ENGINEERING NEWS AND AMERICAN RAILWAY JOURNAL.

VOL. XLIII. No. 3.

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TWO BIDS FOR THE NEW YORK RAPID TRANSIT road were received by the Rapid Transit Commission on Jan. 15. John B. McDonald bid $35,000,000 for the whole work, and Andrew Onderdonk offered to build it for $39,-300,000. Under the form of proposal the route was divided into four separate parts, as follows: The entire line extends from City Hall to Kingsbridge Station on the north, and to Boston Road and Bronx Park on the east. Section 1: From City Hall up Elm St. and 4th Ave., and by way of 42d St. and Broadway to 59th St. Section 2: From 59th St. to 140th St. and Broadway, and from 103d St. and Broadway, under 104th St. and part of Central Park to 110th St., then under Lenox Ave. to 135th St. Section 3: The West Side road from 140th St. to Fort George; and the East Side road from 135th St., under the Harlem River, to Bergen Ave. Section 4: The extension of both the East and West Side lines to their terminals. From City Hall to 103d St. the line is to have four tracks, and above that, on each side, three tracks; the loop around City Hall would have two tracks, to connect later with a line down Broadway. Mr. McDonald's proposition was to build section 1 for $15,000,000; 1 and 2 for $26,-000,000; 1, 2 and 3 for $32,000,000, and the whole for $35,-000,000. Mr. Onderdonk proposed to build section 1 for $17,000,000; 1 and 2 for $28,000,000; 1, 2 and 3 for $35,-500,000, and the whole for $39,300,000. Under the clause asking bids for rental beyond the interest charges fixed by law, Mr. Onderdonk offered to pay 5% of the first million of gross annual receipts, when these should exceed $5,000,000, and 2½% additional for each million additional, until the whole premium should amount to 15% on the surplus above $5,000,000 gross annual receipts. The terms of the contract require the contractor to give a bond for $1,000,000, to continue in force during the whole 50 years of lease, and another bond for $5,000,000 to be released on completion of contract. The city agrees to give the contractor all facilities, and is to acquire for him all real estate needed for terminals, etc., and to pay for all real estate and the cost of the terminals with 10% profit to the contractor. The lease of the road is to begin with the completion for operation of each section, and is to continue for 50 years. At the end of that time the lease may be renewed for 25 years, at a rental not less than that paid in the last ten years of the lease. The lessee is to pay as rental all the interest on the bonds issued by the city for building the road, and the interest on the bonds issued to pay interest during construction; and in addition to this 1% per annum on the whole sum for a sinking fund; provided, that the profits be sufficient to allow the lessee to pay himself 5% on the sum he has invested in the road and its equipment—this equipment is estimated to cost $7,000,000 to $8,000,000. The road must be operated by other power than steam, and this power will doubtless be electric. All the lower part of the line will he underground. On Jan. 16 the Rapid Transit Commission awarded to John B. McDonald the contract for the construction and operation of the whole rapid transit line as given above.

WATER POWER FROM THE DRAINAGE CANAL is to be utilized by the city of Chicago for a municipal electric lighting and power plant, if the city council concurs in the agreement arranged by the city electrician, Mr. Ellicott, and the chief engineer of the canal, Mr. Randolph. The city is to pay annually $4 per HP. at the wheel, and to pay the cost of developing the power and transmitting it to Chicago. The lease is to be for 75 years, and the Draining Board can elect to take over the plant by paying its cost at the end of that time. The city is to have free use of the lands of the canal for the power plant and transmission line, while the Drainage Board reserves the right to use as much power as may be needed for operating bridges and pumping stations, paying only the cost of development. The amount of power which can be developed at the wheels is estimated at 20,000 HP., involving a rental of $80,000 per year, but as it is estimated that 20% would be lost in transmission, the power delivered in the city would be about 16,000 HP. The cost of developing the power is estimated at $3,100,000 (electrical equipment, cables, etc., $1,980,000; dams and works at the wheels, $1,120,000). Allowing for interest and other charges, the cost of the power delivered in the city is estimated at $14 per HP., or $224,000 per annum, while the cost of power developed by steam is estimated at $30 per HP. The construction of the dams and other works is to be under the direction of the Chief Engineer of the Drainage Board. The city is to take all the power developed, and to use it for municipal purposes only. It must commence work within 90 days of the signing of the contract, and complete it by July 1, 1901. The city can annul the contract within six months, on proper notice. The city proposes to raise the necessary funds by the sale of bonds charged to the water fund, claiming that much of the power will be used in pumping water at the pumping stations. Should the Supreme Court hold this issue of bonds illegal, and the city be unable to devise other means of raising the money, then the contract is to be nullified, and the Drainage Board will be free to lease the power for other purposes.

THE NEW TUNNEL for the water supply system of Chicago has been completed, work on the land tunnel having been finished on Jan. 8. The tunnel includes one length under the lake and two lengths (in the form of a Y) under the city. The work has been completed by the city, after having canceled the contracts for the part over which there has been so much litigation. This part has been built by the city's engineer at a cost considerably below that of the original contract. The whole system includes about 12.3 miles of tunnel, a new intake shaft and crib, and two new pumping stations. It has been under construction for five years and has cost about $4,071,000. The work was described in detail in our issue of Aug. 31, 1899.

WATER PURIFICATION AND METERS AT PITTSburg are to be provided for by $2,500,000 of bonds which are to be sold on Jan. 25. It is natural to expect that the purification works will include settling reservoirs and slow sand filters, as recommended by Mr. Allen Hazen, Assoc. M. Am. Soc. C. E., and the Pittsburg Filtration Commission. On the same day $4,500,000 of additional bonds will be sold for a variety of municipal purposes, including $700,000 for water mains and $520,000 for bridge purposes. Bids for the bonds will be received on a 3, 3¼ and 3½% basis. Mr. J. E. Lewis, Controller, has issued a little pamphlet relating to the bond issue. Mr. E. M. Bigelow, M. Am. Soc. C. E., is Director of Public Works and Mr. A. B. Shepherd is Superintendent of Water-Works.

WATER PURIFICATION WORKS AT PHILADELPHIA bid fair to be got under way soon, the councils having authorized the work necessary for the extension, improvement and filtration of the supply of Belmont, Roxborough and Torresdale, and also a loan of $3,200,000 for that purpose. Other ordinances are under way providing for the $12,000,000 water improvement loan recently authorized by popular vote. The Director of Public Works has reported that plans are being made by the Bureaus of Water and Survey for slow sand filtration, substantially in accordance with the recommendations of the experts, in their recent report.

ANOTHER CONNECTICUT DECISION AGAINST stream pollution has been handed down by the Supreme Court of that State. The suit was brought in a lower court, years ago, by Platt Bros. & Co., against the city of Waterbury, Conn., to restrain the city from discharging sewage into the river above the mill privilege of the plaintiff. The present decision upholds that of the lower court.

THE CONNECTICUT SEWERAGE COMMISSION has issued a circular to municipal officials and others in the State on "Promising Developments of Bacterial Processes of Sewage Purification." The circular is really devoted to but one of several bacterial processes, the contact-bed system of treatment, and is chiefly taken up with extracts from Prof. Frank Clowe's report to the London County Council on "The Bacterial Treatment of Crude Sewage * * * * in the Coke-Beds at Crossness," abstracted in our issue of Nov. 9, 1899. The object of the circular is to call the attention of those interested in the subject to the possible availability of this means of treatment where suitable land for intermittent filtration is not at hand. It appears that the Commission proposes to issue timely circulars as occasion arises, instead of holding valuable information for its annual report. The idea is a good one. Mr. Robert A. Cairns, M. Am. Soc. C. E., of Waterbury, Conn., is Secretary of the Commission.

THE 210-FT. DAM FOR THE DENVER WATER-works had reached a height of 35 ft. on Jan. 8, and it is expected that by May 1 it will be up 100 ft. An electrical power plant to deliver 10,000 HP., net, in Denver, is proposed. Two parties are now in the field locating a new conduit line. The above information was kindly sent us by Mr. C. P. Allen, Chief Engineer of the Denver Union Water Co., and the South Platte Canal & Reservoir Co., for whom the work is being done. The original plans for a masonry dam at the same site were outlined, with illustrations, in our issue of Feb. 27, 1897, but the design has since been changed. Instead of ordinary masonry construction, 170 ft. thick at the base, and 20 ft. at the top, the dam, according to the Denver papers, will have a section, from upstream, down, of ⅜-in. steel plates, backed by 2 ft. of concrete, backed in turned by 15 ft. of hand laid dry rubble, beyond all which will be the rock fill body of the structure. The thickness of the dam at the base will be about 600 ft., but its length at the bottom will be only 20 to 25 ft., and at the top some 500 ft.

COMPETITIVE PLANS FOR A BRIDGE over Sydney Harbor, New South Wales, are requested by the Public Works Department, Mr. C. W. Dailey, Engineer in Chief, according to press dispatches. The bridge will, it is stated, cost $2,500,000, and a prize of $5,000 will be awarded for the best competitive design. All designs are to be submitted before Aug. 1, 1900. Mr. Geo. W. Bell is the United States Consul at Sydney.

BRAZILIAN CONTRACT OPPORTUNITIES are reported as follows by U. S. Consul K. K. Kenneday, of Para, Brazil: The building of 100 miles of railway around the falls in the Madeira River. It would open up a rich rubber belt with excellent agricultural opportunities, and the Brazilian and Bolivian governments would grant subsidies. An artificial port and docks are wanted at Manaos, on the Amazon. This is an important port, with steamship service to the United States and Europe every ten days, and touched at by hundreds of river steamers. The largest vessels in the world can ascend the river to it. The cost of the necessary works is estimated at $2,500,000, and the government will give the ground, the right to collect a certain tonnage tax, and the right to build warehouses and collect storage fees. Para also wants a dry-dock, as the nearest one to that port is at Rio de Janeiro. The building of a railway to British Guiana, with branches to Colombia and Venezuela, would open up a new and important market for American goods and open up rubber belts and cattle lands, now inaccessible. For further particulars those interested should address Mr. Kenneday, or Mr. Charles R. Flint, at Para.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred near Pulaski, Va., Jan. 8, on the line of the Norfolk & Western Ry. A passenger train was wrecked at a bridge, resulting in the death of one man and the serious injury of several others.

A LARGE STEAMER WAS WRECKED in St. Mary's Bay, Newfoundland, on Jan. 11. The ship was driven upon the rocks in a gale and rapidly went to pieces, and the entire crew probably lost their lives. It is believed that the lost vessel was the "Helgoland," of the German-American Petroleum Co., which left Philadelphia for Bergen, Norway, on Jan. 5. The "Helgoland" was a three-masted, top-sail, schooner-rigged steamer of 1,510 tons net register, 293 ft. long, 37 ft. beam and 26 ft. deep. She was built in Newcastle, in 1890, by Armstrong, Mitchell & Co.

TANDEM COMPOUND LOCOMOTIVES are being used on the Atchison, Topeka & Santa Fe Ry., built at the company's shops at Topeka, Kan., to the designs of Mr. John Player, Superintendent of Machinery. The engines are of two classes—consolidation freight engines and ten-wheel passenger engines. The former are reported to show an economy of 20% in fuel consumption. The passenger engines have cylinders 14 × 28 ins. and 24 × 28 ins., placed 20 ins. apart, and 8-in. and 12-in. piston valves are used, the low-pressure valve-rod being hollow. The frames, guides, guide-yoke and mud-ring are of cast steel. The two cylinders and valve chambers for each side of the engine are cast with the saddle, in which all the steam passages are formed. In starting, live steam is admitted to the low-pressure cylinders by a 1½-in. pipe, through a valve controlled by a secondary throttle. The engine has driving wheels 6 ft. 5 ins. diameter, with a driving wheel-base of 14 ft. 6 ins., and a total wheelbase of 25 ft. 2 ins. The weight is 169,000 lbs., of which 123,000 lbs. are on the driving wheels. The boiler is 6 ft. diameter and carries 200 lbs. pressure, while the firebox is 95 × 40½ ins. The heating surface is 1,923 sq. ft. and grate area 26.5 sq. ft. The tender carries 8 tons of coal and 5,000 gallons of water. An engine with this system of compounding was exhibited at the Columbian Exhibition of 1893, but the system has not been widely introduced. In Europe, however, it is quite extensively used, but not under the Player patents.

EXPLORATION FOR BED-ROCK AT GILA RIVER DAM SITES WITH DIAMOND CORE DRILLS.

By J. B. Lippincott.*

The Gila Indian Reservation is situated in Pinal Co., Ariz. Upon this reservation are dependent some 7,000 Indians—Pimas, Maricopas and Papagos. These tribes have always been agricultural in their pursuits and self-sustaining from earliest history. During the last ten or fifteen years white settlers have occupied the public lands at points higher up on the river, and by numerous diver-

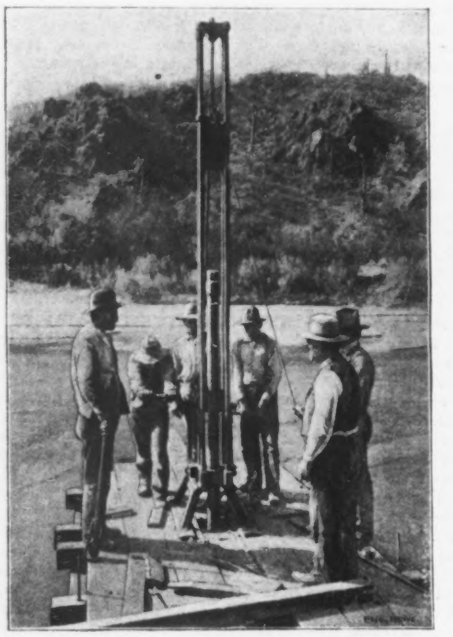

Fig. 1.—Apparatus for Sinking Pipe Preparatory to Using Diamond Drill. Hammer Made by Pierce Well Co.

sions have dried it up at the diversion points used by the Indians. The result has been that the natives have been left without water supply. As the rainfall at the reservation is but about 7 ins. per annum, dry farming is an impossibility, and these Indians are left in a destitute condition, owing to the fact that they have been deprived of their irrigating water. The Government is, therefore, put to the necessity of feeding these tribes as public wards, in order to prevent their starvation. The Indians, on their part, are forced from industrious habits into indolence, mendicancy and vice. Owing to these conditions the Interior Department has instituted investigations for their relief. Preliminary study of the possibilities of storing water on the Gila River was made in 1896 by Mr. Arthur P. Davis, of the U. S. Geological Survey, for the Indian Department, and further investigation and surveys were recommended by him. Large reservoir sites were known to exist on the Gila River, the uncertain element being the condition and depth of bed-rock at the dam sites. The Gila River drains 17,834 sq. miles of high plateau and mountains above a point known as The Buttes Dam Site. Owing to the fact that the basin is almost entirely barren, with scarcely a covering of grass, the precipitation which occurs therein passes off in violent floods. During the period between these floods the river flow is exceedingly small. The result is that not over 3% of the annual discharge of the river at The Buttes is available for diversion purposes by the present canal systems. In the spring of 1898 Congress appropriated $20,000 for the continuation of the exploration of the storage reservoirs on this stream. The work was placed in charge of the Director of the Geological Survey, and by him assigned to Mr. F. H. Newell, Chief Hydrographer. Mr. Arthur P. Davis, Assoc. M. Am. Soc. C. E., Hydrographer of the Geological Survey, was placed in charge of the field work, in January, 1899, and continued it until the first of last May, when he was transferred to the Nicaragua Canal Commission; subsequent to that date the writer was placed in charge. Mr. James D. Schuyler, M. Am. Soc. C. E., was employed as consulting engineer.

As stated above, one of the principal provinces of the investigation was the determination of bed-rock at five dam sites. It is believed that these investigations were of a somewhat original character, and may be of interest to the engineering profession at large. The Geological Survey takes pleasure in making the results of this work available to the profession through the columns of Engineering News.

It was decided to attempt to explore for bed-rock by means of diamond core drills, and machines for this purpose were obtained from the Nicaragua Canal Commission by the Geological Survey. These machines had been used in Nicaragua in exploring for bed-rock along the route of the proposed canal, and had done efficient work. The machinery is in two distinct parts; first, a pile-driver apparatus for putting pipe down through quick-sand, gravel or earth—the pipe being afterwards washed out and the shaft with the diamond bits worked therein; second, the drilling apparatus proper. The machinery is very light, and made so that it can be knocked down to weights that will admit of the sections being carried on the backs of men. The hammer is made by the Pierce Well Co., of 120 Liberty St., New York. This machine is shown in Fig. 1. The hammer is in sections and can be increased or lessened in weight. The bottom section of the hammer is cored out and filled with wood, so that the blow of the hammer will not abrade the head of the pipe. It is raised by means of a hand-winding drum and is tripped when it reaches the tops of the guides and falls upon the pipe. The maximum lift is $11\frac{1}{2}$ ft., and the maximum weight of the hammer is 190 lbs. A tool steel head is screwed into the top of the drive pipe for the hammer to fall upon. The pipe is shod at its lower end with a tool steel shoe, which is thicker and heavier than the pipe, but equal to it in interior diameter. The size of pipe used is $3\frac{1}{2}$, $2\frac{1}{2}$ and 2-in., extra heavy, screw pipe, with extra heavy couplings, which have beveled corners. The smaller diameter pipe is in each case made to fit into the larger diameter, if required. It, however, requires a special make of $2\frac{1}{2}$-in. pipe to go inside of the $3\frac{1}{2}$-in. pipe. The pipe is driven through the sand and gravel until bed-rock is reached. This is indicated by the refusal of the pipe to go any further under driving. The pipe is cut in 5-ft. sections, and as it is driven into the ground new sections are put on until the desired length is reached. When the drive pipe has reached bed-rock, what is known as a chopping bit, which is a bit with openings for water to flow through its point, and to which is screwed a ¾-in. pipe, is worked into the drive pipe. The top of this pipe is connected with a small, double-action hand force pump by a hose. The chopping bit is turned around in the sand which is inside the drive pipe, and the water which is under pressure is discharged through the point of the chopping bit, and floats the loosened sand out over the top of the drive pipe. In this manner a hole can be readily cleaned to depths as great as 130 ft. of sand and small gravel.

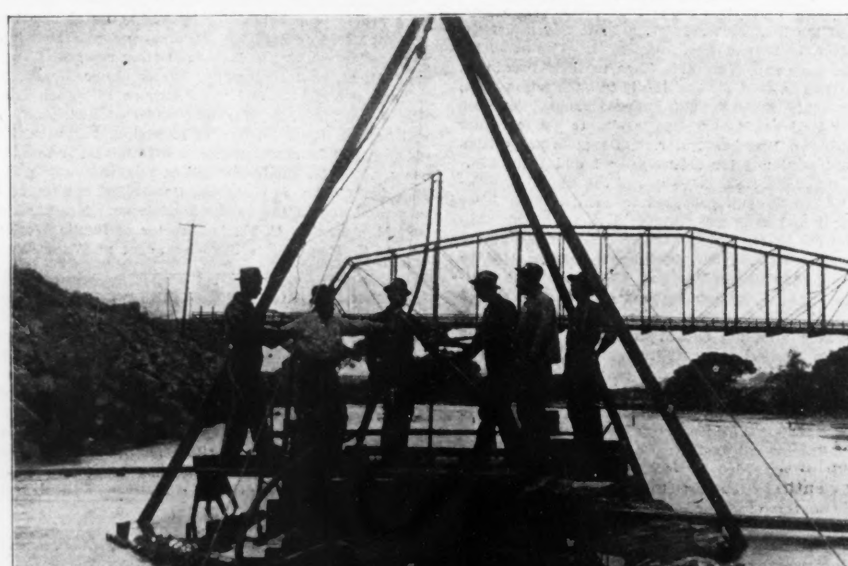

FIG. 2.—DIAMOND DRILL IN USE EXPLORING A PROPOSED DAM SITE. Made by the American Diamond Rock Drill Co.

The diamond drilling machinery is then put to work, when the drive pipe is cleaned out, and it is possible that it may demonstrate that instead of being on bed-rock, the drive pipe has stopped under a boulder. This can be determined by comparing the core which is brought out by the diamond bit with the walls on the side of the canyon, and seeing if it is of the same material, or of a foreign nature. Again, boring should always extend 4 or 5 ft. into bed-rock, and this will cause it to pass through most boulders. As soon as the diamond bit passes through the boulder it drops, which is a sure indication that bed-rock has not been reached. In this event the diamond drill is then drawn and four or five sticks of giant powder lowered through the pipe to the boulder. The drive pipe is then pulled up 4 or 5 ft., and the powder discharged by means of an electric firing battery. This shatters the rock, and the drive pipe may then be forced through the splintered boulder. In this manner pipe of these varying diameters was driven to bed-rock at five different dam sites, and at every location successful results were obtained.

The diamond drilling machine is built by the American Diamond Rock Drill Co., of 123 Liberty St., New York. One inch core bits were usually employed. The diamond drilling machinery is shown in Fig. 2. The drill is operated by hand power, six men being economically employed on this work, as well as on the driving of the pipe. The machine is capable of going 200 ft. into the rock, and will make from 6 to 8 ft. per day, in hard rock, and from 10 to 15 ft. per day in softer rock. The cost of the machinery complete is approximately $1,000, including two bits, which are worth about $200 each, set with six diamonds each. The diamonds are known as black diamonds, and should weigh approximately one carat each. Two machines were used on work in Southern Arizona. There was paid for the pipe $600, including tools and fittings, delivered in Arizona; $100 of this amount being freight from New York.

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This would make a total cost of outfit complete of $1,600.

Cost of Operation, per Month, of Bed-Rock Exploration.

Foreman	$150.00	
6 laborers at $1.50 per day, 28 days	234.00	
1 cook	45.00	
		$429.00
240 rations at 60 cts.		144.00
Total repairs, pipe and lumber for one party for 10 months		$500.00
" commissary charges for team, feed, etc.		350.00
" moving		670.00
" sundry incidentals		200.00
" supervision		350.00
Total for 10 months		$2,070.00
Sundry expenses per month		230.00
Total cost per month		$803.00
10 months at $803.00		$8,030.00
Total number of feet sunk		3,254.20
" cost		$8,030.00
Cost per foot		2.46
Cost per hole (52)		154.42

If the original cost of machinery be distributed over this work we would have:

Operation	$8,030.00
Machinery	1,600.00
Total cost	$9,630.00
Or, average cost per foot	2.86

Both machines are still in good repair.

The total depths penetrated by this machine in all materials at the various dam sites are:

	Bed-rock covering, ft.	Rock, ft.	Total, ft.
The Buttes	1,621.2	196.0	1,817.2
Queen Creek	357.8	55.6	413.4
Riverside	729.8	40.2	770.0
Dykes	80.0	0.0	80.0
San Carlos	143.2	30.4	173.6
Total	2,932.0	322.2	3,254.2

The work at The Buttes at the last three holes and at the Dykes was very greatly delayed owing to the loss of the original drive pipe by breaking beneath the surface. The pipe that was next obtained broke continually under the hammer, and a month's time of one party was lost by these interruptions. The expense of this work is included in the above estimate. Owing to the long move, by teams, of the outfit to San Carlos dam site, and the constant interruption, by flood, of the work at that point, and the consequent small amount of driving done there (173.6 ft), the cost of that portion of the work was about $6 per lin. ft. If San Carlos is not included in the estimate the average cost per ft. for the remaining portion of the work would be reduced about 10 cts. The advantages of this class of work over the shaft method are manifest. It is probable that not over five or six shafts could have been put down with the total funds available for the investigations ($20,000) in case that method was practiced, and it is problematical, even then, if it could have been accomplished. By the drilling method employed the location of bed-rock is not only determined, but an actual sample has been brought up, which can be tested for specific gravity, crushing strength, texture, quality, or in any other manner desired. These samples have been placed in core boxes, properly labeled, and put away for reference, so that any person in the future may examine them. The work was entirely successful except at San Carlos, where the floods became so violent during the month of August that the machinery could not be kept standing in the river, and but two holes reached and penetrated the bed-rock. These were quite satisfactory as far as the indications which they afforded, although it is to be regretted that a greater number of holes could not have been secured at that point.

The most important result of the work referred to above has been the discovery of three great reservoir sites, one at San Carlos, one at Riverside and one at Guthrie. The capacities of these three reservoirs are much alike. With dams 130 ft. in height they will all store over 200,000 acre-feet of water, and with dams 150 ft. in height they will store approximately 350,000 acre-feet. At The Buttes reservoir site a dam 130 ft. high will store approximately 120,000 acre-feet, and a dam 150 ft. high will store about 175,000 acre-feet of water. It has been determined that 174,000 acre-feet of water can be stored at The Buttes reservoir site at a cost of $15.19 per acre-foot, stored; 221,133 acre-feet can be impounded at Riverside at a cost of $9.01 per acre-foot, stored; and 241,396 acre-feet can be held in the San Carlos reservoir at a cost of $4.30 per acre-foot, stored. The result of the investigation shows that sufficient water can be impounded to successfully irrigate 20,000 acres for the Indians, which is estimated as sufficient to relieve their condition, and that there will remain an adequate supply for the irrigation of 100,698 acres of public land. Owing to the fact that dry lands in Southern Arizona are unproductive without irrigation, they remain almost entirely as public domain. If the Indians are given all the water they require, without charge to either them or the Government, and a charge of $10.24 per acre is made against the 100,698 acres, which can be irrigated in addition from the same supply, it is estimated that these public lands with this water right can be very rapidly sold by the Federal Government, because similar lands on the Salt River, with inferior water rights, are worth from $40 to $60 per acre. The expense to the Government of issuing rations to the Indians who are now destitute will be continuously at the rate of at least $110,000 a year. This annual charge capitalized at 4% represents the principal of $2,750,000. The result of the investigation is, therefore, that the Government can build the storage reservoir at San Carlos at a cost of $1,039,000, give the Indians all the water which they require, free, recoup itself by selling its irrigated public lands at a rate of approximately one-fifth of the present market value, relieve itself of a practical debt of $2,750,000, place the Indians on a self-sustaining and industrious basis, and create a home for 40,000 people, where now nothing but desert exists. It would seem from the above conditions that the public duty was exceedingly plain, and it is to be hoped that Congress will provide for the construction of this reservoir.

THE DESIGN AND CONSTRUCTION OF A MODERN CENTRAL LIGHTING STATION.*

By H. H. Humphrey, Member Engineers' Club of St. Louis.

The plant of the Imperial Electric Light, Heat & Power Co. was intended primarily to compete for business in the downtown or underground district of St. Louis. It was required, however, that the system adopted should be capable of being extended beyond this district, and, if necessary, of covering almost the entire city. The success of the three-wire direct-current low-tension underground system in this and other countries naturally influenced the engineers in its favor. On the other hand, the cost of copper for such a system, while not strictly prohibitive, is still so large as to demand most serious study.

The class of service to be supplied consists largely of 500-volt direct-current motors, there being also some 220-volt motors of smaller size. The growing popularity of the inclosed arc lamp indicated that this field would be very profitable, and the furnishing of incandescent light was by no means of secondary importance. In order to reduce the first cost of station equipment and underground work, both conduits and cables, it was deemed advisable that all three kinds of service should, if possible, be supplied from one generator, delivering its output through one underground duct and one service cable.

These considerations led to the adoption of a three-wire direct-current system of distribution, differing in important details, however, from the methods heretofore employed. 220-volt incandescent and 220-volt arc lamps were both to be used on the sides of the three-wire system, while 500-volt motors would be connected directly across the outside wires. The saving in copper over the usual 110-220-volt system, based upon the same percentage of drop, is three-fourths. Furthermore, the area which can be supplied from one central station at the same percentage of loss is increased sixteen times. If in the 110-220-volt system the limit with a certain drop be placed at one mile from the station, in all directions, an area of 3.14 square miles can be covered. With the 220-440-volt system the distance reached from the station in all directions is four miles, covering an area of 50.24 square miles. By the proper use of boosters with storage batteries at the ends of feeders, such a system may be extended over a district within a radius of 10 miles from power plant.

Hypothetical load curves were prepared, covering the service expected from this plant, including incandescent and arc lights and motor service. The three were then combined into one curve representing the entire anticipated output of the plant under the heaviest service of the winter months. (See Fig. 4.) A study of this curve indicated that the number of units in the plant should be at least five. This number fitted both the minimum load, which was about one-fifth of the maximum, and provided admirably for reserve. In case of accident during the peak of the load, the other four units could take the place of the disabled one by each carrying 25% above its rating. In case of the adoption of a storage battery sufficiently large to carry the reduced load during the latter part of the night, and assist the generators during the times of maximum load, it was deemed safe to reduce the number of units to three, the battery to be of the same capacity as each of the units.

In designing steam plant it was necessary to determine beforehand what economical auxiliary apparatus, if any, should be installed in connection therewith, as all of these affect the capacity of the boiler plant. The rule adopted by the engineers in determining whether any species of economical apparatus was worth installing was that it should be able to earn, under a conservative estimate of the conditions of service, and taking into consideration the low price of fuel in this territory, 18% annually upon its first cost.

Applying this rule to the consideration of compound versus simple engines resulted in favor of the compound engine. A further comparison between compound noncondensing and compound condensing engines showed the ultimate economy to be in favor of the condensing type. Economy in the use of water, which is obtained from the city's mains at considerable expense, necessitated the installation of a cooling tower in connection with the condensing plant.

The application of the above rule to the question of fuel economizers showed that they would be a good investment.

It was decided to use water-tube boilers, as this type gives large capacity in small space, is absolutely safe, quick steaming, economical in fuel and can be had in large units. With good draft they may be overworked 50%, and under mechanical draft they may be operated for short periods at double their rating. Down draft furnaces, of the type which has proven so successful in St. Louis, were selected. They are capable of burning low grade coal, running high in moisture and clinker, and may be overworked far beyond the rating of the boilers. They are also simple, easily repaired and not likely to get out of order. The most important characteristic, however, is that they are smokeless, thus complying with the city ordinances. They improve the fuel economy, and add somewhat to the boiler's capacity.

It was decided at the outset to divide the total chimney capacity into two units, for the reason that the draft would be better at light loads, and one stack only needed to be built then, as but a part of the plant was to be installed to start with.

Power House.

Fig. 1 gives a sectional view of building, and Fig. 2 a plan of the engine and boiler rooms.

The entire structure is fireproof. All floors are of cinder concrete carried on corrugated iron arches sprung between I-beams. The roof is of book-tile with composition gravel covering. Beneath the engine room are the storage batteries, extending partly under the sidewalk. Beneath the boiler room is space for coal storage, ash handling and the location of condensing apparatus and piping.

There are four Heine boilers, with a total of 10,872 sq. ft. of heating surface. Each boiler has a rated capacity of 11,250 lbs. of water per hour with feed water from the economizers at 200° F., into dry steam of 175 lbs. pressure above atmosphere, and is guaranteed to be capable of developing continuously one-third more. Efficiency guarantee is 70% of the calorific value of the coal at any load between rating and 20% above. This is equivalent to evaporating 7.21 lbs. of water per pound of Mount Olive nut coal of 10,600 B. T. U. The boilers are designed for a working pressure of 175 lbs. per sq. in., and tested under a hydrostatic pressure of 250 lbs. The entrainment is guaranteed to be less than 1% at rating, and not more than 1½% at one-third above rating.

The present boilers are served by one steel stack, Fig. 1, 7 ft. inside diameter and 140 ft. above street level. The lower 10 ft. are made of ½-in. steel plates; the next 20 ft. of ⅜-in. plates; the next 25 ft. of 5-16-in. plates, and the next 85 ft. of ¼-in. plates. It is self-supporting and unlined. Through the third story of the building it is surrounded by a sheet steel casing which provides ventilation for the boiler room. There is an improved draft gage by which the draft can be read to thousandths of an inch at eight different points, including ash pits of four boilers, two breechings, inlet to draft fan and base of stack.

In order to counteract the effect of the economizers in cooling the gases from the boilers, and to permit crowding when necessary, a mechanical draft system was installed. It is of the induced type, the fan being placed directly behind the stack and between the two batteries of boilers. The bearings of the fan are self-lubricating and water cooled. This fan is driven by means of a direct-geared electric motor, designed to be operated at different speeds on either the 235 or 470-volt circuit. This motor is to be controlled automatically, so as to maintain the steam pressure practically constant, the regulator slowing down the motor as the steam pressure rises and increasing its speed as the pressure falls. The capacity of the fan is sufficient to handle the waste gases from four boilers and furnish a draft equal to 1 in. of water where the gases leave the boilers. It is capable of being speeded in emergencies sufficiently to give a draft of 1½ ins. on all four boilers.

*Condensed from a paper read before the Engineers' Club of St. Louis, and published in the "Journal of the Association of Engineering Societies."

There are two Green fuel economizers, each consisting of 320 pipes, the combined heating surface being 7,680 sq. ft. The economizer plant is capable of heating regularly and continuously 45,000 lbs. of water per hour 100° F. when receiving the water at 110° F., and with the temperature of the escaping gases leaving the boilers at not less than 450° F. One-third more water may be passed through in case of necessity, but of course with diminished economy. These economizers are designed for a working pressure of 200 lbs. per sq. in., and were submitted to a hydrostatic test of 300 lbs. after erection in position. They are provided with automatic scrapers operated by electric motors. The necessary dampers are provided for sending the gases from the boilers either past the economizers and directly out the smokestack or through the economizers and then up the stack, or through the economizers to mechanical draft fan and thence up the stack. The economizers are located in the rear and above the boilers, supported upon a substantial iron framework and bricked in air-tight by 8-in. walls.

The coal and ash-handling plant design consists of a system of cars, tracks, elevator and overhead ash bin. The cinders and ashes from the lower grates drop directly into a metallic ash hopper under each boiler. Running east and west immediately under these hoppers there is a narrow-gage track. The ashes are dumped from these hoppers into small cars and pushed by hand along the track to an elevator, on which they are carried up and dumped into an overhead ash bin, from which they run by gravity into the wagons in the alley. Any ashes which accumulate in the stacks may be emptied directly in the cars in the same manner

The entire space in front of the boilers in the basement is reserved for coal storage, the fuel being dumped through openings in boiler room floor. It is taken from this storage room in the same cars, tracks being provided the entire length of the coal storage space. It is then hoisted on the elevator to the floor above and distributed on tracks over the entire length of the boiler room in front of the boilers.

Steam Engines.

There are now in operation two engines of the Williams vertical two-cylinder cross-compound condensing automatic cut-off pattern, built by Wm. Tod & Co., of Youngstown, O., and designed for direct connection to the dynamos and shafting. The east engine, No. 1, is of 750 I. HP. Engine No. 2 has double the capacity. The heavy flywheels are located between the A-frames supporting the high and low-pressure cylinders. Each engine is so constructed as to be capable of operating continuously at double its rated capacity, and for short intervals only at one-third above its double rated capacity. This additional capacity is obtained by admitting live steam into the receiver or low-pressure cylinder. The high-pressure cylinders are steam-jacketed on the barrel, and both cylinders on both top and bottom heads. The receiver is provided with reheating coils of copper. The main bearings are adjustable, and are provided with water jackets. The guides are water-jacketed on the running side. The cylinders and all bearings are lubricated by the Siegrist lubricating apparatus, which delivers the two kinds of oil to the cups under pressure automatically maintained by duplicate steam pumps. They also have hand oil pumps for additional safety. The cylinders have flat multiported valves driven directly from the eccentrics. The clearance is guaranteed not to exceed 6% in either cylinder. These engines are provided with shaft governors operating upon the valves of the high-pressure cylinders, and capable of varying the cut-off from 70% of the stroke back to minus 3-16-in. opening. The regulation guarantees are that the drop in speed with a constant steam pressure from no load to one-third above rated load will not exceed 2½%. This guarantee also covers a variation of steam pressure between 160 and 175 lbs. with constant load. The variation of speed will not exceed 3½% with the combined changes in load and steam pressure above specified, either with or without the vacuum. The governor is also fitted with a special speeding device by means of which the engine may be brought to the same rate of speed under friction only as under full load. When running with about 170 lbs. pressure at the throttle, at 150 revolutions per minute and under a constant load at their rated capacity, the engines are guaranteed not to consume more than 15 lbs. of water per indicated horse-power hour.

Another 1,500-HP. engine, designed and built by the Lake Erie Engineering Works, Buffalo, N. Y., has just been installed. Dimensions of cylinders, 23 ins. and 48 ins. x 36 ins.; speed, 120 revolutions per minute.

Condensers, Pumps and Cooling Tower.

The condensing plant consists of one Worthington surface condenser, one Worthington cooling tower, two combined air and boiler feed pumps and two circulating pumps of the rotary type. The rated capacity of the plant is 33,750 lbs. of steam per hour, but it will take care of overloads up to 49,500 lbs. per hour with but slight reduction in vacuum. It is guaranteed to produce a vacuum of not less than 22 ins. at above rating and under the worst conditions of service; 25 ins. under fair and average conditions, and 26 ins. under the best. These conditions vary with the humidity and temperature of the air. The condenser has 34,000 sq. ft. of brass tube cooling surface.

The cooling tower, Fig. 1, located on the roof, is 18 ft. diameter, 29 ft. high and its filling or cooling surface is composed of galvanized iron pipe cylinders. It has duplicate fans located on opposite ends of the same shaft drawing air into the tower. These fans are driven by a belted motor in a pent house on top of building.

There are two combined air and boiler feed pumps: one of sufficient capacity to haudle the water required by the 1,500-HP. engine, and the other of sufficient capacity for the 750-HP. engine, and two independent rotary circulating pumps of the same capacities. These pumps are driven by direct-geared motors, so designed that the speed may be varied at least 33⅓%. There are also two injectors for reserve boiler feeds, each having a capacity of 11,250 lbs. of water per hour; and capable of handling water of any temperature below 125° F.

Foundations.

All the foundation work in this plant (except chimney) consists of 1 part Atlas Portland cement, 3 parts clean, sharp sand and 7 parts crushed limestone small enough to pass through a 2½-in. mesh. The brickwork used in foundations of chimney is composed of hard burned brick laid in cement mortar. The engine and generator foundations extend to a depth of 13 ft. 6 ins. below the floor line of the engine room, and form one large monolith extending the full length of the engine and generator machinery.

Power Transmission System.

The engines and generators are connected by means of the Arnold system of power transmission (see Fig. 2), consisting of quills and internal shafts with double bearings, connected by magnetic clutches. The arrangement is intended to make it possible to drive any one, two or all three of the 500-K-W. generators, and either one or both of the boosters, from the large engine in case of accident to the small engine. Two generators and one booster may also be handled by the small engine in case of accident to the large one. The generators are connected to the engines by means of magnetic couplings, so arranged that either intermediate generator or booster may be disconnected from one engine and connected to the other while all are in motion. When it is desired to start up a generator, it is brought up to speed as a motor and then connected to the engine by the magnetic clutches.

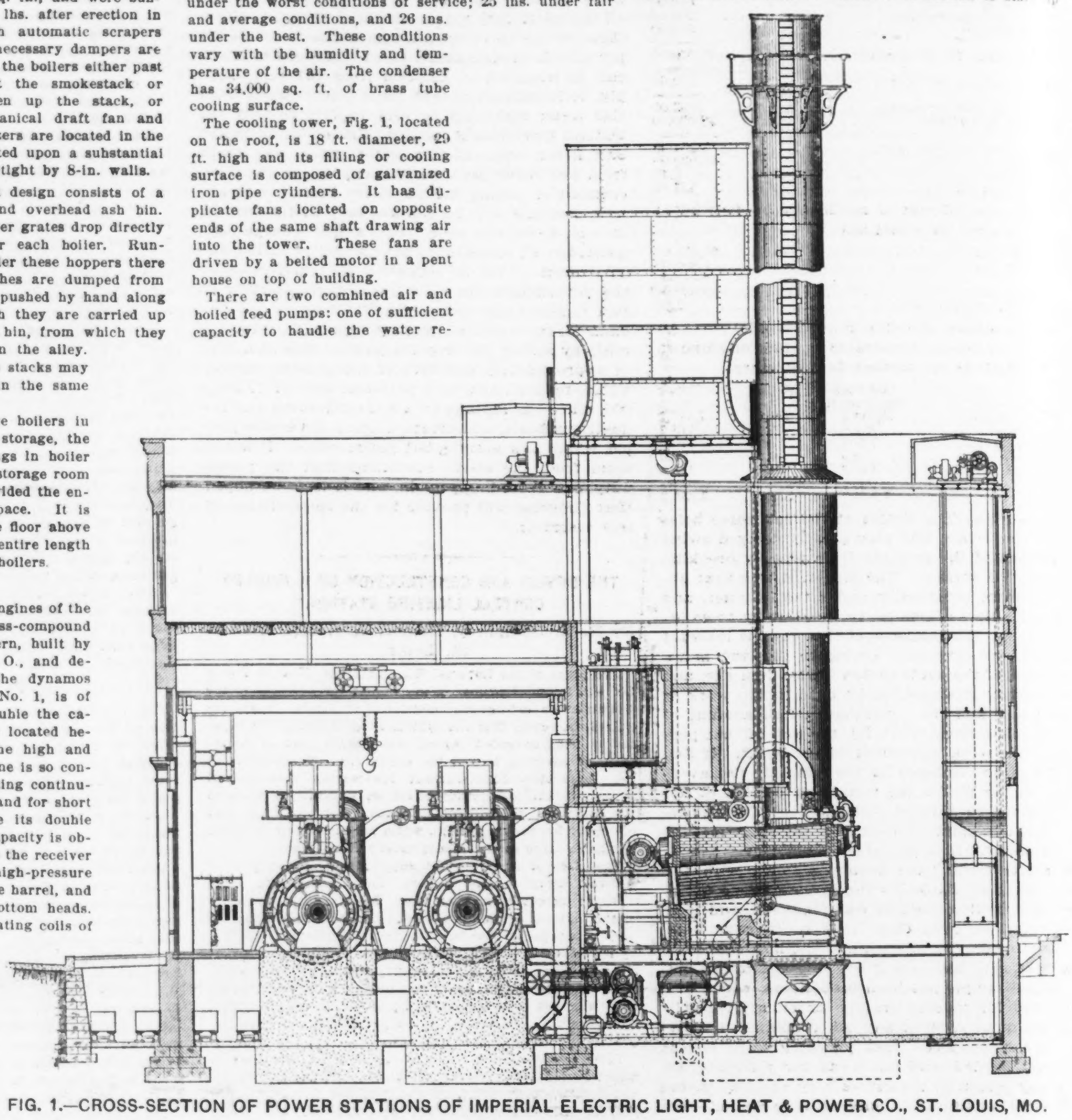


FIG. 1.—CROSS-SECTION OF POWER STATIONS OF IMPERIAL ELECTRIC LIGHT, HEAT & POWER CO., ST. LOUIS, MO.
H. H. Humphrey, Designing Engineer.

Pipe Work.

The entire high-pressure system is designed to operate under a working pressure of 175 lbs. per square inch, and was tested to 250 lbs. hydrostatic pressure. All fittings are extra heavy. All pipe above 3 ins. in diameter has flanged couplings and fittings. All bent pipes are made of steel, and bent hot and of long radius. All valves on live steam pipes and on the feed water connections under boiler pressure are bronze seated. All valves above 10 ins. in diameter are by-passed. The cylinder jackets, reheaters, separators, steam headers and the entire pipe system is drained by means of the Holley system, returning the water directly to the boilers. There is a combined hot well and oil filter located between the condenser and boiler feed pumps. All the pipes are covered with magnesia. A steel exhaust pipe is provided for use when condensers are not in service, and extends through the roof near the stack. Each engine has a Cochran separating receiver located near the main throttle valve. Oil extractors are located between exhaust pipe and condensers. A suitable blow-off tank is provided and connected to boiler furnaces, oil extractors and other hot water drains, with suitable discharge to catch-basin, which in turn overflows to sewer.

Generators and Boosters.

There are three 500-volt constant-potential electric generators, built by the Siemens & Halske Electric Co. of America, of the internal ironclad-armature type. They are

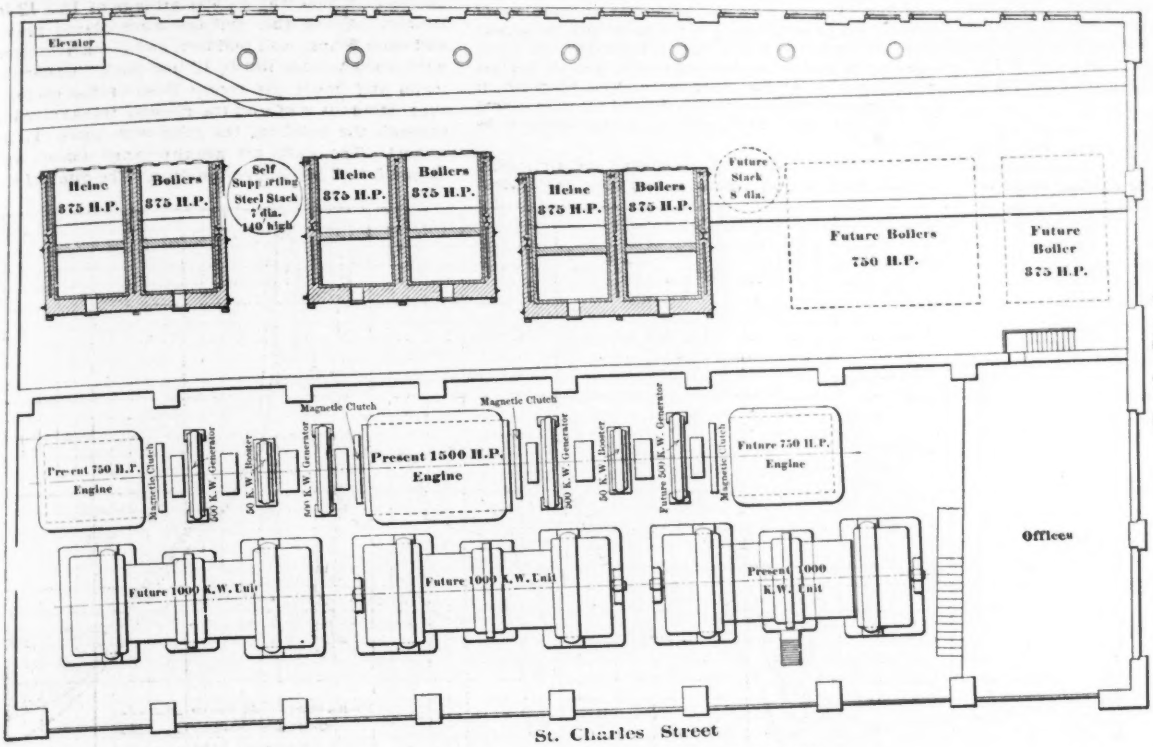


FIG. 2.—PLAN OF BOILER AND ENGINE-ROOMS.

designed specially to fit the system of power transmission adopted. The field frames of the generators may be slid parallel with the shaft a sufficient distance for reaching the armature for repairs. The capacity of each generator is 500 K-W. at 525 volts when operated at 150 revolutions per minute. At this rating the rise in temperature of the armature will not exceed 40° C.; of the field, 35° C.; of the commutator, 50° C. The generators are guaranteed for an overload of 25% for two hours, and 33⅓% for one hour, with a 50% momentary overload without injurious sparking. They will not flash at the commutator when the circuit breaker opens at 50% overload. The commutators are of large diameter, insulated with mica and designed for carbon brushes. The brushes are proportioned for 25 amperes per square inch of contact with rated load, and have hand-wheels for both adjusting and lifting. One megohm of insulation resistance is specified between conductors and frame. The guaranteed efficiencies of these generators are as follows:

At ¼ load	88%
At ½ load	92½%
At ¾ load	93½%
At full load	94%
At 25% overload	93%

There are two separately excited shunt-wound boosters, each of 50-K-W. capacity at 150 sevolutions per minute, and capable of carrying 500 amperes and delivering any voltage from zero to 130 volts. The boosters are of the same general construction and design as the generators, except that the field frames are divided vertically. Two more generators of the same capacity are being made at present by the same company.

Switchboard.

All the electric connections between generator and booster and switchboard are made of asbestos-covered copper cable run underneath the floors and supported upon porcelain holders. The connections between battery and switchboard are made by means of copper bars, lead-covered and painted with an acid-proof paint, and supported upon porcelain racks. The battery is connected through switches to the bus-bars and outside circuits without the intervention of either fuse of circuit breaker.

Storage Battery.

There are 280 cells, Fig. 9, of the Electric Storage Battery Company's accumulators, each containing 13 positive Manchester type plates and 14 negative chloride plates. These are contained in lead-lined wooden tanks which are supported on large porcelain insulators resting upon 4 × 6-in. beams. The elements themselves in each cell rest upon heavy glass plates, and are separated from each other by glass tubes. The capacity of this battery is 2,000 ampere hours at a discharge rate of 250 amperes, and it is capable of maintaining a maximum discharge rate of 1,000 amperes for one hour. It is guaranteed to give a discharge of 500 K-W. for one hour without a drop in pressure below 1.7 volts per cell. The normal charging rate is 250 amperes, and the maximum charging rate 350 amperes.

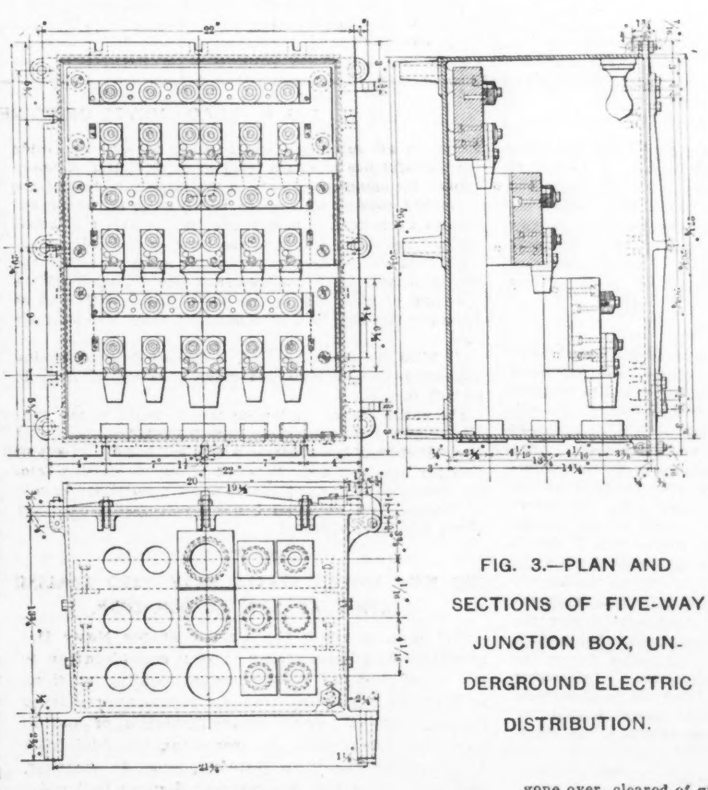


FIG. 3.—PLAN AND SECTIONS OF FIVE-WAY JUNCTION BOX, UNDERGROUND ELECTRIC DISTRIBUTION.

Conduit System.

Many were the criticisms hurled at the heads of the city officials when they declared that all of the high-tension electric companies should occupy jointly a single conduit system. However, the city proceeded upon this line, and issued conduit rights to all the high-tension companies to the ownership of so many ducts each in a joint underground conduit system occupying one side of the street. On the opposite side the low-tension conduits of the telegraph and telephone companies were placed. It was feared that the joint building, ownership and maintenance of a conduit system by the high-tension companies might lead to endless litigation, but a liberal application of the "Golden Rule" to the grouping of ducts and to the location of service boxes, and other engineering details of the work, has produced a system of underground conduits which we believe has few, if any, equals.

The high-tension conduits system consists of 3-in. cement-lined pipe laid on 5¼-in. centers, with 1 in. of concrete between pipes and 3 ins. surrounding the entire group. All ducts are laid to drain to manholes. The top layer of ducts enter service boxes, which are of two sizes —3 × 3 ft. and 3 × 4 ft. Service boxes are placed at most convenient points for reaching customers, and their depth is governed by the depth of the conduit at each location. Manholes are located at every street intersection, and oftener where necessary. They are connected to sewers wherever the sewers could be reached.

Underground Cable System.

While the conduit system provides space for a total of 23 feeders, there have been but five installed at present. Each feeder consists of two 1,500,000-cm. single conductor cables and one 500,000-cm. single conductor cable for the neutral wire. A pressure wire of No. 16 three-conductor cable carried in the same duct with the neutral, and connected to the ends of the feeder, provides means for measuring the pressure at the feeding point by a voltmeter located at the plant. Each feeder goes through two feeder testing boxes placed at convenient distances along its length, and at the end connects to the system of mains through copper fuses located in the junction boxes.

The mains are composed of three conductors, each of the same size, to provide for better distribution of pressure. The rubber tape surrounding each conductor was made of a distinguishing color for convenience in connecting, and very few errors of this kind were made in connecting together the entire system. The junction boxes are shown in detail in Fig. 3, into which these three-conductor mains were run and connected to bus-bars through copper fuses. These fuses are each provided with a small porcelain knob for convenience and safety in handling while fusing up or disconnecting. The lead sheaths on the mains were divided and brought up through the bottom of the junction boxes and sealed water-tight by means of special stuffing boxes. The lead joint at the point of division outside the box was wiped water-tight. The cover of the junction box is screwed tight upon a rubber gasket by toggle bolts, making a thoroughly water-tight box.

For a break-down test the entire system was submitted to 3,000 volts alternating current, and found to withstand this test satisfactorily. The insulation guarantees were also found satisfactory under accurate tests.

The entire inside wiring is done on the two-wire multiple arc plan. All of the inside wiring was gone over, cleared of grounds and brought up to the latest standard of practice, and this has resulted in decreasing, rather than increasing, the fire risk following the introduction of the higher voltage system.

Incandescent Lamps.

The incandescent lamps used on this system are of the 235-volt type, mostly of 16 c. p., although some 10 c. p. and some 32 c. p. are in use. Also small candle-power decorative series lamps. The lamps are all Westinghouse cap and porcelain base. The filaments are either double, two in series, or coiled in several convolutions. The characteristic is due to the extra length necessary on a lamp of this voltage. The lamps were bought under guarantees regarding efficiency, life and the maintenance of candle power, which were entirely satisfactory to the purchaser. In practical operation the light has been entirely satisfactory to customers, and they compliment the character of incandescent service furnished. There were at first minor mechanical and electrical defects, however, such as the sagging of the filament until it touches the glass where lamps are not placed in a vertical position, and the short-circuiting of leading-in wires when a filament burns out near its support, all of which have been remedied in later lamps. There have, however, been no accidents or fires resulting from these causes.

Arc Lamps.

In the original design of this plant, begun fully three years ago, it was anticipated that its principal business would be power service, and that arc lighting would not exceed 15% of the total service. The introduction, however, of the inclosed arc lamp and its remarkable popularity, due to the steadiness of the light and the facility with which its service is metered, has so increased the demand for arc lighting that the arc service is at present a very important part of the company's business. It was believed at the time that the plant was designed that arc lighting might be made secondary to both the incandescent and motor work. The 235-volt inclosed arc lamp was therefore adopted on account of its convenience, one light being controlled independent of all others. It has been found by experience that two arc lamps burning in series on 235 volts give better service than the single lamp. In cases where a single lamp must be used a satisfactory light has been obtained by increasing the current to 3½ amperes.

Motor Service.

The entire power service is taken from the outside wires of the system at 470 volts. These wires inside of the building in all cases are treated as high-tension circuits. It might be surmised that complaint would be made regarding the power service on account of this reduction of voltage on 500-volt motors. This has not proved to be the case. The motors having been previously used upon systems varying in voltage from 450 to 550, the users of power were educated to expect a considerable variation in the speed of their motors. With a steady pressure of 470 volts at the motor terminals, none of the company's customers have complained regarding their power service.

Load Curve.

It may be interesting to submit a preliminary load curve of this plant, prepared by the engineers and submitted to the company two years and a half ago, and to compare it with an average load curve of the plant at present. We have reduced the scale of the former and plotted them side by side in the same sheet. These curves are shown in Fig. 4. Their correspondence in shape is interesting. Their points of difference are explained by the increase in the arc business above referred to. This curve also shows one of the great advantages of the storage battery. The entire plant is shut down from 1 o'clock until five in the morning, and the load carried upon the battery. The machinery is then started and the battery charged during the forenoon, allowed to float upon the system during the afternoon and discharged during the peak in the evening, as shown upon the shaded portion of the curve; and again charged considerably during the first half of the night before shutting down. Interesting features are the large all-night load and the comparatively low peak or maximum load. The average output for 24 hours is 2,198 amperes, which is 39.27% of the maximum load.

Special Features.

The distinguishing features of this plant which marked it as advanced engineering practice are:

First. The 220-440-volt system of distribution.
Second. The entire system is underground.
Third. The battery equalizer and auxiliary.
Fourth. All subsidiary apparatus is electrically driven.
Fifth. Fuel economizers with induced mechanical draft.
Sixth. Condensing apparatus with cooling tower.

(a) The wisdom of selecting the double voltage system will be appreciated when it is stated that the saving in copper alone in the district covered by this plant is equal to half the cost of the building and entire station equipment. This system was almost unknown at the time of its adoption here, but several plants using it have since then begun operation in Europe, and another large installation is being erected in this country. The system is reliable, safe and satisfactory in its service to the public.

(b) The undergrounding of all wires is the ideal method of distribution as regards public safety, reliability of service and low depreciation and repairs.

(c) The value of a storage battery as an equalizer of pressure and as an auxiliary to the steam plant is universally admitted. It has proved indispensable on many occasions in this plant. Its readiness to take all burdens thrown upon it, whether accident to plant, short circuit in underground cables or sudden demand for light caused by a thunder storm, needs only to be experienced to be appreciated.

(d) Driving all boiler feed, circulating and air pumps, elevator, fans, etc., by electric motors saves the condensation in all subsidiary steam pipes, as well as avoids the wasteful use of steam incident to this class of apparatus. By using steam only in the large cylinders of the compound condensing engines and driving all minor apparatus by motors, it is estimated that a saving of about 10% on the entire output of the plant is realized.

(e) Fuel economizers give all the water entering the boilers an additional temperature of 100° F., which effects a saving of about 9% in the use of fuel. With coal at $1.50 per ton, they will earn annually about 25% on their cost.

(f) With all losses deducted, it appears that condensing apparatus as here employed make a saving of from 15 to 20% in fuel.

The entire station equipment was included in one contract, under rigid guarantees from the contractor covering the efficiency of the plant as a whole. A definite cost of coal per kilo-watt hour delivered to outside circuits from the switchboard was guaranteed under a forfeiture in case of failure, with an equal bonus for increased efficiency above the figure specified.

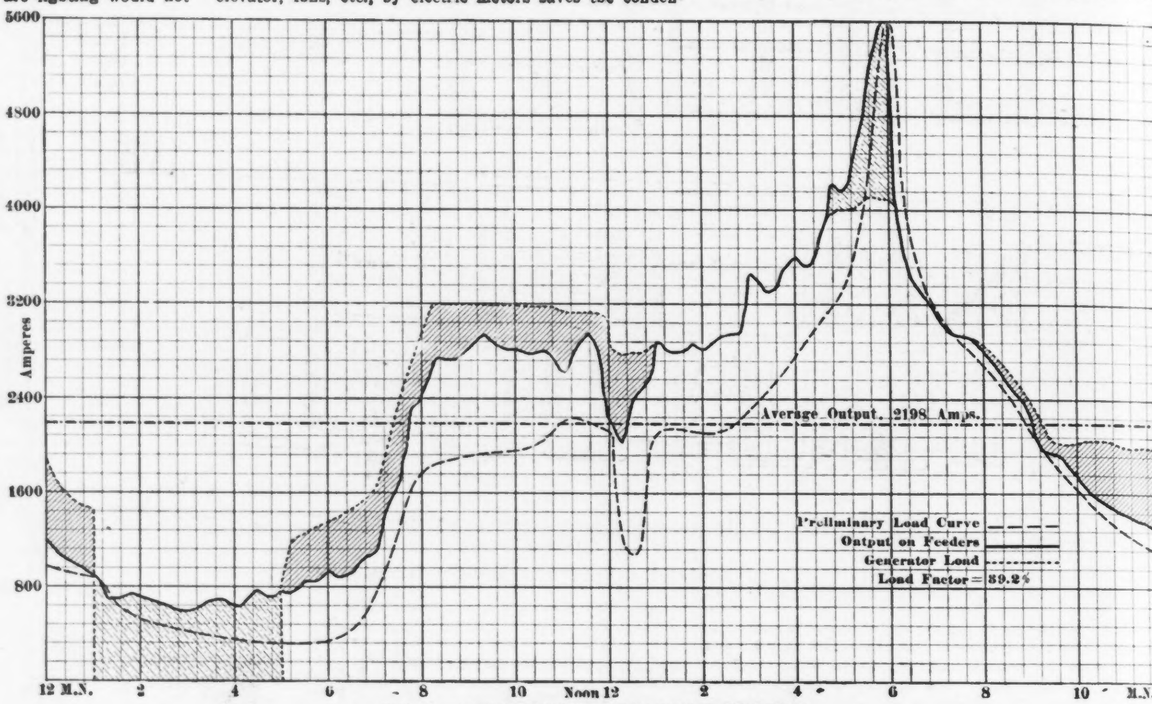


FIG. 4.—LOAD CURVES OF POWER STATION.

THE NEW UNITED STATES NAVY YARD COALING STATION AT NEW LONDON, CONN.

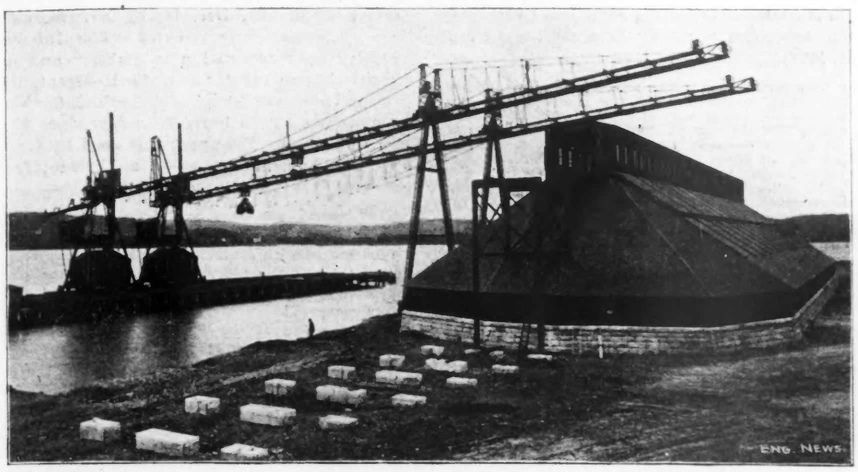
For several years the United States Navy Department has been giving careful consideration to the establishment of permanent coaling stations at the most important strategic points, appreciating the necessity of having an accumulation of coal on hand for emergency; of protecting the fuel from deterioration resulting from exposure to weather, and of constructing mechanical devices to handle coal from store to vessel with the greatest rapidity. The accompanying engraving represents the first completed plant of this kind just finished at the Naval Station, New London, Conn., by the Hoffman Engineering & Contracting Co., of Philadelphia, Pa., whose designs and specifications were selected by the Department of Yards and Docks in competition with a number of other leading firms of engineers. The building has a storage capacity of 10,000 tons, its general dimensions being, length 290 ft., width 97 ft., height of coal 35 ft.

As the building was necessarily located near the water's edge, and on unreliable ground, the foundations required careful consideration. After excavation to low tide level, the entire area was filled with piles, some 1,260 piles being driven. These piles were capped with 12 × 12-in. timber, on top of which was a close grillage of 12 × 12-in. timber. Above this grillage were placed gravel and sand filling, well puddled, and a concrete floor, with a granolithic finish, 12 ins. thick. Under the walls and under the center lines of the columns supporting the roof and the railway tracks running through the building, the piles were more closely spaced. The walls are granite range ashlar, and extend 5 ft. 6 ins. above the floor. The pitch of the roof is sufficient to prevent the coal from coming into contact with the metal. This is also prevented in case of the central columns by jacketing them with sheet iron and filling the space with carefully rammed concrete. In no case does the coal come in contact with metal.

The lantern top to the roof protects the railway tracks, which are standard gage, running the entire length of the building, and also contains the mechanism for opening and closing the hatches, besides giving light and ventilation to the building. As shown, there are 14 hatches on each side of the building, each having independent opening mechanism, giving a continuous line of openings available. The covering of the building is corrugated metal and no wood is used in the construction. A concrete sea wall extends the entire length of the building, carrying a single line of rail on which the inshore legs of the conveyors travel. To carry the conveyor machinery it was necessary to rebuild a portion of the dock. Steel piles 80 ft. long were required, and they were securely capped and braced with steel beams, angles, etc.

The coal conveying and handling plant consists of two of Brown's patent bridge tramways, which, in conjunction with the steel shed as shown, will enable boats of various sizes and with different numbers of hatches to be un'oaded economically and quickly, and the coal transported and deposited into any portion of the coal storage shed. The coal can also be dumped anywhere between the pier and the shed if desired, and transferred direct from small lighters, which can float in the water space behind the pier, to vessels in front of the pier. The coal can also be rehandled through any hatch of the shed to any hatch in vessels or lighters either in front or behind the pier. Coal can also be rehandled from the storage shed by the automatic grab buckets furnished, or it can be shoveled by hand into the dumping buckets.

Bags may also be filled in the building and transported on crates mounted on wheels, and these crates can in turn be lifted through the hatches of the building and conveyed to and lowered through the hatches of the vessels. The arrangement shown makes it also possible to load or unload any other kind of material anywhere within range of the machines and within their capacity, and this material can be conveyed and deposited to any position within their range, or can be transferred to wagons or cars, or to lighters beyond the pier, or between the piers and the shore. In other words, the hoisting and conveying machinery is not only a complete coal handling apparatus in itself, but it also constitutes a perfect traveling crane for handling any material along its entire



VIEW OF UNITED STATES COALING STATION, AT NEW LONDON, CONN.
Hoffman Engineering & Contracting Co., Philadelphia, Pa., Builders.

length, as well as over the entire length of wharf over which it travels.

The front piers of these conveyors contain machinery, engine and boiler housed, movable with them, and travel on rails, as indicated in the photograph near the front of the wharf, and the rear piers supporting the opposite end of the bridges travel on a rail on the foundation wall at the side of the coal shed. The whole structure, together with the engine and operator's houses, is entirely of iron and steel. All the motions of hoisting and conveying may be performed in either direction at will of the operator. The engine power of each tramway is guaranteed to hoist 3,000 lbs. at the rate of 350 ft. per minute.

The front piers containing boilers and engines are arranged to be propelled along the dock by power at the rate of from 50 to 75 ft. per minute. The back pier is arranged to be operated by hand. Both front and back piers have clamps for fastening them to the rails when necessary. Both piers are mounted on wheels of best chilled charcoal iron ground true to tread. There are ten wheels under each double pier, and four wheels under each single pier. With each bridge is furnished one special 5-ton Fairbanks scale, so located along the length of the tramway that each load carried by the trolley can be weighed while moving along the bridge in its regular course with the scale beam on top of the bridges, or at any other convenient point. In general, each of the bridges has sufficient power and strength of mechanism to take a loaded bucket from the hold of the vessel, hoist it and transport it to any distance on the bridge tramway, dump and return it to the hold of the vessel in one minute. The general factor of safety for the bridge construction is five for the moving load, and four for the dead and wind loads.

The building was designed by Mr. F. D. Howell, Jr., the engineer for the builders. The Phoenix Iron Co., of Phoenixville, Pa., were the contractors for the structural steelwork, and Caswell & Moore, of Phoenixville, Pa., furnished the corrugated metal covering. The hoisting and conveying apparatus was designed and furnished by the Brown Hoisting & Conveying Machine Co., of Cleveland, O. We are indebted to the Hoffman Engineering & Contracting Co., Mr. J. H. Hoffman, President, for the information from which this description has been prepared.

REPORT OF THE NEW YORK RAILROAD COMMISSION FOR THE YEAR ENDING JUNE 30, 1899.

The year ending June 30, 1899, was an unusually busy and prosperous one for the railways doing business in New York State, according to the report of the State Railroad Commission, advance sheets of which have just been published. A summary of the results of railway operations in the State for the years 1898 and 1899 presents the following figures:

	For year ending June 30, '98.	For year ending June 30, '99.
Gross earnings from operation.	$214,050,215	$220,027,723
Operating expenses	146,555,720	149,411,333
Net earnings from operation..	67,494,495	70,616,390
Income from other sources....	9,021,145	11,056,136
Interest paid and accrued.....	33,126,669	36,484,810
Taxes	8,543,587	9,049,639
Miscellaneous expenses	1,938,949	1,028,923
Dividends declared	18,591,321	19,126,014
Surplus	6,263,729	8,061,714
Capital stock	776,539,404	785,516,804
Funded debt	787,756,644	799,742,027
Other liabilities	71,135,208	76,130,042
Cost of road and equipment...	1,343,035,902	1,337,536,656
P.c. gross inc. to cost road, etc.	5.69	6.10
" net income to capital stock	3.20	3.47
" dividends on capital stock	2.39	2.43
Miles road in state, main line.	8,064.78	8,075.63
Tons freight carried 1 mile...	21,781,544,107	23,437,573,027
Average, per mile:		
Freight earnings pr ton, cts.	0.665	0.633
Freight expenses pr ton, cts.	0.428	0.401
Freight profit per ton, cts..	0.237	0.232
Earnings per passenger, cts.	2.20	2.17
Expenses per passenger, cts.	1.70	1.68
Profit per passenger, cts.....	0.50	0.49
Passengers carried one mile..	3,150,135,421	3,291,624,483
Percentage of total:		
Maintenance of equipment..	18.14	18.29
Of way and structures ...	16.79	17.08
Conducting transportation .	61.50	61.08
General expenses	3.57	3.55

According to these figures, the gross earnings of steam railways for the year ending June 30, 1899, are $5,977,508.39 in excess of the gross earnings for the year ending June 30, 1898; the operating expenses are $2,855,613.34 in excess of the operating expenses for the year ending June 30, 1898, making the net earnings from operation $3,121,895.05 in excess of the net earnings from operation in 1898. The income from other sources was $2,034,990.89 in excess of 1898. The companies paid in taxes $506,051.74 more than in 1898, and declared dividends $534,692.90 in excess of those declared in 1898. Capital stock increased $8,977,400 over that of 1898; funded debt increased $11,985,383.01 over 1898. The percentage of dividends to capital stock was 2.43 as compared with 2.39 in 1898. The average freight earnings per ton per mile decreased .032 ct. The average freight expenses per ton per mile decreased .027 ct.; the average freight profit per ton per mile decreased .0005 ct.; the average earnings per passenger per mile decreased .03 ct.; the average expenses per passenger per mile decreased .02 ct.; the average profit per passenger per mile decreased .01 ct.

A summary of the accidents to persons on steam and street railways shows the following fatalities for 1899: Steam surface railways, killed 704, injured 1,326; elevated railways, killed 19, injured 20; street railways, killed 126, injured 589. The Commission calls attention to the frequency of accidents on street railways, and renews its former recommendations for operating such roads so as to reduce danger from accidents. The report states that since the grade crossing law went into effect 19 grade crossings have been abolished, and work is in progress which will result in 25 more being abolished. Substantial progress, it is stated, has been made in changing the motive power on the elevated railways of Brooklyn from steam to electricity. The physical condition of the State's railways has been generally improved during the year, and large additions have been made to their equipment of rolling stock. Of the 224,494 freight cars owned by the railways operating in the State 121,661 have been equipped with power brakes and 203,107 with automatic couplers. Litt'e progress has been made in the lighting of passenger cars, of which 5,953 were in operation in 1899. In conclusion, the Commission calls attention to railway consolidation by the following significant paragraph:

> Perhaps the most significant feature of the general railroad situation is the tendency to consolidation of large systems which have heretofore been independently operated. What the result of this will be cannot be foretold, but if the interests of the public are considered by railroad managers to be correlative with the interests of the companies, the result should not be harmful, at least, to the state. However, this may be, the state may regulate its corporate creatures and conserve the interests of its people whether its decrees are issued to such creatures while separated or after they are combined.

SAND-PUMP DREDGING AT LIVERPOOL.

In a late paper presented to the Institution of Civil Engineers, Mr. A. G. Lyster, M. Inst. C. E., described the work done by the large dredgers, "Brancker" and "G. B. Crow," in removing sand from the Mersey Bar. The "Brancker" has a carrying capacity of 3,000 tons and a dredging capacity of about 6,000 tons per hour in the best class of free moving sand; the "G. B. Crow" has a similar capacity. Previous to July, 1893, before the "Brancker" was put to work, the average depth of water on the bar was 20½ ft., and a total of 2,438,710 tons of sand had been removed from the bar and main channel shoals; in May, 1899, the average depth of water was 28 ft. through a channel 1,500 ft. wide, and a total of 41,240,360 tons had been removed from the bar and shoals. The loaded dredgers dump at a site 3 to 4 miles eastward of the bar.

The cost per ton of this dredging, as based upon the work of the "G. B. Crow" in 1898, is given as follows for 4,309,350 tons dredged:

Wages	0.23d.
Supplies	0.25d.
Repairs	0.13d.
Total, per ton	0.61d.

This is equivalent to about 1¼ cts. per ton. The cost of the two large dredgers—the only ones now used on the bar—was $600,000, and the average annual expenditure for three years has been about $100,000. Mr. Lyster argues that any permanent works would have cost enormously in excess of these amounts in both investment and maintenance accounts.

An improved form of hopper has been introduced by Mr. Lyster, as with the old form about 20% of the sand and mud was washed overboard with the escaping water. The new hopper is decked over with light iron plates, with the exception of a strip, 4 ft. wide, along the center of the hopper. This strip is walled in on each side by plates rising 5 ft. above the deck and extending the length of the hopper. The delivery pipes from the dredge are placed below the deck, and as close to the two sides of the hopper as possible, and the openings in them are so formed as to ensure the sand and water being delivered with a minimum of commotion. By this arrangement, all water entering with sand and flowing overboard has to traverse a considerable distance and rise 5 ft. above the deck, and it then flows over the two sides of the trunk made as described. This water thus carries away but very little sand or silt. As a consequence 20 to 25% in time is saved in loading the hopper.

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 320 means that subscription is paid to the 32d week (that is the issue of Aug. 9) of the year 1900; 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 XXI. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.

"The Canadian Engineer" is worried over the dam proposed by the United States Deep Waterway Commission to regulate the outflow from Lake Erie. It sees in it a deep-laid scheme to shift all the loss of level due to the outflow from the Chicago Drainage Canal onto Lake Ontario and the St. Lawrence River, and declares that wing dams will be required to make the St. Lawrence channels navigable, and a dam and locks will be necessary below Montreal at the foot of Lake St. Peter, if Montreal is not to be ruined as an ocean port.

Our contemporary is needlessly alarmed. The proposed dam at the outlet of Lake Erie will only equalize the outflow through the Niagara River, and the total annual discharge will remain practically the same. The effect upon the levels of Lake Ontario will be too small to be measurable, the maximum variation effected in the flow by the regulating works amounting to only about 5%.

As for the influence of the Chicago Drainage Canal on St. Lawrence levels, the accurate measurements of the Niagara River, now available, show that the Chicago Canal will, when discharging 300,000 cu. ft. per second, reduce by 2.3% the outflow from Lake Erie. The per cent. of flow deducted from the St. Lawrence will be considerably smaller than this, as the St. Lawrence flow is larger than the Niagara by the entire run-off from the Lake Ontario watershed. So far from "Montreal being ruined as an ocean port by the Chicago drainage canal, and the Niagara dam," as our contemporary puts it, it is extremely doubtful whether the most accurate gagings will detect any difference of level in the St. Lawrence at Montreal as a result of these works.

The sewage purification plant at Madison, Wis., described in our issue of Dec. 28, 1899, was abandoned by the contractors on Jan. 12, and immediately taken in hand by the city. The reasons for this action can be given best in the language of the official records. On the evening of the day named Messrs. McClellan Dodge and John Nader, Sewerage Engineers for the city, submitted the following report to the city council:

> Since our last report to your honorable body relative to the operation of the sewage disposal plant erected by the Sanitary Engineering company the said plant has been in charge of and has been operated by the said company. We have examined the plant and its operation as late as Thursday afternoon last. The company has not remedied the defects complained of in our last report to you and the plant has not and is not now working to our satisfaction or in compliance with the terms of said contract in several important particulars.
>
> We further report, that late this afternoon we are informed that without tender of said plant to us, said company entirely abandoned the same and it is imperative that some action he taken by your body at once.

At the same session, the city council, unanimously and without debate, adopted a resolution in which it declared (omitting some legal verbiage) that the American Sanitary Engineering Co., of Detroit, Mich.,

> has not constructed said plant as in said contract provided; has failed to comply with the terms of said contract in several important and essential particulars, among others that the cost of operating said plant is in excess of the guaranteed cost of operation; that the degree of purification is not equal to that guaranteed in said contract; that the capacity of the plant is not as guaranteed, and that in other respects said plant does not comply with said contract; and that the manner of operation, and the results obtained are not in compliance with said contract and are not and have not been to the satisfaction of the city engineers, and are not satisfactory to the city of Madison.

The resolution then recited the fact that it has diverted all its sewage to the plant, alleged that the company had "neglected and refused to comply with the terms of said contract," and, as the city was informed, had abandoned the plant. After this preamble, the resolution proper stated that, without waiving any of the rights of the city, its surveyor was instructed to take charge of the plant and operate it; and it further declared that unless the company within a reasonable time resumed charge of the plant and fulfilled the contract, the bond of the company to the amount of $25,000 should be forfeited to the city.

We have given this matter prominence on account of the space which we recently devoted to a description of the plant, and the controversy which has taken place between the city and its advisers and the builders of the plant. The contract over which the dispute has arisen was a peculiar one in many respects, as our abstract a few weeks ago showed. It contained a direct statement to the effect that the system had never been installed in this country before, and that the contractors were making concessions to the city on that account, but notwithstanding this, and the exceedingly high rate of filtration for the effluent from the chemical precipitation tanks, the effluent was to be equal in quality to the waters of the lake which were to receive it, as shown by analyses made ten years ago, and the cost of operation was not to exceed the estimates for operating ordinary chemical precipitation and intermittent filtration plants made by the city's engineers employed by the city. Under all the conditions of the case it is not surprising that the city has on its hands a sewage purification plant which it has already discredited, with probably a lawsuit in addition.

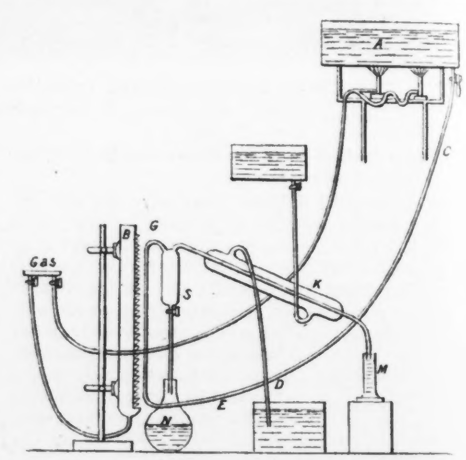
CIRCULATION IN STEAM BOILERS.

We do not recall any subject in the whole range of engineering on which a greater variety and amount of misstatement and false theory has been published in recent years than the one which heads this article. It has long been a matter of earnest controversy. "My boiler is better than yours," says the water-tube man to the shell man, "for it has a better circulation." "Yours has to have circulation or bust," says the shell boiler man, "and my boiler has all the circulation it needs." Again the water-tube advocates have fought among themselves. Each has claimed that his boiler has better circulation than the boilers of his rivals. They have vied with each other in their claims for "positive," "rapid," "thorough" and various other kinds of circulation, and one erratic genius attempted to prove that his boiler needed no circulation at all.

It is in England that the most active battle has been fought over the question of circulation. Some years ago, our influential but sometimes misguided contemporary, "the London Engineer," undertook to set the world right on the question of boiler circulation, and propounded the highly remarkable theory that circulation in a boiler was a positive injury instead of an advantage, as had been commonly supposed. "The Engineer" did not convert the engineering profession at large to its way of thinking, but its rather plausible reasoning in defence of its theory did mislead a good many engineers of more or less prominence, and stirred up a very active controversy abroad over the question of boiler circulation, some echoes of which are still heard at times.

In a very recent number of "The Engineer" (Dec. 29, 1899), we find one of these "echoes" in the shape of a paper read before the Institute of Marine Engineers, Dec. 11, by Mr. George Halliday. The paper is entitled "The Influence of Velocity on Evaporation in Tubes," and it is so remarkable an illustration of self-deception in the interpretation of physical experiments that it is worth some notice here. We reproduce herewith the cut showing the apparatus used by Mr. Halliday, and reprint the following extract from his paper:

> The experiments were made with water heated in a tank A to the boiling point, and made to flow through a tube heated with a Fletcher gas burner B. When it had flowed through the tube, and got heated, the steam was separated from the water in a separator, and each separately measured.
>
> First the fire of the Fletcher burner was kept constant; that is, the heat supplied was kept constant. Under this condition it was sought to determine the influence of the rate of circulation. The rate at which the water

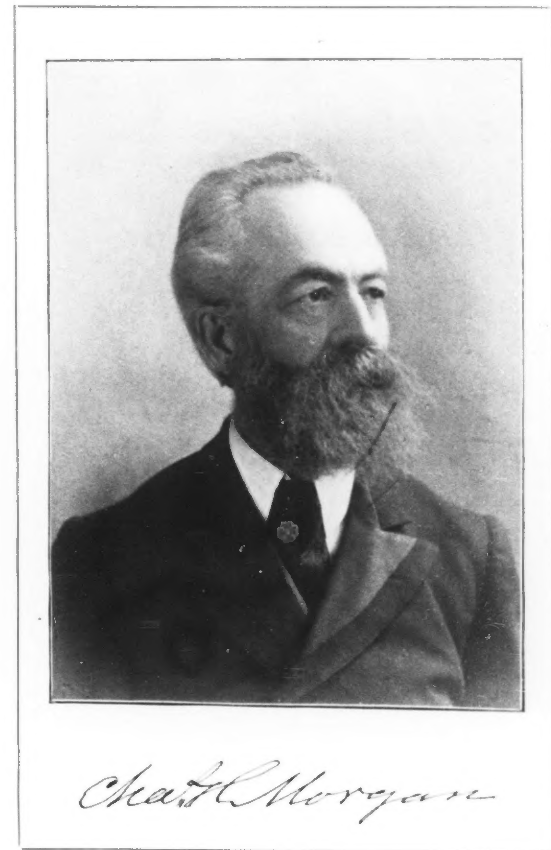


Apparatus for Testing the Influence of Velocity of Circulation Upon the Rate of Evaporation in Steam Boilers.

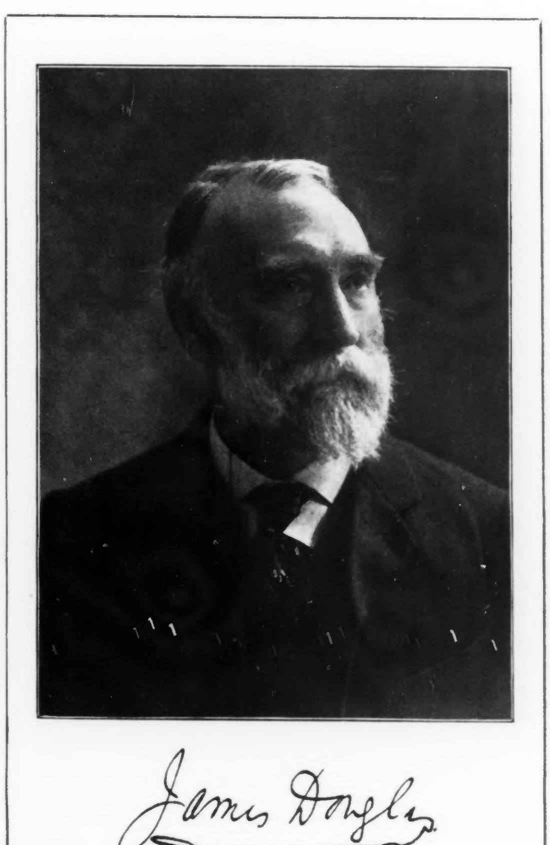
> moved through the tubes was varied. It was sought to determine whether the amount of evaporation remained constant with the heat supplied, or varied with the velocity of the fluid through the tube.
>
> The second question was whether the evaporation increased with the speed of the water and steam through the tube, or in what way the evaporation was affected by the velocity of the water and steam through the tube.
>
> First, then, the tank supplying the water was heated until it gave off steam freely. Then the Fletcher burner was lit and the flames allowed to play on the copper tube G. Then the water from the tank was turned on and allowed to run. After the water had gone through the heated part of the tubes, steam and water together flowed through the separator S into the flask N. After that the cold water was turned on at the cold water tank and made to flow through the condenser K. By that time the whole apparatus was in full working order.
>
> The time settled on for each experiment was four minutes. At the end of four minutes the water was measured and the condensed steam measured also. The sum of the two gave the quantity of water which flowed through the tube for four minutes, and the quantity of steam evaporated for four minutes.
>
> * * * * * * *
>
> Here follows the results of experiments:

Velocity.	Evaporation.	Velocity.	Evaporation.
12	10	175	20
37	29	197	27
40.5	35.5	308	23
68	32	440	20
71	30	478	18
106	26	616	16
106	31	705	15
130	26	1,007.5	7.5
155	25		

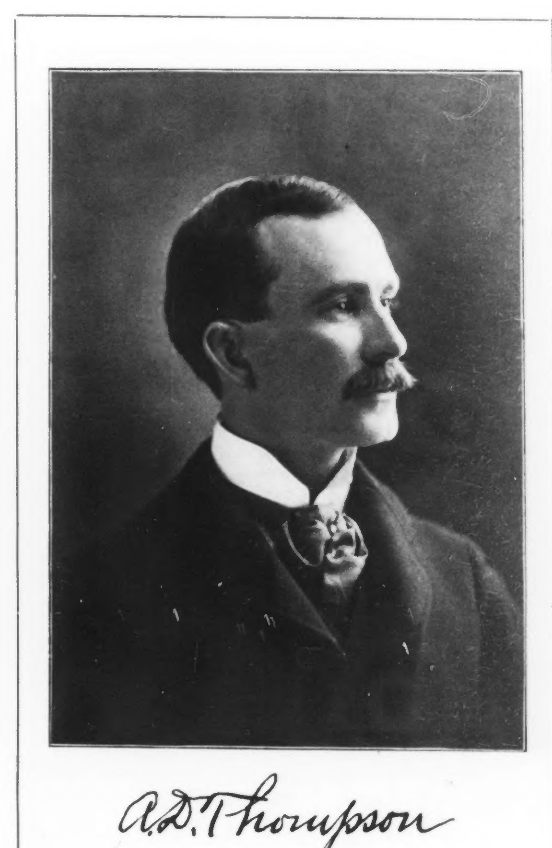
President of the American Society of Civil Engineers.



President of the American Society of Mechanical Engineers.



President of the American Institute of Mining Engineers.



President of the American Society of Municipal Improvements.

THE PRESIDENTS OF FOUR AMERICAN ENGINEERING SOCIETIES.

It will be noticed that when the velocity is very small the evaporation is small. In these two cases the quantity of water supplied was insufficient, and the effect was simply to heat the pipe. The highest evaporation was when the velocity was 40.5. In that case the evaporation was 35.5. Really all the water supplied was evaporated, and the greatest effect took place then. In the case where the velocity was 68, the evaporation was 32. In this case the quantity of water evaporated was about equal to the quantity not evaporated, yet there is a considerable fall of evaporation from the maximum. It is, then, sufficiently shown that the quantity of steam evaporated depends on the quantity of heat supplied to the outside of the tube; and, secondly, on the speed at which the water flows through the tube. The greater the speed of the water through the tubes of a water-tube boiler the less is the evaporation.

From other series of tests with the same apparatus the author reached the conclusion that the heat absorption was a maximum when the rate of flow through the tube was such that half the water that flowed through the tube was evaporated.

The proposition laid down by the author that the rate of evaporation in a water-tube boiler falls off as its circulation increases, is certainly a radical departure from generally accepted principles, and sufficiently contrary to established scientific facts to demand the closest scrutiny before it is adopted as a guide to boiler design.

Examine Mr. Halliday's apparatus carefully and it will be seen that he makes the comparison on which his conclusions rest, solely on the basis of the quantity of water evaporated. He has assumed, apparently, that the unevaporated water leaves the top of the tube G, at the same temperature at which it enters at the bottom. Because the water is at boiling temperature in the tank A, he assumes that it is at the same temperature when it reaches the copper tube G. But as a matter of fact, the water would be more or less cooled in its passage from the tank A to the tube G, through the long pipe C. Besides this, it seems quite probable from the author's sketch that the water in the tube G, where evaporation took place, was under a slight head. This would raise its boiling point about 1° for each foot of head. Inspection of the table quoted above from Mr. Halliday's paper, indicates pretty strongly that the water was slightly below the boiling point when it reached the hot tube; and consequently the greater the velocity of the flow through the tube, the greater was the proportion of the heat used up in heating water and the less was the heat left to cause evaporation.

We make the above criticisms, of course, on the basis of the author's published account of his work. Possibly we are wrong in our interpretation of his experiments; but if so it is due to his too meager description of his work. When anyone sets out to upset established and generally accepted scientific facts, the fullest and most detailed presentation of all the evidence is demanded. On that basis alone, Mr. Halliday's claim to have proved that evaporation decreases with the rate of circulation deserves to be thrown out.

We have cited at some length the above example because it illustrates how erroneous ideas on various matters creep into engineering literature and engineering practice. "Figures won't lie" runs the old adage, and yet it is now commonly understood that statistics in the hands of an incompetent or deceitful man can be made to prove anything. So physical experiment is the only way to ascertain the laws of nature; but in the hands of an incompetent observer, such experiments may establish error instead of truth.

Turning now to the real facts regarding boiler circulation, we shall endeavor to state what we believe these facts to be, according to the best practice of the present day.

The circulation of the water inside a steam boiler is of value in three different ways: (1) as respects its equalization of temperature strains upon the boiler itself; (2) as respects its effect on the rate of evaporation; (3) as respects the deposit of scale and sediment on the heating surfaces. We will consider each of these separately.

The temperature strains in a steam boiler occur chiefly when steam is being raised, and before evaporation begins. Such circulation as takes place at this time in a boiler is due solely to the small difference in specific gravity between hot water and cold water. The temperature strains in the boiler due to this unequal heating are most serious in internally-fired boilers, such as the Scotch marine boiler, or the Cornish and Lancashire boilers so extensively used in England. In these boilers the furnace is some distance above the bottom of the boiler, and the water below the level of the grate-bars receives practically no heat while steam is being raised. For boilers of this class various kinds of jet nozzles have been devised to set up currents in the water and keep its temperature uniform throughout until steam begins to form. These devices, which are dignified by various high-sounding names, are perhaps worth the cost and trouble of installation on boilers of this type in which steam has to be raised frequently. On any other class of boilers they are needless refinements. In the common American externally-fired boiler, for example, the heat is applied at the bottom and also throughout the mass of water in the boiler by the tubes which pass through it. The result is a substantially equal heating throughout the mass of water. Of course in any boiler it is well to heat up as gradually as possible, and the larger the boiler, the greater the magnitude which temperature strains may reach. It is only with the internal furnace boilers, however, that extreme care needs to be taken.

We have referred thus far only to what takes place during the raising of steam. When steam bubbles once begin to form there is no more trouble with temperature strains. The fact that the speed of circulation enormously increases as soon as water "comes to a boil" is common knowledge, and no one who ever saw water boiling in an open pot could doubt it. There was a curious theory put forward a few years ago that the formation of steam bubbles had nothing to do with the circulation of the water. It originated, we believe, with an eccentric American inventor now deceased, who published several curious pamphlets to set forth his ideas. These next blossomed forth in the pages of an English engineering journal, and caused a deal of controversy. As no facts were ever presented in proof of this theory, and as it was evidently based on a misconception of natural laws, it need not be further referred to here.

Next let us consider the second matter referred to above—the influence of circulation upon evaporation, or, stated in another way, will more heat be extracted from the heating surface of a boiler if the water moves over it than if it merely lies stationary upon it?

It is a common idea that evaporation is very greatly increased by a rapid circulation, but there are few facts to support it. We showed two years ago (Eng. News, June 2, 1898), in discussing the transmission of heat in steam boilers, that the great obstruction to the flow of heat was its passage from the hot gases to the metal of the heating surface. Compared with this, the resistance to flow through the metal itself and from the metal to the water are trifling in amount. Now to increase the rate of evaporation we must increase the amount of heat transmitted. If the water side of the heating surface is only a little above the temperature of the water in the boiler, circulation of that water cannot much affect the flow of heat. On the other hand, in the case of heating surface directly exposed to the fire, where evaporation is rapid, a large volume of steam is continually given off, and unless it can freely escape, a mixture of water and steam, instead of water alone, will be in contact with the heating surface. Such a mixture can take up heat less rapidly than solid water, and the result will be some increase in the temperature of the heating surface and a small decrease in the rate of heat transmission and evaporation.

The chief advantage gained by good circulation in a steaming boiler, then, is that the steam is carried off to the surface of the water as fast as it is formed and fresh water is brought in contact with the heating surfaces. Once given a circulation good enough to effect this and any additional speed in the flow of the water currents is of no particular benefit. In the ordinary types of shell boiler the natural circulation is probably sufficient to keep the heating surfaces covered with water. Any arrangement which facilitates circulation, such as arranging fire tubes in vertical rows instead of staggering them is well enough, though it probably has much less effect upon the boiler's working than is frequently claimed.

If we turn now to the water-tube or sectional class of boilers, we find that circulation and often very rapid circulation is necessary in them to secure the end just named—the contact of water with the heating surface.

In this class of boilers the steam cannot rise to the surface as fast as it is formed, but must flow onward with the water, sometimes for 10 to 20 ft. before it can escape to the steam space. Should this flow stop from any cause, the whole of the water will be converted into steam and the temperature of the tube or other part containing it will be rapidly raised. Fortunately, it is usually possible to so design water-tube boilers that circulation will take place much more rapidly and certainly than in shell boilers, where upward and downward currents are often in interference.

The water-tube boiler designer can provide for this; but he can seldom provide for the contingencies of neglect and mismanagement; and where water-tube boilers are allowed to fill with scale and sediment, it often happens that the circulation is interfered with and more or less serious trouble results.

We have spoken above of the temperature strains to which boilers are subjected in raising steam, through the lack of circulation. It will be evident that similar and even greater temperature strains are likely to occur whenever circulation is impeded in a steaming boiler so that steam instead of water is left in contact with the heating surface. To this is probably due the differential expansion of upper and lower tubes in water-tube boilers of the inclined tube type; and boilers of this class with the freest circulation, have, we believe, least difficulty with such expansion. Again the staybolt fractures around locomotive fireboxes are known to be due to the expansion and contraction of the side sheets. It is probable that this expansion is due in part to the fact that a mass of foam and not solid water is in contact with the sheets when the locomotive is steaming hard. With most boiler heating surface, the rate of transmission of heat is so moderate that a mass of foam of, say, equal parts by volume of steam and water will probably keep the plates nearly as cool as solid water. In a locomotive firebox, however, the heat is so intense and its transmission through the plates so rapid that the presence of a 50% mixture of steam and water in the spaces around the firebox may make quite a difference in the temperature of the side sheets.

Turning now to the effect of rapid circulation in keeping heating surfaces free from scale, we find most contradictory statements in circulation. On the one hand it is asserted that rapid circulation is of great value in keeping heating surfaces clean. On the other it is asserted with equal positiveness that circulation can have little effect upon the formation of deposit. This divergence of opinion is due, doubtless, to the great variety of impurities in the water fed to steam boilers. Certain impurities, such as lime sulphate, will adhere to the heating surfaces no matter how rapid the circulation. Even feedpipes and injectors often become coated with scale. Other impurities, such as the mud, clay, etc., held in suspension in Western river waters, are carried along with the water and will not settle unless the flow ceases. Circulation of the water over the heating surface is undoubtedly beneficial in keeping such deposits from collecting and burning onto the plates.

To finally sum up, then, the important facts regarding circulation in steam boilers can be briefly stated as follows: Circulation in a boiler is of value, and should always be secured to a sufficient extent to keep the heating surfaces bathed in water and to prevent their undue heating and the injury of the boiler through unequal expansion. The more rapid the circulation, the better will this end be attained; and some gain is also to be secured through the reduced tendency of sediment to deposit on the heating surface. It is in these directions and not in any increased evaporative efficiency that the gain from good circulation is to be found. While in theory rapid circulation should very slightly improve the economy of a boiler, the gain is too slight to be discernible by any practical tests.

LETTERS TO THE EDITOR.

More Light on the Expansion of Rails.

Sir: I send for your "curiosity drawer" a circular recently received that should go down to history along with that report of the Roadmasters' Association Committee which declared that light rails expanded more than heavy ones, and recited measurements made with a 2-ft. rule to prove it. (Eng. News, Sept. 14, 1899.)

Truly yours, "Expansion."

Chicago, Dec. 15, 1899.

(We take the following extract from the circular enclosed.—Ed.:)

THE LONG-SOUGHT REMEDY FOUND.

To Trackmen, Civil Engineers and Others:

For years, especially for the last 15 years, trackmen, civil engineers and others have gone to great expense and have sought diligently to find a remedy to prevent track-rails from creeping.

After years of careful watching we have come to the conclusion that the first thing to be done, in fact, the main thing to be done, is to secure uniform expansion. Our experiments have been made with these facts in view; and the result is that we are now able to present, for your consideration, a self-acting rail, one whose contraction and expansion will not affect others with which it may be connected. Its action will be wholly confined within its own movements.

The common "T" rail is not a square bar of steel. Such a rail, of from 65 to 75 lbs. to the yard, comprises a ball or cap about 2 ins. wide and 2 ins. thick, a base about 4 ins. wide and ½-in. thick, and a web about 2 ins. high and ½-in. thick. The quantity of metal in these parts is in the proportion of 4, 2 and 1; that is, in a rail of such weight, and of the length of 30 ft., the cap contains 1,440 cu. ins. of metal; the base contains 720 cu. ins., while the web contains only 360 cu. ins. It is well known among trackmen and civil engineers that iron and steel contract and expand in proportion to quantity when subjected to the same changes of temperature. The usual expansion and contraction of such a rail as we have just described is about ¼-in., or ⅛-in. at each end. It will, therefore, be found that while the cap of the rail expends or contracts ⅛-in. at each end, the base expends or contracts 1-16-in., the web expending or contracting only 1-32-in.; these under ordinary conditions; but as the web is protected from the sun, by the cap of the rail, it gets less of the effect of the sun's heat. The base gets less of the sun's heat, as it gives off the heat rapidly to the ties, and through them to the earth. For these reasons the most of the expansion and contraction of the rail is in the cap, as every trackman has noticed. Now if the web or central portion of the rail expands or contracts but a little, if any, it may readily be seen that the evil of "creeping" is due to the expansion and contraction of the other parts.

The rail which we have invented, and the description of which we present for your consideration, is so made that the web has an extension of ⅛-in. beyond the cap and base at each end of the rail, such projection being milled on the end of the rail, at a temperature of about 50°. In laying track with such rails, whatever the temperature may be at the time of laying the track, the rails are to be placed joining at the ends; for if it be at a high temperature the end of the rail will be about square; if at a low temperature, the projection on the web will be full and prominent.

The rights of the inventor have been properly secured, in accordance with the laws and regulations governing the Bureau of Patents, Washington, D. C.

The Balancing and Adjustment of Compass Survey-Notes.

Sir: In my letter published in your issue of Nov. 23, 1899, I stated that in balancing the notes of a compass survey no correction need be applied to the bearings. In some cases, however, especially when angles are read within 5', it may be necessary to alter the bearings of all or some of the courses, so that they will be consistent with the corrected latitudes and departures. Of course, any surveyor knows that both the corrected length and the corrected bearing can be found by solving a right-angled triangle whose sides are the corrected latitude and the corrected departure. But this is an unnecessary refinement, involving some equally unnecessary work. The advantage of the formula that I derived for C' consists in this: That the multipliers

$$\frac{\Sigma L}{\Sigma C} \text{ and } \frac{\Sigma D}{\Sigma C}$$

may, in the majority of cases, be taken to only one significant figure, and this makes the operations indicated in the formula [and the same applies to formulas (1) and (2)] exceedingly simple; indeed, they can almost always be performed mentally.

I would now like to submit the following formula for calculating the corrections to be applied to bearings. For convenience, I shall change my former notation a little, and write:

$$\frac{\Sigma L}{\Sigma C} = k, \quad \frac{\Sigma D}{\Sigma C} = k',$$

δL = latitude correction,
δD = departure correction,
δC = correction to be applied to the length C,

I shall, besides, use differentials for finite increments. With this change of notation, the formulas I used become:

$$\delta L = - C\ k. \qquad (1)$$
$$\delta D = - C\ k'. \qquad (2)$$
$$\delta C = - L\ k - D\ k'. \qquad (3)$$

Let β be the bearing of the course whose length is C, and $\delta\beta$ (in circular measure) the correction to be applied to this bearing. Then

$$\sin \beta = \frac{D}{C},$$

whence, by differentiation,

$$\delta \beta = \frac{C\ \delta D - D\ \delta C}{C^2 \cos \beta} = \frac{C\ \delta D - D\ \delta C}{C\ L}.$$

By a few substitutions and transformations, this can be reduced to the form:

$$\delta\beta = k \sin \beta - k' \cos \beta.$$

If the correction in minutes is represented by $\delta\beta'$, we may write, with sufficient approximation,

$$\delta\beta' = 3{,}400\ \delta\beta = 3{,}400\ (k \sin\beta - k' \cos\beta) \quad (4)$$

It goes wthout saying that if this formula were to be "worked out by logs," it would be a most unhandy thing; but, for the purposes for which the formula is intended, it is sufficient to use natural functions, taking only one significant figure in each of the quantities k, k', sin β and cos β. The operations can be performed mentally (if, indeed, it is not found from a mere inspection of the figures that the correction is not worth making at all). As k and k' are also used in formulas (1), (2) and (3), it may be better to compute them to two significant figures. Whether, in any particular case, the second figure will affect the result or not, can be determined by inspection.

The ratios k and k' are also useful for the determination of the relative error of closure, which is

$$\frac{\sqrt{(\Sigma L)^2 + (\Sigma D)^2}}{\Sigma C} = \sqrt{k^2 + k'^2}.$$

Generally, the greatest permissible relative error is .002 or .003 ($^1/_{500}$ or $^1/_{300}$); and, if either k or k' exceeds these limits, the survey may be at once rejected.

Yours very truly, Antonio Llano.

International Correspondence Schools, Scranton, Pa., Jan. 1, 1900.

Notes and Queries.

In reply to the query of W. W. P., in our last issue, we are informed that at Oberlin, O., Mr. W. B. Gerrish is both City Engineer and Superintendent of Streets, and also fills the position of Superintendent of Water-Works. We believe tha' the combination is satisfactory both to Mr. Gerrish and to the municipality which he serves.

NOTES FROM THE ENGINEERING SCHOOLS.

Massachusetts Institute of Technology.—The Executive Committee of the Institute has announced to the members of the Corporation the resignation of President Crafts, to take effect at the end of the present school year. The Executive Committee has found it impossible to induce President Crafts to reconsider his decision, and has accepted his resignation with great regret.

Part of the President's letter is as follows:

My reasons for taking this step at this time are founded upon my desire to return to purely scientific occupations. My term in office has shown me the wide field of educational problems, both within and outside the Institute, which should be studied, and I have found that such studies and the performance of administrative duties, although not in themselves burdensome, leave little freedom for the pursuit of experimental science. A choice must be made between administrative and scientific occupations, and it is the latter which I wish to choose.

For several months past preparations have been going on at the Institute for the exhibit which is to be sent to the Paris exposition next year. In accordance with the plans of the United States commission the different universities and colleges in the country were asked to make partial exhibits. Harvard has devoted its efforts mainly to astronomy, while the Massachusetts Institute of Technology and Cornell are to proceed along architectural and engineering lines.

University of Pennsylvania.—The University has just received another gift of $250,000 from the Houston estate. $90,000 of this money is to be used for the addition to the University dormitories and the balance as the trustees may decide.

Mr. J. Vaughan Merrick has presented to the University funds covering the purchase of an air pump and jet condenser, indicators, water power engine, milling machine, alternating current volt and am-meters and other small apparatus for mechanical and electrical engineering laboratory work.

Mr. George S. Webster, Chief of the Bureau of Surveys of the City of Philadelphia, delivered an illustrated lecture on the "Construction of the Reading Subway" before the Civil Engineering Society of the University, Jan. 5.

The mechanical engineering students of the University have been making tests on the boilers at the National Export Exposition power plant.

University of Michigan.—A course of lectures on plumbing, heating, ventilating and draining has been arranged for the engineering students in the University. The course is given by John R. Allen, Assistant Professor of Mechanical Engineering.

Professor Israel C. Russell of the department of geology, read a paper at a meeting of the Geological Society of America, held in Washington, D. C., Dec. 25 to 27, on "Deposits of Calcareous Marl in Michigan." Professor Russell pointed out the fact that a large number of lakes and swamps in the southern peninsula of Michigan have been found to contain deposits of calcareous marl suitable for the manufacture of Portland cement. The marl is composed in part of shells but is mainly a chemical precipitate and is still being deposited. The better grades contain from 80 to 95% of calcium carbonate. Several large cement works have already been established and others are contemplated. The supply of marl is practically inexhaustible and Michigan can easily take a leading place in the Portland cement industry.

President Angell, in his speech at the banquet of the Alumni Association of Western New York, held at Buffalo, Dec. 8, referring to the demand for a better training for commercial and industrial pursuits, spoke as follows:

"The time has long since passed when men go to colleges simply for the purpose of studying a profession. We all feel that the country has entered upon a new career; that the country is to reach out in great commercial enterprises that will have to do with the development of trade on the other side of the world, and we are coming to the point where we are hoping to take possession of a large part of the markets of the world. It is certainly going to be by some blunder of our own if we do not.

"It, therefore, seems to me that it is the duty of the universities to train men so that they may be fitted to guide these great international concerns. We should train them in the laws that will govern international trade; train them in the languages that they may be called upon to speak in the conduct of that trade.

* * * * * *

"The day has passed when the great universities can live in seclusion. I think that the public is beginning to appreciate the fact that the colleges are no longer the home of the useless, but are striving, and striving with success, to meet the great needs of American society in all branches of human enterprise."

Five of the largest beet-sugar factories now running in Michigan have been visited by a party of instructors and students from the chemical department. The heads of these factories all deplored the lack of trained American men, and were in sympathy with the university training for this work. Most of the factories are equipped almost entirely with German machinery and operated by German experts.

Purdue University.—The opening lecture for the current year in the course of special railway lectures was given on Nov. 28 by President George B. Leighton of the Los Angeles Terminal Ry. President Leighton's subject was "The Work Ahead" and his talk was a brief outline of the opportunities in prospect for those entering railway work. After a short review of the notable events and inventions in railroading in the past, President Leighton discussed the lines along which the coming engineer must work and in which the chances to distinguish himself will be the greatest.

University of Illinois.—Mr. F. C. Koch, of the Department of Applied Chemistry, under the direction of Professor S. W. Parr, is carrying on an investigation of Illinois coals with special reference to the process of coal-washing. There are perhaps a half dozen coal washers in the state, mainly in Southern Illinois. The process of washing ordinarily removes 50% of the slate and ash ingredients, and 50% of the sulphur. It seems probable that with this reduction in the sulphur ingredients, Illinois coals may be more largely used in the production of gas, the proportion of sulphur after the washing process being lower than in the Pennsylvania coals now generally used.

Dr. Burrill, of the University, has sent to Dr. Reynolds, Health Commissioner of Chicago, a report of bacteriological investigations upon the waters of the Illinois and Michigan canal and of the Illinois and Mississippi rivers, altogether extending from Chicago to St. Louis. The report covers the months of June, July, August, September, October and November, and gives the monthy average number of bacteria found in a cubic centimeter of water taken from each of thirty-eight stations. The laboratory work was done by Mr. James A. Dewey. The figures as tabulated show that the whole stream has been during the time mentioned greatly polluted, but they also show that the water becomes rapidly purified as it flows along from the source of contamination. At Ottawa and LaSalle the number of bacteria has decreased from several million to a few thousand in a centimeter of water. Above Peoria the stream is nearly free from these organisms. Below this city the numbers rise again so as practically to equal those in the canal at Bridgeport. Farther down the water again becomes gradually less infected, so that at the mouth of the Illinois there are less bacteria than occur in the waters of the Mississippi river.

Johns Hopkins University.—The chemical laboratory was recently destroyed by fire, involving the loss of the various chemicals, some expensive analytical machines and a number of rare books on chemistry. The damage to the building from the fire is about $8,000, fully covered by $50,000 insurance; the other damage, to machines apparatus and materials, as well as to the chemical library, which contains many rare annals of early French and German chemistry, cannot be fairly estimated. The trustees have decided to restore the wrecked building at once, and in the mean time working quarters have been assigned the chemical men in the various other laboratories.

Cornell University.—The growth of various departments of the College of Mechanical Engineering, and in particular of the great quantity of illustrative material given the new graduate school of railway mechanical engineering by the railroad companies and manufacturers of rolling stock, has compelled the erection of a separate building for housing this illustrative equipment. The new museum is merely a wooden shed, one story in height, 40 x 100 feet, but as much of the material to be put in it is heavy, it has been very substantially built. It is located between the new Sibley building and the testing laboratory.

It is understood that at the winter meeting of the Board of Trustees a proposition will be laid before the Board for the erection of a wood alcohol plant on the Cornell forest tract in the Adirondacks, for which a proposition has been submitted by a New York capitalist.

McGill University.—The following papers have recently been read before the Applied Science Society: "The Dominion Coal Mines," by S. F. Kirkpatrick; "The Canadian Canals," by G. R. McLeod; "The Efficiency of Mechanical Ventilation," by B. B. Snow, of Boston, Mass.; "Electric Power," by R. O. Mersham, New York city.

University of Texas.—The testing laboratory has just been removed to new quarters, and now contains an Olsen 100,000 lbs. testing machine, which is run by an Otto gas engine, Riehle and Olsen cement testing machines, and an automatic Fairbanks machine, just added. In addition to these there is a Riehle testing machine of 10,000 lbs. capacity. A hydraulic laboratory has been fitted up with motors, meters, weirs, pressure gages, tanks, scales, etc., and acoustic and Price current meters have been added for field work.

The senior class has the following subjects under investigation for theses: "The Strength and Composition of Texas Bricks," "The Extent and Methods of Rice Irrigation in Texas," "The Flow Curve (or Formula) for Rounded Crests, Like the Austin Dam, Based on Actual Observed Velocities with a Current Meter," "The Cost and Methods of Improvement of the Grounds of the Texas Capitol."

REPORT OF THE BOARD OF DIRECTION OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS FOR 1899.

The Report of the Board of Direction of the American Society of Civil Engineers for the calendar year 1899, which was presented at the opening session of the annual meeting of the society held in New York this week, shows a substantial growth in the society's membership, and a very satisfactory condition in its financial affairs. The report in abstract was as follows:

The net increase in membership during the year was 103. The total number of applications received during the year was 259, and action by the Board has been taken as follows:

Passed to ballot as Members	
Passed to ballot as Associate Members	102
Elected Associates	8
Elected Juniors	47
Elected Fellow	1
Total	245
Applications now awaiting action	21

The losses by death during the year number 24. They included three Honorary Members: Julius Walker Adams, George Sears Greene, Horatio Gouverneur Wright; seventeen Members; two Associate Members; one Associate, and one Fellow.

Library.

The following sum of $73.35 has been expended during the year on the Library. The additions to the Library from all sources during the year comprised 976 volumes, charts, etc. The total attendance registered in the Reading Room during the year was 1,761. In its last report the Board referred to the work of re-classifying and indexing the Library as being well under way. It now has the pleasure to report that this work is almost finished. The Library has been divided into general classes, each of which is subdivided as necessity, in each case, seemed to require, the governing idea being to so arrange the books, and so to group the cards, as to enable one unaccustomed to the technicalities of library work to investigate a general subject or pursue a specific inquiry with the least possible loss of time, and by a personal use of the index.

The General Classes are as follows, the number of titles indexed under each being indicated by figures. The work has not been finished in classes marked with an asterisk.

Railroads	3,042	Mining	148
Railroads, Street	220	Roads and Pavements	76
Water-ways	2,425	*Municipal	—
Water Supply	2,194	Landscape Architecture	40
Sanitation	754	Geography	141
Bridges	571	*Engineering Hand Books	—
Mechanical	244	*Society Publications	3
Electric	207	*Periodicals	—
Gas	27	Dictionaries and Encyclopedias	40
Architecture and Building	304	*General Science	573
Marine	251		
Military	221		
*Miscellaneous	142		

The total number of titles classified to date is 11,623, representing 18,055 volumes, pamphlets, maps, photographs and specifications, which have been accessioned, catalogued, labeled and arranged on the shelves. The estimated number of titles awaiting classification is 1,500. The plan of indexing provides also for cross-references between classes, for separate "Author" catalogue, and for a "Subject" catalogue. Under the latter are brought together for ready reference analytical details, the discovery of which would otherwise require much search in the books themselves. The total number of cards written to date is 42,057.

The Board has already had under consideration the advisability of publishing, as soon as the index is complete, a catalogue of the library for distribution to the membership, and it is believed that the financial status of the Society will warrant this being done.

Publications.—At its March meeting, the Board decided to publish in "Proceedings," as well as in "Transactions," all discussion on papers presented, the objects being to secure cross-discussion and to bring the current topics promptly before all members. In the March Number of "Proceedings" there was begun, in an experimental way, a "Monthly List of Recent Engineering Articles of Interest," which has been continued in each subsequent issue. This list has grown rapidly. The total number of titles of articles classified and printed in eight Numbers of "Proceedings" has been 2,229. The net cost of publications has been $9,800.

Meetings.—There have been 32 meetings held during the year. At these meetings 18 formal papers were presented, 5 illustrated lectures were given, and 13 topics were informally discussed. The attendance at the 46th Annual Meeting was 316 members and many guests, and at the 31st Annual Convention, held at Cape May, N. J., the total attendance was 635, the largest meeting in the history of the Society.

Medals and Prizes.—The Normal Medal, for the year ending with the month of July, 1898, was awarded to B. F. Thomas, M. Am. Soc. C. E., for his paper on "Movable Dams." The Thomas Fitch Rowland Prize, for the year ending with the month of July, 1898, was awarded to Henry Goldmark, M. Am. Soc. C. E., for his paper, entitled "The Power Plant, Pipe Line and Dam of the Pioneer Electric Power Company at Ogden, Utah." No award of the Collingwood Prize for Juniors was made.

Finances.—From the balance on hand the Board has decided to make a payment of $10,000 on the debt incurred for the New House of the Society, thus reducing that debt to $75,000. The Board considers it desirable to pay off this debt as rapidly as possible without in any way restricting expenditures necessary to maintain and promote the usefulness of the Society, and to that end has adopted a resolution recommending that in future an annual payment be made upon the debt, the amount of which payment, in any one year, shall be not less than the sum received for entrance fees in that year. If this recommendation is followed, it will practically result in setting apart the entrance fees of new members as a fund to be applied to the extinguishment of this debt, leaving the income from annual dues to be applied to the payment of current expenses and to enlarging the work of the Society in such ways as experience may develop.

Judging from results during recent years, the amount received from entrance fees is not likely to fall below $3,500, and will probably average at least $3,750 per year. Assuming that the debt may be reduced by the payment of the last-named sum annually, the whole principal of the debt will be extinguished in twenty years.

Report of the Treasurer.

Balance on hand Dec. 31, 1898			$7,699.91
Receipts from current sources, Jan. 1 to Dec. 31, 1899			47,215.22
Received from subscriptions to New Society House			225.00
Received from sale of Historical Sketch			80.00
Payment on audited vouchers for current business, Jan. 1 to Dec. 31, 1899		$41,491.77	
Balance on hand Dec. 31, 1899:			
In Union Trust Co	$5,252.63		
In Garfield Nat'l Bank	7,490.73		
In hands of Treasurer	985.00	13,728.36	
		$55,220.13	$55,220.13

THE INTERSTATE COMMERCE COMMISSION'S ANNUAL REPORT.

The 13th annual report of the Interstate Commerce Commission, an advance abstract of which has been furnished to us, sets emphatically forth the fact that National railway regulation is at present non-existent. In the words of the Commission: "Any railway company can charge for its service whatever it pleases and as much as it pleases, without any real power in this Commission or any other tribunal or court to limit the amount of such charge."

The Commission points out that failure to amend the Interstate Commerce law, so that the national supervision of railway rates may be real and not a farce, may perhaps result in "an irresistible demand for the most radical and drastic legislation." Concerning the much-talked-of combinations and consolidations now pending, it says:

It is a matter of common knowledge that vast schemes of railway control are now in process of consummation, and that the competition of rival lines is to be restrained by these combinations. While this movement has not yet found full expression in the actual consolidation of railroad corporations, enough has transpired to disclose a unification of financial interests which will dominate the management and harmonize the operations of lines heretofore independent and competitive. This is to-day the most noticeable and important feature of the railway situation. If the plans already foreshadowed are brought to effective results, and others of similar scope are carried to execution, there will be a vast centralization of railroad properties, with all the power involved in such far-reaching combinations, yet uncontrolled by any public authority which can be efficiently exerted. The restraints of competition upon excessive and unjust rates will in this way be avoided, and whatever evils may result will be remediless under existing laws.

The Commission notes the recent general advance in freight rates through changes in the classification, and points out that whether these changes are justifiable or not, the law as at present interpreted gives the shippers no means of protecting themselves.

As the Commission had such limited legal powers, it resolved to try the effect of moral suasion to induce responsible railway officers to forego the practice of giving secret rebates from their published tariffs. The result was the famous series of conferences with railway presidents which took place early last year. The results of these conferences was eminently satisfactory; but part of this is believed to be due to the great volume of business which has made the roads too busy to spend their time stealing business from each other.

Under the head of "Safety Appliances," attention is called to the fact that automatic couplers with their uncoupling attachments inoperative do not comply with the law, and railway officers are warned to look after the maintenance of this portion of their equipment.

The causes of the large number of deaths and injuries occurring to employees while engaged in railway operation are believed to be: (1) The increased percentage of inexperienced men employed since the decrease which resulted from the panic of 1893. (2) The greater number of tons carried per man employed, owing to the use of cars having greater weight and greater weight-carrying capacity. (3) The use of old and inferior cars, owing to the unusually great demands for transportation facilities on all roads and in all sections of the country. (4) The transition from the link-and-pin to the vertical-plane type of coupler.

LOCATING THE CENTER OF GRAVITY OF A LOCOMOTIVE.

An enormous freight locomotive of the consolidation type has recently been delivered to the Illinois Central R. R. by the Rogers Locomotive Works, and some particulars of this engine we shall give in a later issue. In the present article we describe the method adopted by the builders for locating the center of gravity of the engine, the result of which was to place this point lower than had been expected. The engine weighs 218,000 lbs., and has a total wheel-base of 24 ft. 5 ins.; the center line of the 80-in. boiler is 9 ft. 2 ins. above the rails, while the height to the top of the smokestack and dome is 15 ft.

As described to us by the builders, the test to determine the center of gravity of the engine was made by suspending it on the upper surface of two 3-in. steel pins or journals for pivots; the one at the front being located 6 ins. in front of the cylinder saddle and the other 6 ins. back of the back end of the boiler, both being the same distance above the rails and on the vertical center line of the engine. The engine when suspended was complete with all its parts in place, and the boiler was filled with cold water to the second gage; the driving and truck wheels all cleared the rails about 2 ins. The engine was as nearly as practicable in the same condition and of the same weight as it would be in working order. The 3-in. steel suspension pins were supported at both ends, and the bearing surface resting on them was horizontal so as to reduce the friction at the bearing point to a minimum. On trial, the bearing points as first located proved to be considerably too high. They were lowered and tested again several times until the engine balanced on the pivots. Screws were used at the ends of the bumper for testing and to keep the "roll" to either side within limits when the pivots had been lowered to the point of center of gravity. At that point a lift of about 300 lbs. under the end of the bumper was sufficient to cause the engine to turn in the opposite direction to the extent that the bumper at that end was about 8 ins. higher than the one at the opposite end. On removing the lifting force, the engine would not, of itself, return more than half way back to the vertical position, but required a lift of about 100 lbs. at the low side to bring it vertical (about enough to overcome the pivot friction), but when vertical and free it would remain so. It required about 100 lbs., however, to start it to turn in either direction.

The tests showed that the point of suspension was probably as near the actual center of gravity of the engine as it was practicable to locate it. After the adjustments were all made and the center of gravity determined, measurements showed the bearing point on top of the steel pin at each end of the engine on which it rested to be 4 ft. 2½ ins. above the top of the rails, when the engine had its wheels resting on the track. That point is 3¾ ins. above the top of the main frames. Assuming the bearing point of the driving wheels on the rails to be 4 ft. 8 ins. apart, then the base on which the engine runs is 1.10 times as wide as the distance its center of gravity point is in height above them. The builders state that if the height of the center of gravity of a locomotive like this is 10% less than the width of base on which it is carried, it is probable that the center of gravity could still be placed slightly higher without any detrimental results as regards the movement of the locomotive along the track.

A LIFE-SAVING COLLAR has been invented by Hubert de Wilde, of Ghent, Belgium. It is a cork-collar, 16½ ins. outside diameter, and 6 ins. inside, made of two half-collars hinged together and backed by a strong spring tending to keep it closed. The apparatus weighs about 5½ lbs. and it displaces about 12 quarts of water, or represents a buoyancy of about 20 lbs. Tests made with it show that the collar is better than the life buoy or cork jacket; it is not liable to capsize; the body is submerged and less liable to chilling; the arms are free and it is simple and instantaneous in adjustment.

A "CALLING-ON" SIGNAL for special cases was referred to at a recent meeting of the Railway Signaling Club by Mr. W. H. Elliott, Signal Engineer of the Chicago, Milwaukee & St. Paul Ry. At a certain yard it was desirable to indicate which of four trains was to come ahead when the signal was cleared, and for this purpose a yellow lens is used. There are four lights, and the yellow one is easily distinguished from the white, but it is considered that it would hardly be distinctive enough if used alone, where a man would have to determine whether a signal showed white or yellow.

STEEL TIES ON THE MEXICAN SOUTHERN RY. have given so much satisfaction that they will be adopted for the entire line, 228 miles long, according to information furnished to the "Railway Review" by Mr. T. A. Corry, Resident Engineer. These ties have been used for eight years on 141 miles of the company's lines. The tie at present in use is of pressed steel 5 ft. and 5 ins. long, the gage of the track being 3 ft., and the weight of the rail, 50 lbs. per yard. The tie is an inverted trough with flaring sides, the section at the rail seat being 10 ins. wide across the bottom and 3 ins. deep; and at the middle 9 ins. wide across the bottom and 3⅜ ins. deep. The top table of the tie is 4 ins. wide and 7-16-in. thick and the sides are ¼-in. thick. The extreme width of the tie, at the end, is 11 ins. The top of the tie is not exactly straight, the middle portion being depressed 9-16-in. below the ends, which gives the rail an inward cant of 1 in 24. Experience with this tie has shown it to be weakest at the rail seat owing to the large amount of matter stamped out of the top table to form the lugs, and to correct this trouble a new tie has been designed. This tie is 6 ft. long and 5 ins. deep at both the ends and middle. The width of the tie at the ends will be 13 ins. and the width across the bottom at the middle 8½ ins., and the width of the top table 4½ ins. The rail fastening will consist of a U-bolt, passed up through the tie from underneath, and clips. According to the practice on this road steel ties are not used on bridges, in switch leads or in and around shops or roundhouses. Around shops and roundhouses it is found that metal ties corrode very rapidly. Before laying the ties it is the practice to coat them heavily with tar, to prevent oxidation.

THE TRANS-SIBERIAN RAILWAY is in bad shape, according to accounts sent by U. S. Commercial Agent Greener, at Vladivostock. Mr. Greener quotes from a newspaper of that port, and says that the rails are too light for the traffic; the secondary bridges are made of wood; the roadbed is poorly constructed, and fast traveling is impossible unless the whole line is reconstructed. At present 20 miles per hour is the maximum speed permissible, and only one passenger and two freight trains per day are run. The heavy compound engines being tried tear up the track, and accidents have already occurred. It is said that it takes two weeks' steady traveling to go from Berlin to Vladivostock.

THE KARS-ERZEROUM RAILWAY represents a concession Russia is asking from the Sultan of Turkey, as an offset to the German concession recently granted by Turkey for a railway from Konieh, in Anatalia, to Bassorah, at the mouth of the Euphrates. Russia controls Kars, and the 150 miles of railway wanted would open up a commercial route of considerable importance now served by canals and pack animals, from Tabriz. What the Sultan will object to is that this step is the assertion of a Russian claim to that part of Asia Minor as a sphere of influence. It is also the undoubted purpose of Russia to push her railways towards Persia; and, by an understanding with Germany, to extend the Erzeroum Railway to Angora, or some point connecting with the German system. The ultimate result would be all-rail communication between Constantinople and Teheran, and later with Afghanistan and India.

THE FRENCH RAILWAYS, recommended for purcha[se] by the state by the Budget Committee, include the Ea[st]ern, Western, Orleans and Southern systems. The co[n]cessions for these roads do not expire until 1950, but t[he] state has the right to buy them at any time under cert[ain] conditions. No immediate outlay of capital would be [re]quired, as two of the systems are indebted to the sta[te] and by taking over the four the state would realize [an] immediate profit of 37,500,000 francs. If the state wa[it]s until 1950, it would have paid them in annuities 31[2],500,000 francs. The committee also maintains that und[er] state control the profits would be larger.

THE BRAZILIAN RAILWAY, Sao Paulo & Rio Grand[e], connecting Rio de Janeiro with Rio Grande do Sol, [is] now open for 136.4 miles. This road starts at Itavar[e] on the frontiers of Parana and Sao Paulo, connecti[ng] them with the Sorocaba Railway, and will end on th[e] Uruguay River at a junction with the Southwest Br[a]zilian Railway. The completed length is 558 miles.

DEPRESSIONS IN THE ANDEAN MOUNTAIN CREST are noted as follows by Prof. Bailey, of the Harvard observatory at Arequipa, Peru: The known passes between Panama and the Straits of Magellan number 12[?], with elevations ranging from 2,756 to 16,047 ft. above sea-level. There is no pass north of Santiago, Chili, lower than 11,000 ft.; and in Bolivia the lowest is that of Huesos, 13,573 ft. above the sea. The crossing on the Santiago and Buenos Ayres transcontinental railway is under the Ushallata Pass, 12,700 ft. high, it was first proposed to drive an 11-mile tunnel under this pass, but the scheme has been abandoned, owing to the finding of lower and better passes south of Santiago. One at Antuco, 200 miles south, is only 6,890 ft. high, and a company has already been formed to build a railway across it, and with it a system of railways connecting Chili with the Argentine Republic.

NEW YORK STATE CANAL WORK is reported upon by State Superintendent of Public Works John N. Partridge. He says that under the $9,000,000 appropriation for canal improvement there are forty unfinished contracts, calling for an estimated amount of $4,000,000 to complete. The canal board terminated twenty-eight contracts and found that the amounts properly due aggregated $357,215. There are also other outstanding contracts, which do not come under the provisions of the act, and for which $1,600,000 is needed to complete. Mr. Partridge says that it is for the benefit of the State and the contractors either to terminate these contracts, or to appropriate a sum sufficient for their completion. Unless some action is taken towards enlarging and improving the canal, Mr. Partridge asks that the usual maintenance appropriation of $350,000 be raised to $700,000 to strengthen properly banks, bridges, walls, etc.

THE PROPOSED CAPE COD CANAL was lately described before the Harbor and Land Commissioners, by Col. Reeves, the engineer of the company. Plans and a relief map were produced showing the location of the canal. The canal would be without locks; and, as the maximum tide in Barnstable Bay is 6 ft. above that in Buzzards Bay, the maximum velocity of current through the canal would be 4 miles per hour or possibly 5 miles in storms. The entrance width at the Barnstable end was fixed at 1,000 ft.; though objection was made to this by the Bourne selectmen, who wanted this width made 600 ft. to avoid cutting away property belonging to ex-President Cleveland, at Gray Gables, and also to preserve certain valuable oyster beds. The hearing has been adjourned to Jan. 18, pending an adjustment with railway interests.

THE U. S. CRUISER "ALBANY," built by the Armstrongs in England and bought during the late war, has made on her official speed-trial 19.6 knots under natural draft, and 20.5 under forced draft, with a maximum of 20.87 knots. The "Albany" has a displacement of 3,600 tons, and her engine power is 7,500 I. HP. She is 330 ft. long; 43 ft. 9 ins. beam; 16 ft. 10 ins. draft; coal capacity 850 tons, giving her a steaming radius of 8,000 knots.

THE HAMBURG-AMERICAN STEAMER "Deutschland" was launched at Stettin on Jan. 10. She is a twin screw steamer of 16,000 tons, with 35,000-HP. engines, and her speed is guaranteed at 23 knots. Her length is 686½ ft.; beam, 67½ ft.; depth, 44 ft. She ranks next to the "Oceanic" in size.

THE NEW NAVY PERSONNEL BILL, as interpreted in some of its clauses by the Bureau of Navigation, is causing much discontent among the officers of the old Engineer Corps of the navy. The avowed intent of the bill was to provide all-around officers, instead of specialists, with interchangeability of watch duty on deck and in the engine-room. General Order No. 524, however, declares that hereafter watch duty in the engine-rooms is to be performed by machinists, not by commissioned officers. The objection is made that this is the Spanish method, found so disastrous in the late war, and is not in accordance with the purpose of the personnel bill. Secretary Long, in a letter to the House Naval Committee, only partly meets the question by declaring that the policy of the Department is to give former engineer officers the opportunity to prepare for examinations in line duties, and also to assign at least one line officer on each ship to duty in the engineering department, so that he may gain that experience. The contention is made that this policy would eventually result in all officers being competent line officers, while but few would be experienced engineers, and the main dependence would be on the mechanics, a policy that is likely to prove disastrous in war under modern conditions.

THE BRITISH SHIPPING OUTPUT in 1899 was 1,713,000 tons, as compared with 1,661,000 tons in 1898, and the largest on record to that time. The total of ships built in the United States for the same period aggregated 267,642 tons, including in this vessels of all classes.

THE COAL EXPORTS from the United States are growing, says the Philadelphia "Press." In 1897 it was a little over 3,000,000 tons in 10 months; in the same period in 1899 it was over 4,500,000 tons. Of this total about 3,500,000 tons went to Canada, and about 500,000 tons to Mexico; but 300,000 tons went to Cuba, nearly 20,000 tons to Porto Rico, and 181,000 tons to the rest of the West Indies. A Philadelphia steamer has been chartered to carry 3,500 tons to Lisbon—the first shipment to Portugal; an Italian steamer is taking 5,000 tons to Genoa, and 50,000 tons have been bought for Italian railways. The United States, for the first time, last year produced more coal than Great Britain.

THE COAL AND IRON DEPOSITS OF CHINA have been examined and reported upon by Mr. J. G. Glass, M. Inst. C. E., for the Pekin Syndicate, Limited, of London. He says that the anthracite coal fields of Eastern Shansi are estimated to cover 13,500 square miles; and the bituminous fields of Western Shansi cover 20,000 square miles. Iron ore was associated with this coal in unknown but "practically unlimited quantities," and at one of the foundries visited in Shansi the price of this ore was 1s. 7d. per ton. The coal is reported as resembling in composition Welsh coal of the highest calorific value; the iron ore is "equal to good Spanish ore." At shallow coal mines the Chinese cost of working and bringing to the surface is less than 6d., or 12 cts. per ton; and at two collieries with shafts 220 and 330 ft. deep, the cost at the pit mouth was 1s. 6d. and 2s. 4d. per ton respectively. The cost of carriage, however, is very high owing to bad roads and this cost is prohibitive at a distance of a few miles. With tolerably good roads and a return load provided, coal is carried on pack animals, in wheelbarrows, or carts for 2½d. per ton per mile; but with bad roads, which are the rule, the cost is 5d. per ton per mile. Coal selling at the pit at 4d. per ton, costs 12s. at a distance of 30 miles, and 21s. at 60 miles. With a railway built, Mr. Glass says he could deliver the coal to Tientsin under 9s. per ton; to Nanking for about 10s. At the present time coal mined near Tientsin which amounted to about 1,000,000 tons in 1897, averages in price 15s. 9d. per ton. The best Welsh and Australian coal now commands the following prices: At Shanghai, best Welsh, 39 to 40s. per ton; Australian, 39s. At North Honan, 40 miles from Wei Hui, lump coal is worth 13s. 6d. at the mines, and 36s. at Wei Hui. At Po-tou, 486 miles from Wei Hui, anthracite coal from the Chingwa (Sin-Wu) mines is sold at 101s. per ton; improved transport would reduce this price to one-fifth of this sum. Mr. Glass believes that the manufacture of iron has flourished in Shansi for more than 1,000 years; it is excellent ore for smelting purposes, but too high in phosphorus for the manufacture of steel by the ordinary Bessemer process; but the basic Siemens process would apply. The cost of producing pig-iron, by modern processes, at Tai Yang, Shansi, is figured at 12s. 1½d. per ton. To connect the North Honan coal fields with Tientsin 80 miles of railway, costing with rolling stock £480,000, would be required to reach the Wei River near Taokou; to improve the Wei River and the Grand Canal, over a length of 570 miles, and to provide a steam flotilla, would cost £200,000 more, or £700,000 in all.

CANADIAN NICKEL STATISTICS.—The Toronto "Globe" says that the Ontario authorities have opened negotiations with the English government relating to the development by England of unpatented nickel lands in that Province, with a view to obtaining an unlimited supply of nickel for use in armor-making. The "Globe" says that in 1892-98, inclusive, 591,852 tons of ore were reduced to matte, in the Sudbury region, with estimated metallic contents of 29,705,000 lbs. of nickel and 34,570,500 lbs. of copper. For these seven years the total value of this matte, at the furnace, was $3,294,060 for nickel, and $1,302,805 for copper. The areas of copper-nickel lands are extensive in the Province, and large portions of these lands probably still remain as Crown land. U. S. Commercial Agent Sholts, of Sault Ste. Marie, says, however, that one effect of this movement by the Provincial government will probably be to stop prospecting for new mines, prevent the working of mines applied for but not patented, and seriously to interfere with the early development of mineral deposits in the territory in question.

THE HARGREAVES-BIRD ELECTROLYTIC PROCESS of manufacturing chemicals is being tested at Farnworth, near Liverpool, says U. S. Consul James Boyle. It is claimed that the process is more economical and simple that the Kastner-Keller process, as the latter requires mercury. The process referred to separates chlorine and sodium by the direct decomposition of salt by electrolysis without introducing other ingredients. The salt brine, as pumped from its native bed to the works, is delivered into a cell, or narrow tank, with porous walls; on passing an electric current through this brine a solution of soda flows slowly down from the outside of the wet walls, yielding at once soda crystals. The chlorine, in like automatic manner, passes away for the production of bleaching powder, chlorate of potash, or other chlorine compounds. In the cell a peculiar diaphragm is used, made of a sheet of asbestos composition; non-porous in the ordinary sense, but when forming the walls of the cell, this diaphragm allows molecules of sodium hydroxide to pass, but very little sodium chloride.

THE PRESIDENTS OF FOUR AMERICAN ENGINEERING SOCIETIES.

(With inset sheet of portraits.)

In accordance with our annual custom, we present on our inset sheet this week portraits of the Presidents of four American engineering societies, including in this list the newly elected Presidents of the American Societies of Civil and Mechanical Engineers, and the President of the American Institute of Mining Engineers elected at the annual meeting last February. The fourth place on our inset sheet is usually given to the President of the American Institute of Electrical Engineers. As Dr. A. E. Kennelly, whose portrait and biography we gave a year ago, was re-elected at the last annual meeting of this society, we give this place to the American Society of Municipal Improvements, which is entitled to high rank for the work it is doing in the important field of municipal engineering. The fourth portrait on the sheet, therefore, is that of Mr. A. D. Thompson, of Peoria, Ill., who was elected President of this Society at the annual meeting last summer.

Brief biographical notices of each of the gentlemen whose portraits are given on our inset sheet are given below, prepared with special reference to their professional records.

Mr. John Findley Wallace, the new President of the American Society of Civil Engineers, was born at Fall River, Mass., Sept. 10, 1852. In 1854 his parents moved to Boston, Mass., and in 1856 to Monmouth, Ill., his father, Rev. David A. Wallace, D. D., LL. D., having been selected as President of Monmouth College, which institution he founded, organized and conducted for 23 years. Mr. Wallace resided at Monmouth until 1869, and was educated at Monmouth College. In November, 1869, he entered the service of the Carthage & Quincy R. R. as rodman. In January, 1870, he left that road and entered the service of the Quincy, Alton & St. Louis R. R. as instrumentman. In March, 1870, he was employed on the Rockford, Rock Island & St. Louis R. R. as draftsman, and in May of the same year returned to the service of the Carthage & Quincy R. R. In September, 1870, he again left the railway, and re-entered college. On Aug. 5, 1871, he received an appointment as rodman on the United States Engineer Corps at Rock Island, Ill., and in November of the same year he was promoted to the position of Civil Engineer's Assistant on the staff of Col. M. Macomb. Until September, 1876, he was employed under Col. Macomb, being engaged on surveys and construction work in the improvement of the Rock Island rapids, hydrographic surveys for the guard lock of the U. S. ship canal at Keokuk, Ia., and various surveys connected with river improvements; receiving several promotions during that period. On Sept. 1, 1876, he left the service of the United States Government and was engaged in private surveying and engineering practice until April, 1879, when he was appointed Chief Engineer of the Burlington, Monmouth & Missouri River R. R. The following year this road was merged into the Peoria & Farmington R. R., and Mr. Wallace had charge of the location, construction and operation of that road as Chief Engineer and General Superintendent between Peoria and Keithsburg, Ill., until 1883, when it was merged into the Central Iowa R. R. From this time until 1887 he was engaged as engineer of Construction and Master of Transportation on the Central Iowa R. R., having all transportation matters in his charge between Oskaloosa, Ia., and Peoria, Ill., and was also Engineer in charge of construction work. Among other important works, he designed and constructed yards at Keithsburg and West Keithsburg, as well as inclines, cradles and transfer facilities for the handling of railway traffic over the Mississippi River at that point. In the winter of 1884 he also constructed a winter bridge across the river, and made surveys and located the Iowa Central R. R. permanent bridge at the same locality. Afterwards he had charge of the construction of the approaches to this bridge and the construction of a bridge over the Black Hawk channel.

In February, 1887, he was appointed Resident Bridge Engineer of the Atchison, Topeka & Santa Fe R. R., reporting to Mr. O. Chanute, M. Am. Soc. C. E., Consulting Engineer, and had charge of the construction of that company's bridge over the Missouri River at Sibley, Mo. This was a modern steel structure 92 ft. above the water and three-quarters of a mile in length. In connection with his work as Resident Engineer of the Sibley bridge, he also had charge of river rectification works, extending for seven miles up the Missouri River from the bride site, the object of these works being to maintain a permanent channel at the bridge location. He also had charge of the design of the piers of the bridge over the Mississippi River at Fort Madison, Ia., and later had charge of certain works connected with the protection of this bridge. In April, 1889, he resigned his position with the A., T. & S. F. R. R. and associated himself with Mr. E. L. Corthell, M. Am. Soc. C. E., Consulting Engineer, at Chicago, Ill. While engaged with Mr. Corthell, among other important works, he had charge of the construction of the joint Atchison, Topeka & Santa Fe Ry. and Illinois Central R. R. terminal in the city of Chicago, for the main line of the A., T. & S. F. Ry. and the Sioux City line of the Illinois Central R. R.

On Jan. 1, 1891, he was appointed Engineer of Construction of the Illinois Central R. R., and on March 1, 1892, he became Chief Engineer of the same road. During his term as Chief Engineer he designed and superintended the construction of extensive improvements over the entire Illinois Central system, including the elevation of tracks in Chicago, new terminal station and tracks, World's Fair transportation scheme, terminal facilities at New Orleans and other cities, and many other large and important pieces of work. At the same time he had general charge of the maintenance of the physical condition of the Illinois Central R. R. lines and property. On July 1, 1897, he resigned his position with the Illinois Central R. R. and became Vice-President and General Manager of the Mathieson Alkali Works, of Providence, R. I. (having works at Saltville, Va., and Niagara Falls, N. Y.). On Jan. 1, 1898, he returned to the service of the Illinois Central R. R. as Assistant Second Vice-President, which position he now holds. In his present position, among other general duties, and besides assisting the Second Vice-President in the general management of the property, he has special charge of the physical condition and general improvements on the Illinois Central R. R. system, the Chief Engineer and Consulting Engineer reporting to him. Mr. Wallace is also frequently engaged in a consulting and advisory capacity upon work outside that of the Illinois Central R. R.

Mr. Wallace is a member of the Institution of Civil Engineers of Great Britain. He was elected a member of the American Society of Civil Engineers in 1886, and was Vice-President for two years. He is also a member of the Western Society of Engineers, and was President of that society in 1896. He was one of the charter members and organizers of the American Railway Engineering & Maintenance of Way Association, and is now President of that organization. He is also a member of the Union League, Kenwood and Technical clubs of Chicago, and of the Engineers' Club of New York. He is the author of several valuable papers presented to the American Society of Civil Engineers. Among these may be noted more especially a paper on "The Sibley Bridge," written jointly with Mr. O. Chanute and Mr. W. H. Breithaupt, which was awarded the Rowland prize in 1890 (Transactions, Am. Soc. C. E., September, 1889). He also presented a paper describing in detail "The Lake Front Improvements of the Illinois Central R. R. at Chicago" (Transactions, Am. Soc. C. E., December, 1897).

He was married on Sept. 11, 1871, to Miss Sarah E. Ulmer, of Monmouth, Ill., and has two children. His son, Harold U. Wallace, was born November, 1872, and was married to Miss Lura Wyckoff, of Keithsburg, Ill., in September, 1894; he was educated as a civil engineer, and is now roadmaster of the Illinois Central R. R. at Louisville, Ky. He has also a daughter, Birdena Frances Wallace, who was married to Thornton M. Orr, of Pittsburg, Pa., Sept. 22, 1897.

Mr. Charles Hill Morgan, elected President of the American Society of Mechanical Engineers, at the annual meeting in December, was born in 1831, of New England parentage. His father being a mechanic of limited means, Charles was obliged to work in a factory at the age of twelve, his early education being such as was afforded by the Massachuetts district school of sixty years ago, and the Lancaster Academy.

When fifteen he entered the machine shop of his uncle, J. B. Parker, of Clinton, Mass., as an apprentice. At seventeen he determined to learn mechanical drawing, and through his efforts a class for the study of this subject was formed and was taught by the late John C. Hoadley, who was then Civil Engineer of the Clinton Mills. Those few lessons in drawing, taken at night, after twelve hours of work in the shop, were a most important factor in determining Mr. Morgan's mechanical career, and perhaps of several others in that class.

In 1852, when only twenty-one years of age, Mr. Morgan was put in charge of the Clinton Mills dye-house. He devoted himself to the study of chemistry with great zeal, and filled his new position with entire success, gaining valuable experience in the management of subordinates.

For a time Mr. Morgan was draftsman for the Lawrence Machine Co. Later, from 1855 to 1860, he was mechanical draftsman for the distinguished inventor and manufacturer, Erastus B. Bigelow. In association with him and Charles H. Waters, the agent of the Clinton Wire-Cloth Mills, Mr. Morgan gained at this time an invaluable experience, and may be said to have been trained in a hive of invention.

About this time Mr. Morgan introduced a system of designing and constructing cam curves for looms. This system proved of great value, and was later the subject of a valuable paper read before the Worcester Polytechnic Institute, and subsequently published by Mr. Morgan in pamphlet form.

In 1860 Mr. Morgan joined his brother, Francis Henry Morgan, in Philadelphia, and was for two years engaged in the manufacture of paper bags.

In 1864 Hon. Ichabod Washburn was in need of a superintendent for his works for the manufacture of wire, at Worcester, Mass. His friends at Clinton, engaged in the manufacture of machinery and wire-cloth, warmly recommended Mr. Morgan. Mr. Washburn accordingly engaged Mr. Morgan as superintendent of manufacturing for the firm of Washburn & Moen. Four years later, when a joint stock company was organized and incorporated under the name of Washburn & Moen Manufacturing Co., Mr. Morgan was made General Superintendent. He made seven different trips to Europe for the purpose of visiting the mills of England, Belgium, Germany, France and Sweden. From these visits, from publications devoted to wire manufacturing, and from patents issued both in Europe and America, he kept himself informed of all changes made or improvements adopted. The fruit of this devotion was seen in the increased excellence, variety and amount of the company's manufactures. He was for eleven years one of the directors of the company.

An advance step in the wire business with which Mr. Morgan has been prominently identified was the development of the continuous rod rolling-mill, designed and originally constructed in Manchester, England, by Mr. George Bedson. This continuous rolling constituted a great advance on the ordinary rolling previously practiced. After starting the Bedson mill in Worcester, in 1869, it became evident that its production was limited by the imperfections of the ordinary hand reel. Mr. Morgan's first important improvement was a power reel; his second was the practical development of a continuous train of rolls, having horizontal rolls only. (The first rod rolling-mill had, alternately, horizontal and vertical axes.)

Experience has shown that this mill, consisting of series of horizontal rolls with intermediate twist guides between the rolls, giving the metal one-quarter of a turn in its passage from one pair of rolls to the next, was far superior to a mill with alternate horizontal and vertical rolls.

Nine years after the construction of the Bedson mill, another mill, from new designs furnished by Mr. Morgan, was built on the Belgian and Continuous plans. This mill, the result of Mr. Morgan's studies, was known as the Combination Mill.

The third improvement was the invention, by Mr. Morgan, of automatic reels, both of the pouring and laying types, such as are now in common use in every rod mill in the country. These reels were completed and a successful test made March 10, 1886.

Since severing his connection with the Washburn & Moen Manufacturing Co. in 1887, Mr. Morgan has devoted his attention to the Morgan Spring Co., manufacturers of wire and springs, founded in 1881, and the Morgan Construction Co., of Worcester, Mass., manufacturers of rolling-mill and wire drawing machinery.

The work of Mr. Morgan and his associates, in the last-named company, has been most successful, and their designs and machinery are being widely adopted by an appreciative class of manufacturers. The continuous rolling of such material as billets, merchant bar, rods and hoops, together with the disposition of the product after it has been rolled, has been given special attention and a large number of important installations made. The continuous method of heating billets, while not strictly new in itself, has been carefully developed and introduced, culminating with the continuous gravity discharge furnace invented by Mr. Morgan.

Mr. Morgan has never entered political life, but is active in religious, corporate and educational lines. He has always been interested in educational matters, and he has been most closely identified with the growth and success of the Worcester Polytechnic Institute, having been a member of its Board of Trustees since the institution was founded, nearly 34 years ago.

Mr. Morgan became a member of the American Society of Mechanical Engineers in 1881, the year following the society's establishment, and he served as a Manager of the Society from 1884 to 1887. He is also a member of the British Iron & Steel Institute and of the American Institute of Mining Engineers.

Mr. James Douglas, who was elected President of the American Institute of Mining Engineers in February last, was born in Quebec, Canada, in 1837, and was educated in Edinburgh, and at Queen's University, Kingston, Ont. He was professor of chemistry in Morrin College, Quebec, for several years, and his first practical experience in copper mining and metallurgy was acquired in working the Harvey Hill and other copper deposits in the county of Megantic, in the Province of Quebec.

In 1875 he came to the United States to take charge of the works of the Chemical Copper Co., at Phoenixville, Penn., and he has ever since been a prominent figure in the development of American copper mining and metallurgy. The field of his most active operations has been in Arizona, where he has been identified with some of the largest copper mines in the southern counties of the Territory, and has done some gold and copper mining in the neighborhood of Prescott. He has also been active in linking the mines over which he presides by railroad connection with the trunk lines of the Territory.

He is at the present time President of the Copper Queen Consolidated Mining Co., the Detroit Copper Mining Co., of Arizona, the United Globe Mines, the Commercial Mining Co., the Montezuma Copper Co., of Sonora, Mexico, the Arizona & South Eastern R. R. Co., and the Morenci Southern Ry. Co.

In connection with the late Dr. T. Sterry Hunt he did much original work in the hydrometallurgy of copper and the precious metals, and he has taken out patents for improved roasting and smelting furnaces, and others in connection with the electrolysis of copper.

His literary and scientific contributions have been made to the Literary & Historical Society of Quebec, "The Canadian Monthly," "The Penn Monthly," "Crook's Quarterly Journal of Science," "The Bulletin of the American Geographical Society," "Transactions of the American Philosophical Society," the "Transactions of the American Institute of Mining Engineers," and the "Journal of the Society of Arts," London. He is also the author of a book on the Canadian Question in Putnam's "Questions of the Day" Series. He has received a B. A. degree from Queen's College, Kingson, Ont., and the degree of LL. D., from McGill University, at Montreal. He is a member of a number of literary and technical societies on both sides of the Atlantic.

Mr. Almon D. Thompson, President of the American Society of Municipal Improvements, was born at Gilman, Ill., in 1868. In 1893 he graduated from the college of engineering of the University of Illinois, with the degree of B. S. Four years later the same institution conferred on him the master's degree of C. E. He has risen rapidly through various grades of engineering work, and positions of honor in engineering societies, until he is now city engineer of Peoria, Ill., and President of both the society just named and of the Illinois Society of Civil Engineers and Surveyors. From 1888 to 1890 he was engaged on drainage and railway work, and in 1892-3 he was employed in city surveying and on the Belt Line Survey in Peoria. In July, 1893, he entered the employ of the city of Peoria as a sewer inspector. He was promoted to the position of Assistant City Engineer in charge of sewers the same fall, and the following spring was placed in charge of paving work. Since 1895 he has been City Engineer of Peoria. He has been a frequent contributor to engineering periodicals, and has taken an active interest in engineering societies. He was chairman of a special committee on "Standard Specifications and Tests for Paving Brick and Sewer Pipe" of the Illinois Society of Civil Engineers and Surveyors in 1895, which is said to have been the first committee ever appointed by an engineering society to investigate these subjects. He was chairman of the Committee on Street Paving of the American Society of Municipal Improvements for 1896 and 1897.

TELESCOPIC DRAWBRIDGE OVER THE RIVER DEE AT QUEENSFERRY, ENGLAND.*

By Thomas Walter Barber, M. Inst. C. E.

The Victoria bridge, recently erected for the county council of Flintshire, replaces an old ferry across the Dee on the main high road between Liverpool and North Wales. Originally the Dee estuary at this point was about one mile in width, but a large portion has been subsequently reclaimed by the Dee Company, and the river is confined to an artificial cut about 400 ft. in width. The design adopted was suggested by the very stringent conditions laid down by the county council, who offered a premium of £100 for the best design for an opening bridge, stipulating, among other conditions, that (a) the piers should offer the least possible obstruction to the current of the river, and (b) that its cost should not exceed £13,000. These conditions practically precluded a swing bridge, and were almost impossible of fulfilment by any other of the customary types. The author, therefore, prepared a design for a telescopic or rolling girder bridge, which was accepted and in due course erected.

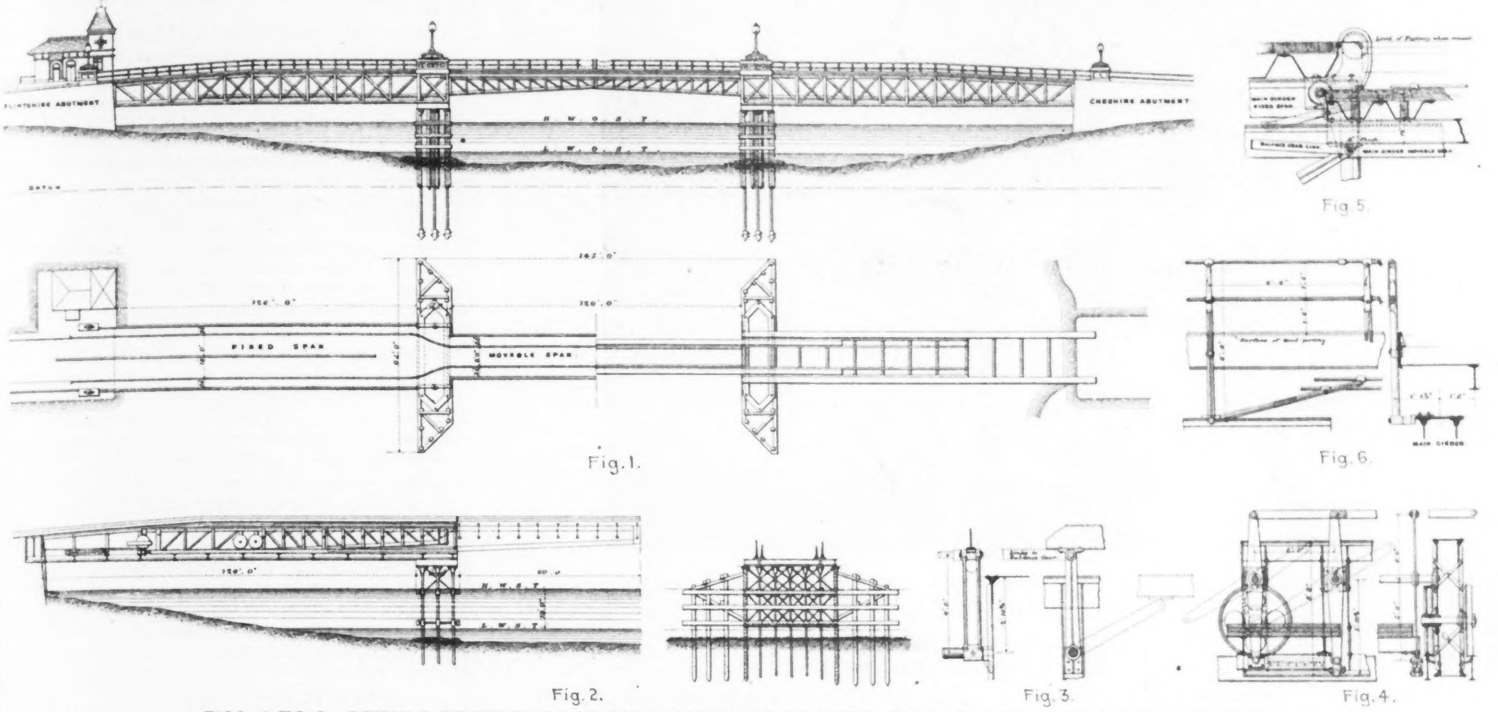
The problem of designing a simple and satisfactory opening bridge at a moderate cost has always presented considerable difficulty to engineers. Swing bridges require massive piers for the swing-span, such piers being costly, especially in a sandy foundation liable to heavy scour, which is intensified by the obstruction such piers

* Abstract of a paper read before the Institution of Civil Engineers of Great Britain.

present to the current. Bascule bridges also require substantial piers; and both types are expensive in the necessary motor machinery, pivoting centers and guiding races. Both descriptions of bridges become occasionally unworkable in high winds, and the swing-bridge usually requires large and expensive fenders to protect the span from drifting vessels while opening or standing open. The telescopic system designed by the author seems to avoid all these difficulties successfully. The piers and fenders required are the same as would be necessary with a fixed bridge under the particular circumstances. The moving there are no cross girders to carry the roadway platform. This platform rises and falls through a vertical distance of 23 ins. to allow it to pass under the fixed platform, and is also formed of trough decking similar to that of the fixed spans, but 9 ins. deep and 3-16-in. thick, covered with thick planking without concrete, the length of the troughs being 16 ft. The center span of the bridge thus provides a single roadway of 9 ft. and two footways of 3 ft. 6 ins., the fixed spans having a double roadway of 9 ft. and two footways.

The movable platform of one half-span is supported by rollers run in these guides strongly secured to each movable platform, which give it its upward and downward movement at the exact point required. The rise and fall of the movable platforms are therefore effected by means of the horizontal travel of the moving spans without any separate motive mechanism.

As the movable platforms have to pass under the fixed platforms, it is evident that the hand-railing must do likewise. This is effected, as shown in Fig. 6, by jointing it into a sort of parallel motion by its vertical standards which are pivoted at the bottom to brackets on the main



FIGS. 1 TO 6.—DETAILS OF TELESCOPIC DRAW BRIDGE OVER THE RIVER DEE, AT QUEENSFERRY, ENGLAND.
Thomas W. Barber, M. Inst. C. E., Engineer.

spans offer very little resistance to wind-pressure, and such resistance does not vary, as in the other types, during the movement, but is practically constant. The motor machinery and traveling gear are not so costly as in either of the other types, and the author is of opinion that an opening bridge on the telescopic system can be constructed at between 50% and 70% of the cost of any other type.

The Victoria bridge at Queensferry consists of three spans, as shown in Fig 1, the central one being movable and having a clear opening of 120 ft.; the two side spans are each 140 ft. and are fixed. The central span is in halves, meeting at the middle of the opening; each half, therefore, projects 60 ft. from the fixed span and constitutes a cantilever of that length. This is extended 40 ft. within the fixed span and is balanced by dead weight at its inner extremity. Thus the moving half-spans are each 100 ft. in total length, the girders being 13 ft. c. to c., and are moved in and out on 12 traveling wheels, 4 ft. 4 ins. in diameter, placed on either side of each of its two main girders, which run on four longitudinal rolled girder paths, 18 x 6 ins. The construction and working are shown in the longitudinal section of one-half of the bridge, Fig. 2. As the 60-ft. cantilever portion of one half-span is balanced by weights at the extremity of the 40-ft. inner extension, the load may be considered as resting at the junction Y of the 60-ft. cantilever with the 40-ft. carriage, and is carried at this point by eight of the twelve wheels, the other four at the balance end Z being merely guide wheels.

The weight of the movable half-span is 90 tons. The fixed spans are formed of two main girders, 20 ft. c to c. and 13 ft. deep, of the Linville type, with box flanges, vertical struts and diagonal ties. These have box end pillars built into the abutments at one end and resting on cap girders over each pier. Cross girders 18 ins. x 9 ins. connect the lower flanges of the main girders and carry the four 18-in. x 6-in. longitudinal roller paths on which the moving half-spans travel. The top flanges are substantially stiffened by the trough decking which is riveted to them. This is of the usual section and 12 ins. deep, pressed cold by hydraulic dies from ¼-in. steel plates in one length of 28 ft.; it is fixed transversely and filled with lime concrete, on which is laid asphalt and 5-in. wood brick paving. The ends of the trough are covered with a cast-iron molded facia which is surmounted by the hand-railing.

As the moving half-spans require to be braced vertically and horizontally to form stiff independent structures or carriages this is effected by framed cross bracings, but twenty-two cast-iron swinging arms or levers, which stand vertically when the bridge is closed; these arms (shown by center lines in Fig. 2, and in detail, Fig. 3) are keyed in pairs to eleven transverse steel shafts, 4½ ins. in diameter, carried in bearings fixed to the main girders; the upper ends of the arms are forked and connected by pins to bearings on the underside of two 12-in. x 5-in. longitudinal rolled girders, to which the platform troughing is riveted. As the arms swing from a vertical position when the bridge is closed through an angle of 60° when the bridge is open, the platform must be balanced with a variable counterweight. This is effected by four balancing levers of wrought iron, Fig. 4, which are also keyed on two transverse shafts at the extreme inner end of each half-span, where the weight is most effective, and

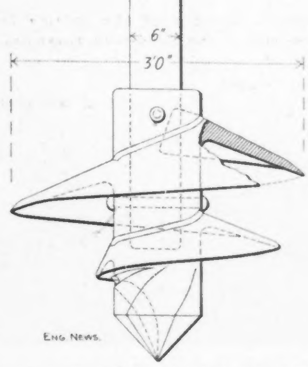


Fig. 7—Screw Piles for Foundations of Telescopic Draw Bridge Over River Dee, at Queensferry, England.

are connected at their upper ends to the 22 swinging supports, by two long horizontal connecting-rods. The balance weights are placed in a box suspended from the lower ends of the four balance levers, which swing through the same arc as the arms, supporting the platform and thus exactly balance it in all positions.

The rise and fall of the movable platforms are governed by segmental cam guides fixed in pairs at the outer ends of the fixed main girders, shown in Fig. 5. Cast-iron girders, and at the top to the horizontal bars of the hand-railing, and intermediately to pins fixed to the edge of the movable platform, so that as the latter rises and falls the railing opens up into position or collapses into a small space level with the platform.

The motive power is hydraulic, and consists of an accumulator, 15 ins. in diameter by 12 ft. stroke, loaded with 60 tons of cast-iron rectangular weights suspended from a massive crosshead by four 2-in. steel bolts. The working pressure is 700 lbs. per sq. in., and is conveyed by 2-in. diameter steel pipes to two 8-in. diameter and 11 ft. 6 ins. stroke hydraulic multiplying cylinders, laid horizontally on the cross girders of each fixed span and geared 6 to 1; one ram opening the bridge and the other closing it by means of 1-in. diameter steel-wire ropes, which are attached to a cross girder on the lower flanges of the movable main girders. The opening or closing movement is effected in 1 min. and could be done in ½-min. if required. Check valves, having a gradual movement, govern the inlet and outlet ports of the hydraulic cylinders to stop the moving spans without shock.

The motive power consists of a pair of vertical duplex pumps, and the boilers are of the vertical cross-tube type of 8 HP. Pumps and boilers are in duplicate, and each pump is capable of filling the accumulator in 7 mins., its contents being sufficient for nearly two single movements of the bridge. The engine-house contains also stores, a keeper's room, and a watch-tower, in which is placed the lever controlling the working of the bridge. Signal lamps, automatically arranged to show red or white lights, are provided, and automatic road bars to stop traffic when the bridge is open, both these being operated by the bridge itself as it opens or closes.

The two piers are formed of clusters of screw piles, each cluster consisting of ten 6-in. diameter solid steel piles fitted with the author's patent mushroom screws, 3 ft. diameter, and screwed to depths of about 18 ft. into the river-bed, which is a fine sand extending to a depth of probably 100 ft. These screws, Fig. 7, have dished flanges and an increasing pitch upwards. The dishing of the flange considerably strengthens the screw and increases its bearing power, while the graduated pitch enables it to enter with less slip than usual, and to clear itself better than the ordinary flat flange screw of regular pitch. Each pile was tested with 30 tons dead load for three days and the greatest settlement observed was ⅝-in. The piers are braced horizontally and vertically by channel-bars and tie-rods, and are surmounted with cast-iron caps and steel-plate cap girders riveted into one piece covering the entire pier. Each pier is protected by two groups of fender piles connected together by long horizontal walings, but not attached to the pier itself, so that blows from passing vessels are not communicated to the bridge structure.

A difficulty arose in connecting the hydraulic cylinders on the Cheshire side of the river with the accumulator-house which is on the Flint abutment, necessitating the laying of pressure pipes across the bed of the river. The bed of the river was found to shift continuously, and was at times subject to extensive scour, so that some flexible form of piping, which would sink into the sand at every point where scour occurred and ultimately settle below the scouring action, became necessary. Annealed copper pipes 1½ ins. diameter and 5-16-in. thick, have fulfilled this purpose admirably, and the difficulty of a satisfactory joint has been overcome by a form of sealed screwed union in which the union is extended in a plain sleeve 1½ ins. beyond the screwed joint, and the space between the union and the pipe heated, tinned, and filled with hard solder and the joint caiked. The joint is cheap and effective and will bear much bending or vibration. No leak has occurred in two years' working, but, as in the case of the engines and boilers, these pipes were also laid in duplicate to prevent any chance of rendering the bridge unworkable from their failure, which might occur from a vessel's anchor dragging. Each half-span is, however, also provided with a hand-winch gear for use in emergency.

Another difficulty that arose was the prevention of freezing in pipes and cylinders during winter. It is evident that in such an exposed position no method of clothing or heating the pipes would be reliable, besides being necessarily incomplete. It was decided therefore to circulate the water in the pipes and cylinders by a small steam-pump during frost, and special valves were fitted for this purpose; the water circulates from a tank in the engine-house, into which the exhaust steam is turned to warm the water. This plan has been thoroughly effective and has the advantage of being easily controlled by the engineer in charge by very simple means.

The bridge was opened by the late Mr. W. E. Gladstone on the 2d June, 1897, and has been now at work for nearly two years without any hitch or stoppage. Its principle of construction may therefore be said to have established for itself a reputation for reliability as well as novelty.

HANDLING EXCAVATED MATERIAL BY BELT CONVEYOR IN FOUNDATION WORK.

We illustrate herewith an interesting application of a belt conveyor for handling the excavated material removed in constructing the foundations of a large power plant in New York city. The new power plant of the New York Gas & Electric Light, Heat & Power Co., now under construction, occupies the entire block bounded by 38th St., First Ave., 39th St., and the East River in New York city, and the excavation for the foundations will go to a depth of 19 ft. below the curb level. The location of this work, with the river at one side, naturally suggested the removal of the excavated material by barges. To reach the barges with material taken from the far side of the excavation, however, required a rather long haul for carts or wheel scrapers, and the contractors, Messrs. Ryan & Parker, of New York, resolved to instal a mechanical conveyor which would reduce the amount of teaming necessary. Figs. 1 and 2 show quite clearly the nature of the conveyor which was adopted.

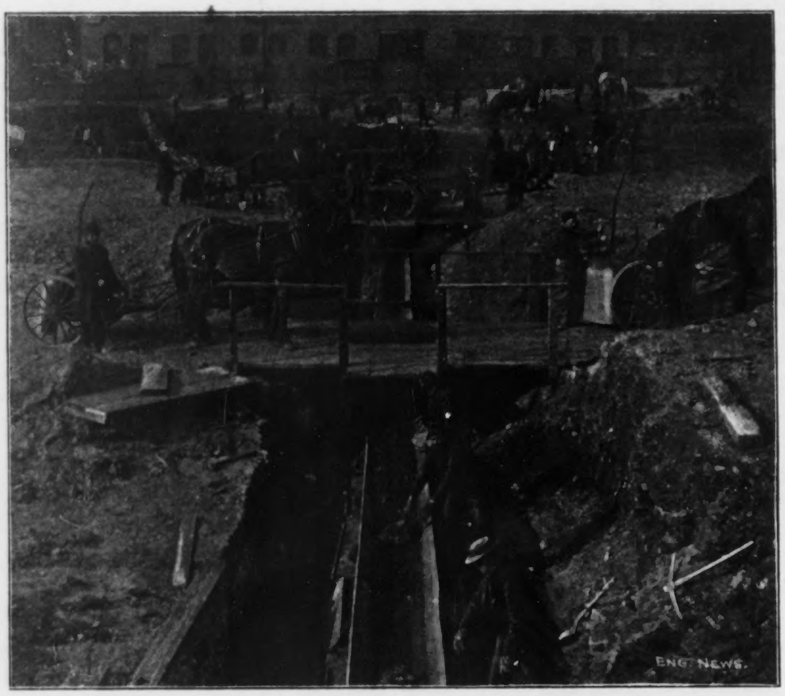


FIG. 1.—GENERAL VIEW OF BELT CONVEYOR PLANT FOR HANDLING EXCAVATED MATERIAL IN CONSTRUCTING A LARGE POWER HOUSE FOUNDATION.
Robins Conveying Belt Co., New York, Builders.
Ryan & Parker, New York, Contractors.

As will be seen from Fig. 1 an open trench about 7 ft. deep was dug running from the river directly back into the lot on a line parallel to and about midway between 38th and 39th streets. In this trench a belt conveyor about 250 ft. long was installed. This conveyor is level for the greater part of its length, but near its East River end it ascends in a vertical curve of about 100 ft. radius until a height of about 20 ft. is attained by the discharge end directly over the barge moored at the river's edge. Across the trench at three points timber bridges were built having near the centers of their floors 3 × 3 ft. openings terminating with hoppers discharging directly onto the conveyor belt below. The wheel scrapers used for excavation travel over these bridges in succession and dump their contents into the center openings as they pass over them.

The conveyor used is the standard form of belt conveyor, built by the Robins Conveying Belt Co., of 147 Cedar St., New York city. It is driven from its head end, which is the discharge end, by a horizontal engine and belt, as indicated by Fig. 2. This illustration shows clearly the nature and arrangement of the discharge and location of the barge which, when filled, is towed out to sea and dumped. The conveyor is rated to have a capacity, when steadily fed with material, of 300 cu. yds. per day. In actual operation on this work, we are informed by the builders, it has taken 1,200 cu. yds. per day, with a force of two two-horse plows and twelve two-horse wheel scrapers. It is stated that the contractors expect to double this force when they get the work fully under way.

The material handled is a heterogeneous mixture of earth, bricks, stone, etc., and at the time the operation of the conveyor was inspected by a member of the editorial staff of this journal this material was being handled without the slightest difficulty as fast as it could be dumped onto the belt. Some of the stones handled were as large as one man could lift. Owing to the method of dumping the scraper loads onto the belt, it is subjected to very rough usage, but it shows very few traces of wear after ten days' continuous operation. In conclusion it is worth pointing out that the successful installation and operation of this plant suggests the possibility of a far greater use of mechanical conveyors in building foundation work in cities than has yet been made of them. At the present time teams are usually employed both to haul the material from the excavation and to transfer it through the streets to the place of disposal. Where the foundation excavation is large and deep it is evident that some mechanical method of getting the material to the street surface would in many instances be a decided gain in time and cost. In such cases the delivery of the material could be made into a large stationary hopper, mounted above the street so that teams could pass underneath or close to one side, and receive their loads through chutes.

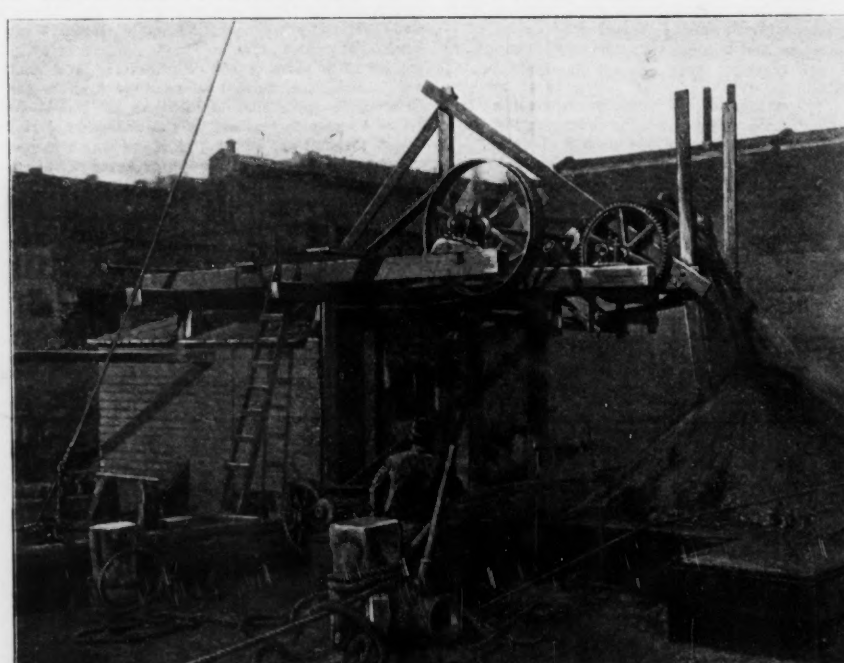


FIG. 2.—VIEW OF DISCHARGE END OF BELT CONVEYOR, HANDLING MATERIAL FROM FOUNDATION EXCAVATION.

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