean Construction Co., New York, $957,000. The general dimensions of this dock are: Length over all, 750 ft.; width on top, 144 ft.; width on floor, 80 ft.; entrance width, 101 ft.; depth from top to floor, 40 ft.; draft at mean high tide, 30 ft. The Pennsylvania delegation to Congress are making a strong effort to have the plans for this dock changed to stone or concrete; and the recent grave defects uncovered in the old timber dry-dock there strengthen their demands. The above bids cover engines, boilers, pumping plant, steel caissons, buildings, wharves and all accessories complete.

THE BUREAU OF YARDS AND DOCKS, through Rear-Admiral M. T. Endicott, Chief of Bureau, is considering the expenditure of about $6,000,000 for new dry-docks, piers and buildings at the New York Navy Yard. The removal of the Cob Dock by dredging and the formation of a large basin by the addition of its land area to this basin was recommended by Captain F. E. Chadwick. This plan would involve the sacrifice of about 7½ acres of extremely valuable land at a yard where the area on the water front is already too small. The plan proposed by Peter C. Asserson, C. E., U. S. N., Engineer in charge of the New York yard, would seem to be better. This plan provides for the utilization of the water front of the Cob Dock by the building of piers; the construction of two piers within the Whitney Basin and the addition of two dry-docks to the yard equipment. This plan would provide eight new piers, the two dry-docks and a bascule bridge across the Wallabout Channel. These new piers, by their position, would also deflect the ebb tidal flow through the Wallabout Basin into the river, and benefit the river channel and yard alike. The final report of Admiral Endicott on these propositions is awaited with interest.

A LIGHTHOUSE IN THE ST. LAWRENCE RIVER, at the Travers, is being established. At this point the river is from 6 to 9 miles wide, while the channel is only one-quarter mile wide. The rise and fall of tide is about 26 ft., with a current running about 8 miles per hour. The foundation for the lighthouse has been secured by sinking a heavy wooden crib in about 20 ft. of water at low tide, and then riprapping the structure. The light will be established about 30 ft. above high tide, making the structure 76 ft. high above the base. The sinking of the crib was attended with considerable difficulty, owing to the rapid current. The work was carried out under the direction of Sir Louis Davies, Master of Marine and Fisheries for Canada.

A PRIZE OF $30,000 FOR LIFE-SAVING DEVICES, in disasters at sea, is offered by the family of the late Anthony Pollok, who, with his wife, perished in the "La Bourgogne" disaster. Mr. Charles J. Bell, trustee and manager of the Pollok estate in Washington, D. C., has transmitted this offer to the U. S. State Department, with the provisions that $20,000 is to be given for the production of the invention and the remainder is to be used in extending the information obtained through the competition. Mr. Bell will doubtless have any number of applications for the prize; but the general usefulness of results will largely depend upon the manner in which the fund is handled.

THE McKINNON LIFE-SAVING DAVIT was successfully tested at the American Line pier in Jersey City on Aug. 3. The shipping interests were represented by officials from the American, Cunard, North German Lloyd, Anchor, White Star and Old Dominion companies. The mechanism of this new device permits of persons entering the lifeboat before it is launched, and the davit is operated while they are in the boat. In the test of Aug. 3 a boat was lowered in one minute and twenty seconds. The steamship "New York" will be equipped with this new device when she sails on her next eastward voyage.

THE HOLLAND SUBMARINE BOAT has been under test by the United States Naval Board in Peconic Bay, L. I., and it is said that the results have been very satisfactory. The boat is to be equipped with Diesel petroleum engines.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a derailment of the Los Angeles express just south of Dos Palos, Cal., on the Southern Pacific, Aug. 8. The engineer and fireman were scalded to death and two passengers were seriously injured. The cause of the accident is said to have been a broken flange on a wheel of the mail car.

A TROLLEY-CAR LEFT THE TRACK on a trestle on the line of the Shelton Traction Company's road, near Bridgeport, Conn., on Aug. 6, and plunged into the marsh beneath. The killed number 29, and about a dozen people were more or less seriously injured. The car ran at a high rate of speed down a 3% grade on the embankment leading to the trestle, and left the rails when passing onto the latter, after which it ran about 80 ft. upon the ties and then toppled over the side. There were no inside guard rails on the bridge, but 6 x 10-in. oak stringers were bolted to the ends of the ties. This was the first day that the road had been thrown open to the public. Cars are now being run regularly over the bridge but at reduced speed.

A STEAMER GANG-PLANK GAVE WAY at the Mt. Desert ferry of the Maine Central Railroad, near Bar Harbor, Me., on Aug. 6, and precipitated 200 people into the water, 20 of whom drowned before they could be rescued. The gang-plank is said to have been 40 ft. long and 10 ft. wide, carried by a hinge at its inner end and supported by chains at the outer end. It was constructed of 2-in. plank laid on five 4 x 12-in. timbers, which were trussed with three 1-in. iron rods. The nuts of the latter pulling through the cross piece at the outer end led to the failure of the wooden beams. The structure was comparatively new, having been built only a few months.

LEAD POISONING FROM LEAD SERVICE PIPES at Lowell, Mass., is causing much agitation in that city. The Massachusetts State Board of Health has investigated the matter and reports that the trouble is due to the carbonic acid in the water from two of the three driven well plants, supplying the city. One sample of water analyzed showed nearly 23 parts per 100,000 of lead, whereas 0.05 parts is considered dangerous. The water in this case was drawn through a lead service pipe 285 ft. long. Water drawn through galvanized iron pipe shows large quantities of zinc, and the Board states that ordinary wrought iron pipe, while giving rise to no injury to health, might render the water unsatisfactory. It states that tin or tin-lined lead pipes could be used with safety, and that cement-lined iron, if the work was thoroughly done, would also be satisfactory.

A VOLCANIC ERUPTION began on the island of Hawaii on July 4, a new crater opening on the side of Mauna Loa at an elevation of about 11,000 ft. above sea level. "The Hawaii Herald" of July 20 contains accounts of a visit to the crater by a party including Mr. C. H. Kluegel, Chief Engineer of the Hilo Ry. Co. He states that volcanic action is evident along a line about two miles long, at one end of which is the crater of July 4, which is now smoking. About a mile from this is the crater which is at present flowing. The rim of this crater is about 80 ft. above the general surface and 250 ft. in diameter at the top. The flowing lava escapes over a break in one side and flows down the cone in a stream estimated at 60 ft. in width and 15 ft. in depth. It flows with a velocity estimated at 40 ft. per second, and falls some 80 ft. in the first 400 ft. of its flow. At the crater explosions follow one another in rapid succession, sometimes several in a second; and the lava is thrown 150 to 250 ft. in the air. The lava flows for half a mile from the crater in a narrow stream with a velocity rivalling the rapids in the Niagara gorge; it then spreads out over a broad, flat area, and forms a lake nearly a mile in width. The heat from the eruptions is so great as to considerably modify the climate of Hilo, the chief city of Hawaii, and make the summer hot and oppressive.

THE IRON-ORE PRODUCTION of the United States for 1898, says Special Agent John Birkinbine, was 19,278,369 long tons; this is 1,760,323 long tons, or about 10%, in excess of the previous maximum product of 1897. This output for 1898 is also greater than that of any other country for one year; the maximum being 18,026,049 long tons mined in Great Britain in 1880. Of American ores produced, 83% of the total was red hematite and 10.3% brown hematite; the remainder was magnetic and carbonate ores. Of the total, Michigan produced 7,346,846 long tons; Minnesota, 5,963,509; Alabama, 2,401,748; Pennsylvania, 773,082; Tennessee, 593,227; and Virginia and Wisconsin also produced over a half million long tons.

PIG-IRON PRODUCTION in the United States for the first six months of 1899 amounted to 6,289,167 tons, according to the statistics collected by the American Iron and Steel Association. The production for the first and second half of 1898 was 5,869,703 and 5,904,231 tons respectively. Of the total for 1899, Pennsylvania produced 3,047,998 tons, and Ohio, 1,075,033 tons. According to fuel used, 5,478,655 tons of the total were made with bituminous coal.

THE "EGGETTE" FUEL ENTERPRISE, which was started several years ago to make artificial fuel from coal-dust slack or other finely-divided fuels, but failed to secure financial success, has again been put in operation, and we are informed that a mill at Portsmouth, R. I., is completed, with a capacity of 400 tons of "eggette" fuel in 24 hours. The process consists in moistening the coal dust with a binding material, and, after thoroughly mixing it, passing it between heavy rolls with egg-shaped cavities in their surfaces. The material is compressed in these cavities, and drops from the rolls smooth, dense and shining. By this process it is said that the deposits of Rhode Island anthracite, which are at present useless, can be made available for fuel. The process is controlled by the National Eggette Coal Co., of Philadelphia, Pa.

COKE IS TO BE USED AS A LOCOMOTIVE FUEL on the Boston & Maine R. R., the supply being obtained from the by-product coke ovens of the New England Gas & Coke Co., near Boston. The locomotives using coke are fitted with water grates. About a dozen have now been changed, and it is expected to have 100 locomotives ready to use coke by the end of the year. Besides the saving of smoke it is expected that the coke will prove advantageous in reducing the number of fires set by locomotives.

THE MASAYA-DIRIAMBA RAILWAY OF NICARAGUA.

The National Railway of Nicaragua, connecting Grenada, on Lake Nicaragua, with Corinto, on the Pacific coast, has been in operation for some years; though one 35-mile section of this route is operated by water transportation across Lake Managua. For some time past a branch railway has been under construction, from Masaya, on the Eastern Division of the National Railway, to Diriamba, southwest of Grenada; and for the following description of this railway we are indebted to Mr. Emil Mueller, C. E., of Masaya, Nicaragua.

This line of railway will open up one of the most populous, richest and most picturesque portions of Nicaragua. Leaving the main line at Masaya, it touches the villages of Catarina, Niquinohomo, Masatepe, San Marcos, and Jinotepe, with its terminus at Diriamba, situated on the west slope of the mountain range skirting the whole Pacific coast line of Central America. Catarina and San Juan, near by, are distinctly Indian villages; but all the others named have a mixed population, with agriculture as the chief occupation.

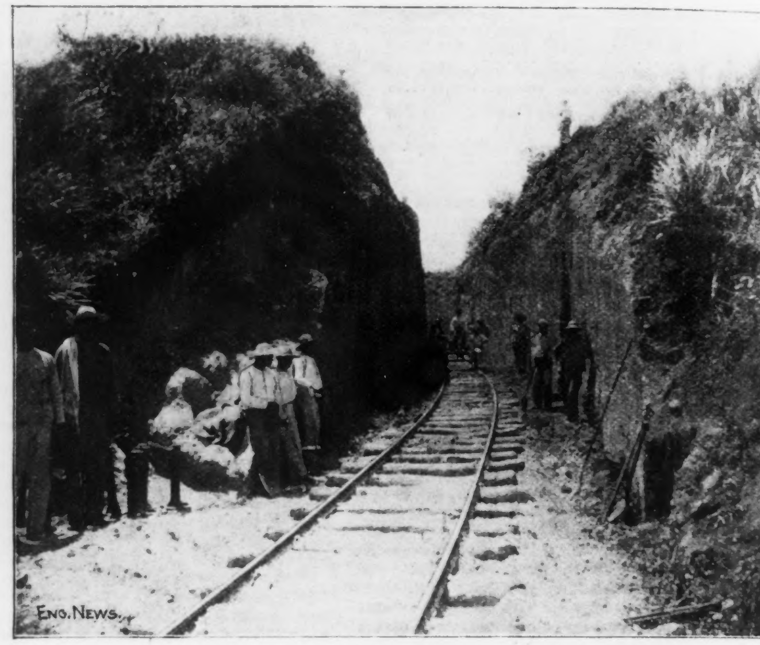
The entire region traversed is well cultivated; and in the higher sections, near San Marcos and Jinotepe, are located some of the finest coffee plantations of the country, with a good-year output of at least 50,000 quintals, of 100 lbs. each. The lower areas are well adapted to the cultivation of sugar-cane, rice, maize and beans; the three last products forming the principal food of the country. The extensive plains lying between San Marcos and Niquinohomo are largely utilized in cattle raising.

Masaya lies 771 ft. above sea-level, and from this initial point the line climbs up the hills through a short tunnel, and by deep cuts and high embankments to a point 6½ miles from Masaya, where the line skirts the precipitous sides of the Lagoon of Apoyo, an old volcanic crater now filled with salt water. The beautiful lake thus formed is three miles in diameter and its surface is 298 ft. above sea-level, and the railway is built inside this old crater at an average height of 1,200 ft. above the water in the lagoon. From points on this location the scenery is most impressive. To the northwest lies Lake Managua, with its smoking volcano of Momotombo, while in another direction we have the beautiful city of Grenada, on the shores of Lake Nicaragua, and the towering peak of the extinct volcano of Mombacho. Across Lake Nicaragua the mountain range of Chontales appears, and far to the south is the Orosi, in Costa Rica.

The climatic conditions are excellent. At Masaya, the average temperature is about 80° F., and the annual rainfall is 60 ins. Up in the villages skirting the line the temperature is some degrees lower; but during the dry season the northeast trade winds blow with great force and continuously across all the country.

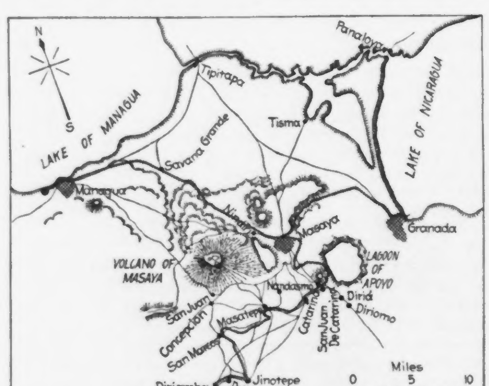
The lack of a sufficient water supply is one of the great difficulties encountered in some of these villages. Catarina has a good spring, coming from one of the ravines in the old crater and heading about 500 ft. above the lagoon; but the road to it is very bad, and in the rainy season it is almost impassable. Niquinohomo has some wells, and Masatepe has a water-works, which pumps water from a spring, near Lake Masaya, 1,100 ft. up the hill to a tank in the village. Unfortunately these pumps are out of order for about ten months in each year. Diriamba has two fine artesian wells, and a third is to be sunk by the contractor for the railway. San Marcos and Jinotepe are very badly off for water; in the latter village a "cantero" of five gallons of water costs 30 cts. in silver, in the dry season. Artesian well water could be secured almost anywhere in this region; and the sinking of wells of this type would not only greatly benefit the country, but also prove a highly profitable enterprise.

PORTAL OF TUNNEL BETWEEN MASAYA AND CATARINA.



DEEP CUT NEAR TUNNEL, MASAYA-DIRIAMBA BRANCH.

VIEWS ON THE EASTERN DIVISION OF THE NATIONAL RAILROAD OF NICARAGUA.



Map of Eastern Division of the National Railroad of Nicaragua.

In 1895 a contract was made by the Nicaragua government with Messrs. Morris, Heyden & Co., of Managua, to construct the branch railway here described; and this firm later associated with it Mr. Julius Wiest, C. E., of the same place, as Chief Engineer and General Manager during construction. The road was located by the contractors, and this work was performed by Mr. Emil Mueller, assisted by Adolfo Cardenas, C. E., of Managua. The earthwork was in charge of Dr. Bruno Mierisch, M. E., and Mr. Wm. Simpson had the management of the general construction. Though political disturbances have caused some delay, the trains are now running to San Marcos, and it is expected that the whole line will be shortly completed.

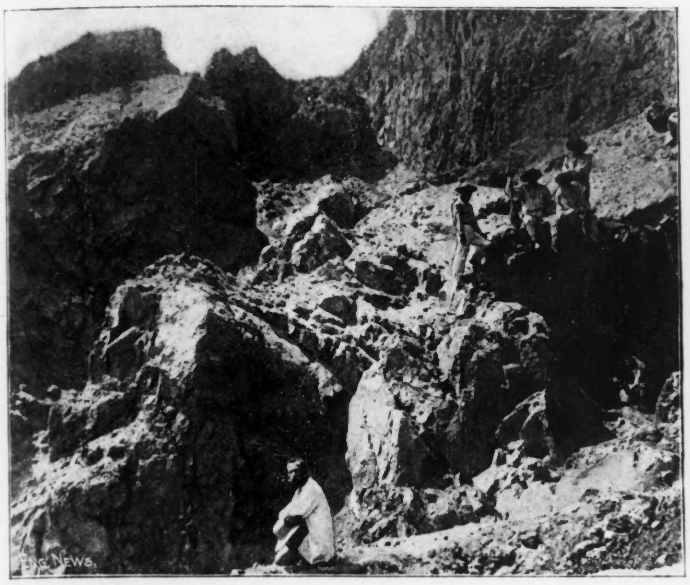
The material handled is volcanic in its origin, and consists chiefly of ashes and sand, deposited by the trade winds on top of the original formation. As may be expected, the depth of these deposits is greatest on the slopes facing the old volcanoes; and they become thinner towards the Pacific and disappear altogether beyond Jinotepe. All cuts and fills are 13 ft. wide, with the usual slopes. The deepest cuts are along the lagoon, where there is one cut 63 ft. deep on the center line and on a slope of 43°. There are no bridges on the line; all the gullies are filled from the excavation and from borrow-pits, and in two cases the fills are 53 ft. high by 200 to 300 ft. long. To accommodate the water passing down the ravines in the rainy season, lasting from May to November, tunnels were driven to one side of the fills, with open cuts on both sides. There are three such tunnels, from 40 to 45 ft. long and 3 x 5 ft. in area; the one at Diriamba was lined with brick.

All work was done by native labor; three men were given from 50 to 500 ft. to excavate or fill, according to the character of the work, at a price fixed before work was commenced. If a harder material was met with than that on which the price was originally based, a new arrangement was made for that part. When completed, the section was inspected, and payments were made every Sunday. These men often hired their own help and thus succeeded in doing a remarkable amount of work; some of them making $2.50 per day in silver.

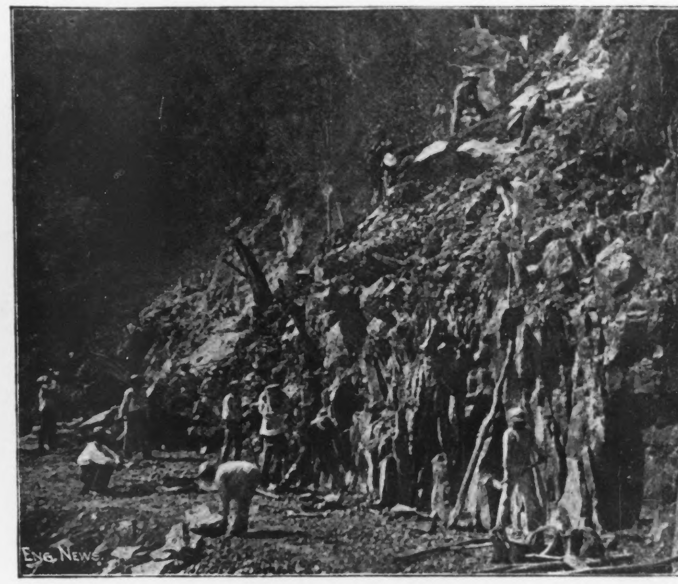
The gage of the branch railway is 3 ft. 6 ins., or the same as on the main line. The rails weigh 30 lbs. to the yard, as compared with 40 lbs. on the old line. The ties are laid 2,400 to the mile, and these are mostly of guachipilin and madera negro wood; many mahogany ties are also used. By special order from the government, all coffee plantations had to be avoided as much as possible. and this ruling involved the use of many curves, some of them very sharp. This was all done to save a few shade trees on the plantations. The total length of the line is 142,000 ft., or nearly 27 miles. Of this length 37.7% is in curve, ranging from 2° to 15°. The section between Masaya and Catarina was the most difficult to construct, and it has 48.1% of curved line in a total distance of 8 miles; one 15° curve has a central angle of 175°. Owing to lack of room for so doing there was no compensation for curvature. The maximum grade is 2.8%, and some of the 15° curves are on grades of 2.5 to 2.7%. On the whole line there are 107 curves, with an average central angle of 8.47°, and the longest tangent is 4,494 ft.

The wooden station buildings are nearly all 45 × 132 ft. over all, with a 12-ft. platform all around, and a galvanized corrugated arched roof. The engines were made at the Baldwin Locomotive Works, and they are of the mogul type, weighing 22 tons. The fuel used on all the government railways in Nicaragua is wood.

As before remarked, the main line, from Grenada to Corinto, is divided into two divisions by Lake Managua. The western division, from Corinto to Momotombo, is 58-ft. miles long, and overcomes a maximum elevation of 416 ft. above sea level. The Managua-Grenada Division is 31 miles long and has a highest elevation of 820 ft., near Masaya. On both divisions the grades do not exced 2.8%, and the sharpest curve is 9° 30′. These two divisions are connected by a line of government steamers making daily trips across Lake Managua, between Managua and Momotombo, a distance of about 35 miles. There is also a small branch railway, 4 miles long, connecting Chimandega and Viejo; and there are well appointed repair shops at Ameya, 10 miles from Corinto, and at Managua. By an act of the Nicaraguan Congress, passed in 1898, the President is authorized to sell all these railways and the government steamers on the lakes.



VOLCANIC TUFA BEFORE BEGINNING WORK.



A SIDE HILL CUTTING.

ROCK CUTTING ALONG APOYO LAGOON.

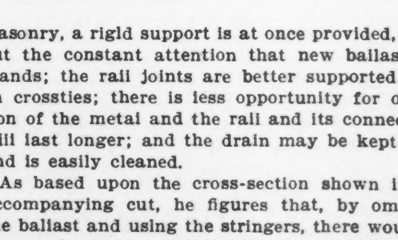
The following table will enable the reader to better understand the map published:

Villages.	Distance from Masaya, miles.	Elevation above sea, feet.
Catarina	8.09	1,663
Niquinohomo	9.76	1,508
Masatepe	14.73	1,501
San Marcos	20.21	1,786
Jinotepe	24.43	1,870
Diriamba	26.91	1,920

COMPARATIVE ADVANTAGES OF BALLASTED CROSS TIES AND UNBALLASTED LONGITUDINALS FOR RAILWAY TRACK IN TUNNELS.

Mr. Jules Michel, in the "Revue Generale des Chemins de Fer," for April, discusses the comparative advantages and cost of using ballasted crossties and unballasted longitudinal stringers for railway track in tunnels. Mr. Michel urges in objection to the use of crossties that the ballast in contact with the metal retains humidity and hastens the oxidation of the rails and their appurtenances; the replacing of the rails and ties is costly; the ballast has to be renewed; and, finally, to provide space for the crossties and ballast requires deeper excavation and more tunnel masonry. To obviate these objections he urges the use of the longitudinal stringers resting directly on the masonry of the invert, or the use of crossties without ballast, as in the Metropolitan underground railway of Paris. He claims that ballast is not an indispensable element in a roadbed, but that it is an expedient only. Its purpose is to spread the pressure from an imposed load over a greater area, when the soil is compressible. This being the case, the thickness of this bed of ballast should be proportionate to the compressibility of the subsoil. When the subsoil is incompressible, however, the ballast is useless and should be omitted, just as it is omitted on a majority of European metallic bridges where the wooden longitudinal has a firm support. The experience on bridges, says Mr. Michel, proves that the track-stringer method meets all the demands of operation. When once well laid the stringers last for a long time without cost for maintenance, and when worn out they can be replaced at a less cost than crossties more or less embedded in ballast.

Another feature in favor of the introduction of stringers in tunnels, and the suppression of ballast, is the decreased excavation and masonry required. With ballast, the distance between the top of the invert masonry and the level of the rail is usually about 3.28 ft.; without the ballast, half this depth is sufficient, and about 5.25 cu. yds. of excavation is saved per lineal meter. This decreased depth of excavation is an important consideration in constructing underground tunnels in cities, especially if the water level of a nearby stream comes into the problem, as in Paris. By placing the wooden stringers directly upon the masonry, a rigid support is at once provided, without the constant attention that new ballast demands; the rail joints are better supported than on crossties; there is less opportunity for oxidation of the metal and the rail and its connections will last longer; and the drain may be kept open and is easily cleaned.



Sketch Illustrating the Saving in Excavation by Using Longitudinal Timbers for Supporting Tracks in Railway Tunnels.

As based upon the cross-section shown in the accompanying cut, he figures that, by omitting the ballast and using the stringers, there would be 3 cu. m. less excavation per lineal meter of tunnel; 2 cu. m. of ballast that need not be provided, and 0.8 cu. m. less masonry to be built. As for the stringers themselves, as compared with crossties, he assumes that 16 crossties to a rail length of 12 m., or 39.36 ft., would amount to a cube of wood equal to about 1.4 cu. ft. per lineal foot of track. These crossties are each 8 ft. 10¼ ins long, 9½ ins. wide and 5½ ins. thick. The stringers he proposes would be 11¾ ins. wide and 5 ins. thick, and the cube of wood per lineal foot would be a little less than for the crossties. On the other hand, however, the longitudinal timbers will cost, in Paris, about twice as much as the crossties; and there will be an additional considerable expense in providing some means of firmly seating the longitudinals on the masonry. He finally estimates an additional cost of about 55 cts. per lin. ft. for the stringer method, but says that this increase will be largely compensated for by the decrease in cost of maintenance, and by the advantages due to a higher excavation level in city tunnels.

The author mentions that ballast is omitted in the City & South London tunnel, though crossties are used. This plan was adopted to diminish the interior dimensions of the tunnel and to avoid the dust from ordinary ballast. The objection made to it is an increase of noise from the passage of trains. In 1886 the track in the tunnel under the Severn, in England, was also laid on longitudinals without ballast, and the same was done in the Mersey tunnel, at Liverpool. In the latter case the noise was not objected to, but the roadbed was declared to be too hard and unyielding, the T-rails being laid directly on the stringers. The builders of the Central London Ry. have also adopted longitudinals, but have substituted a bridge-rail for the T-rail. The Waterloo & City Ry. (London), lately opened, has its track laid on longitudinals.

Mr. Michel thinks that cushion plates should be used between the rails and the longitudinals, and between the latter and the masonry, to give the roadbed the elasticity it would otherwise lack. Under the rail he would suggest the usual steel tie-plates, as these increase the holding power of the fastenings, and the life of the wood, and allow the rails to bend slightly between these supports. Iron bed-plates could be employed under the longitudinals, but he suggests that advantageous use could here be made of compressed turf-fiber, in plates about ¼-in. thick, which have been experimented with on the line of the Eastern Railway of France. These plates are elastic and durable and tend to make the roadway less noisy.

THE LEAGUE ISLAND DRY-DOCK, built only eight years ago, is being repaired under an appropriation made by the last Congress. The workmen find the Southern yellow pine in the part above low tide even more decayed than was expected. The condition exposed is another argument for granite or concrete construction in works of this character.

STRUCTURAL WORK OF THE ST. LOUIS COLISEUM.

(With two-page plate.)

The St. Louis Exposition Building, which is owned by the St. Louis Exposition & Music Hall Association, is about 323 × 460 ft., outside dimensions, occupying an entire city block. In 1897 it was decided to remodel the northern end of the building, and to erect a coliseum or convention hall, 318 × 189 ft., measured inside the walls. The structural design was made entirely independent of the masonry walls, and was based upon the three-hinged arch system, which has been so conspicuously adopted in large train-sheds, and was a feature of some of the largest buildings of the Columbian Exhibition of 1893. The arches rest upon independent footings or foundations, and the curtain walls (which are those of the original structure, except that a new wall was built on the south side) are attached to the structural steel framing in order to give them the necessary stability. The ends of this framing are semicircular, an arrangement which called for special design. The Coliseum has an arena 222 × 112 ft., clear of the curb wall. Ordinarily there are seats for 7,000 persons on the main floor and the galleries, but for convention purposes (with seats in the arena) the number can be increased to 12,000 persons. Fig. 1 is a plan of the whole building.

The steel framework consists essentially of a central arched section adjoined at each end by a half-dome formed by six radial arched trusses. The main trusses, forming the central section, have a span of 178 ft. 6 ins., c. to c. of shoe pins, which are just above the floor line, and the height from shoe pins to apex is 80 ft. There are four of these trusses, spaced 36 ft. 8 ins. apart, c. to c., and connected in pairs by the lateral wind system, as shown in Fig. 4. The upper ends of the cripple trusses or radial arches rest against semicircular rings or collars about 12 ft. in diameter, one at each end, which abut against the main outer trusses at their end verticals, 6 ft. back from the apex pins. The ends of the collars are attached to the main trusses by horizontal pins 3 15-16 ins. diameter, the connection being in direct line with the top purlins. These latter are of special design, having heavy top chords proportioned to resist compression, and act as struts to carry the thrust coming from the end arches across the three central panels. The unbalanced thrust due to wind acting against either end of the structure is resisted by the system of lateral bracing in the central section. This bracing is attached to the upper or outer chord of the main trusses. Above the haunches the diagonal ties are angle irons 5 × 3 ins., riveted by plates to the chords of the arch and to the top chord of the purlins, which latter are utilized as struts. Below the haunches, the diagonal ties are adjustable rods, and are attached to the girders carrying the balcony and floor framing, as shown in Figs. 4 and 6.

The main trusses have chords or ribs of I-beam section, built up of plates and angles, the outer flange of each chord having a broad cover plate. The details of their construction are shown in Fig. 2. The cripple trusses, Fig. 3, are of similar design, except in the top panel, where the diagonal is reversed, and where the pin is at the top rib instead of in the center line of the truss. This pin connects the truss with the semicircular frame or collar above referred to. The pin is the apex of the truss proper, but a light framing was added below in order to facilitate erection and to maintain a uniform outline of the ribs. The chords are partly of I-beam section and partly of T section, as shown. The main trusses are connected by plate and lattice girders between the outside vertical ribs, with diagonal bracing in the upper panels and knee bracing in the bottom panels. This arrangement is shown in Fig. 4, from which it will be seen that the diagonals are attached to connection plates riveted to the trusses and girders. There are also two lines of lattice girders connecting the front vertical ribs of the trusses. In the upper portion, forming the roof, are trussed purlins, of the form shown in Fig. 5, placed about 15 ft. apart. The top lines of purlins on opposite sides of the apex are of special design, and are connected by cross frames and bracing. Fig. 6 shows the general plan of the trusses and bracing, and also of the floor, gallery and roof framing.

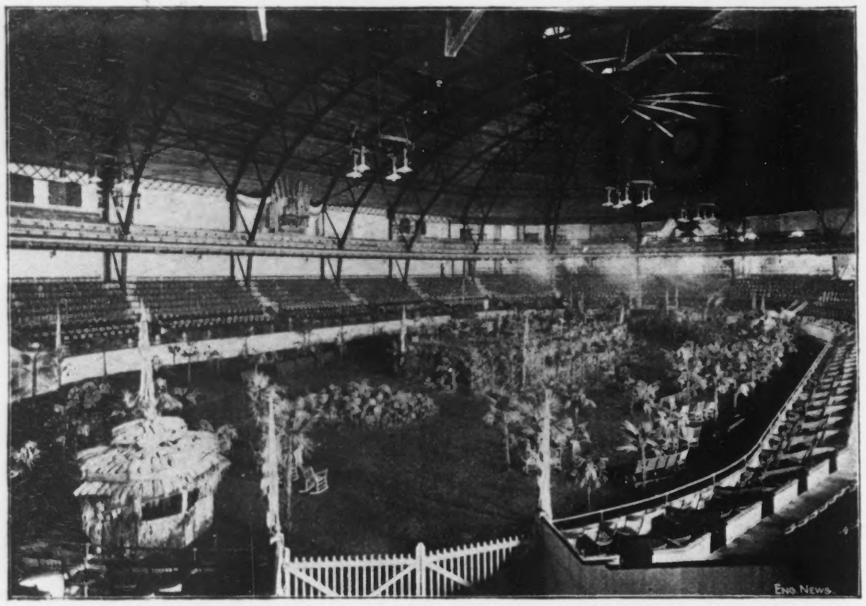


FIG. 6.—INTERIOR VIEW OF THE ST. LOUIS COLISEUM.

It will be seen from the cross section, Fig. 2, that the main floor "banks," or inclined rows of seats, are carried by 9-in. I-beams supported by a low wall, by the lower line of plate girders connecting the outer ribs of the trusses, and by a lattice girder connecting the inner ribs. The banks of the gallery are supported by inclined 8-in. channels, 3 ft. 8 ins. apart. The rear ends of these channels are attached to the upper line of plate girders connecting the outer vertical ribs of the trusses, while the front ends are attached to a lattice girder connecting the inner ribs. The channels project as cantilevers 5 ft. 4 ins. beyond the lattice girder. Fig. 7 is a detail of the framing of the lower banks, which consist of 9-in. I-beams 3 ft. 8 ins. apart, with angle iron members forming steps 2 ft. 8⅝ ins. in width, and 1 ft. 6 ins. in height. By this arrangement of the "banks" the entire load is carried by the shoe pins, with the exception of the small proportion carried by the wall which supports the front end of the main floor beams.

The apex pins are 2 15-16 ins. diameter for the main trusses and 2 7-16 ins. for the cripple trusses, while all the shoe pins are 4 7-16 ins. diameter. There are no transverse tie-rods between the shoes, which are, therefore, placed in an inclined position on inclined concrete pedestals, in order to transmit the horizontal thrust to these foundations.

The steel purlins carry wooden rafters 2½ × 16 ins., 3 ft. apart, to which are nailed ceiling boards on the lower side, and 1⅜-in. roof boards on the upper side, the latter carrying the asphalt and gravel roofing composition.

The vertical loads on the roof and floor framing were as follows: Purlins, 46 lbs. per sq. ft. (wood and composition, 17½ lbs.; steel, 3½ lbs.; snow and wind, 25 lbs.); beams and girders of banks and galleries, 140 lbs. and 112 lbs. per sq. ft.; columns and banks and galleries, 105 lbs.; beams, columns and girders of attic floors, 60 lbs. The lateral bracing is proportioned to resist a wind pressure of 30 lbs. per sq. ft. The cripple trusses are coupled together in pairs with lateral rods down to the haunch. The compression ribs of all the arches are braced against side motion by angle iron ties, connecting to the first panel point in the bottom chords of the purlins. Diagonal rods are also placed in the plane of the first diagonal braces above the haunch, connecting the bottom rib of each truss to the top rib of the next truss. No struts were used between the bottom chords, as they would have been in the line of vision from the rear gallery seats.

To facilitate the shop work, the center lines of a half arch were carefully laid down at full scale on the laying-out floor, and from this the templates were made. By this means, great accuracy in the matching of holes was obtained with a minimum of drafting work, and but little reaming was necessary in assembling the pieces. In erection, the side sections of the trusses were first set up on the pedestals by means of shear-leg derricks, being held up by shores, and were then connected laterally by the main and gallery stringers. The sections from the haunch to the apex were then riveted up on the floor, and timbers were lashed to them to ensure stiffness. The complete section was tilted up by shear-leg and the two traveler derricks, the latter then hoisting it into place. The traveler was 63 ft. long, 31 ft. wide and 42 ft. high, with two stiff leg derricks on top. These derricks had 24½ ft. masts and 34 ft. booms, with a ⅝-in. steel cable carried from the falls to a double drum hoisting engine at the rear of the traveler. The boom falls were of 1¼-in. hemp rope, worked by a hand crab on the floor of the trench. The cripple trusses at the east end were raised by the traveler, as it faced eastward, but at the west end only the two outer trusses could be handled in this way, and the others were hoisted into position by a shear-leg derrick having a pole lashed to it. The erection occupied 3,550 days' labor, about 50 men being employed.

The architect of the building was Mr. Charles K. Ramsey, 824 Wainwright Building, St. Louis; Mr. Louis H. Sullivan being Consulting Architect, and Mr. Julius Baier, Assoc. M. Am. Soc. C. E., Consulting Engineer. The stress diagrams were prepared by Mr. E. W. Stern, M. Am. Soc. C. E., then Engineer for the Koken Iron Works, and the drawings were amended by Mr. Baier before they were approved by Mr. A. H. Zeller, Engineer of the St. Louis Board of Public Improvements. The general contract was awarded to the Hill & O'Meara Construction Co., and the ironwork was built and erected by the Koken Iron Works, of St. Louis.

For the plans and information we are indebted to Mr. Ramsey and Mr. Baier, and also to a paper by Mr. E. W. Stern, on "The Steel Frame of the St. Louis Coliseum," published in the Journal of the Association of Engineering Societies for May, 1898.

THE FORM AND SPEED OF ELECTRIC MOTORS DIRECT CONNECTED TO MACHINES.

By Alton D. Adams.*

Electric motors connected to machine tools have thus far been mostly of some standard type, selected without special care and attached to the driven machine in any convenient manner. An arrangement of this sort may or may not give satisfactory results in operation, but its general appearance and convenience is quite sure to be

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that of two machines attached through necessity, rather than that of one design with properly related parts.

As motor connection becomes more common, the tendency will be to make the motor a necessary, symmetrical part of the driven machine, and it is fortunate that the nature of an electric machine permits this adaptation.

The electric motor consists broadly of two electro magnets, one surrounding the other, and the inner one adapted to revolve.

The outer magnet or frame must have a rigid connection with the bearings that support the shaft of the inner magnet or armature, but the frame may have almost any shape, without effect on its capacity or efficiency. A motor of given speed and capacity requires certain cross-sectional areas in those parts of the magnet frame about which coils are wound, and in those parts called poles, which lie next to, but do not touch the armature; beyond this the frame may have almost any desired shape.

For illustration, Figs. 1, 2, 3, 4 and 5 show types of bipolar magnet frames of the same capacity, and Fig. 6 shows an armature designed to fit any of the frames. If a thin, wide motor is wanted, the multipolar type will be found well suited, as in Figs. 7 and 8, where a magnet and armature are shown having about half the length parallel to the shaft of the bipolar designs in Figs. 1 to 5, but of the same capacity.

The bearings and motor armature and the magnet, if attached independently to the driven machine, should be secured to the same part, as exact alinement of the armature with the magnet bore is very important.

As many machine tools have large metal sections in parts of the bed or the frame, this metal may sometimes serve as part of the magnet frame for the motor, thus saving in first cost and adding to the simplicity, security of alinement and symmetry of the combination.

The relation between the speed of the motor spindle and that of the main working spindle of the driven machine is a most important point. The speed selected for the motor will affect its first cost, size, weight, and to some extent efficiency, besides influencing the method of attachment.

Range of speed in machine tools is fixed by requirements of the work and cannot vary to suit the motor, so that relation between speed of motor and required speed of work, must depend on the method of connection.

The question of connection can usually be at once reduced to one of three alternatives, namely, armature mounted on working spindle, single reduction spur gear between armature and main spindle, double reduction spur gear between armature and main spindle. To decide between these three methods for any particular case is not always easy, but in nearly all instances the single or double reduction will prove the best, and in most single reduction will have the final preference.

Motors with double reduction spur gears were early used for driving street cars. Then came a reaction to the gearless motor mounted directly on the car axle, and practice has now settled on the single reduction spur gear.

The problems of driving street cars and machine tools have many points of difference; yet they are enough alike to give much weight to results reached as to connection after much practice in the former line.

First cost, efficiency and reliability are the three considerations on which the choice of geared or gearless motors for connection to machine tools must mainly turn. The geared motor has a decided advantage as to first cost, and may be expected in general to have a cost one-half to one-third that of the gearless type.

With equally good design in each, the gearless motor has an efficiency which may be stated as 10 to 15% below that of the geared type, but as there is a loss of from 5 to 10% in good spur gearing, the per cent. of consumed energy delivered to the working spindle will not be far apart for the two methods, though the geared motor will show a small saving in many cases.

The gearless motor is quite sure to be more complicated than the geared type, as the number of parts will be from two to four times as great, owing to multipolar construction. As each separate part is as essential to the operation of one type as the other, the motor with two to four times the number of magnet coils, armature coils, commutator segments and other elements is quite sure to require more frequent repairs. As size and weight are much greater in the direct-connected than in the geared motor, the former has less chance to become a symmetrical part of the machine tool, but must in most cases retain its entire individuality.

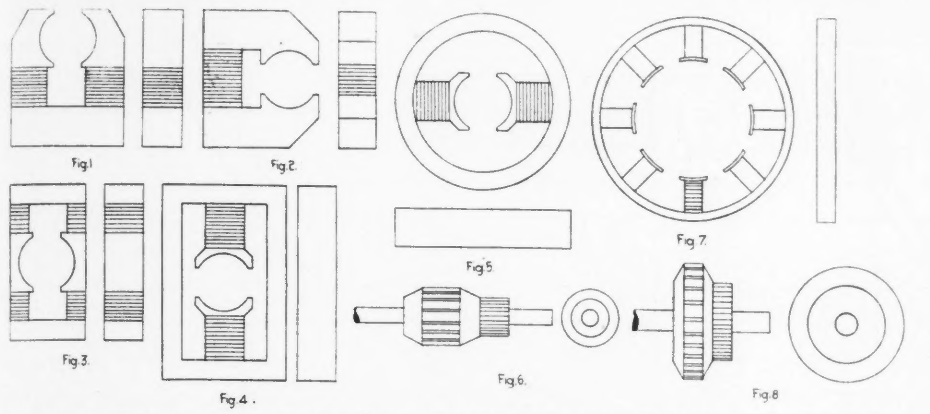
To show the great difference in size and weight between the geared and direct-connected motor for given capacity, consider the case of a machine tool whose main spindle must revolve 200 times per minute at lowest rate. A motor for direct connection at 200 revolutions per minute, to deliver 2 HP., would weigh from 600 to 700 lbs., and 60% at full load would be a good efficiency for it. The cost of this motor at market prices should be about $250 to $300 at the factory.

If a motor with a speed of 1,000 revolutions per minute, which would readily gear at once to the 200-revolution spindle, is used, its weight should be from 250 to 300 lbs., its efficiency 75 to 80% and the market price $100 to $150. In this last case, then, the weight and cost of the geared compared with the direct-connected motor will each be about half, while the geared motor, allowing loss of 10% in gears, will have a net efficiency of 10 to 15% more than the direct-connected type.

The magnet frame dimensions for the direct-connected motor would be about that of a cylinder of 30 to 35 ins. diameter and 7 to 9 ins. long; in the geared machine the magnet should come within the sides of a solid figure about 14 x 12 x 16 ins.

When tens and perhaps hundreds of machines in a factory are each driven by an independent motor, simplicity of construction and ease of repair must be given some weight, and these qualities certainly attach in a higher degree to the high speed than to the very low speed motor.

Multipolar motors are well adapted for very low speeds, but for the range of speed probable for geared motors, the small capacities necessary for machine tools being considered, the bipolar type will in many cases be found cheaper, simpler and of a more convenient form.



Figs. 1 to 5, Fields for Bipolar Electric Motors of Different Forms but Equal Capacity. Fig. 6, Armature for Fields, Figs. 1 to 5. Figs. 7 and 8, Field and Armature for Multipolar Motor of Same Capacity as Figs. 1 to 5.

A 2,000-HP. TRI-COMPOUND ENGINE DIRECT CONNECTED TO A 10,000-VOLT FERRANTI GENERATOR.

For the past winter there has been in operation at the works of the London Electric Supply Corporation at Deptford a 2,000-HP. steam engine direct connected to a Ferranti generator, which is of interest owing to its novel design.

The complete engine consists of three separate tandem compound vertical engines, mounted on the same bedplate and connected to cranks spaced 120° apart. The high pressure cylinders are 19½ ins. in diameter, and are uppermost in each case, the low pressure cylinders being 43 ins. in diameter, and the common stroke 26 ins. The piston rods are continuous, and are threaded for half their length, so that the nut locking the low pressure piston has to be screwed down half the length of the piston rod. This threaded piston rod slides in a long gland between the cylinders, an odd construction to say the least.

Each engine has a single strap eccentric, which operates the valves of both high and low pressure cylinders. The low pressure cylinder has an ordinary flat slide valve mounted directly on the valve rod, which extends on up, outside the high pressure cylinder, to a rocker mounted on top of the cylinder. To the other end of this rocker is attached the rod of the cylindrical high pressure valve. Steam is admitted through the inside of this valve, and exhaust occurs around the outside. The admission cut-off for each engine is controlled by a Pickering fly-ball governor, all operated from the main shaft by bevel gears and small supplementary shafts.

The main shaft is 12 ins. in diameter, and is made in three sections, bolted together. It is made of Siemens-Martin forged steel, and runs in 6 main bearings 15 ins. long. Under normal conditions, with steam at 140 lbs., the engine makes 150 revolutions per minute. Each of the three separate engines is provided with a separate system of steam condensers and atmospheric exhaust, drains, etc., so that any one part can, if necessary, be run idle or disconnected. Directly connected to the engine, but on its own bedplate, is a single 10,000-volt generator of the same type as the other generators in the station. This machine consists of a revolving wheel armature and a stationary field. The armature is a heavy 8-spoked cast-iron wheel with a steel tire shrunk on. It weighs about 38 tons and is made in two sections. To further strengthen the wheel, eight 6-in. tie bolts are passed radially through the tire, and screw into a large steel ring shrunk on the driving shaft inside the space left between the sections of the wheel hub. The driving shaft is 20 ins. in diameter at the center, and tapers to 12 ins. at the bearings.

To the outside of this wheel are radially bolted the 64 flat bobbins forming the armature coils. These are made by winding strips of copper about a form with silk and vulcanite insulation between the convolutions. The coils thus formed are mounted in pairs between bronze clamp-plates, which are provided with substantial lugs, which are in turn secured to a pair of heavy and carefully insulated pins projecting from the periphery of the wheel. The coils are then connected in series and the two terminals led down to the collector rings secured to the hub. As the armature coils swing on a circle with a 22 ft. diameter, the peripheral speed, when the engine is running at 153 revolutions per minute, is over 1,000 ft. per minute.

The field consists of two heavy circular cast frames, each with 64 field bobbins projecting at right angles to the plane of the circle. These castings with their magnets are slid over the shaft and brought up on each side of the armature, until the bobbins leave a narrow space within which the armature coils move at the rate of 1,000 ft. per minute.

At the time the equipment was installed, it was subjected to a test pressure of from 15,000 to 20,000 volts and a current output of nearly 300 amperes or practically double its rated current output.

TRIPLE SCREWS FOR WAR VESSELS.

In our issue of April 27, we published a paper by Admiral Geo. W. Melville, Chief of the Bureau of Steam Engineering, U. S. N., advocating the use of three screws for all war vessels of large size. In the discussion of this paper by the Institution, considerable dissent was expressed from the author's conclusions. In reply to this discussion, Admiral Melville has presented some additional data for publication in the Institute's transactions, and we present this rejoinder nearly in full as follows:

I note that the principal desire expressed by the members of the Institution in regard to this paper is for more data. Much of the information used by me in the preparation of this article is such as I have no right to make public. I am, however, at liberty to give the results obtained from a consideration of the data, and I have done so. The number of trials from which the conclusions were drawn, something over 200, was considered too small upon which to base any absolutely accurate figures, although establishing fully the general law. On that account such figures as have been included in my paper have been specifically stated to be tentative. They are subject to alteration as a result of future experiment. I have attempted so carefully to avoid any exaggeration of the advantages of triple screws that I think the figures enumerating the economic gains due to their use, both for high and low powers, will be found greater rather than less than those given in my paper.

In deference to the expressed desire of the Institution, I submit such data regarding the performance of triple screw ships as may be communicated without breach of a public trust.

Fig. 1 is a speed and power curve of certain battleships reduced to 12,500 tons displacement by Froude's well-known laws of comparison, giving a separate curve to those ships fitted with triple screws. All trials from which these curves were constructed are of ships of approximately the same size; none of them being of less than 10,000 tons displacement; all belong to the same navy; they have the same character of hull and the same general under-water body. They are, in fact, almost identical in all respects, with the exception of the propelling machinery and of the slight modifications in the under-water body necessary from the introduction of a central screw in the ships so fitted.

Consideration of these curves will show at once that the power required is, in all cases, high in proportion to the speed. This is due to the peculiar character of the hulls in all of the ships considered. It is to be noted, however, that these characteristics obtain in the cases of the triple-screw battleships as well as in those fitted with a twin-screw system. The points marked by small circles are obtained from actual trials, and include the power of the auxiliary machinery.

Fig. 2 is a speed and power curve of cruisers, reduced to 11,000 tons displacement by the same laws of comparison. While these vessels are not so homogenous in type as the battleships cited, it will be noted that there is with them about the same gain for the triple-screw system in the power required to attain a given speed. This difference is somewhat greater than that which I have given in my paper as the probable advantage to be derived from the use of triple screws. Each point is from the actual trial of some cruiser, although they are not all from the same navy. Only a part of these trials include the power of the auxiliary machinery.

It appears to me that these curves, drawn as they are to give the fullest advantage to the system of twin-screw propulsion, develop fully the superior efficiency of the triple-screw system for full power trials; or, indeed, wherever all engines are in use. However, as Sir William White says, the matter of the propulsive efficiency of the propellers is but one of the desiderata to be sought in the design of a naval vessel. I submit, however, that the superior propulsive efficiency of triple screws is an element of considerable advantage in their favor, although it must by no means be considered the deciding one. The deciding point in this matter seems to me to be the fact that naval vessels do at least 90% of their cruising at speeds below 16 knots. In vessels of the fast type now so universally prevalent the condensation in the low pressure cylinders is enormous when the ships are making these low speeds.

Mr. Barnaby has pointed out that the greater efficiency of propulsion incident to the use of three screws and consequent upon the utilization of the following wake would apparently imply that a single propeller is more efficient than are twin screws. I have stated that up to a certain speed I consider that a single screw is most economical. Beyond that speed it is necessary to increase the size of this screw so greatly that the efficiency of the propeller is considerably reduced on account of the increased friction, and also on account of the increased difficulty of securing a free run of the water to the blades. I am not sure when the critical point is passed. In the light of experience, however, it would seem that for ships having a maximum speed of as much as 15 knots the advantages due to the division of the propelling instrument into two screws are more than equivalent to the loss due to working these screws in the less advantageous position under the quarters of the ship. This may explain why twin screws are in many cases more efficient than single screws. The use of triple screws, however, includes not only the advantages due to the use of smaller screws, but also the advantage due to the following wake. Triple screws must, therefore, always be more efficient than twin screws.

Data concerning the cruising efficiency of ships fitted with triple screws have been obtained from various sources. Tests of the steam consumption of the main and auxiliary engines of the triple-screw cruiser "Minneapolis" have been made. Trials have been made of this and other ships working with 1, 2 and 3 screws at (A) constant speed; (B) constant power; (C) with a fixed coal consumption.. Trials have been made of the "Kaiserin Augusta" (the details of which have been published), with and without a dragging screw. We have made trials of the "Minneapolis" at a constant speed, and have measured the speed of rotation of the central screw (A) when revolving freely, and (B) when connected with the central engine. Several twin-screw ships have been tried with one engine, with a resultant gain in coal consumption at the lower speeds when there was not only a heavy drag from the idle screw, but also a considerable rudder resistance. Trials have been made of the "Kaiserin Augusta" working with one engine (A) with the center engine and (B) with one of the wing engines, in either case the other screws being left to revolve freely. The difference in power required to attain a fixed speed in the last trials measured the resistance of the rudder.

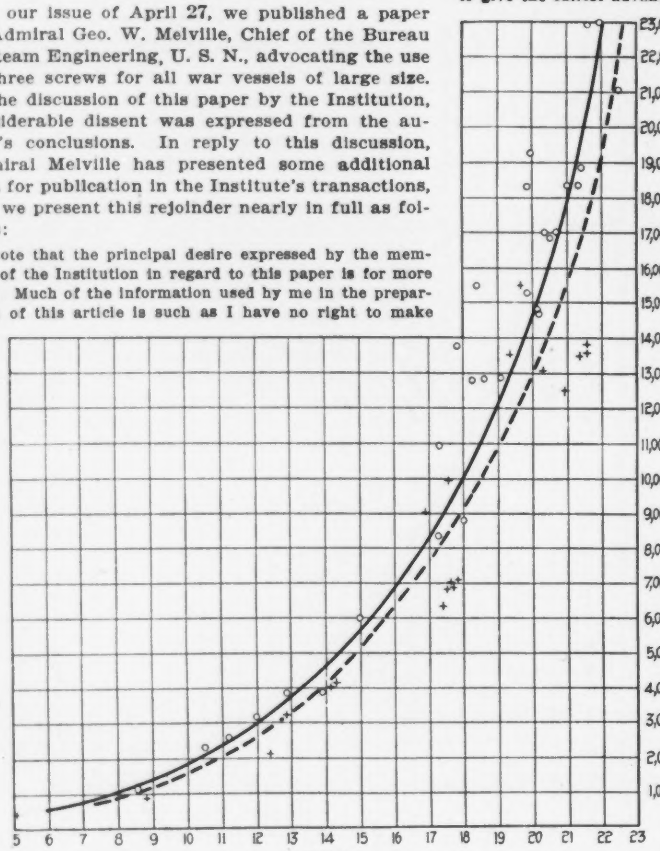


FIG. 1.—SPEED AND POWER CURVES OF BATTLESHIPS OF 12,500 TONS DISPLACEMENT.

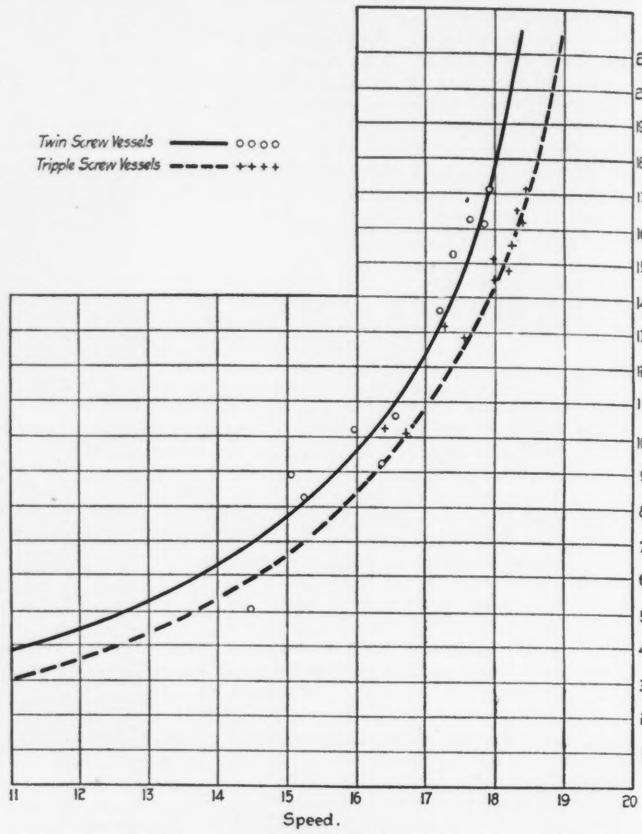


FIG. 2.—SPEED AND POWER CURVES OF CRUISERS OF 11,000 TONS DISPLACEMENT.

The trials of the "Kaiserin Augusta," which were conducted with great thoroughness, measured accurately the drag of the screw and also the resistance of the rudder, the latter being, at a speed of 14.1 knots, considerably more than twice as great as the drag of two idle screws when one of the wing engines was used alone. These trials developed fully the further fact that there is not sufficient propeller area in the central screw (the three screws being equal) to drive the ship economically at a speed greater than 9 knots. Trials of the "Minneapolis" were made with a constant coal consumption and working with both one and two engines, and with absolutely the same auxiliaries in use in both cases. It had been found that the condensation in an engine was approximately a constant irrespective of the power developed, this condensation increasing slightly for the lowest powers. On these trials with a fixed coal consumption, with two engines in use, 938 HP. were developed, giving the ship a speed of 9.53 knots. With one engine only in use there was sufficient steam to give 1,236 HP., though the speed of the ship did not exceed 9.36 knots. Knowing from previous experiments exactly the steam consumption per horsepower of these engines, it was possible to ascertain accurately the condensation, which was found to be, as has been stated in my paper, about 1 lb. of water per HP. of the maximum power of the engine.

The resistance of a dragging screw was measured in the experiments with the "Kaiserin Augusta." It, as well as the engine friction, was also obtained on the "Minneapolis" in the following manner: The number of revolutions of the central engine when coupled with and turned by its dragging screw was observed accurately for a fixed speed of the ship, and also the number of revolutions of this screw for the same speed of the ship and when uncoupled from the central engine. The power developed by the propelling engines (the two wing engines) was observed for the two conditions and the difference between these powers measured the unloaded engine friction of the center engines. Further, on the assumption that the resistance of the dragging screw varied as the square of the difference between the number of revolutions made by it and the number of revolutions which would give it a zero slip, there was obtained the ratio between the resistance of the screw and the resistance of the engine and screw combined. The resistance of the dragging screw ascertained in this manner agreed very closely with that obtained from the results of experiments on the "Kaiserin Augusta."

It is of importance to note that the unloaded engine friction of the central engine was, at a speed of ten knots, considerably greater than the drag of the central screw when the latter was left to revolve freely. If it be granted that the engine friction varies as the power of the engine (this is only an approximation of the correct rule), it is evident from the above that the horse-power required to attain a speed of ten knots is greater with two engines than it would be with one if the latter has sufficient propeller area to avoid excessive slip. This is quite apart from the saving due to the decreased condensation of the engines. In fact, the "Minneapolis" ran at the rate of 9.73 knots with 1,872.6 HP. and with one engine, while with two engines to make a speed of 9.71 knots, she required 1,940.94 HP. On the other hand, however, the speed of the "Kaiserin Augusta" was 9 knots with two engines developing 932 HP., while for a speed of 9.07 knots with one engine 1,050 HP. were required. As I have said, in order that one engine alone may work properly, it is necessary that the propeller should be of sufficient disk area, which is not the case when the propeller is designed to transmit but one-third of the full power, and it is to this cause that I attribute the above comparatively unfavorable results. Experience with twin-screw ships has shown that propellers having a disk area of one-half that which is necessary to drive a vessel at a full speed of as much as 20 knots, are efficient at ordinary cruising speeds. It appears to me that these results form a very strong argument against the use of a small central engine for cruising purposes.

The figures set forth in my paper as to the power absorbed in the drag of the screw are the maximum; those given as to the gains due to the use of triple screws under cruising conditions are minimized. Instead of stretching the case in favor of three screws, I believe that I have done rather the reverse. I have been careful to give the established twin-screw practice the benefit of every doubt, which I think is quite proper. There are, however, a great many points in favor of the triple-screw system which are touched upon in my article, and which have not been controverted in the least. I cannot say that I recommend the installation of triple screws in all naval vessels, but wherever as much as one-half the total power is sufficient to obtain a speed of, say, 16 knots, that system appears to me to be the only logical one to install.

The weight and cost of the machinery in a triple-screw ship is certainly no greater than for large twin-screw machinery of the same power. It is possible, as was shown off Santiago, in the case of the "Minneapolis," to couple up, without damage, the central screw of a triple-screw ship while the vessel has a speed of 18 knots. This was actually done, and is an instance of the great tactical advantage possessed by triple screws over the method of arranging two engines on the same shaft, a system which our recent war experience will probably prevent us from installing in any future naval vessels. In the discussion of my paper, attention has been called to the engines not ordinarily in use under cruising conditions with triple-screw practice. I desire to call attention again to the fact that there is quite as much power not in use in two-screw practice for the same ship and speed. Further, the idle power in triple-screw practice is maintained in much more efficient condition while cruising, and this with considerable more ease than obtains if all the machinery is in motion.

The matter of the short lengths of shafting outside the ship with triple screws is one to which I think not sufficient attention has been paid. It would avoid the necessity for the 70-ft. propeller shafts which, I believe, are now being used.

As to the space gained by the arrangement of triple-screw machinery proposed by me in this paper, I may say, that, in a design now being prepared, it is found that the use of a large central engine and two small engines saves enough space below the protective deck from that required for twin-screw machinery to install the evaporating plant of this ship and to provide for a pump-room.

The United States Navy had a twin-screw ship in 1862, the "Forbes," and for river service in the Civil War had a great many multiple-screw ships, called at the time "Tin-clads." There was also the "Agamenticus" class of twin-screw monitors, constructed in 1863 for our navy. These were four ships of something over 3,000 tons, and one of them visited the Thames something over 30 years ago. This was some time before Sir William White first advocated the use of twin screws in the British Navy.

In conclusion, I desire to thank the Institution for the discussion of this paper. I regard intelligent criticism, whether favorable or the reverse, as of much value in bringing out the points of any matter at issue.

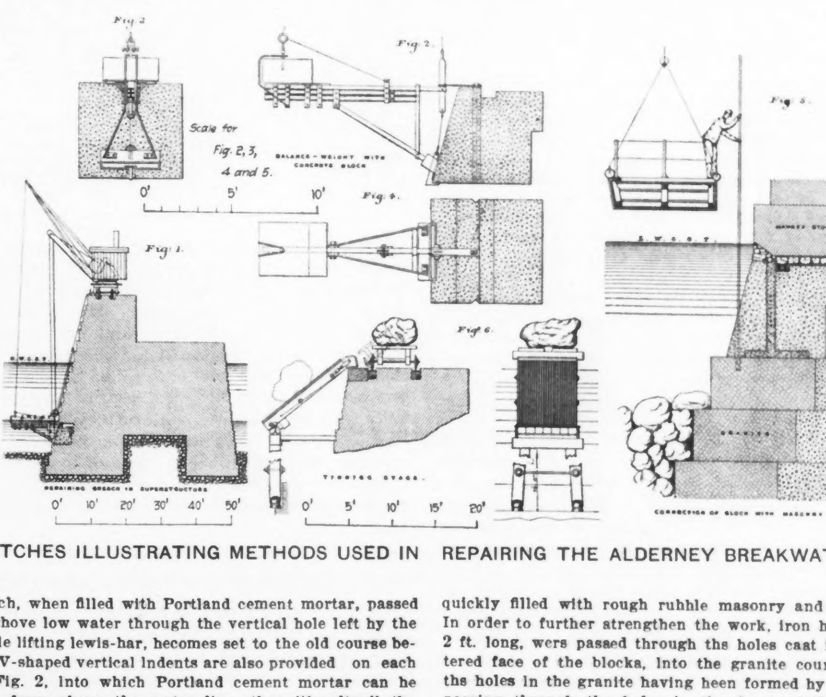
REPAIRS OF THE BREAKWATER AT ALDERNEY.*

By Bernard O'Driscoll Townshend, Assoc. M. Inst. C. E.

Alderney breakwater, one of the most exposed works of the kind in the world, consists of a huge mound of large and small rubble surmounted by a superstructure of coursed and rubble masonry set, above low water, partly in blue lias and partly in Portland cement mortar. The superstructure provides a quay on the harbor side, and a promenade or high level on the sea side, with a line of rails on both levels. The five lowest courses of the superstructure consist of granite backed by concrete blocks, which become dangerously exposed by the lowering of the "foreshore" in front of them during storms, stones, from the fourth and fifth courses especially, being forced out. At times considerable cavities are thus made in the sea wall, the repair of which is one of the most important items in the maintenance of the breakwater.

In executing repairs in 1889, large concrete blocks were substituted with advantage for granite, each being high enough to replace two of the old granite courses, and having a battered face corresponding to the general batter of the sea wall, Fig. 1. They weighed 12 tons, and were of the section shown in Fig. 2, made of 8 parts of sand and rubble to 1 of Portland cement mortar, and faced with hand spalls. Previously to the author taking charge of the works, the concrete blocks were made flush at the bottom, and could not be set when their lower bed-joints were below low water. They are now cast with a square indent, about 2 ins. in depth, in the lower bed-joint, Fig. 3 and 4, consisting of a beam, about 10 ft. long, formed of old rails and square iron bars, having a small iron platform, at one end of which a ½-ton weight was secured, and at the other end a flat bar, about 3 ft. long, working on a center in a pair of short jaws, to which was attached a short chain with a stout iron hook. A wooden cross-beam also abutted against the foot of the concrete block, and was held in position by two flat iron struts attached to the main beam, Fig. 2. This balance-weight enables the crane chain to be shifted from the vertical holding center line of the concrete blocks to a point which permits the block to be lifted, balanced, and swung back into position. The iron hook was placed in the square indent, at the toe of the battered face, cast in the concrete block; and the swinging bar to which it was attached was secured by a chain and link to the top of an iron rail placed vertically in the hole left by the lifting lewis-bar. The wooden cross-beam was butted against the face of the block; and then the whole was lifted by the 12-ton crane being attached to the large link at the top of the swinging bar, and swung into position in a few minutes. The 5-ton crane with the long jib assisted by controlling the chains whereby the actual balance weight at the end was raised or lowered, Figs. 1 and 2. These adjustments were mainly effected from under water by divers, who also assisted in the manipulation by working the guys attached to the balanced end of the apparatus.

When the concrete blocks were in position, iron rails were placed in the square channels on the top, to connect them. Portland cement mortar was passed down the V-shaped indents; and the space above the blocks was



SKETCHES ILLUSTRATING METHODS USED IN REPAIRING THE ALDERNEY BREAKWATER.

2, which, when filled with Portland cement mortar, passed from above low water through the vertical hole left by the portable lifting lewis-bar, becomes set to the old course below. V-shaped vertical indents are also provided on each side, Fig. 2, into which Portland cement mortar can be passed from above the water line, thus "joggling" the blocks. A square channel is left also along the top of each block, Figs. 2 and 5, into which old rails are placed, extending from block to block, before the space between the top of the blocks and the old work overhead is finally filled with rubble masonry and flushed up.

A cavity caused by the gales in 1888-89, extracting the third and fourth granite courses, was repaired in the following manner: The plant consisted of a 12-ton steam crane, a 5-ton steam crane with a long jib, a six-coupled locomotive with trolleys, and a "skid" or guide for the blocks, composed of two whole timbers faced with rails and firmly braced together. The cavity in the wall was 35 ft. long, 6 ft. high, and 6 ft. deep, which was filled in by six concrete blocks of the usual section, the two end blocks being cast with right and left-handed shoulders respectively, in order to break joint with the old remaining granite courses. The divers having cleared the aperture of all debris, and having adjusted the back courses, which was a laborious and risky operation, the cranes were run into position on the high-level wall. The 12-ton steam crane was placed directly over the cavity, its platform area being considerably increased by iron rectangular portable bars run out sideways and resting on wooden blocks; and the crane was also attached to the back of the sea wall by chains and lewis-bars. Before lowering a block, the "skid," Fig. 1, was suspended from the coping to guide the block, and prevent it catching in the steppings of the masonry in its descent.

In order to get the concrete blocks back into position in the sea wall, a balance-weight was designed, Figs. 2,

*From selected papers of the Institution of Civil Engineers.

quickly filled with rough rubble masonry and smoothed. In order to further strengthen the work, iron bolts, about 2 ft. long, were passed through the holes cast in the battered face of the blocks, into the granite courses below, the holes in the granite having been formed by iron drills passing through the holes in the faces of the concrete blocks, and worked from a platform suspended from one of the cranes, and capable of floating in case of need, Fig. 5; and the interstices in the holes in the concrete blocks were filled up with Portland cement mortar.

The foreshore at Alderney breakwater is continually varying; a gale from the southwest heaps the stones high up the face of the sea wall, but they disappear after a succeeding gale from the northeast. The stone for making up the foreshore is either run on to the superstructure and thrown into the sea from side-tip wagons, or large stones are conveyed on trolleys to the high-level, and tipped by means of the long-jibbed crane standing on the low-level line of rails. The empty trolley is then lifted, and lowered by the crane to the low-level rails, while the locomotive pushes the next loaded truck into position for tipping. To prevent the larger stones from striking the protruding masonry courses towards the bottom of the wall, a portable slanting timber platform, Fig. 6, faced with iron rails and supported on the wall by timber uprights, is lowered over the face of the wall in front of the trolleys to be emptied, and secured to the coping.

A train of twelve trucks, carrying about 60 tons of large stones, was usually emptied in 20 minutes. The platform of the trolleys has an opening of about 1 ft. in the middle, to allow the lifting chain to be easily cleared after the stone has been placed on the truck. To make the foreshore up to a satisfactory level, much larger stones should be used. Though, however, very large stones, reaching 300 tons, were occasionally quarried at Mannez, it was necessary to break them up before trucking them down to the breakwater, as the plant at Alderney will not deal with stones exceeding 12 tons in weight.

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
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ALFRED E. KORNFELD, New York, M. C. ROBBINS, Chicago, S. B. READ, Boston, C. F. WALKER, Cleveland, } ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 299 DEVONSHIRE ST.
CLEVELAND OFFICE, OSBORN BUILDING.
LONDON OFFICE, EFFINGHAM HOUSE, 1 ARUNDEL ST., STRAND.

SUBSCRIPTION RATES: United States, Canada and Mexico. One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.60 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current year, 15 cents.

In ordering changes of mailing addresses, state BOTH old and new addresses; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 329 means that subscription is paid to the 32d week (that is the issue of Aug. 10) of the year 1899; the change of these figures is the only receipt sent, unless by special request.

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

The two serious accidents of Sunday, Aug. 6, will serve to impress anew on the minds of engineers the fact, often before pointed out, that the minor details of engineering works, which are apt to be overlooked, are as frequently the cause of accidents as the elements of the structure to which more attention is generally paid. Of the precise history of the gang-plank which broke with such fatal results on the Mt. Desert ferry, we cannot speak; but we know that the design of things of such supposedly minor importance is more apt to be left to some "boss carpenter" than to be turned over to the engineering department. From such meager details of the accident as have thus far come to hand, it seems probable that the design was faulty in the use of too short struts at the center of the truss rods which were placed underneath the bridge, and very likely in the end fastenings of these rods as well, since they are said to have pulled through the wood without breaking. It is possible that some engineer may have committed such a serious mistake as to design the structure in this way; but it seems much more probable that it was the work of some carpenter who did the best he knew how, and who could not have computed the strength of his construction or the safe load it would carry to save his life. If this latter supposition be true, who is rightly held blamable, the workman or the higher officer who placed responsibility upon a man incompetent to discharge it?

As respects the accident on an electric railway trestle in Connecticut, it appears to us to emphasize the lesson that electric railway constructors still need to get away from horse railway ideas and follow steam railway standards in the matter of safety appliances. Old readers of Engineering News may recall the agitation concerning the use of guard rails on bridges which followed the fatal White River disaster in New England in 1887. At the present time it is the exception to find a steam railway bridge or trestle which is not thoroughly protected by guard rails. We fear it is not the exception, however, on electric railway lines.

Some new light on the uselessness of monitors as fighting vessels under modern conditions is furnished by a paper on the "Naval Campaign of Manila Bay," by Lieut. C. G. Calkins, U. S. N., in the "Proceedings of the U. S. Naval Institute." Lieut. Calkins relates the various plans which were considered by the American commanders in the Philippines when the news came that Admiral Camara's fleet had sailed from Spain for the Philippines. Few officers of the fleet, he says, had any doubt of the ability of the American vessels then at Manila to defeat Camara's fleet at the end of its voyage; yet it is probable that the plan of standing off to the eastward with all the vessels in the hope of meeting the monitors somewhere in the Pacific Ocean was also given consideration. Before any decision was reached, however, the news came that Camara had turned back. Lieut. Calkins then continues as follows:

> These hypothetical situations involve the discussion of the value of monitors like the "Monadnock" and "Monterey" in naval engagements and in bombardments. When the "Monterey" came in on Aug. 4 the comments made on her stability as a gun platform in the ordinary swell of the southwest monsoon were far from encouraging. If the Spanish Admiral chose to fight in the open sea during the regular monsoon, or within a week after the passage of a typhoon, or even if the meeting took place in Manila Bay on a summer afternoon, the "Monterey's" battery could hardly have been a decisive factor. The oscillations due to excess of stability would compel her to throw away her shots under such conditions.
>
> If the "Monterey" and "Monadnock" were of uncertain value in a fleet action, their cruising efficiency must be rated still lower. Neither the tactical nor strategical qualities of monitors would justify a future plan of campaign which sacrificed time, moral effect and concrete results to secure such problematic reinforcements.

We call the especial attention of architects and bridge engineers to the paper on the manufacture of ornamental iron work by Mr. Chester B. Albree, on another page of this issue. Mr. Albree points out that in the design of railings and similar ornamental work, the engineer who is well up on shop methods, and who is familiar with the standard sections available, can secure admirable results from an aesthetic point of view at very small cost. Without this knowledge, however, he is working entirely in the dark, and a construction apparently plain and simple may actually be much more expensive than one much more elaborate.

THE PROTECTION OF STRUCTURES FROM LIGHTNING.

To what extent is it profitable to provide protection to buildings from lightning? Can buildings be so protected as to be reasonably secure? How should such protection be applied? These are practical questions, which may fairly be submitted to any architect or engineer by their clients, and we wonder how many would be able to answer them with confidence. There is very little to be gleaned from engineering literature upon the subject. Something may be found in some of the publications devoted to electricity, perhaps; but it is scattered and fragmentary and generally unsuited to the needs of the man in search of practical information. In fact the effect of the information that has been made public through popular channels during the past decade or two has been to leave both popular and professional opinion on the subject in a more unsettled state than ever.

There has recently been issued by the United States Weather Bureau a valuable monograph on "Lightning and the Electricity of the Air,"* which any of our readers interested in the subject will do well to obtain, and we shall here attempt to present some of the information which the pamphlet contains bearing on the questions which were set forth at the beginning of this article.

In the first place, it will be well to get a clear idea of the nature of the lightning flash. In the pamphlet before us it is likened to an avalanche or landslide down a mountain side. The older idea was that the lightning flash would follow the path of least resistance like the electric currents of moderate potential which are in daily use. The lightning conductor was thus likened to a channel made to convey a flow of water. A channel which would convey a steady flow, however, might fail to confine the sudden rush which would follow the breaking of a dam, and a lightning flash is always a sudden rush. On the other hand, the flash of electric current, unlike the flow or water, has no volume following the first discharge. To continue the comparison, the dam which confines the electricity instantly repairs itself as soon as the pressure upon it is relieved. Further, the discharge from it may vary greatly in size. We are apt unthinkingly to consider lightning flashes as if they were all of equal volume. As a matter of fact, however, they probably vary nearly as much in size as the streams of water that flow down the valleys upon a mountain side.

Besides its office in conveying the discharge of an actual flash, lightning conductors act to some extent as silent conveyors of the current. Mr. McAdie, one of the authors of the pamphlet before us, likens them to small drain pipes from a reservoir. If these pipes can carry off the water as fast as it accumulates in the reservoir, the pressure on the dam may not reach the bursting point at all; or, in other words, no flash of lightning will take place. An excellent illustration of this is the infrequency of lightning strokes in cities, where the multitude of exposed points drain the overcharged cloud before the air between it and the roofs and spires beneath becomes strained to the breaking-down point.

From these considerations of the nature of the lightning discharge it is clear that absolute protection of a building or structure from lightning is not practically possible unless the structure is itself a good conductor, as in the case of steel frame buildings or towers. On the other hand both theory and experience show that properly-arranged lightning conductors do afford a very large measure of protection. The actual percentage of the danger which is neutralized depends largely upon the nature of the building itself. Thus a chimney or a church spire may be given almost perfect protection, while a flat roof of large area may have its liability to injury reduced perhaps 75 per cent., more or less, when lightning rods are placed on its exposed points. There is no such thing as a definite "area of protection." An old rule of lightning rod manufacturers is that a rod protects over a radius equal to its height. Perhaps this empirical rule is as good as any to follow in the erection of rods, but it should be understood that the protection thus afforded is relative, not absolute.

Turning now to practical rules for the erection of rods and conductors, we may note that either iron or copper may be used, and the former seems as good as the latter, provided its section be enough larger to compensate for its lower conductivity. Weights of 6 oz. per ft. for copper and 35 oz. per ft. for iron are advised. Surface is more important than cross-section in a conductor, and a flat conductor is, therefore, advised. The old plan of securing the rod with glass insulators is, of course, abandoned. Any secure fastening directly to the side of the building is good enough.

Probably the matter of greatest importance, and that most frequently neglected, is the terminals of the rods at top and bottom. The top of the rod should be plated or in some way protected against corrosion, and its bottom should be connected to a good-sized piece of iron imbedded in the damp earth.

The resistance of the rod is its whole resistance, including the resistance in the passage to earth, just as the resistance offered to water flowing in a pipe is that due to the friction of the whole pipe with all its bends and valves. It is ludicrous to run a rod down the side of a building and neglect the grounding, as is so often done, just as if the lightning were a dangerous bug which could be safely disposed of by being induced to crawl down to the bottom of the rod, and which might then be left to jump off as and where he pleased.

The correct way of looking at it—to return to our comparison above—is to consider the rod as a channel down a mountain side to guide a possible

*Prepared under the direction of Willis L. Moore, chief of the United States Weather Bureau, by Alex. G. McAdie and Alfred J. Henry. Address, U. S. Weather Bureau, Washington, D. C.

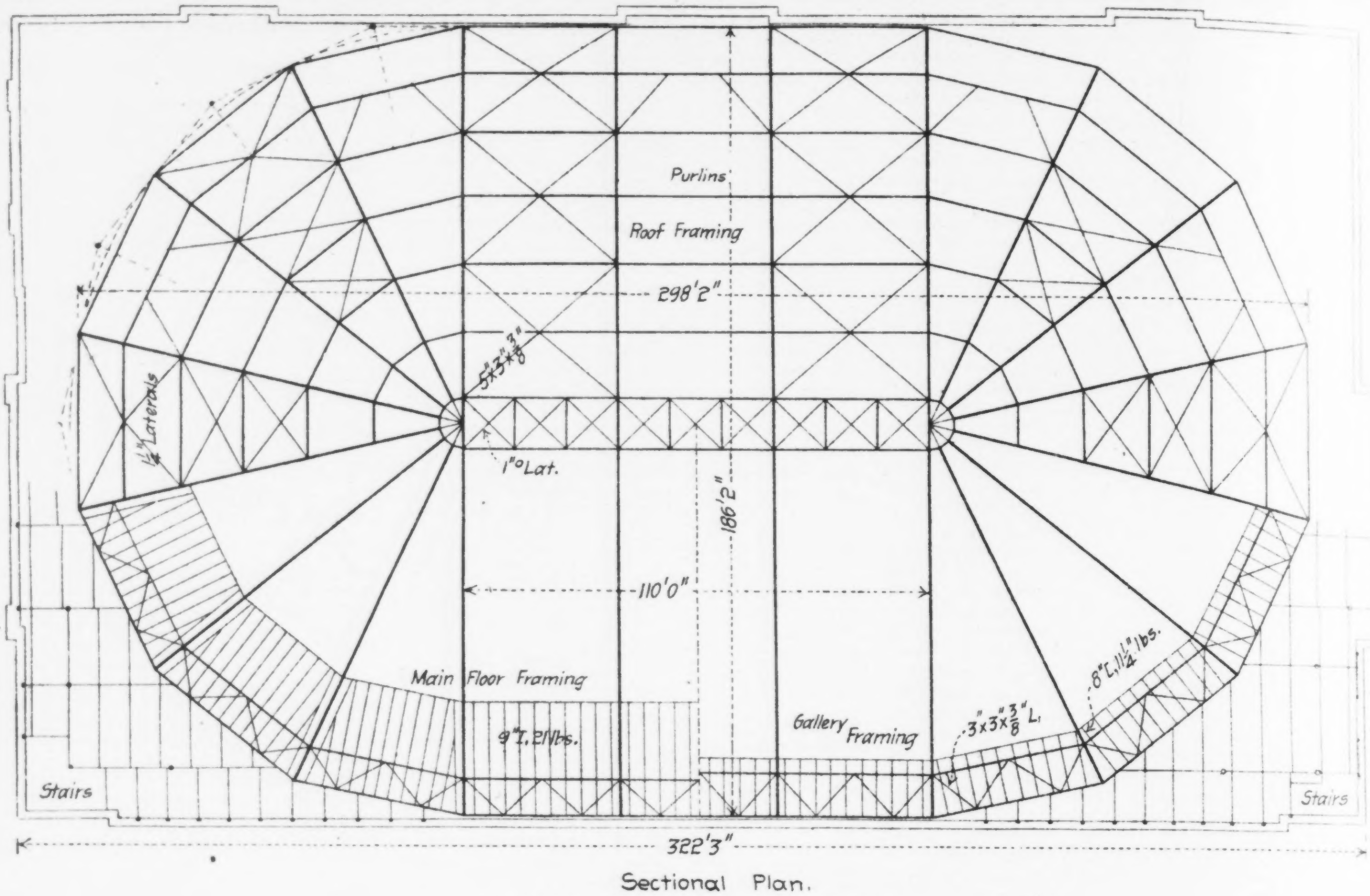


Fig. 1. General Plan of Trusses aud Framing.

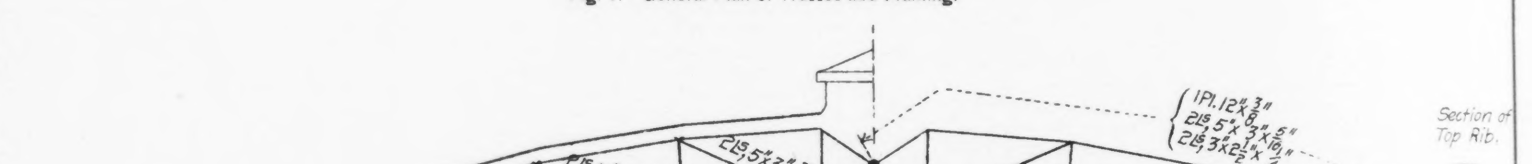


Fig. 2. Cross Section Showing Construction of the Main Trusses.

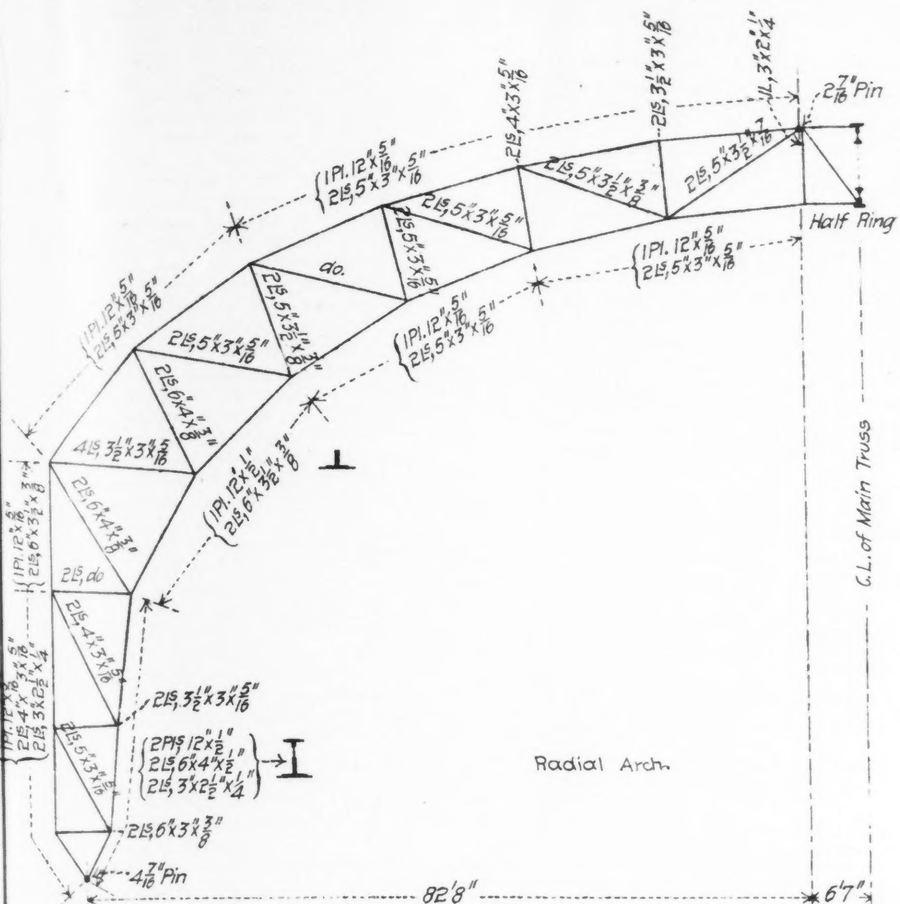


Fig. 3. Details of Cripple Truss.

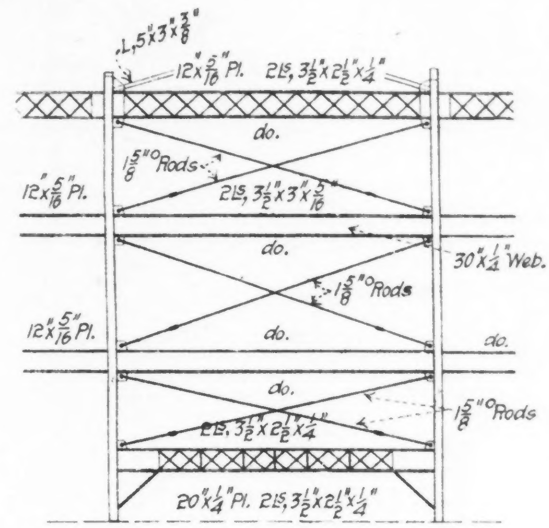
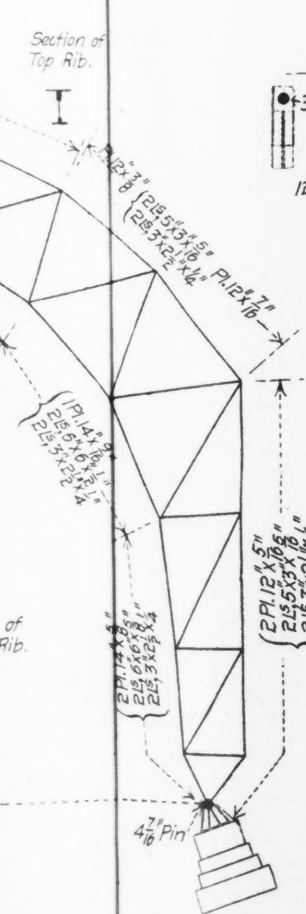
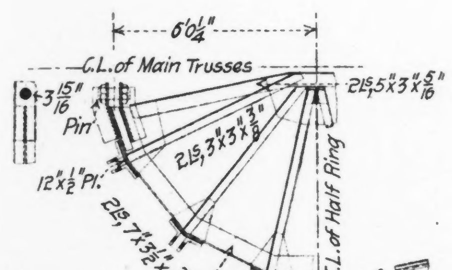


Fig. 4.
Connections Between Outer
Ribs of Main Trusses.





Plan of Half Ring
Connecting Radial Trusses
to Main Trusses.

Fig. 1a.
Enlarged Detail
of Half Ring.

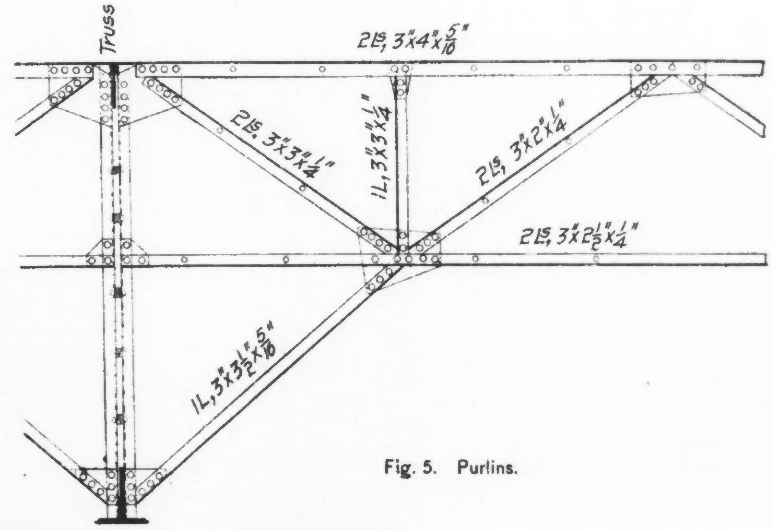


Fig. 5. Purlins.

STEEL FRAMEWORK OF THE ST. LOUIS COLISEUM.

Chas. K. Ramsey, Architect.

Julius Baier, Assoc. M. Am. Soc. C. E.,

Consulting Engineer.

CHAS. HART, LITH., 36 VESEY ST., N. Y.

avalanche. The larger the channel (or the less the total electrical resistance of the whole rod) the more surely will the avalanche be confined and led through the channel provided for it.

We have answered two of the questions enunciated at the outset of this article. What of the third? Does it pay to provide protection from lightning? Is the risk great enough in proportion to the cost of protection to make an investment in lightning conductors a paying one? The pamphlet before us does not answer this question directly, but it does give some statistics concerning the losses by lightning in the United States and also in Germany. According to the "Chronicle Fire Tables," the loss by lightning in the United States during the eight years, 1890-1897, averaged about $2,200,000 per annum. The number of fires caused by lightning varied very greatly, from 457 in 1891 to 1,738 in 1896. The Weather Bureau statistics show a total of 1,847 buildings struck by lightning in 1898, of which 966 were barns, sheds or warehouses, 95 were churches or school buildings and 735 were dwellings, stores or office buildings. The total loss is set at not much over $1,500,000. In Germany, the number of buildings struck by lightning in the years 1884 to 1891 averaged 258 per annum per million buildings insured.

Concerning the annual fire loss by lightning, it must be remembered that a considerable proportion of it is due to large losses on valuable buildings. In Illinois, for example, the burning of one brewery by lightning caused a loss of $300,000. Making proper deductions for this class of losses, it is evident that to furnish complete protection to buildings of all classes from lightning would be a losing investment. That is to say, the saving that could be made by the reduction of loss would not pay the interest on the cost of furnishing the necessary protection.

The risk on farm buildings from lightning is of course far greater than that on any other class of buildings, yet their value is so small that it will almost invariably be far cheaper to rely upon insurance for protection against loss than to attempt to protect them by lightning conductors.

At the other extreme, we may set church spires and high brick chimneys. Here the risk of being struck is great, and the value of the property endangered is generally considerable. Such structures, moreover, can be protected from lightning with great certainty and small cost, and such protection is, therefore, generally advisable.

Beyond these two cases general rules can hardly be laid down. It should be the duty of the engineer or architect in charge of the erection of a building to form some estimate of the risk (which, it need hardly be said, will vary greatly with the location), and of the cost of providing protection. It can thus be determined whether such protection will be profitable. In the case of large and monumental structures, such as expensive public buildings, the cost of protection may be a secondary consideration, and the same thing is true in the case of buildings containing large numbers of persons, where the risk to life from fire or panic is to be taken into consideration. Asylums, summer hotels, auditoriums, and large school buildings are examples of the latter class. Money spent in providing safeguards from lightning on such buildings will generally be well expended.

LETTERS TO THE EDITOR.

An Easy Way to Write an Engineering Report.

Sir: There recently came to our attention a report upon the proposed Arkansas, Guthrie & California Ry., signed by C. E. Coon & Co., Consulting Engineers, of Toledo, Ohio, which is being presented to brokers in this city. This report is practically a verbatim copy, with the exception of necessary changes regarding counties, towns, streams, etc., of a report made by our Mr. P. S. Hildreth upon the proposed Kansas City, Oklahoma Central & Southwestern Ry. now being constructed. It goes so far as to copy the following statement in comparison with the Choctaw, Oklahoma & Gulf Ry. regarding bridges: "With the latter, the firm of which the writer is a member, was connected as consulting engineers." It also contains tables which do not correspond with the mileage. The form, original tables, etc., of our report are closely followed, and special maps and photographs embodied in our report are referred to but not appended.

Perhaps you will have the kindness to request some explanation from Messrs. Coon & Co.

Yours very truly, R. W. Hildreth & Co.

(We can add to the above that we have examined the reports referred to by our correspondent and the evidence of plagiarism is complete. What shall we say of the assurance which attempts to palm off on the investing public a report upon an enterprise which was actually made on another and totally different enterprise?

This journal is published in the interest of the engineering profession; and we deem it our duty to give publicity to the above letter in defence of the profession's good standing and reputation, and in warning to investors who might be misled by the above report. If "C. E. Coon & Co., Consulting Engineers," have any explanation to make, we shall be pleased to receive it; but our previous knowledge of them and of "The Toledo Construction Co., Consulting and Designing Engineers and Contractors, C. E. Coon, Mgr.," does not lead us to expect that any explanation will be forthcoming. —Ed.)

Continuous Blueprint Apparatus.

Sir: In reply to the query of "D. L. E.," I would say that I constructed some 12 years ago a continuous blueprint apparatus, and succeeded in making prints 37 ft. long. The principal roller, holding tracing and blue paper, turned by means of an ordinary 8-day clockwork and a suspended weight (sash weight).

The apparatus worked very well under a cloudless sky, but the prints showed light streaks whenever the sun was obstructed by clouds. This defect may be remedied by using quick-printing paper in a shaded place.

H. Bosse.

U. S. Engineer Office, Rock Island, Ill., Aug. 4, 1899.

Sir: I notice a request for a method of taking prints 30 or 40 ft. long. A friend of mine the other day told me that the Northern Pacific Ry. had in its blue-print department a cylinder about 6 ft. in diameter, mounted in upright bearings. On this cylinder was stretched and pinned the tracing and the blue-print paper, and the cylinder was then given a twirl. It ran, he said, from 3 to 5 minutes, in that manner exposing every part equally to the sun's rays. Yours truly, Earl A. Petithon, C. E.

Detroit, Mich., Aug. 4, 1899.

Sir: I cannot understand how very satisfactory continuous blueprints could be made in successive lengths in a frame with two rollers such as described by Mr. Kirchoffer in your last issue. If two pieces of sheet material of even a short length are laid flat with their ends coincident, and are then rolled together, the ends will not coincide on the roll. The application of the principle to 5-ft. lengths of tracing and blueprint paper would cause a very appreciable "buckle" in one material at the end of each length, which would have to be taken up somewhere, and would prevent continuity in successive sections. By having the tracing outside on one roller and inside on the other, the buckle which would form in rolling up the first section might be taken out in rolling off the second, but the trouble would begin in the third. The apparatus which I referred to in my last communication does not have this defect, and I feel sure that its inventor will not make it public unless it can produce continuous prints of any length quite as well as short ones are now made in a printing frame.

Yours truly, L. F. Rondinella.

728 Stephen Girard Building, Philadelphia, Pa., Aug. 3, 1899.

Kutter's and Darcy's Formulas for Flow in Pipes.

Sir: In Mr. E. Sherman Gould's discussion of Mr. Hawks' measurements of the flow through a 14-in. cast-iron pipe, appearing in your issue of July 13, 1899, it strikes me that the agreement between Kutter's formula and that of Darcy would have been closer had the value of the coefficient "n" in the first-named formula been taken more nearly what it should be for very rough cast-iron pipes. The generalization of Darcy's formula ($Q = \sqrt{D^5 \times h}$) is for the worst condition pipes are supposed to assume. Now, the value of n = .013 is derived from the measure of the flow through a 14-in. pipe in good condition, and it is evident that the theory of Kutter's formula requires a higher value of "n" for application to said pipe when it shall have attained the very rough condition assumed by Darcy's formula.

In the measurements of the steel pipe line of the Jersey City Water Co.'s plant, over which there was a controversy in your columns some two or three seasons since, the value of "n" in Kutter's formula, as derived from the results of said measurements, was found to be .016.

Riveted pipes probably offer more resistance to flow than cast-iron pipes do in their worst condition, but it is not likely that there is much in favor of foul cast iron over riveted steel in the good condition of the Jersey City pipe.

"n" = .015 will probably most nearly represent the conditions assumed by Darcy's formula. In this case the discharge from the 14-in. pipe under a head of .584 in 1,000 would be as follows by the formulas:

Kutter: $Q = (73.5 \sqrt{.2917 \times .000584}) 1.069 = 1.13$ cu. ft. per sec.

Darcy: $Q = \sqrt{1.1667^5 \times .584} = 1.12$ cu. ft. per sec.

For pipes in perfect condition "n" would be equal to .011, and Darcy's formula would be, $Q = \sqrt{2 D^5 \times h}$.

Applying these assumptions to the pipe in question, we have:

Kutter: $Q = (108 \sqrt{.2917 \times .000584}) 1.069 = 1.51$ cu. ft. per sec.

Darcy: $Q = \sqrt{2 \times 1.1667^5 \times .584} = 1.59$ cu. ft. per sec.

This is quite a satisfactory agreement for the only two conditions to which Darcy's formula is applicable. It can be said for the latter, however, that it is much the simpler method, and errs on the side of safety by always assuming a rough pipe. However, the very elastic limits within which Kutter's formula can be developed make the latter of more general accuracy and applicability.

El Paso, Texas, July 31, 1899. J. L. Campbell.

The Design of Masonry Dry-Docks.

Sir: On looking at the inset sheet showing the details of the New Boston dry-dock in your issue of July 20 I am struck by the intricate curve of the face of the wall. Why not make those walls plumb, and instead of altar steps make just "prop-pockets" (if such an alliteration may be allowed) in plumb sides and keep all the extra masonry "in the dock?"

The pumping plant is no doubt as nearly perfect as ingenuity "on the ither side o' forty-five" can make it; but why make several extra feet of head by putting the culvert below the floor when a culvert in the side wall 16 ft. 10 ins. higher (Fig. 3) would lay dry the whole bottom? The bottom need not be of stone surely. Would not an ashlar face where the vessels "bump" be sufficient?

To resist "blowing up," the bottom is probably best protected, first by puddle and honest work and next by under-drains, which give relief to the head and reduce the pressures enormously.

Generally, a well-drained foundation slab across the entire width of the dock upon which plumb walls with longitudinal culverts are built seems more direct and cheaper in resisting water heads and accommodating boats, etc. I remain, Yours, etc., C. R. Coutlee.

Cascades Point, Que., July 26, 1899.

(It must be remembered that the sides of a dry-dock act as retaining walls, and have to withstand the pressure of the earth behind them, which is generally soft material and is often surcharged with heavy weights. Evidently, therefore, the side of the dock must be given a batter to make it withstand this strain economically, and it is probably better to put all or most of this batter on the front side of the wall than on the back side. As to the position of the drainage culvert, it is fair to point out that the head upon the pumps is not increased by its present position. The head against which the pumps work is the difference between the level of water in the dock and the height of the delivery pipes. It is worth noting that the Boston dock has very few altars compared with the older docks; yet to do away with altars entirely and substitute "prop-pockets" as suggested might not suit those who have charge of the docking of vessels. The altars permit a vessel to be propped at any point on her side; and if pockets were cut in the masonry in sufficient number to permit this, they would probably be more expensive than the altars.—Ed.)

Notes and Queries.

W. L. G., Newport, Ky., writes:

There seems to be a wide difference as to the amount of cement required for various classes of masonry, according to the tables published by various authorities, and I would like to know the number of barrels of cement required to lay ordinary limestone rubble masonry, stone averaging 4 ins. thick and 1½ sq. ft. bed, 1 part of cement to 2 parts of sand; also the number of barrels of cement required to mix 1 cu. yd. of concrete, composed of crushed stone averaging 2½ ins. in dimension, 4 parts stone, 2 parts sand and 1 part cement.

R. W. Hunt & Co., Chicago, Ill., inform us that an error was made in the report of the test of a 30,000,000 gallon pumping engine, published on page 75 of our issue of Aug. 3. The boilers were of the "horizontal water tube" type, manufactured by the Aultman & Taylor Machinery Co., Mansfield, O., and not "horizontal tubulars," as stated.

AN ENGLISH TYPE OF ELECTRICALLY DRIVEN AIR PUMP.

The electrically driven air pump illustrated in Figs. 1 and 2, forming part of a condenser equipment recently installed at the generating station of the Glasgow corporation, is an interesting example of English electrical apparatus and methods. The condenser is of the usual surface type with a surface of 1,250 sq. ft., made up of a series of ¾-in. outside diameter solid drawn bronze tubes ending in suitable tube plates or headers and surrounded by a cast-iron casing. As is customary in this class of condenser, the water circulates through the tubes while the exhaust steam fills the casing and surrounds them. The pump is of the three-throw single-acting Edwards type, with 10 × 10-in. cylinders set vertically at the bottom of a suitable cast-iron frame which supports the cross-head guides and bearings for the three-throw crank shaft.

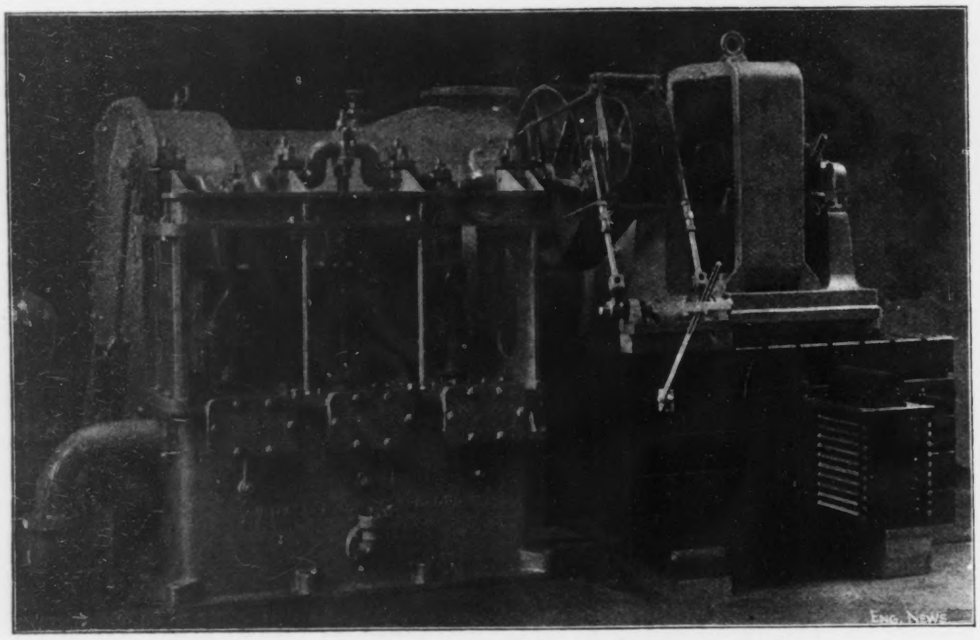


FIG. 1.—AN ENGLISH ELECTRICALLY-DRIVEN AIR PUMP.
W. H. Allen, Sons & Co., Bedford, Eng., Builders.

The crank shaft is forged solid and has on one end a small crank disk which drives the small water circulating pump seen in Fig. 1. On the other end is a heavy friction and belt wheel, upon which runs the belt of the Hollick gear, which is the device used to transmit the power from the motor shaft to the pump and at the same time to reduce the speed from 800 (or that of the motor) to 150 revolutions per minute, which is the maximum pump speed.

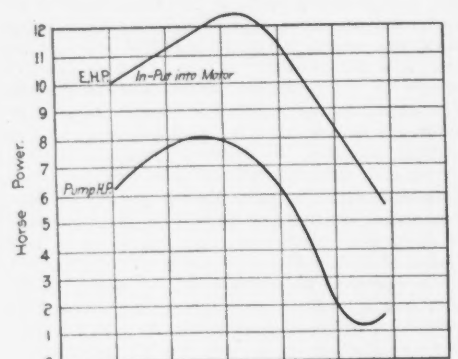


Fig 2.—Curves Showing Input into Motor and Pump Output of a 12 × 12 Electric Driven Air Pump at 150 r. p. m.

This gear consists of a special friction wheel on the end of the armature shaft, which wheel bears against the large wheel of the pump, and the smaller idler, which is partially surrounded by the short belt seen in Fig. 1, and rigidly held away from the pump pulley by suitable spacing rods. The amount of pressure between the various pulleys is nicely adjusted by shifting the frame supporting the idler pulley.

Fig. 2 shows the results of a test of a similar pump but with cylinder dimensions 12 × 12 ins. It will be noticed that the maximum power required by the motor is about 12½ HP., and under these conditions the equipment controls a condenser handling 15,000 lbs. of steam per hour.

NOTES ON THE ADMINISTRATION OF THE UNITED STATES ARMY IN THE PHILIPPINES.*

By Captain S. S. Long, Deputy Assistant Adjutant-General, British Navy, Hongkong, China.

The Hispano-American war has brought forward a hitherto neglected factor, which is bound to have a considerable influence on international questions: the vast citizen army which it is possible for the United States to get together. A study of the American forces operating in the Philippines well illustrates this question and is worthy of attention.

The American army before Manila was, with the exception of a small portion, entirely composed of volunteers; and in spite of defective administrative staff and departments, insufficient equipment, and officers who possessed little, if any, more military training than the privates, these troops displayed a spirit of intelligence and obedience, combined with an individual willingness to perform their duty that might be rivalled, but could not be surpassed by the finest disciplined troops.

They might be aptly described a great military paradox. A body of men of magnificent physique, possessing perfect discipline, yet without any discipline at all. These troops, without previous similar experience, after a journey of 8,000 miles, had, practically without naval assistance, to land themselves upon an inhospitable, hostile shore, carry their stores, etc., through—on most days—a heavy rolling surf, and transport them themselves for two miles through deep mud under tropical rains to their camp, which consisted of shelter tents only. Every third day each unit spent twenty-four hours in the trenches facing the Spanish lines—trenches which were little better than dykes, half full of water and mud, absolutely devoid of shelter from rain, and where, if a man was tired of standing, he had to sit down in slush.

Frequently at night, exposed to a galling and irritating fire from the Spaniards, they obediently complied with orders and patiently bore the enemy's fire without attempting to return it, even when occasionally their comrades were struck beside them. This restraint on the expenditure of ammunition was thought necessary by the American authorities, who feared running short of the supply.

In the advance on Manila on August 13, although it may be said they were unopposed, still, as far as the junior officers, non-commissioned officers, and men were concerned, they were ignorant that this would be so, and their behavior left nothing to be desired. The advance took place between 11 and 12 midday, and by 5 p. m. every road, bridge and gateway of the town was carefully picketed and held by American troops, who, the whole of that night, Sunday, and Sunday night, uncomplainingly remained in the streets under heavy tropical rains, good-temperedly carrying out the difficult and troublesome duty of preventing armed insurgents from entering the town, and carefully abstaining from coming into unnecessary conflict with the large mass of Spanish officers and soldiery, who were rather aggressively parading the streets. The most careful enquiries failed to elicit any report of a complaint being made of any act of pillage or assault committed by an American soldier.

If conduct such as this is obtainable from raw volunteers of no experience, and under such unfavorable circumstances, then it should be borne in mind that troops of this sort are a factor to be seriously considered, particularly after they have had a few months' training.

As it may be of some interest to more deeply study the question of the organization of this expedition, it is proposed to slightly touch on the American army organization showing where on the present occasion this organization may be worthy of imitation or, as is too often the case, fatal to the interests of an army in the field.

The American regular army, which consists of 25,000 men only, is commanded by a Major-General, the highest rank in the United States Army, any higher being conferred only by a special act of Congress. The army is administered by nine departments, each presided over by a brigadier-general; and as all, to a very large extent, work independently of each other, the result is frequently prejudicial to the interests of the service.

These branches are purely departmental, and, as a general rule, an officer selected for employment in one or other serves the rest of his time therein, with the natural result that the staff and departments are largely cut of touch with the army. Appointments to the staff are made from the army generally, usually through political influence, and in some instances even civilians, through similar influences, are appointed to the pay department.

I. The adjutant-general's department deals with all questions of drill, training, and instruction of troops, but not discipline, which is dealt with by the judge advocate general's department, with the result that the senior branch of the staff and in fact all branches, and the army generally, are deficient in a knowledge of legal procedure.

II. The inspector-general's is a special department whose duties are to carry out those usually performed by a general officer commanding in the British service. This department sends its officers to inspect all districts and posts and every branch therein, and reports direct to the Secretary of War.

III. The judge advocate general's department deals with all questions of law affecting the army and is the direct adviser on these matters. Applications for trial by a military court, are, in the first instance, submitted to the judge advocate of the post, district, or force, and the proceedings before confirmation again pass through his hands. The power of the judge advocate, as an expert, was particularly noticeable at Manila, as every proclamation by the general commanding appeared to require his jealous scrutiny to see that it did not infringe the law of the land or the constitution of the United States.

IV. The quartermaster general's department deals with clothing, camping, fuel, light, forage, and all transport, both land and water.

In the district, or in the field, the departmental head is known as the Chief Quartermaster. Each division, brigade, and regiment has its quartermaster attached to it, known respectively by the official title of Divisional, Brigade or Regimental Quartermaster.

This department, which may have understood its onerous duties in time of peace, and when working in its own country, was apparently without organization or initiative at Manila.

The regimental quartermasters were generally regimental officers without previous experience; and although all certainly worked with the utmost energy, they failed, not from want of ability, but of knowledge.

The clothing of the troops left much to be desired. It is true that the expedition was hurriedly equipped and despatched, but even so it ought to have been possible to send troops into the field with some thin clothing in addition to the heavy clothing of their own country, and certainly some effort ought to have been made to provide a better head covering than the ordinary soft felt hat, which afforded little, if any, protection from the sun. As regards this latter point, owing particularly to its being the rainy season, there were no cases of sunstroke reported.

Sea Transport.

A noticeable feature of this expedition was the apparently absolute ignorance of the admiralty and navy as regards their duties towards the army. The army, chartered,

*Originally published in the "Journal of the United Service Institution in India," April, 1899. Reprinted in the "Journal of the U. S. Artillery." The present article is much condensed from the original.

superintended the fitting, equipping and coaling of all transports, with the result that, when they proceeded to sea, they discovered that in some instances they were badly or deficiently found; and, after arrival at Manila, it was noticed that the chief quartermaster was occupied with questions regarding the coaling and detention, etc., etc., of transports more than with the necessities and requirements of the army.

The landing of the troops and stores cannot be too adversely criticised. After the destruction of the Spanish fleet and the capture of Cavite on the 1st of May, all steam vessels, launches, boats, and lighters that remained afloat fell into the hands of the American navy, and as they were blockading an enemy's port, the captured launches were extremely useful for patrolling purposes, etc.

No steps appear to have been taken by the navy to sound and buoy the best landing places for troops. On their arrival, for two days some assistance was rendered to land a portion of them, but after that they were left to their own devices to do the best they could, having as means of transport an old paddle-wheel river steamer and two or three worn out cranky launches, with a few crazy boats and lighters.

No naval transport officer was appointed, and, as a result of this lack of professional assistance, the troops suffered greatly in landing, and a quantity of valuable stores were lost in being brought ashore through the heavy surf. In this way the whole of the ammunition for the Astor Battery was lost, and although a portion was afterwards recovered, this battery was rendered practically useless till the day before the fall of Manila. The work thus thrown on the army would, had they had an enterprising enemy, have certainly led to disaster.

Land transport may be said to have been conspicuous by its absence. A small number of caramatas (a small two-wheel gig drawn by a pony) and a few water buffalo carts had been gotten together, but were utterly insufficient for the requirements, and what transport existed was entirely deficient of any good organization. The stores were landed at Paranaque, about two miles from Camp Dewey, and a large bulk of them were carried to camp through the heavy mud by the men themselves. Had it not been for the splendid energy of the troops, inspired by the magnificent spirit that permeated the whole force, the army would have been but little better than an inert, immovable mass. No portion of the whole operations deserves more praise than the sight of soldiers laboring under heavy loads, in a tropical climate, carrying their camp impedimenta and stores the six, seven and eight miles from Camp Dewey to the city of Manila on the day following its fall. The whole working of this department was an excellent example of the need for specially highly trained officers to administer and carry out these important duties.

V. The Engineer Department.—The work of this department was hardly anywhere observable. It appeared that many of its trained officers were removed from their corps for other general and staff purposes, and their places taken by both untrained and unqualified officers, with a consequent loss of efficiency. No steps were taken to run out piers and landing stages, although such could have been easily done, the country in the immediate vicinity being well timbered, and any quantity of bamboo obtainable; skilled labor was at hand, which, under good guidance, could have rapidly built out a serviceable pier and landing stage.

Little, if any, effort appeared to have been made to improve the roads, which, although exceedingly bad, might have been somewhat less so by clearing the ditches on each side so as to draw off the water, which in many places lay several inches deep and caused veritable quagmires. No special arrangements were made for crossing the river between the Spanish and American trenches, fordable only at its mouth, until the day before the fall of the city, and then some rough bamboo trestles, etc., were hurriedly got together. As far as could be observed, had it been necessary to storm the city, the loss of life would, owing to the inefficiency of this branch, have been enormous and success very doubtful.

The field telegraph appeared to be efficient and to work well, but was very slow in opening communications. In connection with this subject the signallers were well trained and appeared to be most efficient, particularly during the advance on the city.

VI. The Subsistence Department.—The Subsistence Department is administered by the commissary-general, whose chief representative in the district is known as the Chief Commissary. The organization of the department is on similar lines to the quartermaster's.

As its name implies, it looks after all food stuffs required for rationing the troops; and also practically constitutes itself the sutlers of the army.

As far as the troops are concerned, there is only one scale of rations, no matter where they may be quartered. But this scale admits of infinite variation of diet; and as the allowance is very liberal the result is that American soldiers are the best fed troops in the world.

The rations which were provided were of excellent quality and appeared to give universal satisfaction. An entirely new departure, one of unqualified success, was the provision of a refrigerating steamship, loaded with frozen beef and mutton. This vessel, which contained some thousands of quarters of the above, rendered the question of the meat supply one of the utmost simplicity; and, as far as could be ascertained, the cost of provision was most economical.

The price of meat was only 5 cts. per lb., and, adding on the charge for demurrage, a two months' supply for both naval and land forces, only cost about 5 pence per pound.

The point before mentioned, that the department constitutes itself the sutlers for the troops, appears to be an entirely new departure from the custom of other countries. Practically the subsistence department provides at every post, in charge of the commissary or of a commissariat representative, a large store of articles which can only be accurately described as a well stocked provision shop, and of considerably more variety and better quality than the average regimental institute in the British service.

It was stated that until the introduction of this system endless trouble resulted from complaints by posts and detachments in out-of-the-way places that they were unable to obtain goods, or requests for extra allowances to meet the enhanced cost of living at such stations.

This system appears good, and undoubtedly gives great satisfaction and contentment to the troops, and it is stated that in the long run the government is the gainer by having little difficulty in recruiting, no demands or agitations for extra allowances, and a general contentment with their lot on the part of the officers and men serving.

The great defect in the department, which it is considered would be disastrous in any extended operations, requiring rapid or continuous movement of troops, is the separation of the transport from the control of the commissariat officer. If it be accepted as an axiom that to be a good commissariat officer a man must have an intimate knowledge of transport, and vice versa, then the United States' system must result in failure. That transport should always be subversive to commissariat, being simply a means to an end, was noticeable at Manila. The subsistence had everything that the troops could possibly want, but no means of taking it to them, and had they not helped themselves by carrying their own supplies, they would have had to go without.

VI. The Ordnance Department.—This department did not appear to be much in evidence during the operations, and no opportunity occurred for observing its work.

A point which is fatal to the interests of the country is that there is no such organization as an ordnance committee to decide on the armaments, rifles, and weapons to be used by both naval and land forces. The navy and army have committees of their own, who work quite independently of each other, and, as a consequence, there is no interchangeability of weapons between the services.

VIII. The Medical Department.—Considering the hurried way the expedition was despatched, this department appeared well equipped, and though at no time were they put to any great strain, still the work they had to do was well and excellently performed.

The sick were accommodated in light marquees, six men to a tent, bedded on a folding camp bed with wire-wove mattress, 2 ft. 6 ins. width, a blanket, pillow, also a bedside table and chair, the space between the beds about 2 ft., any extra bedding or blankets being brought from his unit by the patient. The system adopted at Manila was that surgeons of the regular forces were employed with the brigade and base hospitals, and volunteer medical officers did duty with each regiment or unit. No man was taken into the hospital unless his state was such that, in the opinion of the medical officer, he required special treatment or diet, otherwise he was treated in his own regimental camp, and performed such duty as the medical officer considered him fit for.

The hospital appeared to be very well found in the way of medicine, drugs, instruments, and appliances. The medicines and drugs were made up in the most portable form, such as compressed tabloids, etc., and the dressings, etc., were in the handiest shape, and in packets ready for immediate use. It speaks well for the skill of the department that they were completely successful in a large number of cases of abdominal wounds.

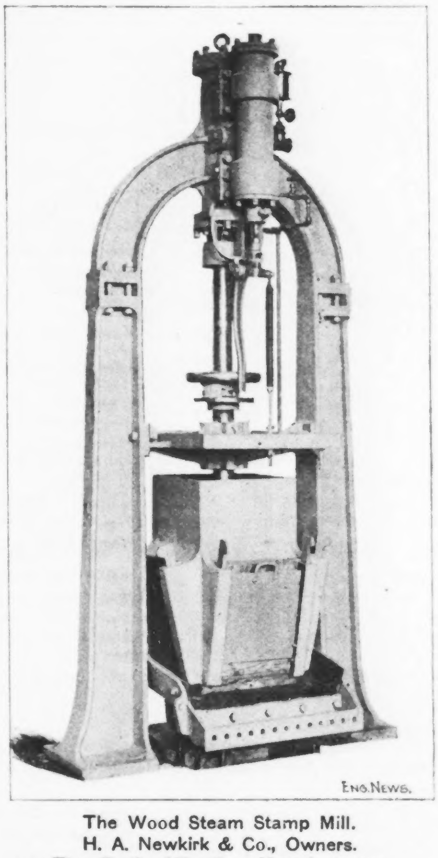
The health of the troops was extraordinary, and was subject of constant remark. Out of 8,000 men who were in camp before Manila only 124 were left behind sick when they advanced on the town on the 13th of August, and of these more than one-half were wounded. The following day—Sunday—the sick were moved into the town and the greater portion walked, as there was only transport enough to carry the bad cases. If the spirit of the troops was excellent it was even surpassed by that of the medical branch, who in spite of a defective transport and many other difficulties, always had their hospitals as complete and efficient as it was possible for human ingenuity to make them.

IX. The Pay Department.—This department performs similar functions to that in the British service, except that they deal with and decide all questions affecting the pay, etc., of the army, and are quite independent of the quartermaster-general's department. It committed a great error in bringing to Manila over a million and a half of dollars in gold for the payment of the troops. The consequences were that the men found great difficulty in getting change and lost considerably by the natives refusing to see any difference between an American gold dollar and a Mexican or Manila silver dollar, although the former was in actual fact worth slightly more than double the latter.

A DIRECT-ACTING STEAM STAMP MILL.

Stamp mills for reducing ores usually rely upon gravity for performing their work, the stamps being raised by cams operated by power and then released and allowed to fall by their own weight. In the Wood stamp mill, however, steam pressure is employed to raise and lower the stamps, the machine resembling a steam hammer in design and operation, as shown by the accompanying cut.

The horseshoe frame which carries the cylinder is mounted on foundations independent of those of the mortar, and the arched top member is adjustable, blocks or shims being inserted or removed between the member and the side columns to allow for the wear of the shoe and die. The shoe, bosshead, piston rod and piston weigh 550 lbs., and the drop, or length of direct stroke, can be regulated by the operator. The diameter of the shoe is 8 ins.; the piston rod, 3⅛ ins., and the piston, 5½ ins. The steam admission and exhaust is controlled by a piston-valve operated by a bell crank engaging with a tappet on the main piston rod. The machine is operated by steam at 60 to 75 lbs. pressure, or it may be operated by compressed air when the latter is available. It works very rapidly, and can make 200 blows per minute, but the speed is largely dependent upon the ability to keep the die thoroughly covered with material. The total weight of the machine is about 4,000 lbs., and it is made with a view to permit of transportation in difficult country. The mortar is especially designed to withstand the severe work of the mill, and three of its sides are utilized for screening purposes, thus giving ample exit for the pulp, which is discharged upon an apron mounted on the mortar. A Wood ore feeder, for wet or dry ore, is used, and the arrangements made for mortar amalgamation are said to have given very satisfactory results.



The Wood Steam Stamp Mill.
H. A. Newkirk & Co., Owners.
The E. P. Allis Co., Manufacturers.

At the Mammoth mine, in Arizona, where no ore crusher was in use, one of these mills has reduced 12 tons of very hard quality ore to 40-mesh pulp in 342 hours. This is said to be a greater capacity than three heavy gravity stamps, and on gold ores of average hardness the capacity is claimed to be about 8 to 15 hours per day.

The stamp mills are manufactured for H. A. Newkirk & Co., 1442 Monadnock Block, Chicago, by the E. P. Allis Co., of Milwaukee, Wis.

ARTESIAN WELLS FOR THE WATER SUPPLY OF CHATHAM AND MADISON, N. J.

By Louis L. Tribus, M. Am. Soc. C. E.*

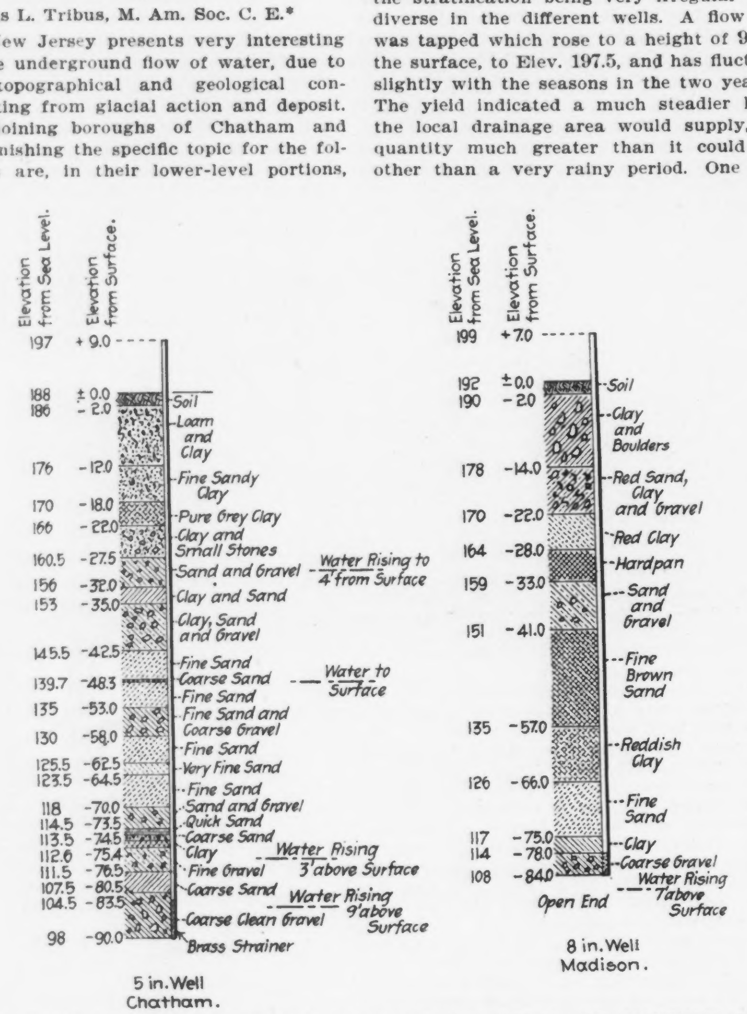
Northern New Jersey presents very interesting studies in the underground flow of water, due to the curious topographical and geological conditions resulting from glacial action and deposit. The two adjoining boroughs of Chatham and Madison, furnishing the specific topic for the following notes are, in their lower-level portions, practically identical in formation, both being situated on the gravel and sand banks back of a terminal moraine.

In designing a public water system at Chatham, numerous active springs were noted particularly, opening out at about Elev. 195 ft. above sea level and without local drainage area of sufficient capacity to warrant their continuous flow. Much speculation has been indulged in as to their source.

Some two miles southwest from Chatham are the head waters of a branch of the Passaic River in what is known as the Great Swamp, a tract covering many square miles, lying at about Elev. 240 ft. above sea level. According to some, this swamp marks the last visible evidence of the ancient Lake Passaic. The dividing hill between the swamp and the lower portions of Chatham and Madison is of but slight height and seems to be entirely of gravel and sand.

It seems not an unfair assumption that a portion of the stored waters of the Great Swamp should seek an outlet through this gravel divide, flowing out as springs a little above the river's level; traversing thereby about two miles through the ground instead of ten or twelve or more miles by the river's course, first southwest, and then northeast. The curious windings of the present Passaic River, and the very small surface tributaries from Long Hill and the Madison and Morristown ridges, with the large accessions from springs, tends to strengthen the opinion.

Acting on this supposition, wells for Chatham were so located as to be within what seemed to be a natural line of flow for such waters, and where a number of bright springs gave corroborative evidence. These pipe wells were driven to an approximate depth of 100 ft., passing through grayish clays, sand, hardpan and into gravel; the stratification being very irregular and quite diverse in the different wells. A flow of water was tapped which rose to a height of 9 ft. above the surface, to Elev. 197.5, and has fluctuated but slightly with the seasons in the two years of use. The yield indicated a much steadier head than the local drainage area would supply, while in quantity much greater than it could yield, in other than a very rainy period. One 5-in. and three 6-in. wells were driven by ordinary methods with an oil-well outfit, and were connected up to the pumps for direct suction.



SECTIONS SHOWING STRATA PIERCED BY ARTESIAN WELLS, AT CHATHAM AND MADISON, N. J.

The flow from the four wells, with slight suction lift of say 12 ins. vacuum, has been easily 1,000,000 gallons per day, while under ordinary service, at rate of pumping of about 300,000 gallons per 24 hours, the water practically flows into the water cylinders of the pumps 3 ft. above the ground level at the wells.

A few months after the inauguration of the Chatham plant, questions of increased supply for Madison were submitted to the writer. The water supply there had been drawn from a large dug well, 30 ft. in diameter, and 30 ft. in depth, fed by very active springs of about 250,000 gallons daily capacity. On the same property were other lively springs which could have been used also, but in the interest of precaution against possible future contaminating influences, and in view of the success in the adjoining borough of Chatham, it seemed best to adopt similar methods.

Before calling upon the writer, the council had caused two test wells to be driven, one of 42 ft. depth, striking a moderate flow, the other 68 ft., abandoned for lack of success. After some consideration, plans and specifications were prepared, and a contract made with the Hydraulic Construction Co., of New York, the lowest bidders. Similar methods were adopted as in Chatham, except in the substitution of 8 for 6-in. piping. The first well was driven to a depth of 84 ft., there striking a remarkable flow of 440 gallons per min., measured 2 ft. above the ground; 200 gallons per min. at 6 ft.; and rising to a point of rest at 7 ft., or about Elev. 199. This was 2 ft. higher than the similar level at Chatham, 3/4 mile to the southeast

The other wells, located about 100 ft. apart, ranged in depth respectively 100, 101 and 148 ft., securing the same waters as found in the first well but not in such strength of flow, though rising to the same elevation at rest. The temperature in summer of both of these waters at Chatham and Madison ranges about 53°-55° Fahr.; the analyses are also very similar, indicating between 4 and 5 degrees of hardness, and very gratifying purity.

The yield of the Madison plant has not been closely measured, but is conservatively estimated at from 1,500,000 to 2,000,000 gallons per 24 hours from the four wells, under ordinary suction, or about 1,000,000 gallons natural flow at the surface, into the receiving well.

The wells are so connected that if need arise, the suction main can be extended to the pump, and for that purpose, so as to be on a rising grade all the way, it is buried from 7 to 9 ft. in the ground, the wells being cut off as suitable depths and the controlling well heads and valves protected by manholes. At present, however, the discharge is into the large dug well, below the water level, so that pumping from the latter induces siphon action in the well system.

While formerly the level used to be lowered some 23 or 24 ft. in the large well, and then not refilling fast enough for the needs of service, now 4 to 5 ft. only marks the lowering of level, at the maximum rate of pumpage with the present plant.

The slightly increased head of the Madison over the Chatham wells may be readily due to their lesser distance from the Great Swamp, and consequent saving in frictional resistance.

At Madison, as at Chatham, the stratification of the soils penetrated was found to be very different in the different wells, clearly indicating the glacial origin. The accompanying sketches show the strata penetrated by the wells.

*Consulting Engineer, 84 Warren St., New York city.

THE MANUFACTURE OF ORNAMENTAL IRON WORK.*

By Chester B. Albree, M. Am. Soc. M. E.†

In America, the fireproof building has made a demand for iron stairs, elevator enclosures, and other work in iron, that has been met by a combination of wrought and cast iron, with bronze and other metals. Cast newels, stringers, fascias, with wrought-iron grilles and railings, are now used, that have never been equaled, either in design or workmanship. The designs for the castings are first modeled in wax by artists, plaster molds and cast obtained, and an iron pattern made and tooled, until the very character of the original is obtained. Then careful molders, with fine sand, reproduce the pattern. The casting is cleaned and parts polished, and in the best work electroplated with some desired finish, to preserve it from rust and to please the eye. Such work calls for thorough knowledge of ornament and design, engineering ability to determine the strains and stresses, and mechanical knowledge of a high order to accomplish the results, together with large capital invested in machinery, patterns and buildings.

There is, however, a class of work, lying between the fine work described and structural iron work and bridge building, embracing fences, railings, stairs, sheds, ornamental roofs, and other work, where ornamental effects are desired, but also where cost enters to prevent the employment of the highest class of work. Great numbers of duplicate pieces must be produced at low cost, both for material and labor. Methods of assembling the pieces must be devised that will be rigid, yet allow of rapid work. The modern manufacturer has at his disposal a host of advantages and resources, unknown to his predecessors.

Primarily is to be placed the product of the rolling mill, giving the manufacturer choice of material rolled in almost any desired shape and size and of any specified quality. The invention of labor-saving machinery of all sorts has made entirely mechanical much that was formerly only to be accomplished by the skilled mechanic by hand. Thus punching, drilling, riveting and tapping, with shearing and bending, can all be done, to a very great extent, by machine. As a result, the easiest way to get ornamental effects is no longer as practiced by our forefathers, but on modern lines. We often see work today put together in imitation of the earlier methods for

*Extract from a paper read before the Engineers' Society of Western Pennsylvania.
†16 Market St., Allegheny, Pa.

the sake of effect. This may do for occasional pieces, but for any larger quantity of work it would be wasteful and rather foolish.

In addition to rolled shapes of the ordinary bar, plate or structural mill, we can now obtain certain special shapes, made exclusively for ornamental work. Moldings, both plain and decorated, in great variety of size and contour, suited for many different kinds of work, can be purchased. They are made in Germany, and the obtainable sections demonstrate that our rolling mills can learn a good deal from our brethren across the water. The mere fact that there is a market in Germany for such material is of itself an argument as to the character of their iron work, from an æsthetic point of view, for I know of no mill in the United States that can approach this work in character or finish. Drop forged pickets, rosettes of all shapes, leaf forms, and various other decorative designs, well illustrated in Braun's catalogue, can be had, as also a large choice of hand-made leaf, flower and other work that could not well be machine made.

By the use of the ordinary and extraordinary kinds of material described the iron worker of to-day has only to sketch out his idea full size, modify it a little here or there to fit the catalogue lists, order his material and work it up to produce work that in appearance, strength and workmanship combined with uniformity and cheapness of production, is the par of any produced by entirely hand work. But even this class of work is too costly for use where very large quantities of duplicate work is required, and hence means are used to produce ornamental effects, at the very lowest possible price; in fact, at prices that vary but slightly from the present pound prices for bridge work.

As an illustration sometimes conveys information much better than whole volumes of books, a full detail of a panel for the Harlem River speedway railing for New York city, designed by Prof. Burr, of Columbia College, is shown in Fig. 1, in which the rosette is omitted in our picture to show the construction. The top rail was casing and all the holes were punched by using a long bar, carrying die in end, inside of tube and holder outside. The

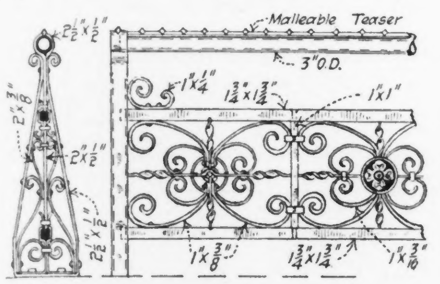


Fig. 1.—Railing for Harlem River Speedway, New York City.
Prof. Wm. H. Burr, M. Am. Soc. C. E., Designer.
Chester B. Albree, Allegheny, Pa., Builder.

"teaser," or cast malleable iron pointed top piece, was all punched and sheared to gage. The small round projections, fitting in top pieces of post, were to prevent the pipe turning. The 1¾-in. sq. rails were really steel billets. The holes were at first punched, but as that swelled out the bars, they were later drilled, except the depressions, holding the vertical twists in place, which were punched. The twists were machine made, cold. The nicks or offsets were pressed under a punching press. The scrolls were first sheared and punched, then bent over a former to the required shape, all to gage. The scrolls were assembled as shown, later being fitted into the special cast rosette, and finally the hands put on and clinched with a dovetail, as you see.

The post was more difficult. Most of the smaller pieces were first punched, then passed through "bull-dozer" for the preliminary bend, then through special hand or machine formers to give the final shape. The exterior part was gage-punched, scrolls beaten out and turned, and finally dropped into a form and both sides drawn around as indicated. Thus, each part was made up by the thousands, brought to the assembling spot, riveted or clamped, and passed on for painting and inspection, most of the work being paid for by the piece. As there were many grade panels, requiring special dies and forms, very close watch had to be kept to keep the pieces separated, for the external appearances were very similar. There was some 17,000 ft. of this railing, weighing 60 lbs. per lineal foot, or considerably over 1,000,000 lbs. of this comparatively light work. To lay off the vast number of duplicate pieces to be sheared and punched would be very slow and expensive work. This is avoided by means of little jigs and gages. One that is quite simple, for accurately spacing a lot of holes irregularly spaced along a number of bars, is to lay off the required holes, reversed, on a bar, screwed to a table, so that the bar is in line with the punch; a little dog, with a projection just fitting into the holes described, is made, having a little upwardly projecting lip. Inserting this dog into the hole furthest from the punch, the bar to be punched is shoved against the lip and hole punched in other end. The dog is moved to next hole, bar put again against lip, and hole punched in other end, of course just the required distance from the hole last punched. All that is necessary is to have the bars cut off the right length, and no other laying out is required.

Special punches and dies are continually required. In order to execute this class of work quickly and cheaply, hand work must be largely eliminated, and the ingenuity called upon to devise jigs or processes to avoid it. Architects, and, alas! bridge and structural engineers, often entirely overlook these features, and wonder why some designs of their own cost so much more than others apparently calling for much greater labor in construction. It is, of course, due to a failure to understand the construction of such work from the manufacturing standpoint, and if the designer would call in the assistance of a practical man, it would often save a great deal of needless expense, and generally result in very much improving the design of the work.

AN IMPROVED FORM OF PORTABLE PHOTOMETER.

We illustrate herewith a form of portable illuminator photometer which on account of its compactness, simplicity and reliability will be of service in setting disputes between indifferent private lighting companies and municipal authorities, or between overzealous aldermen and well behaved lighting companies. Its use, however, is not restricted to the purpose just outlined for the instrument is also intended to measure illumination, no matter how produced.

The general appearance of the photometer is well shown in the small illustration, Fig. 1, which affords an idea of its compactness and portability.

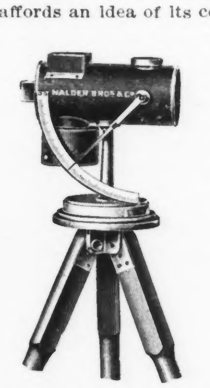


Fig. 1.—A Portable Illumination Photometer.

Nalder Bros. & Co., Great George St., Westminster, London, Makers.

Fig. 2 represents a somewhat diagramatic section. The instrument in its present form consists of an enclosed horizontal cylinder mounted upon a standard and containing at one end a reflecting screen (R) and at the other a small standard amyl-acetate lamp (L). The lamp is mounted in two cylindrical boxes which are so perforated as to admit the necessary air for combustion while protecting the flame from drafts. The flue for the heated air rising from the lamp flame is also arranged so that no external air currents can drift through and disturb the flame. The body of the lamp is provided with an outside thread and the flame height can be adjusted by turning the lamp one

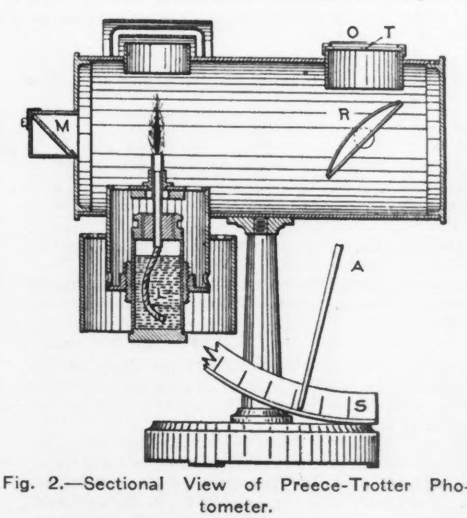


Fig. 2.—Sectional View of Preece-Trotter Photometer.

way or the other until the tip of the flame just touches the point of a needle, as shown in the inclined mirror (M), which is used only for this purpose. The reflector (R) is mounted on a horizontal axis provided at one end with a pointer arm (A), which swings over the curved scale seen in Fig. 1.

Directly over the movable reflector is a horizontal screen, slightly tinted blue to remove color difficulties. There is also an outer screen made of paper with a narrow slit (T) set across the line of the instrument. If the instrument is set up near any source of light the general illumination falls upon the outside screen. Through the slit the inner screen can be seen by an observer with his eye vertically over the slit. It is at once apparent that if the outside screen is better illuminated than the inner one, the slit will appear dark. If the contrary is true then the slit appears light. It is, therefore, possible by shifting the arm (A) to balance the respective illuminations, so that the screen and slot appear alike. The scale reading at that instant gives the illumination compared with one standard candle at one foot—that is, a reading of ten would indicate that the general illumination of the region about the instrument was ten times as great as would exist at one foot from a standard candle.

At the center of the pivot of the reflector (R) is a small projecting needle. If the instrument is held horizontal and is so placed that the shadow of this needle strikes the scale at 45° the vertical height of the lamp above the needle just equals the distance from the needle to the vertical line through the lamp. This needle also enables the candle-power of a light to be determined with a fair degree of accuracy. Fig. 3 is an illustration of the method of measuring the candle-power of an arc light, and will serve to illustrate the prin-

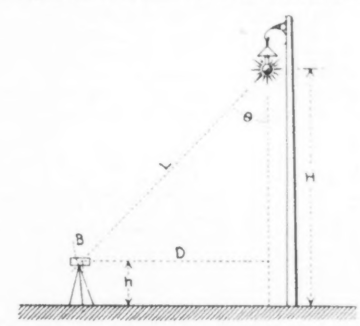


Fig. 3.—Diagram Showing Method of Determining Candle Power with the Preece-Trotter Photometer.

ciple in any case. (D) and (h) are measured with a tape line, (θ) is obtained by means of the shadow of the needle and the scale before mentioned. The other quantities require the use of the following equations:

$$H - h = \frac{D}{\tan \theta}$$

$$L = \frac{H - h}{\cos \theta} = \sqrt{D^2 + (H - h)^2}$$

$$\text{Candle-power} = \frac{\frac{c}{f^2} \times L^2}{\cos \theta}$$

in which $\frac{c}{f^2}$ = the illumination of candle-power at one foot or the scale reading obtained as already explained.

The instrument, as at present constructed, is an improved form of the Preece-Trotter illumination photometer, first described in a paper read before the British Association for the Advancement of Science at its Ipswich meeting, held in the fall of 1895. It is manufactured by Nalder Bros. & Co., Gt. George St., Westminster, London, England, to whom we are indebted for the material from which this description has been prepared.

MINE SURVEY STATIONS, where the roof is too bad to permit the placing of a plug, are made as follows in some of the Ohio collieries, says "Mines and Minerals." Plugs are made of horseshoe nails flattened at the end and a small hole punched in this end. Two of these plugs are driven in one side of the gallery, near the station to be marked, and one on the other side; from these three plugs a triangular piece of thin galvanized iron (1½ ins. long on each side) is suspended by three brass chains, each about 5 ft. long. In the center of the triangular piece is a small hole admitting a thin wire to which the plumb-line is attached. In practice, the chains are hooked in the holes in the plugs; the plumb-bob is suspended from the centerpiece, and the transit is set up under the plumb-bob.

APPLICATION OF THE PRINCIPLE OF WATER STORAGE TO NEW ENGLAND RIVERS.*

By J. Herbert Shedd, M. Am. Soc. C. E.†

New England is a distinct section of the country, having a broken surface of considerable elevation above the sea, and somewhat separated from the rest of the United States territory by mountain ranges near its western limit, and having for a portion of its northerly boundary the range which divides the basin of the St. Lawrence River from the coast slope.

The climate, though perhaps fickle, is equable, and it has a considerable range of temperature and moisture resulting from the nearness of the Gulf Stream on one side and the Arctic currents on the other. The line of mean annual temperature of 40° runs through the northern portion, varying from month to month from about 10° to about 62°, and that of 52° runs through the southern portion, varying from month to month from about 32° to about 74°. The fluctuations of temperature within the year are less than in the inland sections of the country. The climatic advantages afford a choice of the most favorable conditions for widely differing industries.

The extraordinary indentations of the coast, causing on the coast of Maine a water line of about ten times the general length of the shore, and the sudden dropping of the land surface below the level of the sea, form excellent harbors, favoring the development of ocean traffic. There is a decided contrast between the shore of New England and that farther south, and Point Judith, at the southern extremity of Rhode Island, marks the dividing line between the rock-bound coast of this territory and the low, sloping, sandy Atlantic and Gulf Coast of the rest of the Union.

The geological formation is such that a greater number of concentrated falls is to be found here than anywhere else east of the mountain system separating the Atlantic slope from that of the Mississippi or St. Lawrence, and the valleys are so situated as to form favorable lines for railroad construction. The great slopes of the rivers in their working portions are more marked in Maine than elsewhere east of the Mississippi, except on the upper Hudson, and the holding of a relatively high elevation near the coast is favorable to the development of large powers. The conditions are also generally favorable for safe and economical construction of dams and service channels to those on most of the large rivers farther south. The rocks which prevail through the territory are hard and generally so disposed as to be of permanent value in the preservation of the falls.

The rainfall is well equalized through the seasons, and the great number of lakes and natural ponds favor the equalizing of the yearly flow of the streams, which is more uniform than farther south, and the artificial regulation by reservoirs can be much more economically accomplished than in the Middle or Southern States.

Building materials are abundant and easily secured, including stone, wood, clay for bricks, lime and slate.

Prof. George P. Swain, Special Agent, Tenth Census, United States, after enumerating the various conditions affecting water power which prevail in New England, and contrasting them with those of other sections of the country, says:

> Considering all these circumstances, it must be allowed that on the Atlantic slope the streams of New England are in all respects the most favorable for water power; and of the New England streams few will compare with the great rivers of Maine. One cannot read the list of splendid powers in that State, many still lying idle, without becoming convinced that her water power is unsurpassed. Her lakes, many of them lying at a greater elevation than that of Lake Itasca, the source of the Mississippi, or than Lake Superior; her rivers plunging over ledge after ledge of unyielding granite in their short courses from these reservoirs to the sea; her extensive woods, adding their regulating effect to that of the lakes, and her navigable bays and inlets, reaching to the last great leap of the rivers—all these constitute an array of favorable circumstances which, in spite of some opposing disadvantages, would be difficult to equal.

And again, after having given many local particulars and results of observations and experiments in New England, he says:

> Reviewing what has been written in the previous pages, the topography and the geology of the region affording a rapid declivity from the mountains to the sea, broken by sudden falls over the ledges of hard rock; the favorable character of the bed and banks as regards foundations and freedom from overflow; the favorable arrangement and small extent of the mountain region; the low temperature, causing a large rainfall and a small evaporation; the favorable distribution of the rainfall through the year; the immense facilities for storage; the extensive forests; the absence of very destructive freshets and ice jams; the rock-bound coast, affording facilities for utilizing the large rise of the tide; the prevailing fogs, and the accessibility of the region, together constitute an army of favorable circumstances which may well entitle New England to the first rank as a water power district.

The precipitation in Boston for 28 years in average monthly periods has been as follows:

	Depth, ins.
December	3.26
January	3.92
February	3.51
Winter	10.69
March	4.02
April	3.44
May	3.59
Spring	11.05
June	3.05
July	3.48
August	4.38
Summer	10.91
September	3.08
October	4.12
November	4.61
Autumn	11.81
Total for the year	44.46

It is usually assumed in New England that about half the total rainfall of the year is lost to the streams through the various forms of evaporation and deep percolation. But this loss is not uniform during the different periods of the year. In Massachusetts it has been found that the evaporation from an open water surface amounts in winter to about 3.4 ins. vertical depth; in spring, 7.7 ins.; in summer, 17.5 ins.; in autumn, 10.5 ins.; or a total for the year of about 32.9 ins. The total evaporation of all surfaces combined and the deep percolation together amount ordinarily in a year to 22 to 24 ins.

The rainfall upon an open water surface for a year in Massachusetts is usually 5 or 6 ins. greater in depth than the evaporation from the same water surface, but while there is gain from the rainfall in the whole year there is a positive loss in the summer months from such a surface to the extent of 5 or 6 ins. depth for the season. The effect of such inequality needs to be corrected by reservoirs in order to avail of the full value of the power of the stream. The above figures in regard to the evaporation apply well to Southern and Western New England, but the temperature and fogs and woods of Eastern and Northern New England tend to lessen very much the ill effects of evaporation upon the uniformity of flow.

The more important water power basins of New England are those of the Housatonic, the Connecticut and the Shetucket, emptying into Long Island Sound; the Blackstone, emptying into Narragansett Bay, and the Merrimac, the Saco, the Androscoggin, the Kenebec and the Penobscot, emptying into the Atlantic Ocean.

The areas of these basins and the falls, in the principal power section of each, are about as follows:

Name.	Area. sq. miles.	Fall in ft. Power section.	Fall in ft. From near head to sea.
Housatonic	1,870	1,140	1,600
Connecticut	9,775	1,100	2,040
Shetucket	1,254	620	1,000
Blackstone	481	726	1,110
Merrimac	4,758	710	1,950
Saco	1,559	410	1,880
Androscoggin	3,270	1,256	2,917
Kennebec	5,715	1,023	3,113
Penobscot	7,910	930	1,808

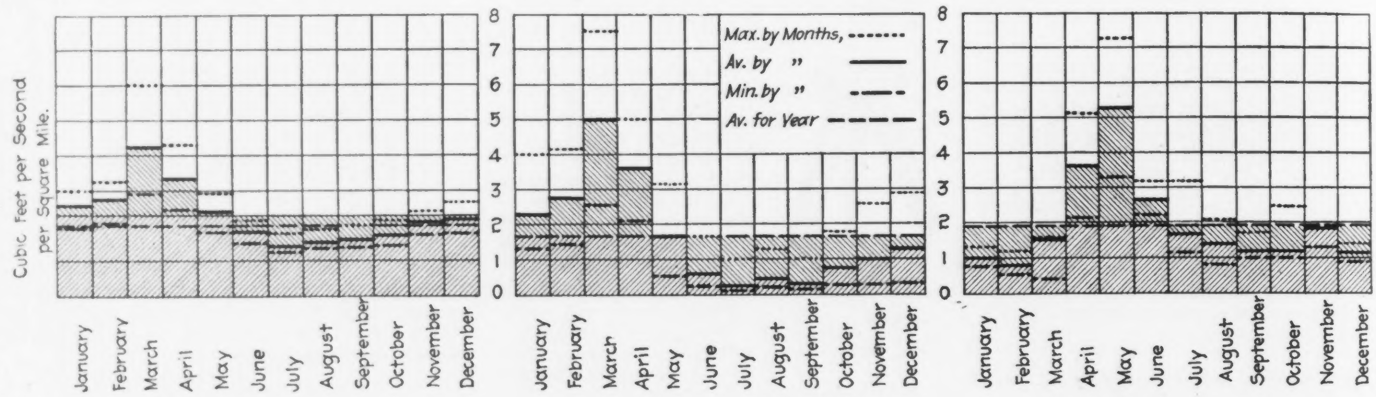


Fig. 1.—Blackstone River, Rhode Island. (Additional storage required, 13.7%.)

Fig. 2.—Sudbury River, Massachusetts. (Additional storage required, 35.5%.)

Fig. 3.—Androscoggin River, Maine. (Additional storage required, 24.9%.)

DISCHARGE OF BLACKSTONE, SUDBURY AND ANDROSCOGGIN RIVERS IN RELATION TO STORAGE.

The precipitation in several river basins is given in the census report of 1880, as follows, in inches of vertical depth:

	Winter.	Spring.	Summer.	Autumn.
Merrimac	9	10	11	13
Concord	10	11	11	12
Sudbury	10	11	11	12
Charles	10	11	11	12
Connecticut	10	10	12	12
Housatonic	10	12	12	12
	59	65	68	73
Average	9.84	10.83	11.33	12.17
Boston, as above	10.69	11.05	10.91	11.81

In interior Massachusetts and Southern New England about the following seasonal rainfall map may be expected:

10.9	10.9	12.3	11.9

It may be fairly said that about 11 ins. depth of rain and melted snow may be expected in each period of three months, with rather more in the autumn than in the winter or spring.

The total rainfall of Maine is probably less than elsewhere in New England, but there is also less evaporation, which tends to keep the available yield into the streams high. The forests have a regulating effect, but are much less controlling than a low temperature and a moist atmosphere, which greatly lessen the amount of evaporation. Maritime winds also contain more moisture, and thus take up less from the rivers and lakes and from vegetation and tend to a uniform flow of the streams.

It results from the relatively even distribution of rainfall in New England that the freshets are much less destructive than elsewhere and the low water run is greater.

Of these basins the Androscoggin furnishes a remarkable instance of high-power producing capacity. The fall, after reaching a point where the river has received the water from 0.7 of its drainage area, is about 600 ft. through a country well adapted to the establishment of industries requiring power. No other large stream has so much fall for so large a proportion of its drainage area. The Penobscot for 0.6 of its area has a fall of about 190 ft. The Kennebec, for 0.7 of its area, has a fall of about 130 ft. The Merrimac for 0.6 of its area has a fall of about 180 ft. The Connecticut for 0.7 of its are has a fall of of about 180 ft., and for five-ninths of its area has a fall of about 280 ft.

The drainage of the principal streams, at the point where the last marked fall occurs on each, are as follows:

	Sq. miles.
Penobscot at Bangor	7,910
Kennebec at Augusta	5,715
Androscoggin at Brunswick	3,270
Presumpscot at Falmouth	613
Saco at Saco and Biddeford	1,559
Merrimac at Mitchell's Falls	4,758
Blackstone at Pawtucket	481
Pawtuxet at Pawtuxet	227
Shetucket at Greenville	1,254
Connecticut at Windsor Locks	9,775
Housatonic at Shelton	1,870

The combined effect of rainfall, evaporation and percolation upon the yield of streams has been carefully measured in many instances, and for some streams the measurements have been continued through many years. A few illustrations representing different conditions may be interesting.

I will take three cases for examples—one of a fully

*Slightly condensed from a paper read before the American Paper & Pulp Association at its meeting in New York, Feb. 15 and 16, 1899.

†Of Providence, R. I.

occupied stream, another giving uncontrolled natural flow and a third stream having large reservoirs partially controlled artificially.

The Blackstone River.

This is a well reservoired stream, artificially controlled and fully occupied from near its source to its mouth by water power plants. The drainage area is about 481 sq. miles, and the utilized fall is 726 ft. There is developed and usable on this stream in water power 22,829 HP., equal to 47.5 HP. per sq. mile of drainage area. No other considerable river known to me has developed half that power per square mile of drainage area. The ponds and reservoirs in the Blackstone drainage area measure 13.16 sq. miles in area. They are about 134 in number, and the largest—Quinsigamond—is 1.22 and the smallest 0.002 sq. miles in area. The water area is 2.74% of the total area.

The use of water power in this stream is mainly for textile manufacture, and the mills are usually stopped at night. The measurements of flow which I gave were made in the eleven working hours of each day. The diagram (Fig. 1) is intended to illustrate graphically the average yield of water by the stream in each month of the year. The horizontal base of the diagram is divided into twelve parts, and each part is given the name of a calendar month, but the flow of that calendar month is not always used in ascertaining the average flow of the month as represented. It is more instructive, in studying the yield of a stream, to arrange the discharge for each month in the order of dryness or relative amount of yield for each month in the year. For instance, in the Blackstone the month of least yield is ordinarily July, and therefore, the month of least yield in every year being classed together and the average taken, the result is plotted over the name July, though the least yield in some of the years probably occurred in some other calendar month. And the month of greatest yield is usually March, and therefore, the months of greatest yield in all the years are classed together, and the average is plotted over March. The result is that the diagram shows a greater irregularity in the monthly flow than would appear if the averages for the calendar months were given, but not more irregular than actually occurs in the run of the stream. In order that the record of the monthly flow may be more complete, the yield of the month of least flow and that of the month of greatest flow, for each month in its relative position, are plotted below and above the average for that month of the year. The line representing the average flow cannot be expected to be a mean between the least flow and the greatest flow, because the average is deduced from all the records of all the years, and not from a mean between the least and the greatest.

In order that the elements affecting the flow of different streams may be compared with each other, it is convenient to reduce the records of the yield of the several streams to cubic feet per second per square mile of drainage area, thus eliminating in a measure the question of size. For instance, speaking broadly, if a given district has an annual rainfall of a 4 ft. depth in a year, and one-half of this depth is found, in the course of the year, flowing in the main drainage stream, the yield of that stream would be equivalent to an average discharge of 1.7678 cu. ft. per sec. per sq. mile of the area drained. In the case of the Blackstone River the measured discnarge represented an average flow through the year equivalent to 2.2966 cu. ft. per sec. per sq. mile of area drained. This seems very large, but it is to be remembered that the measurements were during the working hours of the day; and in a reservoired stream controlled for day use the night flow would be much less than the day flow.

The vertical distance above the base to the heavier line, on the diagram of the flow of the Blackstone River, represents the average discharge, in cubic feet per second per square mile, for each month of the year, as designated.

The maximum, minimum and average monthly discharge during working hours is shown by Table I.

TABLE I.—Discharge of the Blackstone River.

	Cu. ft. per sec. per sq. mile. Maximum.	Minimum.	Ave.
December	2.670	1.809	2.1942
January	2.999	1.975	2.5745
February	3.233	2.066	2.7452
March	5.995	2.937	4.2149
April	4.333	2.414	3.3424
May	2.952	1.841	2.3849
June	2.191	1.504	1.8151
July	1.743	1.225	1.3927
August	1.877	1.339	1.5048
September	2.004	1.346	1.5799
October	2.149	1.452	1.7228
November	2.366	1.777	2.0883
Total	34.512	21.685	27.557
Average	2.876	1.807	2.2966

7.5139 ÷ 3 = 2.5046 for winter.
9.942 ÷ 3 = 3.3141 for spring.
4.7126 ÷ 3 = 1.5709 for summer.
5.3910 ÷ 3 = 1.7970 for autumn.
9.1866 ÷ 4 = 2.2966 for the year.

It will be noticed that there is still considerable variation in the yield in different months. In order to secure an entirely uniform flow throughout the year, there should be provided additional storage to receive the surplus water during those months in which the yield is now above the average, and supply it to the stream during the months when the yield is below the average. This could be accomplished by a further storage of about 13.7% of the annual yield of day use, which would add to the present available supply more than 3,000 HP. When power is taken by eminent domain away from these mills, which are doing business based on the power they use, it is thought to be worth about $1,000 per horse-power, but I suppose the value of the addition of new power, requiring new arrangements of mills and business, might be reckoned at, say, half of this, or $500 per horse-power. Even at this rate the new storage basins, if secured, would be worth $1,500,000. Upon such streams as those in Maine, having numerous large natural lakes, the cost of such an amount of storage would be very small.

The amount of increase in the ordinary flow by artificial storage has been carefully observed on the Blackstone, and it was found to be almost exactly doubled. The average minimum monthly yield on a stream like this, in natural condition, is often not more than 20% of the average annual yield, but in the present improved condition of this stream, the average minimum monthly yield is about 60% of the average annual yield.

The horizontal line midway in the diagram represents the average yield of the stream of 2.2966 cu. ft. per sec., and is plotted at that distance above the base on the vertical scale. The area below that line, cross-hatched in one direction, represents the quantity of water available up to the average flow of the stream, without further storage; and the area above that line, cross-hatched in the other direction, represents the volume of water yet to be stored to fully equalize the flow of the stream, and it just equals the area, cross-hatched in a similar way below the average line, which represents the amount of water to be drawn from the new reservoirs in the months otherwise yielding less than the average flow.

TABLE II.—Discharge of the Sudbury River.

	Cu. ft. per sec. per sq. mile. Maximum.	Minimum.	Ave.
December	2.875	0.312	1.295
January	4.033	1.323	2.236
February	4.205	1.409	2.753
March	7.584	2.537	4.990
April	5.020	2.058	3.576
May	3.150	0.527	1.617
June	1.659	0.229	0.566
July	0.996	0.067	0.195
August	1.256	0.181	0.412
September	0.998	0.130	0.272
October	1.761	0.275	0.738
November	2.571	0.278	1.039
Total	36.108	9.326	19.689
Average	3.009	0.7777	.....

6.284 ÷ 3 = 2.0947 for winter.
10.183 ÷ 3 = 3.393 for spring.
1.173 ÷ 3 = 0.3910 for summer.
2.049 ÷ 3 = 0.6830 for autumn.

I have prepared another diagram (not reproduced.—Ed.) on which the average monthly discharge for each month of the year, in the order of the dryness, and plotted in that order for 14 rivers, is plotted in 16 lines.

The greatest differences in yield, from the dryest to the wettest month, are found in the smaller rivers. For instance, the west branch of the Croton River—a small stream of little more than 20 sq. miles of drainage area—has a smaller minimum average monthly flow than any other stream noted, to wit: 0.170 cu. ft. per sec. per sq. mile; and it has also the largest maximum average monthly flow, to wit: 7.146 cu. ft. per sec. per sq. mile. On the other hand, the Connecticut, draining an area of 10,234 square miles, at Hartford has an average minimum monthly flow of 0.648 cu. ft. per sec., and an average maximum monthly flow of 5.275 cu. ft. per sec. The heaviest lines show the average monthly flow of the Blackstone and distinctly exhibit the effect of reservoirs in increasing the dry weather flow.

The Sudbury River in Massachusetts.

This is a small stream having only about 76 sq. miles of drainage area, but its yield has been so carefully measured for a period of 22 years as to make it a valuable example for study. About 3% of its drainage area is water surface, chiefly artificial, but the measurements have been so taken as to give the natural yield unaffected by the storage in the artificial basins, except as influenced by evaporation there. I use the stream, therefore, as representing a purely natural flow. It is to be remembered that the variations in the amount of monthly flow are greater in a small stream than in a large stream. The month of average minimum flow is July, and the month of average maximum flow is March, as in the Blackstone basin. The description of the diagram given for the Blackstone River can be readily applied to this (Fig. 2). It will be noticed that the amount of artificial storage necessary to fully equalize the flow of this stream is 35.5% of the average annual flow, or about 2.6 as much storage as is still needed on the Blackstone.

This amount of storage is impracticable in the Sudbury basin. The maximum, minimum and average monthly discharge in cubic feet per second per square mile are shown in Table II.

The average yield in the stream of 1,641 cu. ft. per sec. per sq. mile is equivalent to a depth of about 1.86 ft. in a year saved out of the rainfall.

The Androscoggin River in Maine.

This river furnishes in some respects the most remarkable water-power basin within my knowledge. A large proportion of its drainage area lies high above the level of the sea, and it is naturally well reservoired near the headwaters and in a cool and favorable climate. The water surface of its larger lakes and ponds is estimated to be about 6½% of its total drainage area. These lakes are generally deep, and well adapted to the artificial increase of depth of storage, a more important condition than mere extent of storage surface. The records of measurements which I give, and from which the diagram is constructed, were made at Rumford Falls, above which point the drainage area is estimated at 2,320 sq. miles, in which the water surface of the larger lakes and ponds is about 4.2% of the total area. In neither of these perceutages is any account made of a large number of small ponds which exert a favorable influence in regulating the flow.

The average annual run of the stream is equivaleut to a depth of 2 ft. 2 ins. saved out of the rainfall.

It will be seen from this diagram that the month of greatest yield is May. This results from the cold weather of winter and spring, which causes the precipitation to be largely in the form of snow, and so delays the melting of the snow as to cause it to give its greatest yield about two months later thau that occurreuce in Souhern New England.

The value of natural storage with some artificial increase and control is well showu in the fact that the entire uniformity in the flow could be secured by an additional storage capacity of about 24.9% of the annual flow. This is about 70% of the amount of storage required in such a natural stream as the Sudbury River.

The general descriptiou given of the Blackstone diagram can be readily adapted to this oue (Fig. 3).

The maximum, minimum and average mouthly discharge in cubic feet per second per square mile are given in Table III.

TABLE III.—Discharge of the Androscoggin River.

	Cu. ft. per sec. per sq. mile. Maximum.	Miuimum.	Ave.
December	1.379	0.901	1.099
Jauuary	1.371	0.780	0.987
February	1.289	0.530	0.807
March	1.737	0.366	1.524
April	5.177	2.168	3.608
May	7,289	3,280	5.249
Juue	3.194	2.190	2.631
July	3.168	1.073	1.629
August	2.086	0.832	1.342
September	1.737	0.970	1.128
October	1.646	1.073	1.164
November	2.466	1.310	1.838
Total	32.539	15.473	23.006
Average	2.712	1.289	1.917

2.893 ÷ 3 = 0.9643 for winter.
10.381 ÷ 3 = 3.4603 for spring.
5.602 ÷ 3 = 1.8673 for summer.
4.130 ÷ 3 = 1.3767 for autumn.
7.6686 ÷ 4 = 1.117 for the year.

The saving of so great a depth from the rainfall as is represented by 1.917 cu. ft. per sec. per sq. mile indicates, in addition to a low evaporation, a relatively small loss by deep percolation through the earth to the sea—a loss which there is reasou to believe is unusually large from the basin of the Sudbury River.

Another departure from the rule as to the rate of mouthly flow in Southeru New England is noticeable in the wiuter mouths, wheu the yield of this stream is less than in summer. This coudition of extreme wiuter drought does not obtain probably on all the streams iu Maine, and it is to be easily corrected by reservoir control.

The employment of reservoirs for equalizing the flow is usually the first step in fully developing the water power of a stream. In districts like the State of Maine this is ordinarily accomplished, to a certain degree, easily and economically. Here the very large number of lakes and ponds give enormous natural facilities for storage, and they are susceptible of great artificial development. The lakes may be usually increased in depth, without greatly increasing the area, thus avoiding much increase of evaporation, which usually accompanies artificial increase of storage, and their great depth and quiet condition lessen the trouble from ice jams, floating ice and anchor ice.

Wells give the number of lakes connected with the streams of Maine—not counting small ones—as over 1,600, covering at least 2,300 sq. miles in area, there being in Maine 1,567 having an area of 2,200 sq. miles. This gives one lake to about 19 sq. miles of territory, and 1 sq. mile of lake surface to about 12.6 sq. miles of land surface, and the lakes are not isolated bodies of water, but integral parts of the river systems. The extraordinary fact thus appears that about 7.3% of the total surface of Maine is in lakes. No other district of equal size in the Union contains so many lakes at such high elevations, having the fall to the sea within its limits. In the other New England States the lakes are not so numerous, but are still of very great value in connection with the water power.

The cost of the power utilized by reservoirs, even when they are wholly artificial, is usually much less than its value.

It is probable that this country has more water power in use than any other country of the world, and New England's share of this—being in 1880 34½% of the whole—is very great in comparison with her area. The census report of 1890 gives the amount of water power used in manufactures by the New England States as 501,629 HP., which is 43¼% of the total horse power of all kinds used for that purpose.

The relative percentage of water power and steam power in use varies very much among the various industries; those requiring the greater amount of power for a given value of product obtaining it in greater percentage from water. The great power required for wood pulp grinding and for paper making must in the interest of economy be obtained from water in order to secure a fair return upon investments in that industry.

The census report of 1890 gives the following amounts of steam-power and water-power as in use in New England in that year for all kinds of paper making:

	Horse-power.	
	Steam.	Water.
Maine	812	6,570
New Hampshire	690	2,915
Vermont	126	17,872
Massachusetts	15,213	29,148
Rhode Island	160	.....
Connecticut	4,451	6,659

The total amount being 84,616 horse-power, of which about three-quarters is water-power.

I have estimated approximately, in round numbers, the total amount of water-power now in use in the several states of New England, and arranged them in the order of their high development as follows:

		Assumed HP. in use in 1899.	
States.	Miles.	Total.	Per sq. mile.
Rhode Island	1,085	30,000	27.65
Massachusetts	8,040	170,000	21.14
Connecticut	4,845	70,000	14.45
Vermont	9,135	90,000	9.85
New Hampshire	9,005	80,000	8.89
Maine	29,895	160,000	5.35

The development of water-power in Maine is relatively small, but no other State in the Union, outside of New England, has even so much per square mile, except possibly New York, which is thought to have nearly the same. The State of Maine is much better adapted to the development of water-power than is Rhode Island, and yet five times as much water-power as is now used might be developed in it without relatively equaling the amount now developed in Rhode Island. The devolopment of the power of the Androscoggin River to the extent obtaining on the Blackstone, which is easily feasible, would yield a total of 155,325 HP., which is nearly as much as is now assumed to be in use on all streams of Maine.

A new demand for water-powers has risen in recent years because of their increased availability through electrical transmission. Streams hitherto thought to be too small for the purpose have now, by reservoir storage and electrical transmission, been brought into profitable use. This has been extensively practiced in Germany and Switzerland, and a large increase in such utilization may be looked for in New England, where the conditions are peculiarly favorable for its development. At the present time it is estimated that the amount of water-power in use for developing electricity in New England is about 25,000 HP., in perhaps 50 to 60 plants, which may be probably 40% of all such development in the country.

With the advantages which I have tried thus briefly to enumerate, it is not surprising that New England is eminently a manufacturing section of the country, and its yet undeveloped resources of natural power, favorable as they are for economical use, must enable its people to continue to hold and increase the prestige of this section as a manufacturing district.

THE WESTINGHOUSE AIR BRAKE has been adopted as the standard for both the government and private railways of Russia. The terms of the government order requiring its adoption are as follows:

(1) All freight locomotives and tenders, and a sufficient number of freight cars to secure brake control of all freight trains within the Russian Empire, must be equipped with air-brake apparatus prior to January 1, 1903.

(2) The Westinghouse Air Brake has been adopted, and must be purchased for this purpose, by all roads, private and State.

(3) The use of any other kind or make of air-brake than the Westinghouse is prohibited, with the provision, however, that a trial of any other brake system may be made, in connection with the Westinghouse, upon local trains. Each such trial must be conducted, under the direction of the Imperial Brake Commission, for a period of at least three years, after which the suitability of the brake so tried must be considered by a congress of rolling-stock representatives of all the railways, and the conclusion of the congress must subsequently be submitted to the Imperial ratification before any such brakes can be used in general service.

To supply this equipment the Societe Anonyme Westinghouse has been organized, and has erected works in St. Petersburg, which has now been in operation about two months filling an order for about $2,000,000 worth of equipment which was given by the Russian government at the close of 1898. It is estimated that to fulfil the requirements of the above imperial order will require the manufacture of equipment for 350 locomotives and 1,750 cars per month for the next 3½ years. To meet this demand the St. Petersburg works will be doubled in size.

"SCIENTIFIC AIDS" are to be appointed in the Department of Agriculture to work in the scientific divisions of the department and at the same time pursue post-graduate studies, thus taking advantage of the facilities which the department has for advanced study and fitting themselves for posts of usefulness in the department, or in agricultural colleges, experiment stations, etc. Candidates are limited to graduates of colleges receiving the benefit of grants of land or money from the United States and must file application with the U. S. Civil Service Commission, Washington, D. C., on blanks furnished by the commission in order to be placed on the eligible register. The length of service of aids so appointed is not to exceed two years, and the salary will not exceed $40 per month.

THE MISSISSIPPI RIVER COMMISSION'S ANNUAL report has just been given to the press. Concerning the controversy as to whether levees along the bank of a river cause its bed to rise, the commission says:

All of the available data deduced from the special surveys point to an enlargement of the cross section area of the stream below the high water banks, and 75% of the length of the river under consideration shows a decided depression of the bed under dissimilar and unfavorable conditions of comparison.

These investigations give no evidence of a general progressive elevation of the bed of the stream, but do justify the belief that with the banks properly revetted to prevent erosion, the ultimate effect of confining the floods by means of levees will be a depression of the river bed and consequent enlargement of the channel capacity.

The annual report shows that there has been expended on the river for the year ending June 30, 1899, $1,075,000, and allotments for 1900 amounting to $1,250,000 have been made. During the year the United States has built 7,686,758 cu. yds. of levees, and state and local authorities 3,136,541 yds.

The commission has recognized in the past the obligation of giving an equal degree of security against overflow to each of the basins and districts, and the allotment of government funds has been based on this intention with such modifications as economic and financial conditions make advisable. Large districts, thickly populated and cultivated, should, say the commission, be kept in a greater degree of security than small and unimproved sections.

THE EAST BOSTON TUNNEL SCHEME has reached the stage of building and testing an experimental section in Maverick Square, says the Boston "Post." A pit 20½ ft. square and 22 ft. deep has been prepared, and in this is being built a section of concrete tunnel, 4 ft. in length. This tunnel section will then be tested by loading it to an extent surpassing by two or three times the load expected on the finished tunnel. At a depth of 10 ft. in the pit water was encountered in very considerable quantity.

A NEW FORM OF STEAM SHOVEL EXCAVATOR has been designed by Mr. Harvey C. Lowrie, M. Am. Soc. C. E., Denver, Colo., and is covered by U. S. Patent No. 629,576, issued July 25. In this machine the excavating bucket travels on an inclined boom, and is pulled upward toward the machine instead of being pushed away from it, as in the ordinary steam shovel. The machine appears to be especially suited for trench excavation, and can be used in connection with an automatic carrier for back-filling on such work.

ELECTRIC TRACTION IN MARSEILLES is reported upon as follows by U. S. Consul Robt. P. Skinner: The traction system in use is the Dickinson overhead trolley, and a concession is held by the Compagnie Generale Francaise de Tramways, of Paris, for the principal streets of the city. This company is now at work changing the system, and by the end of this year electric motors will be in operation on all the important streets. At the present time the fares are regulated by distance; these ranging from 10 to 40 centimes, or 2 to 8 cts. When the electric lines are installed, the fare is to be uniform at 10 centimes. The company pays the city annually 100,000 francs for the use of the streets; when the gross receipts reach 7,000,000 francs per year, a supplementary fee will be paid, as follows: Over 8,000,000 francs revenue, 40,000 francs; over 9,000,000, 50,000 francs; over 10,000,000, 60,000 francs, and for every million over ten million, 60,000 francs. Four cars form the maximum electric train, and the length of the train must not exceed 118 ft. and the speed must not exceed 12.4 miles per hour. This concession expires on Dec. 31, 1950, when the State becomes the owner of the track, appurtenances and all property located on the public domain. During the last five years of the concession the State may seize all the company's revenue if it appears that the property is not being maintained in good condition. The State may also take all the rolling stock, tools, etc., at a valuation fixed by experts. The State may purchase at any time at a price fixed by the net annual revenue of the seven preceding years, including the fees paid the city. From this total will be deducted the net revenue of the two least profitable years, and the average of the five remaining years will represent the amount of an annuity to be paid to the company for each unexpired year of the revoked concession.

THE INTERNATIONAL ASSOCIATION FOR TESTING materials has appointed a committee to collect data concerning tests of metals, wood and stone, as entering into finished materials supplied in large quantities to railways, manufacturers, etc. The American committee of the Association is charged with the task of collecting this data for the United States; the object of both committees being the final establishment of standard methods of tests for these materials handled in large quantities. The committee asks the co-operation of engineers and all interested, and it will supply upon application a classified list of some of the articles about which they wish information. This list covers the testing of cast-iron pipes, etc.; wrought-iron materials; low-steel and high-steel products; objects of tool and spring-steel; copper, brass and bronze castings, tubes, plates, etc.; objects made of aluminum or glass; tile; cement and bond materials; textile fabrics; leather belting, etc.; rubber products; paper and wood. The names of those interested, or likely to possess information useful to the American committee, will be welcomed by Mr. M. H. Wickhorst, Engineer of Tests, C. B. & Q. R. R., Aurora, Ill.

ELLESMERE LAND, in the Polar regions, is to be explored by Mr. Robert Stein, of the U. S. Geological Survey, and a party of scientists. They will be landed this summer from the Peary supply steamer "Diana," near Cape Sabine, and establish a camp, from which they will attempt to work westward next February or March. The expedition will return to this station in May, and there spend about two months in making natural history collections within a radius of 50 miles of the station. No attempt has been made to explore this region since the McClintock expedition of 1852. The party is booked to return in August, 1900.

BOOK REVIEWS.

SNOW ON THE HEADLIGHT.—A Story of the Great Burlington Strike, by Cy. Warman, Author of "The Story of the Railroad." New York: D. Appleton & Co. 12mo.; cloth; $1.25.

The preface to this book is short enough and unique enough to be worth quoting in full:

Here is a Decoy Duck stuffed with Oysters. The Duck is mere Fiction. The Oysters are Facts. If you find the Duck wholesome and the Oysters hurt you, it is probably because you had a hand in the making of this bit of History and the creation of these Facts.

The book is a record of an event in the railroad world which will not soon be forgotten. The author writes as an impartial and broad-minded historian, and many of his "oysters" deserve to be seriously pondered over.

PORTLAND CEMENT.—Its Manufacture, Testing and Uses. By D. B. Butler, Assoc. M. Inst. C. E. Spon & Chamberlain, New York. Cloth; 6½ x 8½ ins.; pp. 360; illustrated. $6.

The author of this book is the successor of the late Mr. Henry Faija and a cement expert of recognized ability. He has produced an unusually reliable book on the manufacture, testing and use of Portland cement. In some respects perhaps the chapters on manufacture will be the most interesting part of the book to American engineers. The selection of the raw materials; the relative advantages of the wet and dry processes of mixing them; the comparative value of mill stones and mills grinding between metal surfaces, and a great variety of other interesting details of machinery and methods are fully discussed. We would recommend all of our readers to study what the author says respecting the relative character and value of the cement produced by mill stones and by the various edge runner and ball mills employing metal grinding surfaces. In the chapter on testing there is particular interest in the author's remarks on weight, specific gravity and color, on adulteration and on cement specifications. The remarks upon the importance of maturing cement before using it are also worth careful study.

A PLAT AND PROFILE BOOK FOR CIVIL ENGINEERS AND CONTRACTORS.—New York: The Engineering News Publishing Co. Flexible leather; 9⅝ x 4 ⅛ ins.; 28 and 90 profile pages, with tables. $1.00 and $2.00.

The value of a pocket-book for plotting profiles and recording notes of alinement, right of way, benchmarks, etc., has long been established, and this particular form of book has been published since 1882. The present edition is issued in two forms; one containing only 28 profile sheets and a new set of tables; and the other, bound in heavier leather, with a tuck, and containing 90 profile sheets and the same tables. The scale employed is 400 ft to 1 in., and the paper used is such in thickness and quality that the heavier vertical and horizontal profile lines show through and enable the blank page to be utilized for field-mapping. The four pages of tables have been carefully selected from Trautwine's and Kent's "Pocket-Books," and they cover information of especial value to contractors and engineers. They include excavation and embankment tables, in 100-ft. prismoids, with slopes of 1 on 1½; ballast, tie and rail data; strength and weight of materials; sewer and water-pipe data; electrical and mechanical units; weight, length and resistance of copper wire, etc.

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