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THE U. S. BATTLESHIP "ILLINOIS," launched this week at Newport News, has the following dimensions: Length on load water line, 368 ft.; extreme beam, 72 ft. 2½ ins.; normal displacement draft, 23½ ft.; maximum displacement, with all ammunition and stores on board, 10,000 tons; estimated speed, 16¼ knots; normal coal supply, 800 tons; loose storage, 1,200 tons; full bunker capacity, 1,500 tons; complement, 40 officers, 449 men. The main battery will include four 13-in. guns in Hichborn balanced turrets on center line, and 14 6-in. rapid-fire guns. The secondary battery will include 16 6-pdr. and four 1-pdr. rapid-fire guns, two Colt and two field guns. The armor-belt is 16½ ins. thick at the top, 9½ ins. at bottom, tapering to 4 ins. at the stem; it extends from 4 ft. below the normal water line to 3½ ft. above this line. Diagonal 12-in. armor connects the belt armor and the barbettes, and abaft the after turret the protective deck is 4 ins. thick on slopes and 2¾ ins. thick on the flat; this deck forward is 3 ins. and 2¾ ins. thick. The armor on the 13-in. gun turrets is 17 ins. thick on the front and 15 ins. on the rear and sides; on the barbettes the thickness is 15 and 10 ins. Above the armor-belt the sides of the ship, and diagonals connecting these sides, will be 5½ ins. thick. Coffer-dams, generally 3 ft. thick and extending the length of the ship, contain about 12,500 cu. ft. of corn-pith cellulose, as a protection against the entrance of water. Independent of the cellulose pockets, there are nearly 300 water-tight compartments, for containing the motive power, coal, stores, ammunition, etc. Any of these may be flooded or pumped out. There will be about 80 auxiliary engines in the vessel; and there will be two sets of triple-expansion, twin-screw engines, with a total of 10,000 I. HP. at 120 revolutions per minute. There are eight single-ended cylindrical boilers, each 15½ ft. diameter by 9 ft. 11½ ins. long; with a total grate surface of 685 sq. ft. and 21,200 sq. ft. of heating surface; the working pressure is 180 lbs. per sq. in. The characteristic of this ship is her high freeboard—20 ft. forward and 13¼ ft. at the stern. The axis of the 13-in. forward gun will be 26½ ft., and the after 13-in., 19 ft. above the water surface. The 6-in. guns will be from 15 to 22½ ft. above the water. The first keel plate of the "Illinois" was laid Feb. 10, 1897, and from 53 to 54% of the work is now done. The contract price was $2,595,000, and she is to be completed by Oct. 5, 1899.

BIDS FOR THE FOUR HARBOR-DEFENCE MONITORS were opened on Oct. 1, under the limit price of $1,250,000 each. The bids were as follows: Lewis Nixon, $825,000, to be finished in 24 months; Newport News Co., $860,000, in 27 months; Bath Iron Works, $862,000, in 27 months; Union Iron Works, $874,000, in 27 months; Maryland Steel Co., $876,000, in 26 months; Wolff & Zwicker, $937,500, in 27 months; The W. B. Fletcher Co., $927,000, in 21 months; Columbian Iron Works, $1,015,000, in 27 months; and John Dialogue, $1,171,000, in 26 months. The four bidders first named are likely to get one monitor each.

SHIPBUILDING IN THE UNITED STATES, for the year ending June 30, 1898, is reported upon by the Navigation Bureau. There were built and documented in that year 952 merchant vessels of 180,458 gross tonnage, compared with 891 vessels of 232,233 tons in the preceding year. The decrease is almost wholly in the Great Lakes; the construction on the Pacific Coast amounted to 49,789 tons, as compared with 7,495 tons in the preceding year. This Pacific increase was chiefly in ships built for the Alaskan-Pacific and Alaskan river trade. On the Atlantic and Gulf Coast the returns show 514 vessels of 63,090 gross tons for the last fiscal year; on Western rivers, 123 boats of 13,495 tons were built. In the last year the returns show 359 sailing vessels of 180,458 gross tons; 343 wooden steamers of 57,337 tons; 51 iron and steel steamers of 48,501 tons; 20 canal boats of 2,386 tons; and 169 wooden barges and 10 steel barges of 37,818 tons in all.

THE ATLANTIC TRANSPORTATION CO. OF NEW York has chartered some 35 vessels from the Lake fleets, having a total carrying capacity of over 50,000 tons of cargo. In addition, this company will build 12 or 15 new barges, with a combined cargo capacity of 36,000 to 45,000 tons. The total fleet of the company will eventually comprise about 70 craft of all kinds, with room for over 100,000 tons of cargo. Mr. Walter S. Bosse, of New York, is the General Manager of the Atlantic Transportation Co. It is a New Jersey corporation, with $3,000,000 capital, and has its headquarters at No. 1 Broadway, New York city. The lake vessels chartered will come down the St. Lawrence; and existing contracts call for the movement of more than 4,000,000 tons of coal annually from Newport News to New York, Boston and New England.

A SELF-PROPELLING PUMP DREDGER, designed by Mr. Lindon W. Bates, is being built in Belgium for the use of the Russian government on the Volga River, says the "N. Y. Commercial." This dredger is double-hulled, each hull being the largest that will pass through the canal system uniting the Baltic Sea with the Volga. They can be operated together, making a single cut 62 ft. wide, or singly with a 31-ft. cut. The draft in working trim will be 4½ ft. and the hulls are built of steel. Each half is 216 ft. long by 31½ ft. and 9 ft. deep. They will be propelled and operated by electricity, each half-hull having its own generating plant, with four motors of 125-HP. each. There will be a stern-wheel tender connected with the dredging plant for use in towing, surveying, setting anchors, etc. No test has been made of this dredger as yet, but Mr. Bates expects an output of 7,000 cu. meters per hour under the conditions prescribed by the Russian government.

THE DISMAL SWAMP CANAL may be completed by Jan. 1, next, in the widening and deepening work now going on, says the Baltimore "Sun."

THE PROTECTION OF SANDY HOOK against wave encroachment is to be undertaken by building sand-catching dikes and planting soil-binding grass to preserve the beach made. The Sea Lyme and Marram grasses are best for this purpose, according to the long investigations of Prof. F. Lamson-Scribner, the agrostologist of the Agricultural Department. The Sea Lyme grass flourishes best along the Maine coast, but will grow as far south as Cape Hatteras, where it is replaced by the creeping bitter panic grass. The Marram grass does well from New Jersey to Florida. The Rolling Spinifex, of Australia and New Zealand, is being introduced in this country with a like purpose by the U. S. Agricultural Department. Japanese lawn grass is another variety which is being tried.

A 2,000-C. P. SUBMARINE ARC LAMP for use in connection with raising sunken vessels, examining existing work or constructing bridge piers, coffer-dams and the like, has been undergoing a test at the Brooklyn Navy Yard, with apparently considerable success. The lamp is the invention of Messrs. Irving E. Burdick and Francis G. Hall, Jr., who were employed by the government in connection with torpedo and mine work in several of the Maine harbors. The idea of perfecting such a lamp occurred at that time. Later the Navy Department granted them permission to experiment. The result is the lamp before mentioned, which consists of an outer cylindrical casing ending in a straight glass globe, protected by a wire guard frame. Inside is the operating mechanism and what is termed an enclosed arc, a small opalescent globe surrounding the carbon ends, thus excluding the air. The lamp burns from 100 to 150 hours with one set of carbons. The wires carrying the current pass through a water-tight bushing in the top of the casing. A check valve is also provided to permit the escape of any gas which may form inside.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred, Sept. 28, on the Pictou branch of the Intercolonial Ry., near Stellarton, Nova Scotia, in which five persons were killed, and several were injured. The accident is attributed to a misunderstanding of orders, which caused a special excursion train and a work train carrying 60 miners to meet in a butting collision on a sharp curve.

HEAVY WINDS raged along the Southern Coast on Oct. 2, doing a large amount of damage. The wind velocity is reported to have been from 50 to 75 miles per hour, and the conditions much the same as in the tidal storm of 1893. The abnormally high tide inundated large tracts of low land along the Georgia and Carolina coast. The loss of life is not at present known, but appears likely to reach a hundred or more.

FATAL FOREST FIRES are reported from the northern part of Wisconsin. The town of Cumberland and a number of towns in that vicinity are surrounded by fires and in danger of destruction. Reports from Denver, Colo., state that Colorado timber reserves are fast being depleted by forest fires which have destroyed many ranches and farms.

TIMBER STANDING in the western part of Washington is, according to Mr. Henry Gannett, of the U. S. Geological Survey, 103,504,376,000 ft. B. M., made up as follows: Fir, 66,208,861,000 ft.; spruce, 6,403,405,000 ft.; cedar, 16,192,276,000 ft.; hemlock, 14,699,834,000 ft. The report states that about 45% of the timber district has been cleared, 23% having been cut and 22% burned. Only merchantable timber is considered, and the estimates are based upon present wasteful methods of logging.

EXPERIMENTAL TREE PLANTING IN THE PLAINS is reported upon, in a pamphlet of 94 pages, by Mr. Charles A. Keffer, Assistant Chief of the Division of Forestry, in the Department of Agriculture. This experiment was commenced by the government in 1896, in Minnesota, South Dakota, Nebraska, Kansas, Colorado and Utah, and new stations are being established in Texas, Oklahoma and Montana. About 13 varieties of pines and 26 other and broad-leafed species are being tested at these stations. It is yet too early to arrive at and definite conclusions, and the present report of Mr. Keffer deals rather with the principles underlying such plantations and the best methods to be pursued.

THE SMALL WATER CONSUMPTION of European cities is a standing wonder to those in charge of water supplies in American cities. The following is an official statement of the average daily consumption per capita in a number of the leading English cities, including also the average for the several water companies which supply London:

	Gallons per head.		Gallons per head.
Grand Junc. (London)	55½	Liverpool	31½
Chelsea (London)	47	Croydon	31
Southwark and Vauxhall (London)	45	Manchester (aver. 27)	30
Brighton	43	Halifax	29
Plymouth	43	Swansea	28
Hull	43	Blackburn	25
London (average)	41	Bristol	23½
Lambeth (London)	40	Bolton	23½
West Middlesex (London)	39	Birmingham (average)	23
New River (London)	35½	Huddersfield	23
Bradford	35	Burnley	23
Leeds	35	Oldham	22
East London (London)	34½	Cardiff	22
Preston	34	Sheffield	21¾
Kent (London)	33½	Nottingham (aver. 17½)	19
		Birkenhead	18
		Leicester	18

A PRIZE FOR THE BEST ESSAY on the economic arrangement and construction of subways, for carrying the sewers, water, gas, etc., in great cities, is offered by the "Cosmopolitan Magazine," of Irvington-on-Hudson, N. Y. The amount of the prize is $250.

THE BUSK-IVANHOE TUNNEL on the Colorado Midland Ry. has been abandoned. The railway as originally built crosses the range at Hagerman's pass, 11,528 ft. above sea level. The tunnel was built by a separate company (The Busk Tunnel Co.) in 1892-3. The railway company made a contract to pay 25 cts. per ton of freight and 25 cts. per passenger for the use of the tunnel, and guaranteed the principal and interest of the 7% bonds which the tunnel company issued. All went well for the tunnel company until the railway company became bankrupt and the road was sold under foreclosure. Under the plan of reorganization the bondholders of the tunnel company were offered 4% bonds in exchange for their 7% bonds; but they refused to accept them. The sale under foreclosure, of course, wiped out the old railway company and rendered void its traffic contracts. The managers of the new company asked the owners of the Busk tunnel to accept lower tolls on traffic through the tunnel; and when they refused, the connections were torn up and the old line over the summit of the mountain was put in condition for operation, and trains were turned over it. Passengers greatly prefer the old line on account of the scenic attractions and because it avoids the smoke and gas of the two-mile long tunnel. In winter rotary snow plows will be used to keep the line open. Meanwhile the owners of the Busk tunnel have a tunnel for sale or to let and no customers in sight.

FOREIGN PATENTS IN JAPAN, since 1897, are issued with the same rights as are accorded to Japanese. The Japanese Patent Regulations are avowedly modelled on those of the United States; but the following are not patentable: Articles of food, drink, or fashion; medicines, or methods of compounding them; and articles which have been in public use before the application for the patent. The latter exception is rigidly enforced by the Japanese examiners; and if a foreign patent has been issued one day before the Japanese application, and though there can thus be no public use, the application is rejected. For the year ending March 1, 1898, 104 foreign applications for patents were made in Japan; of these 10 had been finally rejected, and only one was granted. Of trademarks, 2,133 had been applied for in this year and 1,594 were registered.

THE PRESENT STATUS OF THE PANAMA CANAL.

By General Henry L. Abbot, Corps of Engineers, U. S. A.

After the failure of the old Panama Canal Company in February, 1889, the property passed into the hands of a receiver, who, seeking to save from ruin the vast number of subscribers of moderate means, referred the technical problems to a "Comite d'Etudes" selected from among the best engineers of France. In May, 1890, this commission made an able report, indicating the numerous points which demanded further investigation before final plans could be judiciously adopted, but suggesting the general features of such a plan, based on a study of all existing data. To make these further investigations a new company was organized in October, 1894; and since that date it has quietly prosecuted its labors and has now collected all the information needed to command the confidence of engineers in its definitive project. It is to set forth this project, and to indicate its superiority to anything possible in Nicaragua, that the present article is written. It may be proper to add that the writer, as a member of a technical commission of engineers, made last spring a careful examination of the entire route of the Panama Canal, and is thus possessed of definite personal information, in some degree assisted by having formerly traversed Nicaragua. The following are the essential features of this project, endorsed, with some possible future modifications in details, by a Comite Technique, composed of French, English, German, Russian and American engineers. Among them the chief engineers of the Manchester and of the Kiel ship canals.

The original plan contemplated placing the canal in the bed of the Chagres, and conducting the river to the sea through artificial channels. This project was long ago definitely abandoned, being replaced by the familiar system of locks and dams which has been so often successfully applied to other rivers. Careful measurements and studies of the regimen of this torrential stream have shown the system to be entirely applicable to it, and that none of the constructions demanded will exceed the limits of recognized engineering practice. To these advantages it should be added that two good harbors already exist at the Atlantic and Pacific terminals; that an American railway is in active operation parallel and in close proximity to the line of the canal throughout its entire extent; that about 40% of the whole length has been actually excavated, and that great progress has been made on the intermediate portions; and finally, that extensive preparations have already been made for accommodating the army of laborers which will be required on any Isthmian canal. These reasons certainly demand that the comparative merits of this route should be considered before adopting any other location for the canal now generally believed to be essential to meet the needs of our Atlantic and Pacific coasts.

In Nicaragua the general conditions are distinctly inferior. Two ports must be artificially prepared; one at least of great practical difficulty, since nature has already closed the old harbor. About 120 miles of railroad must be built, mostly traversing a wilderness. Almost nothing has been done in the way of construction or of preparation for the work. Of the whole length of 176 miles, 68 miles follow the bed of a crooked river, where the prevailing trade winds and the currents resulting from the whole outflow of Lake Nicaragua will unite to aggravate the difficulties of shipping in transit. The length of the route is about four times that of the Panama canal, adding proportionately to the time of passage; finally, at least one dam is demanded, quite without precedent in our canal construction, besides several miles of huge embankments in the San Francisco basin, where the foundations are extremely bad, and where a rupture at any future time would entail veritable disasters.

But passing from generalities, the details of the Panama project will first be considered.

The Canal Proper.—The total length is 75 kilometres (46.5 miles), of which five (3.1 miles) lie in the Bay of Panama, between Isle Naos and La Boca. Of the 70 kilometres (43.4 miles) of inland construction, 24 kilometres (14.88 miles) on the Atlantic side (between Colon and Bohio) and 7 kilometres (4.34 miles) on the Pacific side (between La Boca and Miraflores) will be at the sea level, and of this distance about 25 kilometres (15.5 miles) are now essentially excavated, thus there remains only 38 kilometres (23.5 miles) to be traversed by the aid of locks; and here also so much actual work has been done that no visitor can pass over the line without appreciating that the canal can no longer be regarded as an experiment.

Of these 38 kilometres between Bohio and Miraflores, the first 22 (13.64 miles) extending from Bohio to Obispo will traverse a vast lake 5,500 hectares (13,585 acres) in extent, created in the valley of the Chagres by a dam at Bohio. Its level above the sea will range between a minimum of 16 metres (52.48 ft.) and a maximum of 20 metres (65.60 ft.), the normal level being 17 metres (55.76 ft.). A reservoir of 150 million cubic metres (52,950 million cu. ft.) is thus provided to control in part the floods of the river. Access to the lake will be furnished by two double locks at Bohio.

There thus will remain to be considered only the 16 kilometres (10 miles) lying between Obispo, where the canal leaves the Chagres River and Miraflores, where sea-level is reached. This section includes the continental divide at the Culebra, approached on the side of the Atlantic by the valley of the Obispo, a tributary of the Chagres, and on the Pacific by the valley of the Rio Grande. The great economic problem to solve has been to determine the most advantageous level for the bottom of the canal between these two points, with a view to afford the best balance between the cost and the time of constructing the locks and dams on the one hand and deep cutting on the other.

This problem, with its adjuncts of how to best supply the summit level during the dry season, how to regulate the floods of the Chagres during the rainy season, and how to provide hydraulic power for lighting and operating the canal at all seasons, has been most thoroughly studied on the spot by the new company since its organization in 1894. Space is lacking to detail the trial excavations, aggregating 3 million cubic metres, the surveys, the borings, the gagings of the water courses and the many other details which have been investigated in the most elaborate manner. Suffice it to say that, after comparative estimates of 16 variants, the Comite Technique has advised the adoption of a level of 20.75 metres (68 ft.) above mean tide, which, should experience in the active prosecution of the work render it expedient, will admit of modification, either by adding two more locks, raising the level of the cut to 29.5 metres (97 ft.), or of suppressing one or perhaps two locks, and thus reducing it to 10 metres (33 ft.).

This definitive plan, placing the bottom of the canal at a level of 20.75 metres, involves two double locks at Obispo, raising the water surface at the summit level to a maximum of 31.25 metres (102.5 ft.) and a minimum of 29.75 metres (97.58 ft.); one double lock at Paraiso dropping these levels to 23.25 metres (76.26 ft.) and 22.25 metres (72.98 ft.); two double locks at Pedro-Miguel, dropping them to 6.25 metres (20.5 ft.) and 5.25 metres (18.22 ft.); and a tidal lock at Miraflores, where the water level varies between 3 metres, or 10 ft., above, and 3 metres below mean tide. (On the Atlantic side the tidal oscillation is only a few inches, and no such provision is needful.) The length of these levels in every case exceeds 2 kilometres (1.24 miles), thus avoiding trouble from oscillations due to lockages. In reference to the deep cutting at Culebra—the bugbear of former days—it is only needful to say that the excavation has already been carried below the level of the soft upper strata, which gives so much trouble by sliding, and is now and will continue to be in an indurated clay schist, requiring blasting, and passing to veritable rock. Serious trouble need no longer be apprehended here. This problem has been studied most thoroughly by the new company—involving the removal of about 2 million cubic metres of material, the sinking of many pits and borings, and the construction at the worst point of a tunnel 210 metres long (689 ft.) at a level of 41 metres (134.5 ft.).

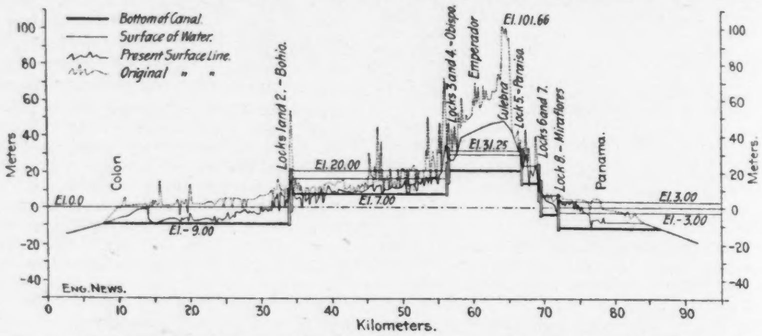


FIG. 1.—PROFILE OF THE PANAMA CANAL; BOTTOM OF SUMMIT LEVEL, AT ELEVATION 20.75 M., OR 68.06 FT. ABOVE DATUM.

LIFT OF LOCKS.

Atlantic Side.

Location.	Order, No.	Lift, ft. Maximum.	Lift, ft. Minimum.
Bohio	1	32.80	26.24
"	2	32.80	26.24
Obispo	3	25.02	16.00
"	4	25.02	16.00

Pacific Side.

Location.	Order, No.	Lift, ft. Maximum.	Lift, ft. Minimum.
Paraiso	5	29.52	21.32
Pedro-Miguel	6	29.52	26.24
"	7	29.52	26.24
Miraflores	8	30.34	7.38

In locating the line of the canal, great care has been taken to avoid abrupt curves. A minimum radius of 2,500 metres (8,200 ft.) is adopted for the central cut, and of 3,000 metres (9,840 ft.) for the rest of the line, except near Bohio, where radii of 2,500 metres and 2,000 metres (6,560 ft.) occur in enlargements having a bottom width of 62 metres (203.4 ft.), and near Obispo, where one radius of 1,700 metres (5,576 ft.) occurs with a bottom width of 80 metres (262.4 ft.). Even with the large standard curves adopted, suitable enlargements will be provided to render the route perfect in this important detail, in respect to which it is more favored by nature than either Kiel or Manchester, as appears from the following figures.

	Canals: Manchester.	Kiel.	Panama.	Nicaragua.
Total length, kilos.	54	98.6	74.5	284
Minimum radius, meters	571	1,000	1,700	....
Normal radius, meters	..	..	2,500* / 3,000†	1,220§ / 1,311‡
Length, straight	63%	63%	57%	....
Curvature:				
2,500 meters or more	15%	..	41%	....
Less than 2,500 meters	22%	..	2%	....
2,000 meters or more	27%	29%	42%	....
Less than 2,000 meters	10%	8%	1%	....

*Central. †Elsewhere. §Eastern divide. ‡Western divide.

The cross section to be given the canal varies in different localities, as shown in the following table: The depth is uniformly 9 metres (29.52 ft.); and the side slopes usually 3 base to 2 height in earth, and 2 base to 3 height in rocky cuts. In respect to berms and revetments, the latest practice, as recommended by the recent International Congress of Engineers at Brussels, will be followed.

	Earth: Section, sq. m.	Earth: Bottom width, meters.	Rocky cuts: Section, sq. m.	Rocky cuts: Bottom width, meters.
Colon to Bohio	406.5	30	380.2	34
Lake Bohio (minimum)	571.5	50	531.0	53
Summit level	379.5	36	379.5	36
Paraiso to Pedro Miguel	406.5	30	380.2	34
Pedro Miguel to Miraflores	406.5	30	380.2	34
Miraflores to La Boca.*	720.0	30	...	..
Bay of Panama (low tide)	60[illegible]0	50	...	..

*Low tide.

Enlargements 600 metres (1,968 ft.) long and 60 metres (196.8 ft.) wide at bottom, to enable vessels to pass each other, will be provided in the canal at intervals of about 8 kilometres (4.96 miles); but immediately above and below the locks these dimensions will be raised to 700 metres (2,296 ft.), and 62 metres (203.4 ft.).

The Locks.—The locks, all founded on rock, are to be double, the larger chamber having a serviceable length of 225 metres (738 ft.), a width of 25 metres (82 ft.), and a depth of 9.5 metres (31.16 ft.) at the sides, and 10 metres (32.8 ft.) at the middle. The smaller chamber has the same serviceable length, with intermediate gates to reduce it to 130 metres (426.4 ft.) when desired; a width of 18 metres (59.04 ft.); and the same depth as the other. The larger will be constructed first, together with the foundations and head of the smaller, thus permitting the latter to be completed after opening the canal to traffic. The maximum lift has been fixed at 9 metres (29.5 ft.), except at Bohio, where provision for 10 metres (32.8 ft.) will be made, for use during extreme floods of the Chagres, which last only for a few hours.

The gates will be of the pivoted single leaf type, and water will be supplied by pipes buried in the lock floors and delivering on each side and throughout the whole length of the chamber, the flow being regulated by valves of the low level cylindrical pattern. Entrance to the chambers from either direction will be facilitated by crib piers, 60 metres long, with detached heads to protect the structure against shocks.

The Dams.—There will be six dams, five located on the line of the canal at Bohio, at Obispo, at Paraiso, at Pedro-Miguel and at Miraflores, and one at Alhajuela, 16 kilometres (10 miles) above, on the upper Chagres. Of these only the first and last need be considered, as the other four are minor affairs presenting no engineering difficulties (three of them are to be of masonry and one of earth).

The dam at Bohio will be of earth, abutting on conglomerate rock at the sides, and founded on a compact bed of clay, believed to be diluvial. The length of the crest will be 392 metres (1,286 ft.); the extreme height above the bed of the river, 23 metres (75.4 ft.), and above the foundation 28.5 metres (93.5 ft.). The width at the crest which rises 3 metres (10 ft.) above the highest level of the lake will be 15 metres (49.2 ft.); the upstream slope has a height of 1 on a base of 3, with four berms each 3 metres (10 ft.) wide, the whole riveted with stone laid dry; the downstream slope has a height of 2 on a base of 3, with one berm 3 metres wide, and is supported by a mass of loose rock rising to a sufficient height to protect the dam if, in spite of all precautions, it should chance to be overtopped by a sudden flood during construction. A puddled core, and a concrete wall at the upper toe, will cut off any possible leakage. The mass of the dam will be of excellent material found in the close vicinity. During construction the river will be diverted through the rock cut for the locks, with ample provisions by deversoirs for combatting larger floods. All the details have been carefully studied and the project has received the unanimous approval of the Comite Technique.

The dam at Alhajuela will be of concrete masonry founded on and abutting against compact rock. The length of crest will be 285.5 metres (936.4 ft.); and the height, 41 metres (134.5 ft.) above the bed of the river and 50 metres (164 ft.) above the deepest part of the rock foundations. The cross section conforms to the conditions of recent engineering practice.

To facilitate construction, a tunnel 300 metres (984 ft.) long and 75 square metres (807 sq. ft.) in cross section will be driven through the ridge to a bend of the river below, and a temporary dam will divert into it the minor flood discharges of the river. To meet the case of larger floods, the dam will be raised alternately on the two sides, thus allowing space for a portion to be overflowed without interrupting the work. These details have been carefully studied, and met the approval of the Comite Technique.

Engineers will recognize the immense advantages possessed by the Panama route, in the matter of dam construction, over the conditions found in Nicaragua, where the diversion of the San Juan river is admitted to be impracticable, and where the foundations present extraordinary difficulties and demand an unusual structure quite without precedent for canal purposes.

Regulation of the Chagres River.—This subject, comprising the control of the floods and the supply of the summit level, has received the elaborate investigation demanded by its importance. Space is lacking for details, but the general features are the following.

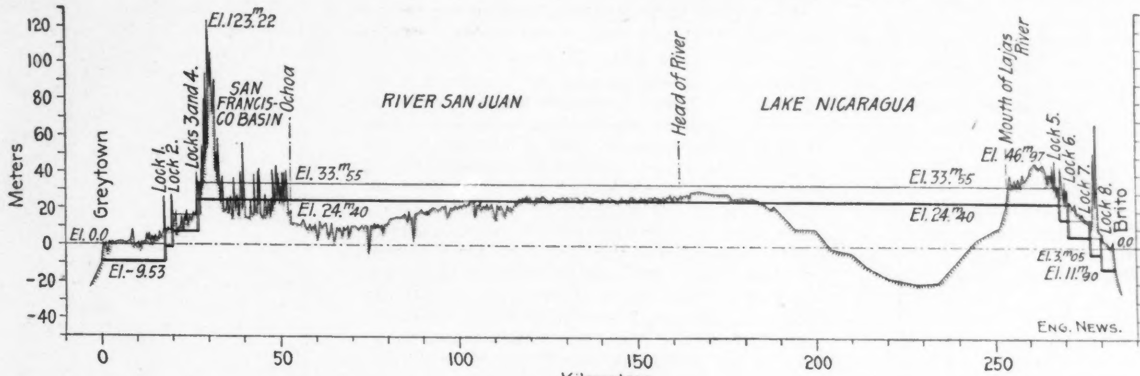
At Alhajuela the low water surface of the river is 28 metres (91.84 ft.) above sea level; at Gamboa, 14 metres (46 ft.); and at Bohio, 0 metres. The mean annual discharges at these three points respectively are 63 cubic metres (2,224 cu. ft.), 84 cubic metres (2,965 cu. ft.), and 121 cubic metres (4,261 cu. ft.) per second. During the three low water months (February, March and April) these mean volumes fall to 27 cubic metres (953 cu. ft.), 31 cubic metres (1,094 cu. ft.), and 39 cubic metres (1,376 cu. ft.), the minimum being 9 cubic metres (318 cu. ft.), 10 cubic metres (353 cu. ft.) and 14 cubic metres (459 cu. ft.). The maximum flood volumes, closely estimated on the basis of the floods of 1879, the largest within the memory of the inhabitants, is at Gamboa 1,630 cubic metres (57,539 cu. ft.) per second, and at Bohio 3,100 cubic metres (109,410 cu. ft.). The floods of the river, great and small, are all of the torrential type, resulting from the heavy and widespread tempests of the rainy season. Their duration is extremely short, rarely exceeding in the greatest floods 48 hours at Gamboa and 96 hours at Bohio. The maximum heights ever attained above the low water stage are about 11 metres (36.1 ft.) at Gamboa, and 12 metres (39.36 ft.) at Bohio. These figures, resulting from years of patient and careful observations, have furnished the basis for solving the two great questions of river regulation presented by the problem of the canal.

Upon an estimate, known to be safe, of allowing 1,000 cubic metres (35,300 cu. ft.) per second to freely pass Gamboa and 1,200 cubic metres (42,360 cu. ft.) to freely pass Bohio, reservoirs to contain 1 million cubic metres (35,300,000 cu. ft.) above Alhajuela, and 1.5 million cubic metres (52,950,000 cu. ft.) above Bohio are needful to restrain the greatest known floods; and these reservoirs are provided by the dams already described. In no other than the flood of 1879 would so large volumes be demanded.

The level of these lakes to be regulated by overflow weirs of the Stoney type, which have given perfect satisfaction on the Manchester canal, and which have the great merit of allowing the sills to be placed below the water surface without serious leakage.

The volume of 1,000 cubic metres (35,300 cu. ft.) per second permitted to pass Alhajuela will follow the bed of the Chagres to Lake Bohio. The volume of 1,200 cubic metres (42,360 cu. ft.) allowed to escape from the latter, will pass by two overflow weirs—one to the left of the canal discharging 500 cubic metrese (17,650 cu. ft.) per second through the bed of the Chagres and its derivations; and the other at the sources of Rio Gigante discharging 700 cubic metres (24,710 cu. ft.) by a route also separated from the canal.

To supply the summit level during the season of low water, the inflow of 20 cubic metres (706 cu. ft.) per second will be required. To provide 7,000 horse-power for lighting the canal and operating the gates, 15 cubic metres (530 cu. ft.) per second are demanded, falling 32 metres (105 ft.) at Alhajuela, and 16 metres (52.5 ft.) at Bohio, and acting on turbines driving dynamos to transmit the power in the form of electricity. The reservoir capacity, in excess of the low water flow of the Chagres, to supply these two needs, is 130 million cubic metres (4,589 million cu. ft.). The area of the lake above Alhajuela is 2,300 hectares (5,750 acres) at the level of 61 metres (200 ft.) above tide water and 3,000 hectares (7,500 acres) at the level of 65 metres (213 ft.), the crest being 69 metres (226 ft.), calling for a layer of water 9 metres (29.5 ft.) deep to contain 1 million cubic metres for flood storage and 130 million for low water supply. Upon this basis the capacity of the lake has been regulated.



PROFILE OF THE NICARAGUA CANAL; BOTTOM OF SUMMIT LEVEL AT ELEVATION, 24.40 M., OR 80.03 FT. ABOVE DATUM.

LIFT OF LOCKS.

Atlantic Side.

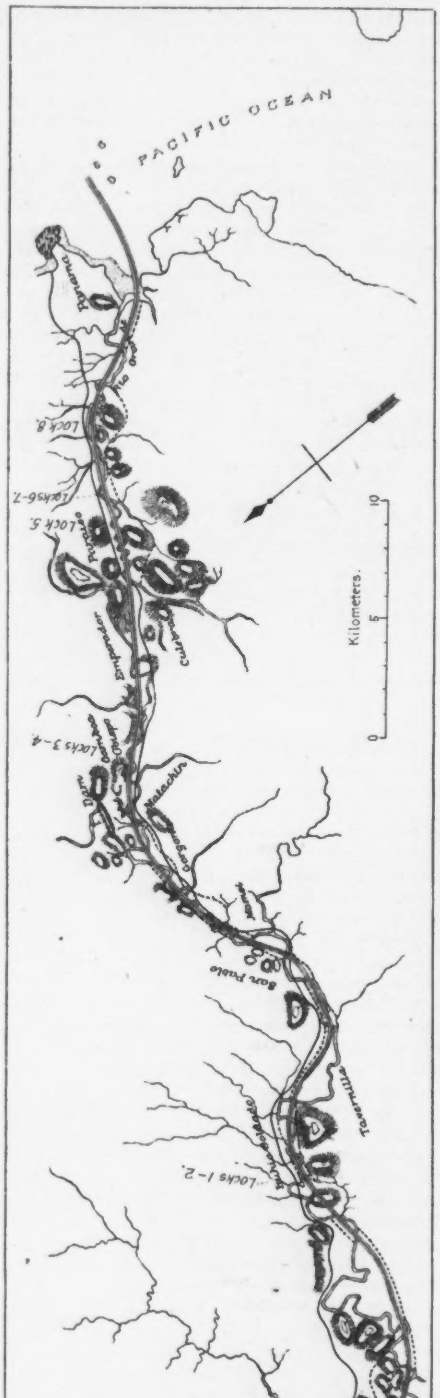
Location.	No.	Normal lift, ft.	Normal level of bottom of canal above mean tide, ft. — Lower.	Upper.
17.70 kilos.	1	26.00	0.0	26.00
19.83 "	2	28.00	26.00	54.00
26.95 "	3	28.00	54.00	82.00
27.15 "	4	28.00	82.00	110.00

Pacific Side.

Location.	No.	Normal lift, ft.	Normal level of bottom of canal above mean tide, ft. — Lower.	Upper.
268.60 kilos.	5	30.00	110.00	80.00
271.10 "	6	30.00	80.00	50.00
276.90 "	7	30.00	50.00	20.00
280.00 "	8	20.00	20.00	0.0

Note.—The height of tide being 1.25 ft. on the Atlantic side and 8.9 ft. on the Pacific side, the maximum lift of the locks at each end must be increased accordingly.

To transport the needful volume of water (20 cubic metres per second) from Alhajuela to the



MAP OF THE PANAMA CANAL.
(Reproduced from a map published in 1886.)

summit level, a feeder 16 kilometres (10 miles) long will leave the lake at a level of 58 metres (190.3 ft.) above tide, and follow the left bank to a lateral valley, discharging gently into the summit level about a kilometre (0.62 miles) from the locks at Obispo. The fall between the lake and point of delivery will be 17 metres (55.8 ft.), and the cross section is established to carry from 25 (882) to 40 cubic metres (1,412 cu. ft.) per second, with a view to meeting all possible contingencies of a largely increased traffic. At these heights water will flow into the canal even if the higher summit level should finally be found to be the more advantageous. The feeder traverses a difficult region and will be costly, but all details of construction have been successfully elaborated.

At Lake Bohio, as already stated, a capacity of 1.5 million cubic metres is needed for storage during great floods, and to assist the overflow weirs in regulating the level during the sudden influx of smaller floods. This volume calls for a layer of water 3 metres (10 ft.) deep; and another metre has been added, to contain a reserve for supplying evaporation in the lake during the dry season.

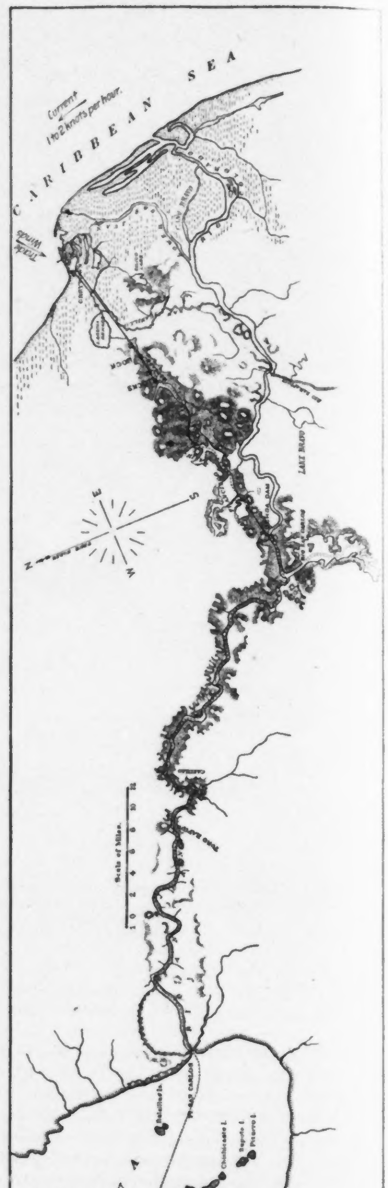
From the foregoing it will be seen that the hydraulic problems presented by this turbulent river—at one time regarded as so serious—admit of satisfactory solution. This is hardly the case in Nicaragua, where one of the great difficulties of project is the regulation of a summit level depending on that of an immense lake 2,700 square miles in extent, receiving directly the drainage of 8,700 square miles of territory, together with that of 2,250 square miles more through the tributaries of the San Juan river above the dam at Ochoa; conditions which render the ordinary method of storage reservoirs wholly inapplicable. Nevertheless a delicate regulation of this level, and at an artificial height, is essential to avoid on the one hand drowning a cultivated district on the west shore, and on the other hand exposing rocks in the navigable bed of the San Juan. These difficulties are aggravated by the necessity of placing the overflow weirs near Ochoa, at a distance of more than 100 kilometres (62 miles) from the lake.

In this connection it may also be noted that in the matter of rainfall the Panama canal is the more fortunate. All the difficult excavations and works of construction, except those near Bohio, lie in the interior where the annual downfall, as determined by 32 years of observation, is 93 ins., or only about 50% more than on our Gulf coast; while in Nicaragua, the most difficult constructions, including the Ochoa dam and the San Francisco embankments, lie in a district where the downfall, as determined from the data collected by the Nicaragua canal company (about 7 years observations), is 256 ins., or nearly three times as much.

Estimates.—This subject has received the most careful study, both in determining quantities and unit prices. Much valuable data as to the latter, based on actual experience on the Isthmus, has been available. The cost of each different project, and there have been 16 different variants, has been estimated in detail, and a selection between them has thus been reached intelligently. The sum needed for the work of construction proper is, in round numbers, one hundred million dollars. The element of time is more difficult to determine, but the volume remaining to be excavated at the Culebra being a little less than 12 million cubic metres (15,600,000 cu. yds.), it is believed that ten years is a conservative estimate.

The Nicaragua Canal.—To the general relative merits of the two canals already considered may be added that the Panama route lies in the interior of Columbia, while that by Nicaragua lies near the Costa Rican boundary; where hostilities are liable at any time to cause difficulties, as they already have done during the canal examination by the Walker commission last spring. Also that in respect to danger from possible earthquakes, which might easily cause trouble at the great locks, Panama is by far the more safe, because no active volcano is found within a distance of at least 200 miles from it, while three lie in the close vicinity of the route of the Nicaragua canal, and one within only 40 miles of its western locks. Last April an earthquake destroyed substantial masonry buildings at Leon, only 100 miles distant from these lock sites.

But while it is thus easy to compare the two



MAP OF THE NICARAGUA CANAL.
(Reproduced from a map accompanying the Report of the Ludlow Commission of 1895.)

canals in their general features, and to see that the route by Panama is much superior to that by Nicaragua, when details are considered, we are confronted by the fact that really no definitive project can be claimed for the latter. The company's project, as revised by the Government Commission, of which General Ludlow was president, is shown on the accompanying drawing; which may be compared with that given to illustrate the Panama project, but it should be noted that the latter has double the horizontal scale, thus failing to impress the eye, by fifty per cent., with its relative merit in respect to length. The data upon which this project was based were so unsatisfactory to the Ludlow Commission that they reported for obtaining the necessary data for the formation of a final project, eighteen months' time, covering two dry seasons, and an expenditure of $350,000, will be required." A new commission has been appointed, and new surveys inaugurated; and it appears from the views of the individual members, as given before the select committee of the Senate in June, 1898, that the changes undergoing study are radical in their nature, and that, although some at least of the engineering difficulties which impressed the former Government Commission are recognized as grave, no means of avoiding them have yet been discovered. Under these conditions it is apparent that confidence cannot be accorded to such a project; and that really there is only one canal, that of Panama, whose construction could be judiciously undertaken at the present time. It to to be hoped before the Govermnent embarks on so important a work that the relative merits of the two routes will be examined and judged by a commission of expert engineers, for it is certain that only one canal is now needed, and that that one should be the best possible.

(We are indebted to Gen. Abbot for the profiles accompanying the above article. The two profiles have the same vertical scale; but the horizontal scale of the Panama profile is double the horizontal scale of the Nicaragua profile. The map of the Nicaragua Canal is reproduced from the map accompanying the report of the Ludlow Commission of 1895. The map of the Panama route is reproduced from a paper by Mr. Chas. D. Jameson, M. Am. Soc. C. E., in the "Journal of the Association of Engineering Societies" for August, 1886.—Ed. Eng. News.)

THE NATIONAL ACOUSTIC CO. has been organized, in Buffalo, N. Y., to carry out the ideas of Mr. E. Henri Kelly regarding the best form for churches and public halls with regard to their acoustic qualities. Mr. Kelly believes that these buildings should be so constructed that the interior should be shaped like the inside of an eggshell, and a church of that form has just been completed in Buffalo. Mr. Kelly's idea, however, was long ago adopted in the old Mormon temple at Salt Lake City; and it is a fact that this building has wonderful sound carrying qualities.

NOTES FROM THE ENGINEERING SCHOOLS.

Purdue University.—The engineering laboratory has, during the summer, been supplemented by the addition of a room 50×100 ft., known as the "Railroad Laboratory." In this room the equipment of machines for testing strength of materials, and the brake-shoe testing machine of the Master Car Builders' Association are already in place. There is also a full-sized model of the front end of a Richmond compound locomotive, and an exhibit of typical steel car trucks. The equipment of this room will be completed during the Fall by the installation of the air-brake testing rack of the Master Car Builders' Association. The number of students matriculating for the new year is larger than for several years past. The freshman class will number about 200, nearly two-thirds of whom are in the engineering courses. There are but few changes in the corps of instructors in the engineering department. Mr. Leopold O. Danse, for several years senior instructor in mechanical engineering, Lehigh University, has been appointed an instructor in machine design, and Mr. Robert S. Miller, assistant in the engineering laboratory, has been made instructor in the mechanics of machinery.

Public Appreciation of the Value of Engineering Education.—We frequently have complaints to the effect that the engineering profession is not as highly appreciated by the general public as it deserves to be, but there are indications that the public sentiment in this regard is gradually changing. We take pleasure in reprinting, as an evidence of this change, the following extracts from an editorial on "Progress in Education," in the "New York Tribune" of Sept. 27:

The increase of students in colleges and universities during the last 25 years has been very marked. In 1872 only 590 persons in 1,000,000 were enrolled as college students, while in 1897 the number had risen to 1,216 in 1,000,000, being more than double the number. Moreover, during the same period the standard of admission to colleges and universities has been raised to such an extent as to require an average of an additional year's work in preparation for the freshman class.

But it is in the remarkable multiplication of scientific and technical schools that education in this country best shows its value in fitting pupils for the duties of modern life. These schools have already gained a world-wide reputation. Pupils are sent to them from South America, Europe, and even from Asia, and their graduates are employed for difficult feats of engineering, mining and railroad building in every civilized country of the world. In the numerous developments of electrical science Americans now hold a position of unchallenged supremacy, and their future work in this fruitful field is likely to be still more important. Mechanical and electrical science is to-day revolutionizing the world, and is calling into its service a great army of able and brilliant men. The learned professions, important and honorable as they are and always will be, no longer dominate life. The real leaders of the world to-day, we may almost say the real builders of civilization, are the engineer, the electrician, the inventor, the man who, ignoring the barren logomachies of the philosopher, devotes his life to the discovery of some hitherto unknown law of Nature in order to make it serve the needs of the human race.

The only amendment we would make to "Tribune's" statement is to add the words "of law, medicine and theology" after the words "learned professions," for the words as they stand tend to give countenance to the idea that engineering is not a "learned" profession. No other profession has a stronger right to the title "learned." The engineering schools require of their entering students a higher standard of preliminary education, and their four years' courses are more severe, requiring longer hours of study, more intense application, and a stronger equipment of health of body and of brain to complete them, than do the professional schools of any other of the learned professions.

University of Wisconsin.—The Department of Electrical Engineering, which is under the charge of Prof. Dugald C. Jackson, has issued a circular giving the names of students who have taken degrees in electrical engineering during the last six years, with the positions now held by them. It states that over 20% of the members of the first five classes that graduated from the course have already become managers, chief engineers or superintendents in important industrial enterprises, and approximately 15% are teachers of engineering and science.

Rensselaer Polytechnic Institute.—H. H. Rousseau, of the class of 1891, Principal Assistant Engineer of the Pittsburg Bridge Co., stood first among the candidates in the recent examination held in Washington for civil engineer in the United States Navy. About 50 men started and 18 finished the examination. All these 18 were graduates of engineering schools. Last year at a similar examination, the papers of which were afterwards published in Engineering News, two other graduates of the Institute, Messrs. Chambers and Parks, stood at the head of the list. Another graduate, Mr. Arnold Sutermeister, of the class of 1892, recently passed first among the candidates for the position of Superintendent of Grade Crossings under the Railroad Commission of this state, and was appointed to that position.

Syracuse University.—The departments of civil and electrical engineering, physics and biology have moved into the new hall of physics, which is named after Mrs. Esther Baker Steele. Mrs. Steele will furnish the physical laboratories with a complete equipment of modern apparatus. The laboratories of the engineering departments have also been furnished with the best apparatus procurable.

Columbia University.—The list of appointments made since July 1 includes the following: Earl B. Lovell, C. E., adjunct professor of civil engineering. Richard S. McCaffrey, M. E., assistant in metallurgy. William A. Anthony, Ph. B., lecturer in electrical engineering.

Cornell University.—A portrait of John Fritz, the famous metallurgist and engineer, founder of the Bethlehem Iron Works, has been added to the portrait gallery of Sibley College.

George H. Shepard, Assistant Engineer, U. S. Navy, has been added to the staff of Sibley College and will have charge of the work pertaining to elementary steam engines.

Dexter S. Kimball, Stanford, '96, has been appointed instructor in machine design.

The new hydraulic laboratory of the College of Civil Engineering in Fall Creek has been formally transferred to the custody of that college. The laboratory will be in charge of a new professor, G. S. Williams, Michigan, '89, whose chair has just been created. Professor Williams has spent the nine years since graduation in the city waterworks construction, on the U. S. Lighthouse Board, and as civil engineer to the Detroit Board of Water Commissioners.

Fifteen graduates of Cornell are serving in the Volunteer Engineer Corps of the army. Forty Cornell men tried the examinations and all passed and were put on the eligible list, but 25 did not receive appointments because the lists were full when the war closed.

THE METROPOLITAN AND BELT RAILWAYS OF BERLIN.

(With two-page plate.)

In the May number of the "Revue Generale des Chemins de Fer" is a lengthy illustrated description of the Metropolitan Railway of Berlin, from which we abstract the following:

As long ago as 1872 the Deutsche Eisenbahnbau-Gesellschaft asked for a concession for building a railway through the city of Berlin; but as the cost was then estimated at 150,000,000 marks, the scheme was abandoned. The project was taken up again in 1873-74 by the Berliner Stadt-Eisenbahn Gesellschaft, and a contract was made with the city on March 20, 1874. The capital was fixed at 48,000,000 marks; and of this amount the state was to pay 21,000,000 marks, the construction company 12,000,000, and the three railways interested the remainder. A beginning was made; but a new agreement was entered into in 1878, raising the required capital to 65,100,000 marks, and modifying the original project by providing four tracks throughout. After much debate it was finally decided that no goods should be transported on this line, and that the four tracks should be devoted solely to the service of passengers; that the line should not be independent of the railways entering the city, but intimately united at all points with them; for the convenience of passengers arriving in the city. It was also decided that the tracks must be elevated in every part, so as not to interfere with surface traffic.

While work was actually commenced on the viaduct in the autumn of 1875, the slowness of appropriations and the modifications of plans found necessary delayed progress to such an extent that at the end of 1877 only about 3,000 lin. ft. of the viaduct were completed. In 1878 the Government actually took hold of the construction, and in this one year finished 9,184 ft. of the line and had half as much more under construction. Work now progressed rapidly and the line was opened, for city travel at least, on Feb. 7, 1882; and on May 15, 1882, it was ready for the terminal traffic of the great railway lines. The line was generally built by contract under State supervision, the State itself only building some special parts of the work. The operation of the railway was placed under the direction of the State Railways, Berlin System, by a decree of Aug. 18, 1881.

The actual cost of the construction of this system was 68,129,000 marks, or $17,032,250. This sum includes a portion of the cost of the terminal station at Charlottenburg, and the reconstruction of the other terminal station at Silesia. The

MAP OF THE NICARAGUA CANAL.
(Reproduced from a map accompanying the Report of the Ludlow Commission of 1895.)

whole cost was divided as follows, figured in marks, worth 25 cts. each:

	Marks.
Land acquired	33,305,184
Viaduct construction	18,602,212
Earth work	198,000
Superstructure, including falseworks	2,191,573
Signal system	281,740
Stations	7,870,869
Rolling stock	2,424,449
Engineering supervision	2,131,812
Miscellaneous expenses	737,898
Interest on capital during construction	384,062
Total	68,128,699

Since the completion of the work in 1882, little of any importance has been done; the additions only include new posts for the block system used and two new stations, opened in 1885 and 1896, for city service.

A general description of the Metropolitan Railway can be given as follows: The total length of the system, including the terminal stations of Charlottenburg and Silesia, is 39,835 lin. ft., or nearly 8 miles. Of this length, 16,038 ft. is curvature with radii of from 918 to 1,640 ft.; the grades are light, and the difference in level between the two ends is only 2.3 ft. In the central part of Berlin the viaduct is generally masonry, with the streets crossed by girder bridges, with a minimum clearance of 14.43 ft. under the lower chord. In only a few cases was it necessary to change the grade of the streets crossed. At the extreme ends the tracks rest upon simple earthen embankments, for lengths of 2,214 and 5,520 ft., respectively; but the remainder of the system is divided into 26,122 ft. of masonry viaduct, including masonry bridges, and 5,979 ft. of metallic viaduct and bridgework. The free space beneath the masonry viaducts is utilized for shops and storehouses near the streets crossed and wherever the viaduct borders on parallel streets.

The system has four tracks throughout; with the two northern tracks reserved for city service and the secondary stations, and the other two tracks are set aside for the service of the trunk line railways and the great stations. These two sets of tracks are separated by a central space generally 4 m., or 13.12 ft. wide. The rails were originally placed upon steel ties of the Haarmann type; but owing to rapid deterioration these ties were only retained upon the bridges and some other places where it was difficult to replace them, and heavy wooden ties were substituted, with eleven ties to every 27.5 ft., or one rail length. The first rails used weighed about 54 lbs. per yard; but those now laid weigh about 70 lbs. per yard, and to add to the security of the line an interior guard-rail is laid on all curves. The eleven stations vary in distance apart from 2,263 ft. to 5,543 ft.

There are five main stations open at all times to both city service and that of the trunk railways; while the intermediate stations are used only for city traffic. The general plan of the main stations is as follows: The station itself is formed by a widening of the viaduct, as indicated in the plan, with the two central tracks preserving their normal alinement and the two outer tracks widening out sufficiently to permit the establishment of the two platforms between them and the straight inner track. These platforms have a width of from 32.8 to 49.2 ft., and a length varying from 656 to 820 ft.; they are provided with six spacious stairways, three to each platform. The stairs for city service are divided into two parts by a central railing, one side being used for ascent and the other for descent; the entrance upon the platform is through a gateway where one employee receives the tickets of descending passengers, and another punches the tickets of ascending passengers. The public were formerly freely admitted to the platforms of the main stations; but admission is now only possible on the payment of 2½ cts., or the lowest fare. Beneath these platforms is a large room enclosing the stairways and accessible from two sides, extending the full width of the viaduct; and in this room are the ticket offices, distinct for the two services, placed near the stairways. There are also rooms for the reception and distribution of baggage, waiting rooms for the separate classes of passengers, a restaurant or buffet, water-closets and a police station. There are also offices for the operators of the line and storehouses, for tools, oil, etc.

On the level of the rails the entire space, including the platforms and lines of rails, is covered over by one corrugated, galvanized iron roof, generally semi-circular in form, and closed at the sides by light walls about 23 ft. high. This upper station varies in length from 475 to 538 ft., and in width from 115 to 131 ft.; it is lighted by a monitor running the length of the top and by side windows. At each end of the platforms of main stations are installed hydraulic elevators for handling baggage; indicator arms announce the destination of the coming train, for both tracks, and between the central tracks a fence completely isolates the two services, with a passage through it for the use of employees only.

The lower part of the station is warmed by steam heat to a nearly uniform temperature of + 20 C. when the outside temperature is — 20 C. The lighting is assured in the daytime by windows and a glass pavement between the central tracks, and at night by arc lamps. Advertising was at first prohibited in these stations; but a recent decree permits the placing of advertisements in the waiting rooms and vestibules and also on the curved ends of the platforms, an annual revenue of about $25,000 being now secured from these privileges. The writer of the article trusts that the administration will not be led into temptation by this revenue and permit such abuse of the available space as to make these advertisements a nuisance to the public—"as in England."

At the smaller stations the structure only covers the tracks for city service; or the two northern tracks. The outer track is widened out as before for the reception of one platform having a width of 23 or 30 ft. and a length varying from 426 to 558 ft. The lower story is usually raised about two steps above the street, and includes a large hall, waiting rooms, two water-closets, and offices for the employees. There are usually two stairways, and on the level of the rails is a glazed kiosk at the head of the stairs for shelter from the wind, and another kiosk for the stationmaster, telegraph, signals, etc. The platform and two tracks are roofed over for a length varying from 164 to 492 ft. and for a width of 39 to 52 ft. This shed is lighted by a monitor in the roof and by windows in the lateral walls.

The Belt Line Railway, which with the Central Metropolitan Railway makes up the city system, has replaced the so-called Junction Railway, built in 1851 to unite the stations of the trunk railways existing at that time. The definite plans for the belt line were adopted and the first work was commenced upon it in 1867. It was constructed entirely by the State, the first section being opened in 1871 and the circle finished in 1877. It was generally upon embankment, with some parts in cutting and a small part on the level of the surrounding country; it was built for double track, and the original completed cost was $6,948,500. The connection of this belt line, in 1887, with the central rapid transit system, gave it a greater importance than before, and the line now has four tracks, the stations have been remodeled and increased in size, and a number of new stations have been built; all grade crossings have also been removed. These improvements represent an expenditure of about $5,848,000.

This Belt Railway forms a continuous line 23.37 miles long, completely surrounding the city. But since the opening of the Metropolitan line it has been divided into two sections, the North and the South Belt, each of which, with the great diametrical artery, forming a complete circuit about the two semi-circular parts of the city, north and south. Upon these two circuits are located 22 stations. The details of construction on the central viaduct and upon the belt line are not entered into, but the illustrations given sufficiently indicate the character of the Metropolitan viaduct, the more important of the two in this connection.

STRESSES IN RAILWAY RAILS UNDER MOVING TRAINS.*

Our present railway rails are in reality girders supported at many points, more or less elastic, upon which the weight of the locomotive or train is concentrated at a few points, i. e., the points of contact between the wheels and rails. There is a great diversity of opinion respecting the proper weight and shape of rails. In assuming that the rail acts as a girder, a perfectly proper assumption, and in making calculations on that basis the uncertain factor is that the point of support is indefinite, owing to the compressibility of ties and ballast. As the load rolls onto any section, the rails deflect, Fig. 1, and the ties, ballast and roadbed are compressed until action and reaction are equalized, or until the resistance of the roadbed equals the load imposed, the greatest deflection, as would be expected, occurring directly under the points where the load is applied. There is an unmistakable compression of the fibers in the head of the rail under the rolling contact, Fig. 2, a tension on the lower or base side of the rail and a shearing stress across the rail section at or near the ties which at that instant are bearing the load. The span of the deflection of the rail under the wheel is as a rule longer than the tie spacing. At a point a little distance on either side of the wheel the stresses are reversed, the head of the rail becoming in tension and the base in compression. The general effect of the weight of a locomotive and tender upon the track and the distribution of this weight from the track to the ties, ballast and roadbed, as just described, is shown in Fig. 1, which represents the base and wheel loads of a 100-ton Boston & Albany locomotive standing on 95-lb. rails. In plotting this the vertical scale was enlarged to make the depressions more distinct. The engine truck wheels carry 20,350 lbs. per pair; the drivers 37,500 per pair; the front tender truck wheels 18,500 per pair, and each pair of wheels in the rear truck, 23,500 lbs.

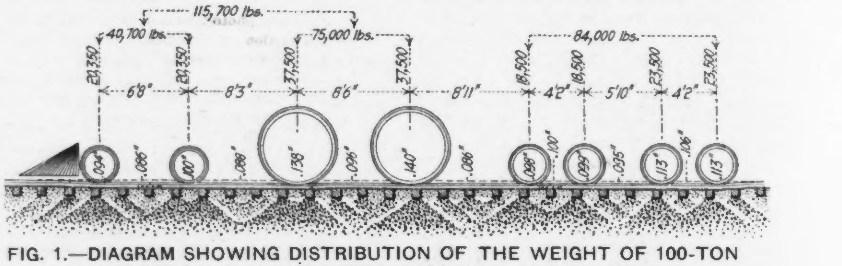


FIG. 1.—DIAGRAM SHOWING DISTRIBUTION OF THE WEIGHT OF 100-TON LOCOMOTIVE AND TENDER, BOSTON & ALBANY R. R.

The depressions of the rail were found to be 0.094-in. under the front truck wheel of the engine; 0.086-in. between the wheels and under the rear truck wheel 0.100-in. In the wheel space between the truck and the drivers the depression was 0.088-in. Under the front driver it was 0.138-in.; be-

*Abstract of a paper read by P. H. Dudley, C. E., before the New York Academy of Science and printed in the Academy Annals for 1898.

TABLE I.—Maximum Fiber Stresses in Base of Rail.

Weight of rail per yd.	Ballast.	Locomotive.	Weight in lbs.* Total.	Engine. Pilot.	Engine. Drivers.	Tender.	Tensile fiber stress, per sq. in. Pilot.	Drivers.	Tender.
60 lbs.	Broken stone	Freight, No. 557 R.	188,600	11,000	113,800	63,800	11,160	16,050	9,770
70 "	" "	" "	188,600	11,000	113,800	63,800	6,470	11,510	6,470
85 "	" "	" "	188,600	11,000	113,800	63,800	4,300	10,030	5,020
100 "	" "	" "	188,600	11,000	113,800	63,800	3,510	8,430	4,220
60 "	Stone	Passenger, No. 806 Pk.	197,050	39,750	87,300	70,000	11,860	19,540	9,770
70 "	"	" "	197,050	39,750	87,300	70,000	10,070	14,390	7,910
85 "	"	" "	197,050	39,750	87,300	70,000	7,160	10,750	4,300
100 "	"	" "	197,050	39,750	87,300	70,000	6,320	9,840	5,620

*To obtain weights on one rail these values must be divided by 2.

tween, it decreased to 0.096, while under the rear driver it increased to 0.140-in. These and the depressions found under the tender are shown in the figure. The amount of tension and compression in the different portions of the rail were measured by the Dudley "Stremmatograph," a device which is clamped to the rail at any desired point and records on a moving metallic strip the compression or elongation of the metal in a given length of the rail base. The section included is 5 ins. and the changes induced in this

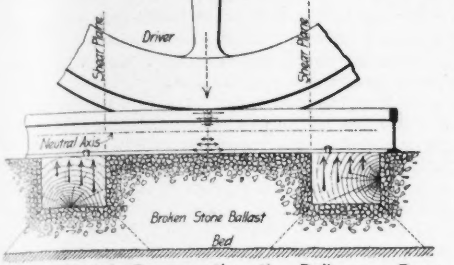


Fig. 2.—Sketch Representing the Rail as a Beam with Load Concentrated Between Ties.

by the load rolling over the rail or standing above moves a system of multiplying levers which shifts a scriber which in turn traces a curved or wavy line upon the record plate. The departure of this line from a datum line, ruled when the track is not loaded, affords a direct measure of the tension or compression induced.

In the case under consideration the following

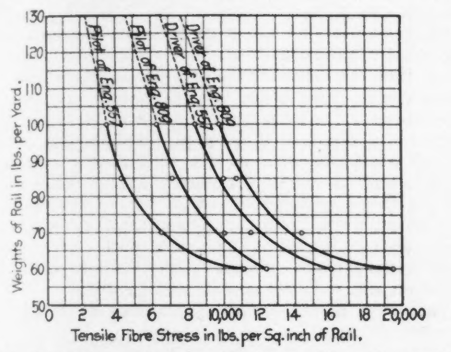


Fig. 3.—Curves Showing Maximum Fiber Stress in Base of Rail; Plotted from Values in Table I.

results were obtained, the values being reduced to apparent stresses per sq. in.:

	Tension, lbs.	Compression, lbs.
Front engine truck wheel	6,780	.....
Center of wheel space	.....	1,530
Rear engine truck wheel	5,340	.....
Center space bet. rear trk whl & driver	.....	3,050
Front driver	9,160	.....
Center of space between drivers......	.....	3.050
Rear driver	9,920	.....
Center space, drivr & front tendr whls	.....	2,290
Front truck front tender wheel..........	3,820	.....
Center of space between wheels	.....	760
Front truck rear tender wheels.........	3,820	.....
Center space between tender trucks..	.....	1,530
Front wheel rear tender truck..........	6,100	.....
Center of space between wheels	.....	0000
Rear wheel of rear tender truck........	6,870	.....

Further experiments along these lines were conducted since 1895 by Mr. Dudley and Mr. James E. Howard, Engineer of Tests at the Watertown Arsenal, Watertown, Mass., and the results of some of these tests are given in Mr. Dudley's paper. In Table I., which has been prepared from these data, it will be noticed that records were taken with two locomotives, a freight and a passenger, running on different weight rails (described in Table II.), using stone ballast in both cases. The curves in Fig. 3 are plotted from the figures given in Table I. for the tensile stress per sq. in. in the base of the rail due to the trucks and the drivers. While there are too few points to make these curves more than approximate, their general agreement in direction affords a sufficient check to permit their use to present to the eye the results obtained by the use of the Stremmatograph.

With the two locomotives used in the tests it will be seen that in rails below 70 lbs. per yd. the stress increases very rapidly. Tracing the curves in the other direction they are seen to become much steeper and straighter, showing, from about 90 lbs. on up to 125 or 130 lbs. per yd., almost a straight line with a slope of approximately 1 to 40, or a decrease of 40 lbs. per sq. in. in tensile stress for each pound increase in weight of rail per yd.

The fact that the Stemmatograph records directly with a considerable degree of accuracy the extension and compression of rails under moving loads, and hence, though indirectly, the stresses induced by the moving loads suggests its use for solving the mooted question of locomotive balancing and just what shape and disposition of counterbalance produced the least shock to track and bridges. It would settle once and for all the dispute as to the pounding produced by the present method of counterbalancing, and answer the question: Does a uniform wave of deflection travel along the track with the train or are there recurrent points of greater deflection and therefore greater strain when the counterbalance is up or down?

A number of instruments could be mounted, on any section of track, in connection with photographic apparatus in such manner as to record the extension of the rail base and the position of the counterbalance at the instant the driver was over the instrument. By doing this with several engines at different speeds data could be obtained and comparisons made by means of curves which would show what really occurs when an engine runs over a track under working conditions of weight and speed.

TABLE II.—General Dimensions of Rails.

Wght, pr yd., lbs.	Height, ins.	Width, Base, ins.	Width, Head, ins.	Thickness, web, in.	Moment of Inertia, I.	Moment of Resistance, $R = \frac{I}{n'}$	Distance neutral axis to outside fiber, Head, n.	Distance neutral axis to outside fiber, Base, n'.
60	4¼	4¼	2⅜	½	14.222	6.693	2.125	2.125
70	4½	4½	2⁷/₁₆	½	18.055	8.282	2.32	2.18
85	5	5	2⁹/₁₆	¹⁷/₃₂	26.374	10.853	2.57	2.43
95	5¹/₃₂	5½	3	⅝	32.280	13.563	2.65	2.38
100	5½	5½	2¹³/₁₆	⅝	38.957	14.812	2.87	2.63

PHOTOMETRY OF THE ENCLOSED ALTERNATING ARC LAMP.*

Arc light photometry, in so far as it involves the mere determination of luminous intensity yields unsatisfactory results for three reasons: The first is the marked difference in quality between the light of the arc and that of any of the ordinary standards. The photometrist realizes the general unsatisfactory character of the existing standards for the study of sources of a quality similar to that of gas light. Nevertheless, he is vastly better off, in this respect, than he is in the matter of a standard of suitable quality and intensity for arc light measurement. The eye estimates accurately an equality of brightness in two surfaces only when those surfaces are of the same tint. Moreover, with a color difference, the judgment of an equality differs with different observers. It should be said, however, that the difficulty arising from difference of color is less troublesome in the case of the enclosed arc than in the case of its progenitor, the open arc. The inner, opalescent globe absorbs the rays of short wave-length in greatest proportion, a fact which brings the color of the arc nearer that of the standard. When an outer globe of milky glass is used—the standard being a glow lamp maintained at, or above, its normal voltage—there is no annoyance from color difference.

The second obstacle to careful measurement is to be found in the variability of the quantity to be measured. These variations are largely due to the wandering condition of the arc—a peculiarity that is especially noticeable in the open alternating arc, and in both types of the enclosed arc. Indeed, it is to this feature of the enclosed arc that the flat-ended carbons are due. The change in luminous intensity corresponding to a shifting in the position of the arc from one side of the carbons to the other side is enormous.

To arrive at a fairly close value it was necessary to take the average of a number of readings. This required the construction of a special recording device which permitted rapid readings to be automatically recorded. This consisted of a long cylinder arranged just under the scale of the photometer and a marking point attached to the carriage which, when depressed, recorded the carriage position upon the cylinder. The details of this device were illustrated and described. Further apparatus, consisting of a Krüss-Bunsen photometer, a swinging crane with a 45° mirror, an incandescent glow lamp, a Hefner standard lamp, and various voltmeters, ammeters and wattmeters were employed.

A number of enclosed alternating current arc lamps placed at the disposal of the authors by their manufacturers were investigated very fully, and the paper described in detail the various tests and the results obtained.

*Abstract of a paper presented by Messrs. C. P. Matthews, W. H. Thompson and J. B. Hilbish at the last meeting of the American Institute of Electrical Engineers held Sept. 28.

The experiments show with considerable certainty that the economy of the alternating arc is less than that of the direct current lamp; that the use of opalescent globes materially reduces the candle power and that the great and rapid variation or fluctuations of intensity are due to the hunting of the arc rather than to any shifting of the carbons.

In opening the discussion Mr. L. B. Marks said that to his mind the first part of the paper was of the most value. There was a difference in the color of light to contend with, which made the setting of the photometer carriage difficult. An example of this was the Hefner lamp which has a reddish flame and the arc lamp which was decidedly violet. The sensation of color had a great deal to do with lights and there was no photometer which would take full account of this. The use of opalescent globes, he thought, had a tendency to change the quality of a light and to interfere with a correct comparison of the candle powers of a standard, such as the Hefner lamp, and an enclosed arc. He asked if the authors had not reversed "hunting" and its cause, and explained that he considered the flat ends of the carbon due to the burning with limited amount of oxygen and the hunting a result of the flat ends. The recording device was a good idea and likely to be of service to allusing photometers.

Mr. W. H. Freedman said that the flat ends were bound to result where the carbons were enclosed, and as the arc would always seek the path requiring the least expenditure of energy, hunting would naturally follow. His experience had been that in considering the alternating arc there was a power factor other than that due to the inductance of the mechanism. Its existence would be shown by determining the actual watts with a wattmeter and the apparent watts from voltmeter and ammeter readings.

He regretted that the results given in the paper were not in candle powers, as engineers were familiar with such units and could more readily make comparisons. The character of globe used made a very decided difference in the distribution of light and was quite capable of causing the difference in the form of curves which were shown in the paper.

Capt. John Millis, of the U. S. Lighthouse Board, asked Mr. Marks to explain more fully what he meant when he said that there was a difference between candle power and luminosity.

Replying, Mr. Marks stated that the term candle power implied a comparison. In the case of two candles the quality of light was the same; between a candle or a standard of some sort and an incandescent lamp a difference of quality might exist and there would be a still greater difference between the standard and an arc light. The latter might be 400 times as intense under a photometric test, but would it, if put in a room or out in the open, allow the observer to read or observe 400 times as clearly or as well. In other words, does not the illuminating power depend upon the use to which the light is to be put. There is something missing in the term candle power, for it should take into account the quality.

Capt. Millis considered it quite possible to obtain fairly close approximations notwithstanding slightly varying standards and different colors. In light-house work the vital question was how far could a certain light be seen, while in ordinary commercial work it was how much light. Two candles would give twice the light but they could not be seen further than one. The automatic recording device was good and would greatly facilitate photometric observations. Referring to the custom of painting the interior of photometer rooms all black, he had found that an arrangement of curtains was possible whereby the room could be white, or at least not black, thus making it pleasant to work in.

Open alternating arcs, as far as his experience went, had proved very satisfactory, especially with cored carbons. Prof. A. E. Kennelly said that engineers in making lamp tests should not forget that the ordinary buyer judges by appearance and prefers a pleasant and steady light without so much regard to its quantity. In considering the candle power of a lamp he favored the mean spherical candle power which could be described by calling it that light which could be caught up by a bag surrounding the lamp. The variation in candle power so frequently referred to he believed to be more largely a variation in direction than in the total candle power.

PAPYRISTITE is a new artificial stone, made from purified paper pulp and other ingredients by Fr. Gehre, a civil engineer of Zurich. It is an improvement on papyrolitte, invented by the same man. It is especially intended for jointless roofs or floors, and is a non-conductor of heat, cold or sound. It is hard as a stone, but has a soft, linoleum-like feeling under foot, and is noiseless. It weighs less than stone or cement, and 220 lbs. of the preparation in powdered form, spread 0.4-in. thick, will cover 90 sq. ft. The cost is said to be exceedingly low, and it can be laid without special machinery; it is dry in 24 hours and can then be highly polished. The Papyristite Co., Post Fach 10,409, Zurich, Switzerland, will supply samples at \$4.50 per 220 lbs., free on board cars at Zurich, to those wishing to make experiments.

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We are glad to record that each of the great political parties in the state of New York has formally promised the voters that if it is placed in power it will visit with exemplary punishment those who have been responsible for the wholesale frauds on the New York State Canal improvements. The planks on this subject in the two party platforms are as follows:

Republican.

We pledge the candidate this day nominated to a resolute and thorough continuance of the investigation, so fearlessly begun by Gov. Black, into all alleged mismanagement of the canals. If there are errors in the system and the law, we will correct them. If there has been fraud, we will detect and punish the wrongdoers.

Democratic.

We pledge the people an honest and economical administration of the canals of the state; no squandering of the public moneys; no more millions to be stolen, wasted, or needlessly expended, as reported by a Republican investigating commission to have occurred with the nine-million canal improvement fund; all public contracts to be fairly and honestly awarded to the lowest bona fide bidder; no special privilege to pet surety companies favored by political influence. We favor a reduction of canal expenditures, and are opposed to the intrusting of the work of carrying on further canal improvements to Republican officials responsible for the prodigality, favoritism, and corruption which has characterized the present administration of the canals. Reform in canal management is the supreme issue of the hour. We promise the taxpayers that, if intrusted with power by the votes of the people, there shall follow a vigorous procedure on all canal officials implicated in the theft, waste, or misuse of the public moneys, and the recovery of so much of the diverted funds as it may be possible, by diligent effort, to procure through legal proceedings.

We need make no comment on the above pledges. Either of them could easily be criticised from the point of view of the other side; but either of them certainly commits the party responsible for it to a vigorous prosecution of those who are responsible for the loss to the state treasury of over a million dollars. The high character of the candidate named by each party for the office of Governor gives good ground for the belief that the party pledges above quoted will be faithfully kept; and this outlook must give satisfaction to every friend of good government.

In our opinion this matter of uncovering the canal frauds and visiting the penalty of the law upon those responsible for them is the most important issue by far before the voters of New York. The men who were false to their trust and who secured the state's money by unlawful means did so with their eyes open and with the full knowledge that they were committing a misdemeanor, for which the penalty is imprisonment. They deliberately took the chances, believing that the political influence behind them was strong enough to keep them out of trouble. If they are right, and if they escape scot-free, a precedent will be established in the conduct of New York's public works that will not be forgotten. The state may as well say good-by to honest work and honest administration hereafter, unless it can prove its ability to inflict exemplary punishment on those who have proved so false to their trust.

We sincerely hope and believe, therefore, that whichever party's candidates may take the state government next January, those responsible for the canal frauds will receive the punishment their deeds deserve. It should not be overlooked that the injury they have done is not measured alone by the direct loss to the state treasury in dollars and cents. Every such case of dishonesty in public office and disregard of the obligations of trust, strikes at the very root of popular government. If public officers may make merchandise of their positions with impunity, the state certainly cannot safely undertake the construction of great public works. Nay, more: it cannot even fulfil the ordinary governmental obligations to punish crime, protect persons and property and maintain public order. If those who are engaged on public works may use their official position for their own or even for their party's gain, why may not those who detect and punish crime and those who administer justice do the same? This means, it is true, the blackmail of the innocent, the shielding of the guilty for a bribe and the sale of justice to the highest bidder; but it is only the logical result of such frauds as those on the New York State canal works, if allowed to go unpunished.

In the conduct of the late war, no one feature was more faulty than the transport of troops and supplies on ships commanded by civilian sailors nominally under the control of the Quartermaster's Department of the Army. From the hasty shipment of troops at Tampa to the carriage of sick soldiers home from Cuba and Porto Rico, the accounts of the work done by these transports furnish evidence of the lack of experience of the army officers in responsible charge and of the insubordination of the civilian captains of the vessels. At Santiago, for example, these captains, instead of anchoring where they could be found, put to sea whenever they pleased, with their holds full of food, ammunition, and supplies imperatively wanted on the fighting lines. The officers of the quartermaster's department, who were nominally over the captains of these transports, were, in nine cases out of ten, too ignorant of the handling of ships and their cargoes to exercise anything more than a nominal authority, and the result was a disorganization and lack of system that called forth expressions of astonishment from the foreign military attaches.

It seems to us that in considering how to remedy this evil we will do well to look to the practice of England, whose experience in conducting military operations in foreign lands exceeds that of any other nation. When British soldiers are transported by the sea they are simply passengers on Her Majesty's ships; and every army officer on board below the grade of captain is under the immediate command of the captain of the ship, and the senior naval officer present. In other words, this transport service is entirely in the hands of the naval establishment. The men who are thus placed in responsible charge are not only experts in the handling of ships and the transport of goods and passengers by sea, but are subject to rigid naval discipline and are under the direct orders of the naval commander in chief. There is no division of authority under this system, and the troops and their supplies are moved and landed with certainty and despatch.

The need for a reform in the transport service has been brought to the attention of the War Department by Captain F. M. Dickins, U. S. N., of the Bureau of Navigation; and it was proposed to convene a joint board of army and navy officers to discuss this subject and submit a plan for the more perfect carriage of troops and supplies at sea. The army, however, has declined to accept this invitation, and unless Congress intervenes and orders some change in the system the transport of troops for the occupation of Cuba is very likely to result in the repetition of past scandal. The army proposes to improve the ships used for transport service, as we have already recorded; but it had no officers experienced in handling vessels, loading and discharging them, and caring for the men and materials on board ship and must continue to rely on civilians for this service. It is too much to expect, however, that the civilian sea captain in charge of a vessel will be really subordinate to a landsman, ignorant of nautical matters, and the division of responsibilities can work only mischief in the future, as it has in the past. The refusal of the army to even discuss this subject with the naval authorities is most regrettable. Apparently the army authorities feel that the movement of the troops is their business alone, with which the navy has no business to interfere. As we said before, however, the movement of men and materials in ships is not the business of the army, and it is to be hoped that Congress will place the responsiblity for this important evil where it belongs.

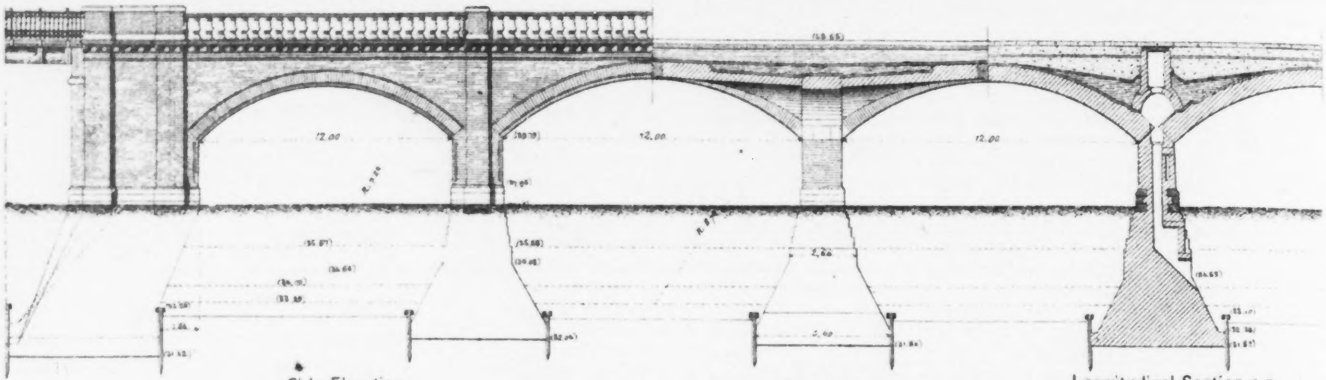
THE PRESENT STATUS OF THE PANAMA CANAL ENTERPRISE.

Elsewhere in this issue we present a carefully prepared paper by Gen. Henry L. Abbot, U. S. A., on the present status of the Panama Canal enterprise. As the American member of an international commission of engineers appointed to report upon the plans for the completion of the Panama Canal, Gen. Abbot has personally examined the works at the Isthmus and has studied in every detail the plans now adopted for finishing this great work. As most of our readers are aware, Gen. Abbot is one of the most eminent members of the Corps of Engineers, and was in charge of important works from his assignment to duty with the Corps at the close of the war until his recent retirement for age. General Abbot's distinguished position and wide reputation as an engineer make whatever he has to say on the Panama canal matter worthy of serious consideration.

It must be confessed that up to the present time American engineers have been inclined to receive with a good deal of incredulity the reports concerning the resumption of work at Panama. It has seemed impossible from both the engineering and financial point of view that the terrible wreck in which the De Lesseps' scheme was involved could ever be repaired. It is apparent that those in charge of the new Panama Canal company realized that it could only be done by beginning wholly anew and by laying a foundation of careful engineering preparation, the lack of which was one chief cause of downfall of the De Lesseps company.

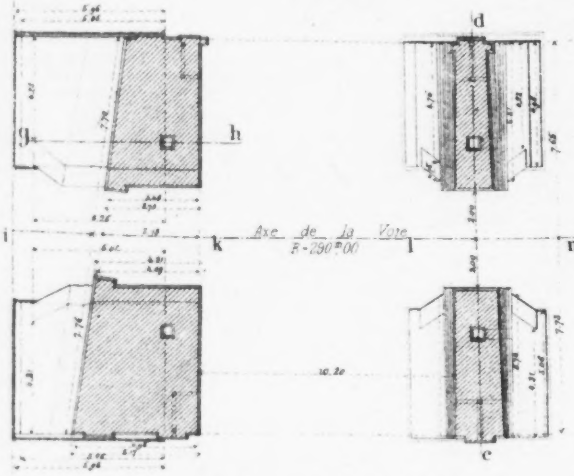
As some of our readers may recall, after the Panama bubble burst in 1890, and work on the canal came to a standstill, the company's affairs were placed by the courts in the hands of a "liquidator," or receiver, as we should say, who remained in charge until 1894, when the concession and all the assets of the old company were transferred to the new company.* According to information from official sources, this new company was organized by leading bankers and financiers of France who had no connection whatever with the old company, and by them a working capital of $13,000,000 was subscribed. In taking over the old company no cash was paid for its assets; but the holders of stock in the old company are entitled to receive a certain portion of the residuary profits of the new company from the working of the canal, should there be such

*A partial list of the officers of "la Nouvelle Compagnie du Canal du Panama" is as follows: President, M. Bannardel (said to be also President of the Western Ry. Co. of France, though his name does not appear in the International Directory of Railway Officials for 1898); Directors, M. Brolemann, of the Credit Lyonnais; O. Mellon, a Director of the Comptoir Nacional D'escompte of Paris; MM. Chanove, De St. Quentin and others; Director-General, M. Maurice Hutin; Company's Agent in New York, X. Boyard, 29 Broadway; Attorneys in New York, Sullivan & Cromwell, 45 Wall St.

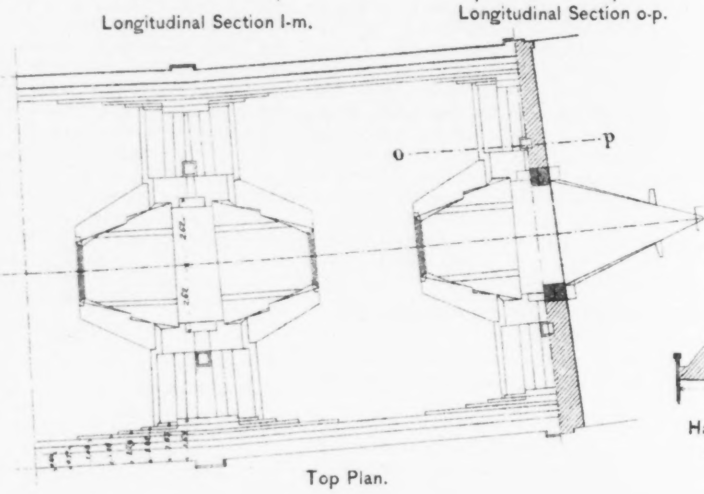


Side Elevation. Longitudinal Section l-m. Longitudinal Section o-p.

Transverse Se



Sectional Plan at Springing Line of Main Arches.



Top Plan.

Half Transverse Section g-h.

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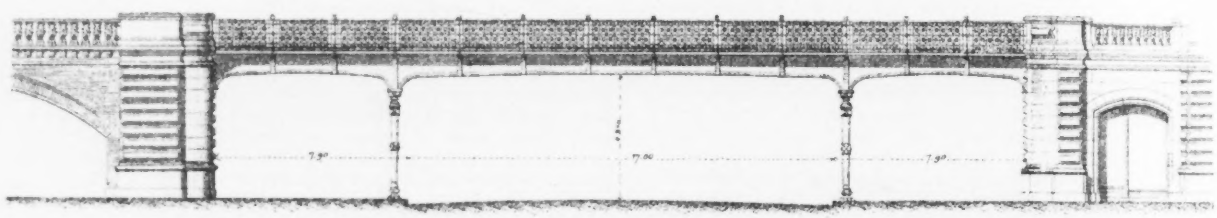
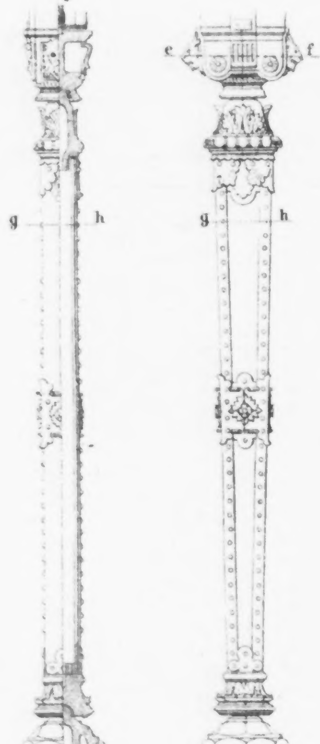
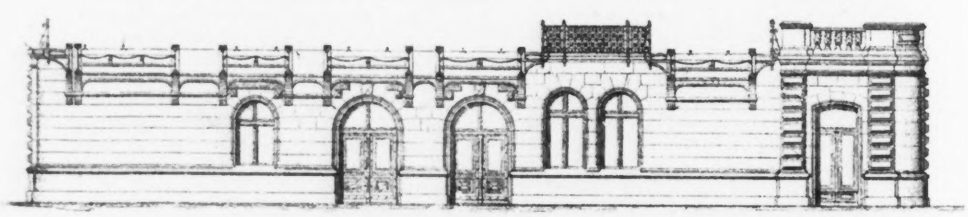
TYPICAL MASONRY VIADUCT.



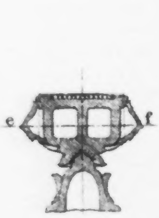
Side Elevation.



Column Details.

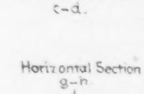


Transverse Section of Superstructure and Elevation of West Abutment.

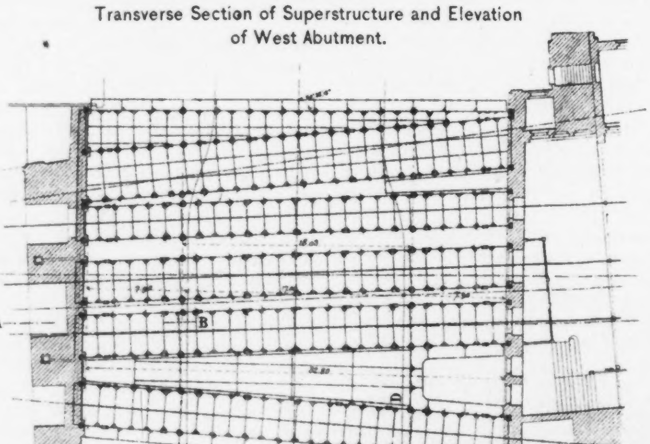


Vertical Section c-d.

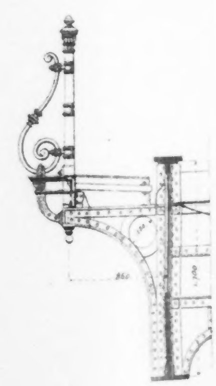
Horizontal Section g-h.



Horizontal Section e-f.

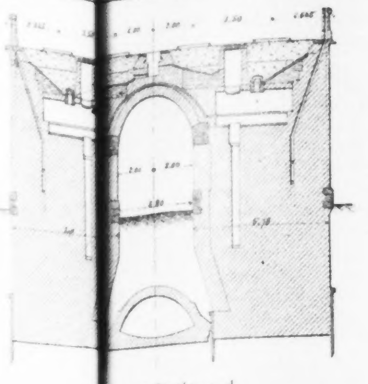


Sectional Plan.

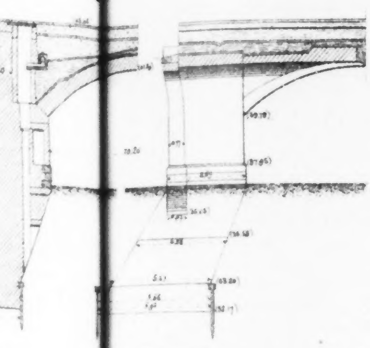


Transverse Section C.D. on Plan.

BRIDGE OVER KOENIGSSTRASSE.



Tr nsverse Section c-d.



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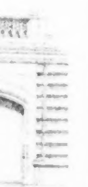
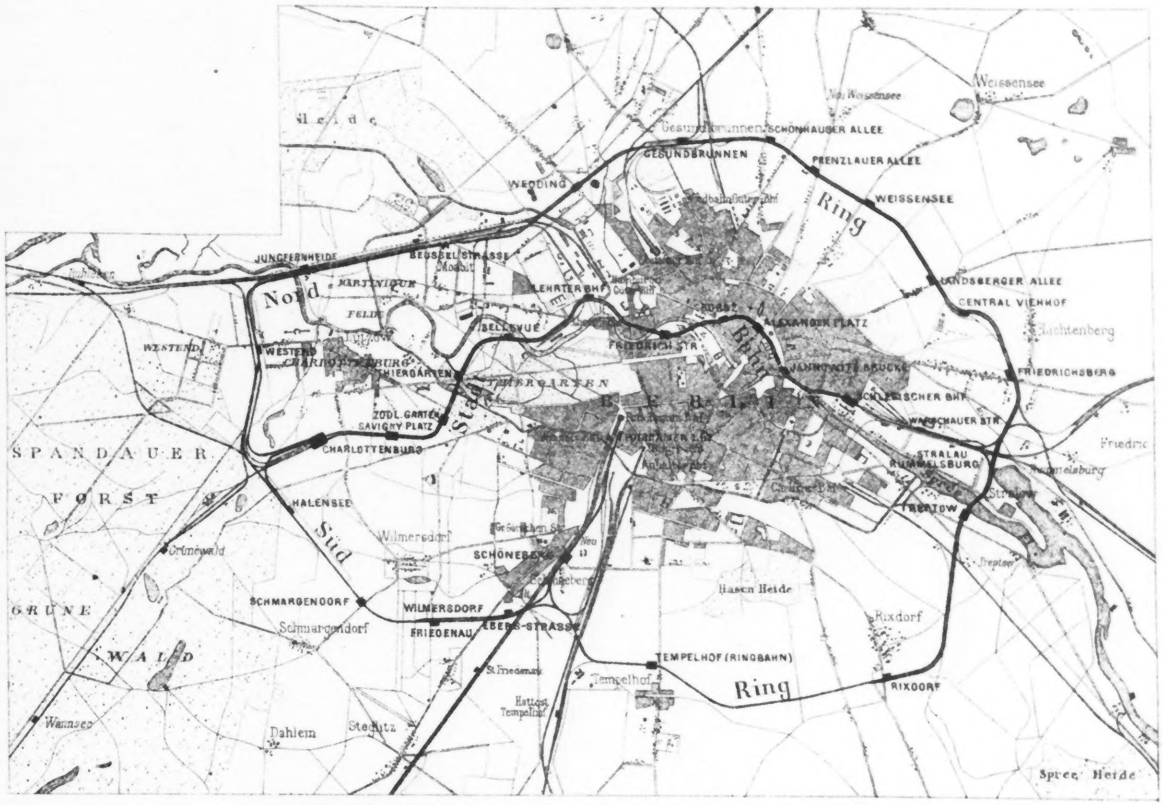
Half Transverse Section i-k.





GENERAL PLAN OF THE BERLIN METROPOLITAN AND BELT RAILWAY.

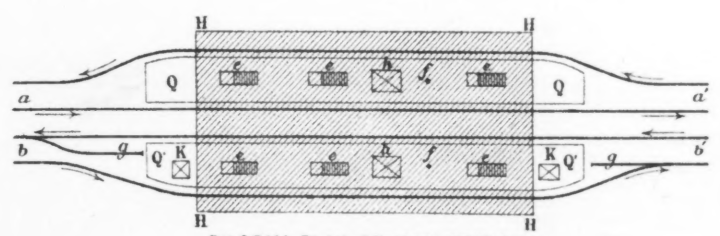


DIAGRAM PLAN OF MAIN STATION.

H. H. H. H. Dimension of Shed.
a a' Urban and Suburban Lines.
b b' Trunk Line Service.
Q Q Q' Q' Passenger Platforms.
e. e Stairways to Platforms.
h h Offices.
f. f Posts Indicating Destination of Trains.
g g Sidings for Several Cars.
K. K. Hydraulic Baggage Elevators.

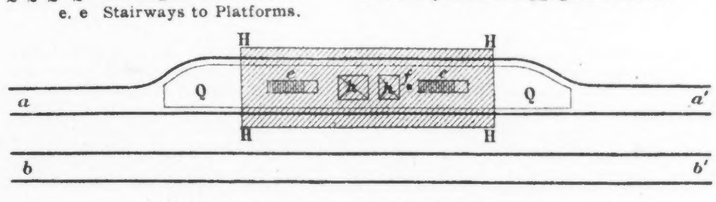
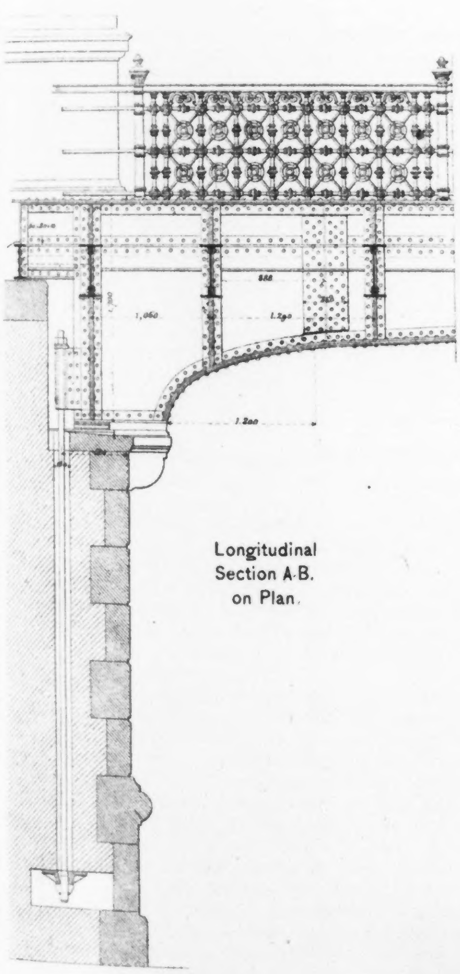


DIAGRAM PLAN OF SECONDARY STATION.

H. H. H. H. Dimension of Shed.
a a' Urban and Suburban Lines.
b b' Trunk Line Service.
Q Q. Passenger Platform.
e. e Stairways to Platform.
f. Post Indicating Train Destination.
h h Office and Shelter for Passengers.



Longitudinal Section A-B. on Plan.

ransverse ction C-D. on Plan.

THE METROPOLITAN AND BELT RAILWAYS OF BERLIN.

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

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profits, after the charges on the securities to be issued by the new company have been provided for.

From all we can learn, this new company has devoted itself almost entirely to the task of investigating the engineering problems at Panama and determining in the most thorough manner the best solution of these problems. De Lesseps' proposition for a sea-level canal was abandoned, it will be remembered, even before the collapse of the old company; but the details of a new location, the height of its levels, the lift of its locks, and more important than all, the questions of the control of the Chagres River and of the sliding of the great earth mass at Culebra, had all to be investigated and settled by the engineers of the new company.

The detailed plans thus prepared were submitted first to a board of French consulting engineers, which included representatives of the Receiver of the old company. After this board had further elaborated the project and approved it in detail, an international engineering commission was appointed, which again went over the entire project, visiting and inspecting the works on the Isthmus, and examining the engineering problems involved.

General Abbot's paper in this issue of Engineering News is the first publication to be made anywhere respecting the work of this Commission and the conclusions which they reached. According to this paper, a satisfactory plan has been developed for the control of the Chagres, and the water supply of the summit level. Additional work at the Culebra cut has shown that the sliding of its sides can be successfully controlled. The work actually done by the old company is estimated to have been equivalent to an expenditure of about $125,000,000; and the cost of the work remaining to be done to complete the canal ready for traffic is set at $100,000,000. The time required to complete the canal is apparently fixed by the excavation remaining to be done on the great Culebra cut, and is set at ten years. The interest charges on the company's securities during this period are apparently not included in the above $100,000,000, and will increase the actual cost of the canal by one-fourth or more.

General Abbot's paper makes little or no allusion to the financial status, prospects or plans of the new company, which is the question of greatest practical interest just now; and the company's representatives in this country are not authorized to make any statement as to its future policy, except to say that no governmental aid will be asked from any source.

From all the information that we can glean, however, we believe that a few months hence, when the complete report of the International Engineering Commission is made public, an effort will be made to raise funds for the completion of the work; and it seems quite probable that the project will be placed in so favorable a light before European financiers that the required amount may be obtained.

This report of the Engineering Commission, we are informed, will probably be ready for publication before the close of the year, and will be accompanied by reports prepared by eminent French statisticians (among them M. Leroy-Beaulieu) upon the probable traffic and earning power of the canal. This is a matter which has been heretofore lightly passed over, both by De Lesseps and the Nicaragua Canal promoters, and the results of a careful statistical investigation will be awaited with interest.

The most important matter upon which General Abbot touches in his paper—at least to Americans—is the relative merits of the Panama and Nicaragua enterprises; and we are obliged to say that this seems to us the weakest part as well, for points in which the Nicaragua route has advantages over its more southern rival are left untouched. We shall not attempt, however, a discussion of the relative merits of these two enterprises at this time, for the very good reason that the public is not yet in possession of the data which would enable a fair and intelligent comparison to be made. When the full report of the International Commission of which General Abbot was a member, is made public, and when the detailed reports of the surveys made under the Walker Commission in Nicaragua are presented, an independent examination of the relative merits of the two enterprises from an engineering point of view will for the first time become possible.

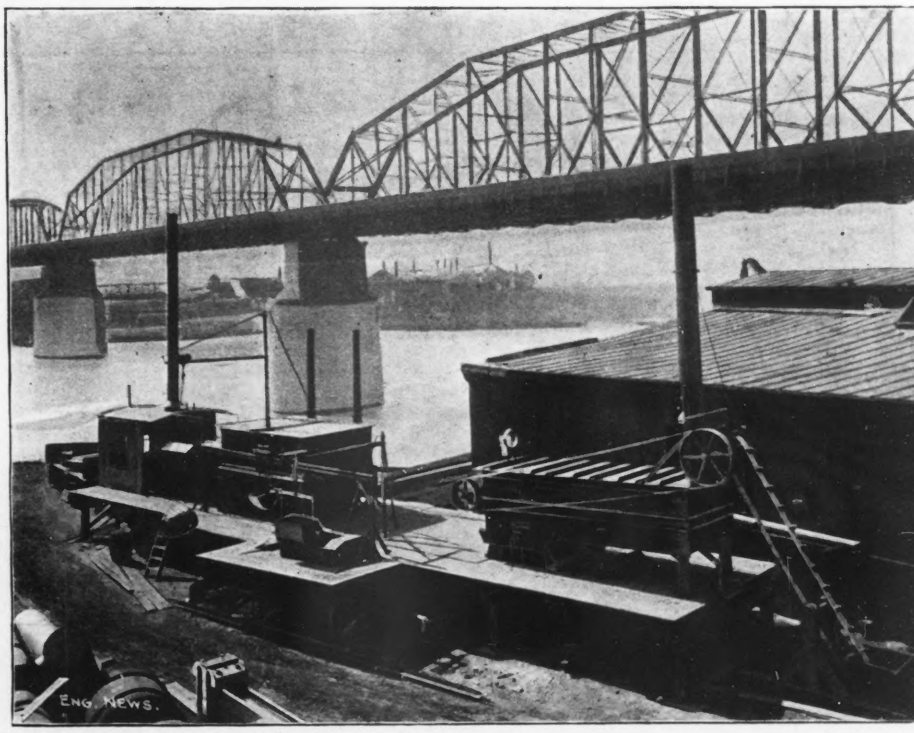
General Abbot's paper does make clear, however, the very important fact that the Panama canal enterprise is not dead, but very much alive; and that it must be taken into consideration in making our decision as to what our national policy is to be with respect to the Nicaragua enterprise.

LETTERS TO THE EDITOR.

The Cause of Rails Creeping.

Sir: In the committee report of the annual meeting of the Roadmasters' Association of America (Eng. News, Sept. 15, 1898) I notice again the current explanation for the creeping of rails, viz., the wave-motion of the track under load. According to my experience the creeping of rails is partially due to this wave-motion, but not exclusively. Of even more importance are the shocks between the wheels and the rail-heads (at joints and when the flanges come in contact with the rails). The effects of these shocks on the track have always a horizontal component in the direction of the traffic; and are, of course, heavier on the outer rail than on the inner rail of a curve, on the down-grade than on the upgrade. Although generally the methods for restricting the creeping of rails will be the same for both causes, it may be desirable to reckon in special cases with the shocks as the principal factor. J. J. Israëls.

312 McPhee Building, Denver, Colo., Sept. 23, 1898.



THE FIRST PORTABLE ASPHALT PLANT IN OPERATION AT CINCINNATI, O.

The Original Portable Asphalt Paving Plant.

Sir: In connection with the very interesting description of the portable asphalt paving plant manufactured by Messrs. Hetherington & Berner, of Indianapolis, in Engineering News of Sept. 15, your readers may be interested in a brief description and the accompanying photograph of the pioneer portable asphalt paving plant.

This plant was designed by the writer, and built by the Warren-Scharf Asphalt Paving Co., in the year 1889. It was intended for use in the towns and smaller cities where the amount of work likely to be required would not be sufficient to justify the erection of a permanent local plant. It was designed to turn out sufficient mixture to lay from 500 to 700 sq. yds. of pavement per day, but it has done much better in practice, and its actual capacity is about 1,000 sq. yds. per day.

Without going into a lengthy description of the machine, I may say that it is built on two flat cars, one of which carries the two revolving drums for drying and heating sand, the sand being fed to them from the ground, at the rear of the plant, by elevators. The front half of the car is used as a platform for storing the heated sand. The mixing apparatus is at the side of the car, near the stored sand, and is supported on a platform which, when the plant is to be moved, slides back onto that part of the car used for storing hot sand when the plant is in operation.

The second car carries the steam boiler and a 20-HP. engine protected by a cab. The engine drives a main shaft supported under one side of the cars and having a universal joint between the two cars to provide for any lack of accurate alinement of the cars. The same car carries the large kettles for melting the asphalt. The sides of the cars are hinged, and when let down form a platform around them. The plant was designed to use either oil or coal for fuel, but oil fuel has been found best and most economical.

The photograph, which was taken at Cincinnati, shows the plant set up, ready for operation, gives a good idea of its general plan and some of the details. (N. B.—This is a photograph of the paving plant, notwithstanding that the most prominent feature in it is the Chesapeake & Ohio Ry. bridge over the Ohio River.)

The design and construction of such a plant necessarily requires some ingenuity and mechanical skill in adapting well-known mechanism to the ends in view, but does not necessarily involve much invention. Such features of the plant as were novel were patented at the time. (Patent No. 451,989, issued to the writer May 12, 1891.) It will be seen that while the later plants, like the Hetherington & Berner, are larger, and involve some improvements and some new features, they follow pretty closely in general design this pioneer plant. The plant is still in use, and while limited in capacity, compares, in economy of operation, quite favorably with its more pretentious successors. S. Whinery.

New York, Sept. 22, 1898.

Notes and Queries.

On the double-page engraving in our issue of Sept. 15 the numbers and titles of Figs. 5 and 6 were accidentally transposed. The cut marked Fig. 5 is properly Fig. 6, the Northern Pacific R. R. truck; and that marked Fig. 6 is properly Fig. 5, the Schoen pressed steel truck.

R. S. W., Milwaukee, Wis., asks which corrodes the most rapidly, wrought iron or steel?

According to the best information at hand, the difference in liability to corrosion between the two is not great, and the corrosion of a given specimen will vary with its chemical composition and probably also with its physical structure. This refers, of course, to soft structural steel. Harder grades of steel and tool steels, we believe, corrode more slowly. If any of our readers can answer the query more definitely we shall be pleased to hear from them.

C. W. S., New Rochelle, N. Y., writes:

Will you give through the columns of your paper your views as to the proper way in which the Department of Public Works should be administered in cities having a population up to 100,000? It is a subject in which engineers are interested, and the appointment of others than engineers as the head of such department is often a detriment to the profession as well as expensive for the taxpayer.

Our correspondent asks an easy question. The Department of Public Works in any city, large or small, should be administered on business principles, that is with the sole aim of carrying on all operations under its charge in the public interest. A competent engineer, if he has executive ability in addition to his technical knowledge should make an ideal head of a Public Works Department; but equally good results may be attained with a business man in that place, provided he also possesses executive ability, that he knows enough to seek expert advice on technical matters, and above all, that he is unswervingly honest and faithful to his trust. This is what ought to be. We are obliged to confess that those who select candidates for such offices are generally more particular to inquire concerning a candidate's "popularity with the boys," the extent of his probable contribution to the campaign fund, and the likelihood that he will use his official position to help his party.

ELECTROLYSIS OF WATER PIPES AT DAYTON, O.

One of the most thorough investigations of damage by electrolysis in a city's water mains that has been made in a long time was undertaken last summer at Dayton, O. Several cases of serious damage by electrolysis had come to light, and the trustees of the city water-works decided to have the extent of the damage determined as carefully as possible. They, therefore, called in as experts, Messrs. Harold P. Brown, of New York city; E. E. Brownell, of Dayton, and J. H. Shaffer, of Pittsburg. The reports of these engineers, together with a report by Mr. Chas. E. Rowe, Secretary of the Dayton Water-Works Board, have just been printed, and form a valuable contribution to the engineering literature on this subject.

It is now generally admitted that electrolytic action exists in all localities where a "ground return" is used for heavy electric currents. Any denial by railway companies that their currents are causing injury is always based upon the claim that the tracks are well bonded and that an ample metallic return circuit is provided for the current.

The burden of proof that damage is done is therefore thrown upon the complaining party, and an investigation, such as that undertaken at Dayton, must be made.

The fact that an electric current is flowing along a line of water or gas mains can be easily established by taking voltmeter readings at different points, attaching one terminal of the instrument to the hydrant, fire-plug or gas pipe being tested, and the other to the rails of the electric railway. Quoting from Mr. Brown's report:

The current to operate the trolley cars leaves the dynamo and passes through the trolley wires in various parts of the city, then through the motor of each car and the wheels to the rails. To complete the circuit, it must return to the negative pole of the dynamos. To reach this pole, two paths are open to it; first, by the rails and feeder wires leading from the rails to the dynamos, and second, through the moist earth to the water or gas pipes below, along which it passes until within 1,000 to 3,000 ft. of the power house, when it leaves the pipes, again passing through the moist earth to the rails. A current of electricity passing through a conducting fluid, like water, decomposes it, and the oxygen and acids, if any, in the compound are delivered at the positive or outgoing pole, while the hydrogen and alkalies are delivered at the negative or receiving pole. This oxygen corrodes the metal of the positive plate, while the hydrogen produces no chemical effect on the negative plate.

It will be seen from the above that the tendency to corrosion by electrolysis on a line of underground pipes will exist wherever the current is leaving them. In remote parts of the city where the current passes onto the pipes or where it is passing along them without leakage there will be no electrolysis.* Wherever the current is leaving the pipe for the rails, however, the fact will be indicated by the pipe being at higher potential than the rail. In the Dayton investigations by Mr. Brown, voltmeter readings were made on all the streets of the city having electric railway tracks, and the difference between the trolley wire and the rail, between the trolley wire and the water main, and between the water main and the rail. At each hydrant along the line of the electric roads these readings were repeated for each of the four rails of the double tracks.

*It has been claimed by some engineers that electrolytic corrosion to a certain extent will take place at the lead joints of a pipe along which a current is flowing. The amount of such corrosion, however, is a disputed point. We may also note here that soon after the destructive effect of electrolysis was first observed it was suggested that the trouble could be remedied by reversing the polarity of the railway system—that is, by making the current on the overhead wires positive. This was tried in a number of instances, but it was soon found that the cure was worse than the disease, for, instead of preventing the electrolytic action, it simply removed the destructive region from the vicinity of the power house to distant and scattered sections of the city.

In making the readings, the time of the day was also noted, since the pressure depends upon the amount of the load carried at the power house. The results of the voltmeter readings were plotted upon a map of the city, showing the railways and water mains, and the extent of the mains where current was leaving the pipes and electrolysis was going on was thus plainly shown.

It was next necessary to determine the extent of the damage already done by exposing the pipes here and there at places where the instrument observations indicated the greatest action. Quoting again from Mr. Brown's report:

A number of excavations were made in different parts of the city to determine how much damage had been done to the pipes and how much electrical pressure was required to seriously injure the cast iron. A pressure of three volts and less was found to cause a graphite-like coating not exceeding 1-32-in. in depth; the iron beneath seeming uninjured. At potentials of 3 to 4½ volts the thickness of the layer is increased in a ratio which depends upon the length of time the pipe has sustained this pressure. With a knife or file soft spots can be found in the pipe from 1-16-in. to ¼-in. in depth. With higher pressures the extent of the injury is even greater. * * * * * In ordinary soil the effect of electrolysis upon cast iron, if unprotected by sufficient amount of tar, is to produce an oxide of iron, which is a poor conductor of electricity, so that, with a given pressure, the deeper the layer of iron rust, the slower the rate of corrosion. To my surprise, the soil in which the pipes are buried, in Dayton, gives an entirely different reaction when the current passes from a pipe to the moist soil. The tar seems to be no protection whatever and the pipe is covered with a layer of black material, resembling graphite. This material proves to be an excellent conductor, so that instead of checking the action, it tends to increase the action by reducing the resistance of the path through which the current must flow. Furthermore, the stones or pebbles near the pipes, seem to be electro-plated with the metal of the pipe. This condition I have not seen in any other place, and as far as I know it has not been observed before.

It was next necessary to determine whether the soil itself had caused corrosion of the pipe in any degree, independent of the electric current. A pipe was uncovered which had been laid in 1874, at the same time as some of the pipes, which had been found seriously corroded. This pipe showed no evidence of electrical current and was so located that it could not carry current from one part of the city to another. It was in soil apparently the same as that surrounding the corroded pipes. It was still heavily coated with tar, and on scraping through this layer its surface was found as good as new. It was, therefore, evident that the soil contained nothing which would injure a cast-iron pipe, unless assisted by electrolytic action.

The question of the amount of injury which pipe has received is one difficult to determine in any quantitative way. The best method probably would be to take up several lengths of corroded pipe and compare the results of hydrostatic tests upon them with similar tests of pipe removed from unaffected districts. An easier method is to cut test pieces from the pipes and subject them to physical tests.

In the investigation at Dayton, four test bars were cut from the very best portion of the pipes, and tensile and transverse tests were made which gave the following average results:

	Tensile strength, lbs. per sq. in.	Transverse strength, lbs. per sq. in.	Deflection, ins.
Affected pipe	11,425	1,085	0.20
Unaffected	16,000	1,800	0.25

That is, the affected pipe had only 69.4% of the tensile strength and 54.3% of the transverse strength of the unaffected pipe.

The pipe from which these bars were cut was also tested hydrostatically and leaked in several places at a pressure of 150 lbs. per sq. in.

An analysis of pieces of these pipes, the incrustation upon the corroded one and soils from around both pipes was made by Mr. Jas. O. Handy, Chief Chemist of the Pittsburg Testing Laboratory, with the following results:

	Unaffected. pipe.	Affected. pipe.	Incrustation.
Phosphorus	0.789	0.800	1.821
Sulphur	.073	.057	none.
Silicon	2.270	2.500	not det.
Iron	not det.	not. det.	33.4[illegible]
Combined carbon	.13	.24 }	
Graphitic carbon	3.48	2.88 }	7.1[illegible]

	Alkalinity, %	Salt, %
Soil from unaffected locality	0.016	0.015
Soil from affected locality	.032	.810

Table I. has been prepared from data given in the report of Mr. J. H. Shaffer, which forms one section of the complete report from which we have been quoting. In it are shown the effects of electrolytic action as they were found at 15 places where the mains were uncovered. It will be noticed that the distance between pipe and rail varied from 3½ to 7 ft., and, further, that the pipe in all cases where actual corrosion was found, had a positive potential, which ranged from a fraction of a volt to as much as 9 volts, and in every instance the destination of the pipes varied with this difference of potential, being greatest for the higher and least for the lower values.

This is what could be expected, and the facts are well stated by Mr. Brown, who says "the amount of electrolytic action is directly proportional to the amount of current transmitted (which depends upon the potential) and the length of time the current flows; it is inversely proportional to the area in contact with the soil." This being the case, we would expect, what actually does happen, a greater or more rapid destruction of the smaller pipes.

The following remarks are also taken from Mr. Brown's report. While not absolutely new, they will bear repetition since they are applicable to nearly all cities and towns where electric railways are operated:

The rate of electrolysis depends directly upon the electrical condition of electrical pressure between the positive and the negative plates (the pipes and rails). This rate is increased by the presence of any acid or alkali in the fluid (or soil in contact with pipes and rails). A slight leakage from the gas pipes, or a small amount of acid from the surface, or the presence of an alkali in the soil will increase the action, and the current itself, by carrying the metal oxide into the (ground) water, reduces the resistance of the solution, and tends constantly to cause a further increase of action. This increase of rate is augmented by the rusting of the bonds between the rails and by their mechanical loosening by hammer-blows from car wheels. The maximum laboratory electro-deposition of iron is obtained from a saturated solution of sal-ammoniac. In such a solution 100 amperes of current will remove over 3 lbs. in 24 hours, or with the proper solution, the same amount of current will remove over 20 lbs. of lead in the same time. The lead calking or service pipes will therefore sustain more damage than iron pipe. A difference of ½ volt between a lead pipe and a rail will injure the pipe. The fact that the bell of the iron pipe is nearer to the rail than the lead tends, however, to reduce the rate of injury of the lead below it. Since wrought-iron pipes are much more rapidly destroyed than cast iron, all natural gas service pipes in the vicinity of electric railway power houses should be ventilated at the curb, in order to prevent leakage into the houses and explosions. Inasmuch as gas can be ignited by sparks between separated portions of gas pipes, as at terminals where meters are to be inserted, the use of wire conductors between gas service pipes and gas pipes in houses is advisable. The difference of pressure between water and gas pipes in private houses has often been sufficient to cause fire, and it is therefore advisible to bind together electrically water and gas service pipes inside of the house line.

It has been claimed by some that cast-weld joints would entirely obviate the effects of electrolysis. A comparison with the measurements made last February in the business portion of Dayton, O., however, does not bear out this claim, since the only variation is directly proportional to the variation of the loads then and now. To definitely determine this, measurements were made be-

TABLE I.—Effects of Electrolysis on Water Pipes at Dayton, Ohio.

No. of reading.	Time.	Size of mains, ins.	Date of laying.	Distance from rail ft.	Character of soil.	Potential with reference to rail (volts)	Remarks.
1	July 11, 1898 4:45 p. m.	6-in.	1874.	3½	Moist gravel.	+9	Tar coating destroyed; iron reduced from ½-in. thickness to ⅜-in.; iron decarbonized.
2	July 11, 1898 5:00 p. m.	6-in.	1874.	4	"	+5½	About the same as No. 1; lead pipe nearly completely destroyed.
3	July 11, 1898 5:30 p. m.	6-in.	1874.	4	"	+9	Pipe badly damaged.
4	July 12, 1898 2:20 p. m.	4-in.	1888.	4	"	0	Remote from influence of current; coating unaffected, showing no soil corrosion.
5	July 13, 1898 5:00 p. m.	6-in.	1893.	4½	"	+4½	Pitted and badly eaten; will soon give out.
6	July 15, 1898	6-in.	.....	6	"	+3½	Coating destroyed, good evidences of electrolytic action.
7	" "	4-in.	.....	7	"	+4½	Practically the same as No. 6.
8	" "	6-in.	.....	5	"	+4¼	Pipe eaten from ⅛ to 3-16-in.
9	" "	4-in.	.....	4	"	+2¼	Coating destroyed and pipe affected about 1-16-in.
10	" "	6-in.	.....	7	Dry gravel.	+1¾	Coating destroyed and slight evidence of electrolytic action.
11	" "	4-in.	.....	4	Good "	+2	Practically the same as No. 10.
12	" "	12-in.	.....	3½	Moist "	1†	Very slightly eaten.
13	" "	10-in.	.....	4	Good "	−5	Perfectly preserved; coating not the least affected.
14	July 16, 1898	12-in.*	.....	..	....	..	Perfect; made for electrical purposes.
15	" "	6-in.	.....	4	Good.	+2	Coating disturbed; pipe slightly affected.

*12-in. gas and 6-in. water. †Neutral at light loads.

tween two hydrants on different corners along the line two blocks apart. Similar readings were then taken on each of the four rails opposite these hydrants, using in each case an insulated wire stretched along a dry, paved street. The measurements showed that the pipes between these points were carrying 19-20 of the current returning, while 1-20 was divided between two of the rails; and the other two were carrying no current.

The report concludes with a resume of the results obtained, and a calculation of the damage done based upon the data obtained during the tests. In making the calculations no account was taken of mains that were found neutral or negative to the car rails, but only of those that were positive. The total length of affected pipe, ranging in size from 4 to 16 ins. in diameter, amounted to 46,065 ft., the indicated voltage as taken showing this amount of pipe to be carrying from 0.3 to 9 volts positive to the rails. This was made up as follows:

	ft.
Total length of mains on streets running parallel to the railway	40,825
Length of 143 intersecting streets, estimated as affected 20 on each side	2,860
112 fire hydrant branches, affected 20 ft.	2,240
7 fire cistern branches, affected 20 ft.	140
Total	46,065

The idea of calculating 20 ft. either side from the car tracks for side streets and fire hydrant branches, is based on the fact that in making excavations little effect of electrolysis on the surface of the pipe is observed, beyond this distance. As already stated the measurements were taken to pipes contiguous to the track, yet it is not improbable that the current in seeking the most favorable path would follow other pipe lines away from the tracks, and the water pipes could become positive to either the artificial or natural gas pipes. It was known that service pipes have been destroyed, about 1,300 ft., beyond the limits of the danger district. The conditions at the time of the tests were ordinary, and as all were favorable to obtaining average values the figures here given are considered very fair.

Mr. Chas. E. Rowe, Secretary of the Water-Works, says, in concluding his report:

In making the report the matter of damage is confined entirely to the city's property, which comprises the main lines and fire hydrant branches. No account is taken of the enormous risk, in case of fire, while removing the damaged pipes and replacing them with new ones, which will require closing off some of the main arteries for probably weeks. Neither is any pecuniary consideration given of the loss and inconvenience to the business interests of the city in closing off hydraulic elevators, fire protection and power lines. There are 110 of this class of consumers, whose services range from 2 to 6 ins. in diameter, whose pipes are undergoing the same process of destruction. There are also in the confines of this positive district 1,419 domestic and other consumers with lead service connections, ranging from ½-in. to 1½ ins. in diameter.

The action of the current on lead and wrought-iron pipes appears to be much more destructive than on cast iron, and as it is known that the aptness of pipes to destruction by the electric current is for cast iron, 1, for wrought iron, 3, and lead, 7, which fully accounts for the large number of services, both water and gas, that have had to be repaired, and the difference in the thickness of the metal between large and small pipes, naturally destroys the small pipes in much less time than the mains. Wherever the main lines are damaged to the extent that they would have to be replaced, service pipes would be in a much worse condition and replaced several times.

As the property owner is responsible for the repairs to the service from the main, the cost of replacing the services and repaving the streets would be very great (and almost ruinous to the streets), which entire cost would have to be borne by the property owners on the abutting streets, and no estimate is here made of the cost. Of the nearly 9 miles of pipe lines affected there is only 1,600 ft. of the pipe on unpaved streets. There is 10,845 ft., or more than two miles of the pipe line, that is laid directly between the two car tracks, or under what is called the dummy track. The ties of the railroads nearly join each other between the tracks, and it will be very difficult to get at this pipe, and the annoyance of the cars passing and repassing adds still more to the expense, and will be very dangerous to the workmen.

In calculating the cost of replacing the pipes in the whole affected territory, it is estimated at $77,208.80. There is 17,513 ft. of pipe that shows a voltage of from 2 to 9 volts positive, and from pieces of pipe removed where electrically charged to this extent, it is found that they have deteriorated 50% in four years. Where they were required, when laid, to withstand a hydrostatic pressure of over 300 lbs. per sq. in., a pipe, when tested, after being subjected to 4.5 volts for four years, leaked at 150 lbs. pressure. It has been clearly demonstrated by the test made that the physical condition of the pipe corresponds to the voltage of current traveling thereon. At 4.5 volts it has been shown that a 6-in. pipe can certainly become useless in five years. At a lesser current the pipes are being corroded, but the life of the pipe is simply prolonged to correspond with the amount of current.

The fact having been established that all pipes positive to the car tracks are damaged, and the agent causing the damage not having been removed, and the fact that the water pipes are used to convey the return current of electricity to the power stations of the electric railways, a purpose for which they were never intended, it remains for the Board of Water-Works Trustees, or others having authority, to see that the city is reimbursed for the damage sustained, and to enjoin the railway companies from using the water pipes as a return conductor. There is 28,412 ft. of pipe that shows .3 to 1.75 volts positive. This division is made to show that at least a portion of the pipe that is positive from 2 to 9 volts is now in a very dangerous condition, and from the tensile and hydrostatic tests made would indicate that at the ratio of depreciation the pipes are now undergoing that they would soon burst under the fire pressure (100 lbs.). It should be stated that the coating on the water pipes hermetically seals the iron from any ordinary conditions that would be apt to corrode them, but after the electric current has affected the pipe so that the coating begins to scale, the destruction will be much more rapid.

In conclusion, Mr. Rowe suggests the following pertinent questions:

Should the pipes be at once replaced, or should the city wait until some calamity occurs? With the direct pumping system would not the unexpected bursting of some large main be apt to damage the pumping machinery? If new pipes and services are put in where others have been destroyed, and the current is not eliminated therefrom, or the pipes made neutral to the rails, are the conditions changed, and will not the pipes so replaced be again subject to destruction?

MODERN CUPOLA PRACTICE AND THE PHYSICS OF CAST IRON.*

By Bertrand S. Summers, Chicago, Ill.

The question is sometimes asked, What is the most important element governing the quality of cast-iron for any particular purpose? Some twenty years or more ago, silicon was regarded by foundrymen as one of their worst enemies; but since the work of Turner and of Keep, silicon has been greatly growing in favor, until it is regarded in some quarters as the panacea for all evils encountered in the iron-foundry. This has led to the founding of a school, the followers of which seem to regard silicon as the one element of decisive importance in pig-iron. It is the writer's opinion that graphite is the controlling element in pig-iron, and that a greater success is obtained where this metalloid is governed, than in cases where the silicon only is watched.

The most prominent function of silicon is that of promoting the formation of graphitic carbon, while it also lowers the saturation-point of iron for carbon. The former is the property that concerns the foundry-man almost exclusively; and it is necessary for him to know about how much silicon cast-iron should carry, in order to have the desired properties. It seems fair to say that nothing absolute can be stated regarding this question. Frequently, we notice in text-books and journals, that if iron carries this or that percentage of silicon it will have certain properties. This sweeping general proposition the writer cannot accept, being of the opinion that other conditions will affect the content of graphitic carbon as much as, if not more than, the content of silicon. In general, if it is desired to make good machinery-castings of close structure, and at the same time so soft that no difficulty will be experienced in tooling them, the silicon should be between 1.50 and 2%, or may even run to 2.25%. It is always wise in these cases to consider the iron used in the mixture. It is well enough to say in a general way that if we have the same chemical composition in cast-iron we will have the same properties, but experience has shown that this is true in a general way only. For example, mixtures in which the chief component is charcoal iron, show a perceptible difference from those made entirely from coke-iron. The reason for this seems to lie in the different conditions of the carbon, which will be mentioned later.

For light hardware, in which great strength is not a very important item, it is well to run the silicon up even as high as 3%. This practice tends to make the iron more fluid, so that it will take delicate molds well, and avoid difficulty or loss due to shrinkage. It is also said to enable the foundry-man to carry more scrap in his mixture. This assertion, however, is open to serious doubt, as the amount of scrap which a mixture will carry is dependent upon the carbon-content of the mixture and the scrap.

As silicon approaches or exceeds 3%, the casting becomes more and more brittle, and it is desirable to keep well within the limit of 3% in most classes of foundry-work. For most foundry purposes, on the other hand, a silicon-content below 1.5% is to be avoided.

Sulphur.—The good effects of silicon are frequently counteracted by the presence of sulphur, and mysterious troubles encountered in the foundry are not infrequently traceable to this element; the practical foundry-man being, in this respect usually at the mercy of the pig-iron manufacturer. Most brands of soft iron, both charcoal and coke, are usually considerably below the danger-limit in sulphur. Foundry-men, however, are frequently misled by the statement that sulphur need not be considered, as it never occurs in pig-irons in sufficient quantities to affect the results of their work. If analyses are made of drillings from castings that give trouble to foundry-men not possessing means for determining sulphur, the trouble will, in many cases, be traceable to this element. In most instances, sulphur is introduced into the mixture through the ferro-silicon irons used to supply the silicon to the charge. The writer has found well-known brands of ferro-silicon containing 0.17 and 0.18% of sulphur, and in one case 0.34%. If a careful watch is not made of these irons, or if strict specifications are not drawn upon them, it is not infrequent that 0.10% of sulphur is found. Most furnace-men endeavoring to do so can keep the sulphur below the limit of 0.05%.

*Condensed from a paper to be presented at the Buffalo meeting of the American Institute of Mining Engineers, Oct. 18, 1898.

A maximum limit of sulphur for good foundry-practice should be fixed at 0.10%; but foundry-men should strive to keep it below 0.08%.

Phosphorus.—The element is present to a greater degree than is commonly supposed in most cast-irons. It may be said that for the greater part of foundry-work it is an excellent ingredient up to a certain limit. This limit, for most cases, is about 1%. Where great strength and resiliency are desired, the phosphorus should be very much below this point. However, in cases of this kind, it will seldom be noticeable in high graphitic iron, where it is kept below 0.5%. In snap-flask work phosphorus is a very desirable element to the foundry-men, tending to make the metal fluid and to keep it so. Its effect on strength is not immediately discernible, if the test-bar of cast-iron is subjected to a transverse stress. A severe blow upon the bar, however, will soon make apparent the difference in irons. It is weakness under sudden shock that phosphorus most distinctly promotes; and for this reason it should be kept low, wherever this property would be a detriment. Like sulphur, phosphorus occurs in large quantities in the ferro-silicon irons commonly used in foundry-mixtures. It may be stated that most of the common brands of these compounds on the market carry 1% or more of phosphorus. The writer has known cases in which 7% silicon-iron carried more than 1.60% of phosphorus. Of course, this is unknown to most foundry-men not having facilities for analyzing their iron; and in this way phosphorus is frequently introduced into mixtures which never should carry a high percentage of it.

Manganese.—Manganese is an important element in many ways. It will scarcely be noticed in a mixture, up to 0.8%, as far as the ordinary foundry-man is concerned. Frequently an excellent casting is found to contain over 1% of manganese. It is not long since it was suggested that manganese is a very beneficial element in cast-iron, and it has been asserted by some metallurgists that a considerable content of this element is desirable. The writer's experience with manganese in general practice has not been extensive, but it seems to him that this modern view is to be looked upon with favor. Although it is well known that manganese promotes combined carbon, silicon predominating in the iron would tend to counteract this effect. Manganese, however, has considerable effect on the magnetic properties of the iron, which have been discussed in another paper by the author ("Journal of the Society of Chemical Industry," December, 1897).

Carbon.—The consensus of opinion seems to be that a great deal is yet to be discovered relative to carbon. There is no question that graphite carbon is the softening agent in cast-iron; and, so far as silicon can control this, it is the governing agent. The writer hopes to show, however, that, in many cases, silicon is powerless to effect this change in the state of the carbon.

Combined Carbon.—It is usually admitted that combined carbon embraces more than one kind of carbon. This is, to some extent, substantiated by work upon the magnetic permeability of metals relatively high in carbon. However, the present state of the art will not permit much to be said with certainty in this direction. Reference may be made in this connection to recent work of Messrs. Donath and Haissig on silicon-irons, in which they cite the fact that a high-silicon iron, when analyzed for carbon by ordinary methods, gives about 1.36% less of carbon than when the drillings are oxidized completely by combustion with lead chromate, or volatilization in chlorine. Lower results were also obtained when the metal was oxidized with chromic and sulphuric acid. This difference, Messrs. Donath and Haissig suggest, is due to some silico-carbide. The writer has endeavored to duplicate these results, working on a ferro-silicon containing about 7.5% of silicon. The total carbon, obtained by solution in a double chloride and the residue burned in a combustion-furnace, was 2.24%. In every case in which the carbon was determined either by direct combustion with lead chromate, or the residue from the chlorine treatment burned in a combustion-furnace, the results agreed quite closely with those obtained by solution in a double chloride. It is possible, however, that the results obtained by these scientists may be true for ferro-silicon higher in silicon; or it may be that the metal used for their experiments was in some respects anomalous.

Relation of Silicon to Graphite.—Let us now endeavor to see what grounds there are for the assumption that silicon is the governing factor in cast-iron. If we have several pieces of cast-iron, made at different dates from practically the same mixture, the analyses of which show practically the same total carbon and a variation in silicon, we have an excellent opportunity to trace the effect of silicon. For example, in the following table, are irons which would seem to show this quite clearly:

Table 1.—Analyses of Charcoal-Iron Castings.

	I.	II.	III.	IV.
Silicon	2.20	2.66	2.92	2.41
Graphitic carbon	2.92	2.93	2.77	2.98
Total carbon	3.44	3.48	3.41	3.42

The other constituents of these irons are nearly the same, and all of them are controlled as far as possible in foundry-practice. They were made from almost identical mixtures, as is clearly indicated by the uniformity of total carbon. It is evident that this table does not support the unqualified assertion that an increase in silicon causes a proportional increase in graphite, and the practical rule, based on that theory, that silicon may be blindly added to the foundry-mixture, without considering other conditions, in order to increase graphite and soften the iron, is not substantiated. Comparing irons I. and III., we find that although the latter contains 0.72% more of silicon than the former, the graphite is 0.15% lower, while the total carbon is practically the same. Obviously this increase in silicon has not produced graphite, yet the total carbon indicates that there was no marked difference in burden.

Taking IV. as the second in the series, we see that silicon increases by about 0.20%, yet that the graphite is nearly constant, except as to III., which is both highest in silicon and lowest in graphite. The fair deduction seems to be, either that silicon has no marked effect upon graphite in ordinary foundry-practice, or that there are other conditions more potent. The latter view seems the more probable.

The above analyses are taken from a vast number made in the course of practice, which confirm this conclusion. Daily records for months show conclusively that the silicon varying between 2 and 3% has not nearly the effect on the graphite that it is usually supposed to produce. No relation apparently exists between the change of silicon and the content of graphite within these limits, and there is little if any doubt, if we can judge from this long series of tests, that there are other influences in cupola practice which are more potent than the variation in silicon.

Another proof of this proposition is seen in the analyses of pig-iron, before they are introduced into the cupola. Pig-iron shows the effects of the metalloids in the blast-furnace, instead of in the cupola; yet even in the blast-furnace, with its high temperature, the silicon is not always able to govern the graphite. For example, the following are strong indications in this direction:

Table II.—Analyses of Pig-Irons.

	I.	II.	III.	IV.
Silicon	7.94	7.43	3.36	3.30
Sulphur	0.041	0.029	0.051	..
Phosphorus	1.39	1.05	0.606	..
Graphitic carbon	2.02	1.95	3.31	3.26
Total carbon	2.24	2.19	3.33	3.37

Here it appears that the irons carrying more than 7% of silicon have less graphite in proportion to the total carbon than the one containing 3.36%. Number III., however, is a remarkable iron, and one that is seldom seen, although its high proportion of graphite to total carbon is quite characteristic of the brand, and has been found in most shipments received from this furnace. This anomaly must therefore be due to local conditions.

The castings in Table I. were all compounded from high-graphitic charcoal-iron. In coke-iron mixtures the failure of silicon to increase the percentage of graphite is even more marked. The following analyses are taken from casts made entirely from coke-irons:

Table III.—Analyses of Coke-Iron Castings.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Silicon	2.85	3.76	2.62	2.47	3.18	3.11	2.79	2.95
Sulphur	0.073	0.083	0.074	..	..	..	..	..
Phosphorus	0.557	0.612	0.469	..	..	..	..	..
Manganese	0.39	0.260	0.42	..	..	..	..	..
Graphitic carbon.	3.13	3.05	3.17	2.55	2.69	2.78	2.67	2.61
Combined "	0.18	0.24	0.08	0.74	0.51	0.62	0.54	0.60
Total carbon....	3.31	3.29	3.25	3.29	3.20	3.20	3.21	3.21

The first four members of this table have about the same total carbon, and were made from the same irons, with but minor changes in the burdening. From these irons little if any relationship can be traced between the silicon and the graphitic carbon. Looking at the last four members, the total carbon contents are seen to be practically identical, while the graphitic carbon is very nearly the same in the irons containing the highest and the lowest content of silicon; and, again, no relation can be traced between silicon and graphitic carbon. As in the case of the first four, these mixtures were compounded from the same irons with but minor changes in the burdening.

That temperature controls the effect of silicon is shown when a close examination is made of different shipments of the same brand of pig-iron, the blast-furnace running on the same ore-mixture. A case came under my personal observation recently, in which the graphitic carbon ran from 3.40 to 3.50%, the silicon remaining in the neighborhood of 1.5%; but when the silicon rose to 1.8 or 2%, the graphitic carbon rose above 3.50%. In nearly every case of this kind a decrease in the total carbon was likewise noticed. This has also been frequently noticed with other brands of iron, and it is more apparent with charcoal-irons than with coke. The heat in the blast-furnace seems to be great enough to make the silicon a more important factor.

It is hardly legitimate to attribute these differences to the effect of the other elements, as a glance at the tables will show that they do not vary enough to enter into the consideration. It would seem, on careful consideration, that the effect of silicon is largely governed by the temperature at which it is allowed to act. It is doubtful if the necessary temperature is obtained in the cupola to permit the silicon to have a very strong effect upon the carbon, where its contents does not vary beyond certain limits. It also seems probable that, where the burden is light, the effect is not as marked as in the case of large burdens, where more heat is developed.

Influence of Oxidized Material, Especially Rusty Scrap, Upon Mixtures.—Little attention has been paid to the peculiar effect of introducing rusty material into the cupola. Only one experience of this kind is necessary to convince a foundry-man of the deleterious effect of corroded scrap. The surface-rust on pig-iron is usually not noticeable, but where corrosion has taken place to any considerable depth, a very bad effect is quickly discovered. This is particularly true where light scrap is used, and a large surface has been exposed to the corrosive effect of the atmosphere, in proportion to the small volume. A prominent effect in bad cases of this kind is to make the iron exceedingly dirty and spongy, and when this dirt is noticeable, the cleaner the material introduced into the cupola, the cleaner will be the casting obtained.

Effect of the Blast.—There is scarcely any one factor in cupola-practice deserving of more close and constant attention than the blast. There are reasons to believe it exerts considerable influence in furthering the mutual reactions of the different elements in the metal, but this has not been clearly demonstrated in the tests thus far made. Aside from its effect in this way, increase of blast seems to have a decided tendency to increase the total carbon in the cast-iron, and correspondingly to increase the percentage of graphite. It is not unlikely that when the results of further investigation are known, the amount of air passed through the cupola will be found to condition, to a certain extent, the effect of the metalloids in the iron.

Iron-Mixtures and Iron-Specifications.—An attempt has been made in the foregoing pages to demonstrate that the desire for silicon has been carried to an extreme. This desire has become a mania in some quarters. If the foregoing tables prove anything, they certainly prove that high-silicon irons are, in many cases, a useless luxury. A certain amount of silicon is undoubtedly necessary, but the plan of gaging the value of irons by their content of silicon is but one step in advance of the old fracture-method. The carbon is undoubtedly the governing factor in irons, and the most radical advocate of silicon can do nothing with foundry-mixtures without a certain carbon content. It seems, then, that total carbon is one of the most important elements to specify in purchasing foundry-irons. The writer has yet to meet with an iron too high in carbon to be of excellent use in the foundry. It has been the custom in our practice to specify 3.75% of total carbon in our No. 1 iron, especially when charcoal-irons are purchased, while a very lenient specification is allowed in silicon, it being, for charcoal-iron, not below 1.50%. The furnace man is allowed to have silicon about anywhere he wants it as long as he can furnish iron with the necessary carbon. A minimum graphite specification is also inserted in nearly every case. In the cupola, comparatively little combined carbon is changed to graphite, and this is especially true when the heats are small, and, consequently, the heat developed is not sufficient to produce any marked change in this direction. This fact can easily be demonstrated in practical work, where frequent analyses are made of daily casts, and the compositions of the irons composing the mixture are known.

In these specifications the minimum is specified, and any variation must be above this limit. This is thoroughly practical, and has been in operation long enough commercially to demonstrate its value. It is difficult to get iron merchants to make carbon-determinations, but they will agree to furnish iron under specifications requiring certain minimum limits of total carbon and graphite. Whether the latter is specified or not, there can be no doubt about the necessity of specifying total carbon. Very little attention is paid to silicon in the work, as most of the high-carbon irons will carry sufficient silicon for most classes of work. However, it is often useful to require a certain silicon-content in the iron, so as to get sufficient graphite, as the heat of the blast-furnace is sufficient to enable the silicon to control the graphite to a great extent. In the best snap-flask work, where a large proportion of charcoal iron is used in the mixture, 2% of silicon is found to make elegant castings, and in such mixtures no ferro-silicons are used; but a high-silicon coke-iron, carrying over 3% of silicon and about the same of graphitic carbon, is used. This gives good results, especially where a high grade of machinery-castings and fine snap-flask work are poured from the same mixture. This is further substantiated by analyzing some of the best castings of tools and machines that can be found on the market. Some of the best-known firms making this class of work will be found to be using this variety of iron. With coke-iron it is well to run the silicon a little higher, although for machinery-work it is best not to have it too high.

When trouble is experienced with open or spongy iron, and the trouble cannot be traced to some such cause as rusty scrap, a good procedure is to run the total carbon in the casting as high as possible. This will give a higher content of combined carbon, and at the same time the high content of total carbon, with the graphite, usually increased slightly in this way, will keep the iron soft. When this is done it is well to consider the content of silicon, and if this is much over 2% a decrease will be found beneficial.

The Use of Carbon.—As mentioned in the first portion of this paper, silicon is commonly believed to enable a mixture to carry more scrap. This belief is open to serious doubt. It is obvious that if a mixture is running low in carbon, and ferro-silicon is added in greater amounts to enable the mixture to carry more scrap, this procedure will not only fail to enrich the carbon content, but will actually impoverish it. The reason for this lies in the fact that high-silicon iron carries less graphitic and total carbon than a good scrap, and much less than a good cast-iron. Inasmuch as the iron is dependent upon carbon for its softness, it is open to grave doubt whether, by increasing the silicon, and thereby decreasing the carbon, by adding ferro-silicon, any more scrap can be carried, and the same quality of iron poured from the cupola. The amount of scrap that can be loaded into the cupola without changing the quality of the iron is dependent upon the carbon, and especially upon the graphite. Even if we admit that an increase of silicon can cause an increase of graphite, yet, if there is not sufficient carbon present to be changed into graphite, the graphitic carbon cannot be obtained in the required proportion. Further, when it is doubtful that silicon will cause any appreciable increment in the graphite, it is open to question if the ferro-silicon does not tend to lower the scrap-carrying ability of the mixture.

A high-carbon mixture averaging, for example, 3.10% graphite, and about 2% silicon, will carry considerably more scrap than a mixture containing over 3% silicon, and lower in graphitic carbon, or than a mixture impoverished in total carbon, no matter what the silicon-content. This assertion can be proved in practical work, and it would seem that the popular idea to the contrary is based on a fallacy.

SPECIFICATIONS FOR FOUNDRY CASTINGS.

The specifications for castings adopted by the J. I. Case Threshing Machine Company, of Racine, Wis., are given in the "Iron Age" of Sept. 29. We reprint them in a slightly condensed form below. They will be found to differ in some essential particulars from those given by Mr. Summers in the article printed elsewhere in this issue.

No. 1.—Special Hard Iron. (Close Grained.)

Designed for air and ammonia compressors, high pressure engine cylinders, valves, etc.

Silicon must be between 1.20 and 1.60%. (Below 1.20 the metal will be too hard to machine; above 1.60 it is liable to be porous unless much scrap be used.)

Sulphur not over 0.095%. Any casting showing 0.115 or more of sulphur will be the cause for rejection of the entire mix. (Above 0.115% produces high shrinkage, shortness and "brittle hard" iron.)

Phosphorus below 0.70%, unless specified for special thin castings. (High phosphorus gives brittle castings under impact.)

Manganese not above 0.70%, except in special chilled work.

Transverse breaking strain, with load applied at the center and supports 12 ins. apart, on a square test bar 1 in. square and 13½ ins. long, must stand a stress of not less than 2,400 lbs. All bars to be micrometered and figured to an exact square inch.

Deflection not less than 0.08 in.

Shrinkage, measured on a 13½-in. bar cast in a yoke, giving chilled ends, must not exceed 0.161 in. after deducting one-tenth, so as to compute the shrinkage in 12 ins.

Chill, measured on the end of a test bar cast in a yoke, not more than 0.25-in., except in chilled work where certain depth is required.

Tensile strength of an extra test bar cast in sand, without the yoke, not less than 22,000 lbs.

The castings must be free from blow holes, slag, dirt, shot, cinder, kish and cold shuts.

A clean, close grained and strong iron is required for this class of work.

The mixture for this iron may be made from charcoal iron, low silicon foundry, home scrap and steel scrap not to exceed 25%, or wrought scrap not to exceed 10%.

Enough scrap should be used so as to keep the graphitic carbon down low enough to produce a close grained iron.

Extra strength and greater chill may be obtained by adding from 1 to 10 lbs. of 80% ferromanganese to every 1,000 lbs. of the charge, but should not be added unless specified.

No. 2.—Medium Iron.

For engine cylinders, gears, pinions, etc.

Silicon to be between 1.40 and 2%. (Silicon 1.50 gives the best wearing result for gears.)

Sulphur not over 0.085%. Any casting showing on analysis 0.095% or more will cause the rejection of the entire mix. (Sulphur preferred at 0.075 to 0.080%.)

Phosphorus below 0.70%, except in special work.

Manganese below 0.70 unless otherwise specified.

Transverse breaking strain, as described under No. 1, not less than 2,200 lbs.

Deflection not less than 9.09-in.

Shrinkage on test bar cast in yoke not over 0.151-in.

Chill below 0.15-in.

Tensile strength of a test bar cast in sand, above 20,-000 lbs.

The iron must be free from blow holes, shrink cavities, slag, kish, shot, cold shuts, blisters, etc.

This mixture may be made with No. 1, 2 or 3 foundry pig, home and foreign scrap. Total scrap should not be over 50%. For safety, in a 50% mix the foreign scrap should be figured at 0.100% of sulphur.

No. 3.—Soft Iron.

For pulleys, small castings and general agricultural implement work.

Silicon not less than 2.20 or more than 2.80%, with a preference for about 2.40. (Below 2.20% small castings will be very hard; above 2.80 large castings will be somewhat weak and have an open grain.

Sulphur in no case over 0.085%. (If above 0.095 the whole lot will be condemned.) High sulphur makes iron "brittle short" and causes excessive shrinkage.

For frictional wear in brake shoes, etc., the sulphur may run up to 0.150%.

Phosphorus below 0.70%, except in cases where great fluidity is required, as in thin stove plate, when it may run up to 1.25%. (Phosphorus makes iron brittle under impact.)

Manganese below 0.70%, except in chilled work. (Manganese toughens iron, produces chill and causes excessive shrinkage.) For a heavy chill the manganese may vary from 0.70 to 1.25%.

Transverse breaking strain not under 2,000 lbs.

Deflection not under 0.10-in.

Shrinkage in no case above 0.141-in., when figured to a 12-in. bar, this being equivalent to ⅛-in. to the foot on castings molded in sand.

Chill should be under 0.05-in.

Tensile strength on a sand cast bar not below 18,000 lbs.

The iron must be free from defects, such as blow holes, shot, blister, cold shuts, slag, shrink cavities, kish, contraction cracks, etc.

Misplaced cores, poor molding and insufficient cleaning will also be cause for rejection.

This mixture may be made from Nos. 1 and 2 foundry pig, home and foreign scrap.

Scrap should be used in sufficient quantity to prevent formation of kish and to obtain the desired strength. It should run from 30 to 50%, being governed by the sulphur. Equal parts or 15% home with 30% foreign scrap is a good proportion to use. Scrap or remelted iron gives strength to castings by reducing the graphitic carbon and closing the grain.

In mixing by analysis it is better to figure foreign scrap at 0.100% sulphur.

When the sulphur in the castings rises above 0.081% the per cent. of scrap should be reduced in the next mix in order to regulate the sulphur. With low sulphur (0.071% about) 50% of scrap may be used.

THE VOLUME INCLOSED BY TWO INTERSECTING CYLINDERS.

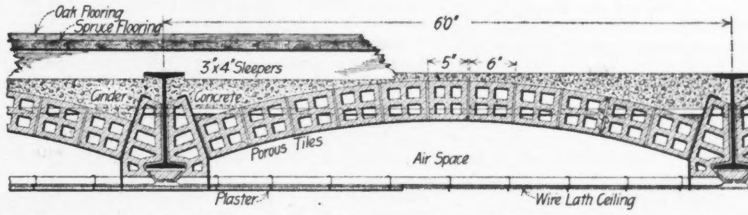
Notwithstanding the excessively warm weather of the past summer, a number of our readers sent us solutions to the problem suggested by Mr. Alex. Miller in our issue of Aug. 4, in which the volume included between two cylinders of different diameter intersecting at right angles was desired. These solutions received are of two kinds, the geometrical and the mathematical, the former depending upon scale drawings, developments of the same and the use of the planimeter; the latter using the calculus and winding up in most cases with a long formula in the form of a series. In these each term decreases in value so that all except the first three or four terms may be neglected.

We cannot spare space to give the derivation of the various formulas and the necessary explanation, but we present in the accompanying table the formulas suggested, and the names of their authors. If values are given to (a) and (r) and the formulas tested, it will be found that 4, 5 and 6 agree quite closely. We also received a solution from Mr. Guy P. Burch, of Dubuque, Ia., and Mr. Chas. H. Clark, of Canastota, N. Y.; but as their final formulae contained other quantities than the radii of the two cylinders we do not give them here.

We desire to compliment our correspondents on the industry they have displayed at a season when industry is not popular. We are still inclined to advocate the "solution by water," which we originally suggested, as the coolest way, at least, of solving the problem for a given case.

THE MERRICK FIREPROOF FLOOR.

We illustrate herewith a new form of fireproof floor construction designed by Mr. Ernest Merrick and controlled by the Merrick Fireproofing Co., of 1 Broadway, New York, N. Y. This floor consists of a true curved arch of porous terra-cotta blocks, filled above with cinder concrete, and having a wire-lath ceiling suspended beneath the arch. As will be seen from the illustration, a special skew-back block protects the floor beam, and has suspended from it a metallic hanger which hooks over its top and passes down the joint between the skew-back and the adjacent arch block, with a free end, to which is fastened the metal bars supporting the wire-lath ceiling. The arch is constructed on light portable centers of pressed steel construction, the skew-back blocks being set first and the wire hangers inserted before the arch blocks are set. This construction permits the ceiling bars and wire-lath ceiling to be erected by the plasterers after the centers have been removed and the floor proper has been completed in all other respects. Among the other claims made for the floor, in addition to the cheapness and convenience of the ceiling construction, are the greater strength of the circular arch construction and the especially complete protection of the floor-beam flanges. We are indebted to the Merrick Fireproofing Co. for the information from which this description has been prepared.



THE MERRICK CIRCULAR ARCH, TERRA COTTA FIREPROOF FLOOR WITH SUSPENDED WIRE-LATH CEILING.

The Merrick Fireproofing Co., New York, N. Y.

FIRST ANNUAL CONVENTION OF THE CENTRAL STATES WATER-WORKS ASSOCIATION.

The first annual convention of this association was held at Springfield, O., Sept. 27 to 29. The membership now numbers about a hundred. The number of papers presented was small, partly due to the youth of the organization, which was only started in February of the present year. The membership is divided into two classes, active and associate, and the former are subdivided into resident and non-resident active, on the plan which has been so successfully followed by the New England Water-Works Association. The resident active members are limited geographically to Ohio, Indiana, Michigan, Illinois, Kentucky, West Virginia and Western Pennsylvania, and the place of meeting must be within this territory, a restriction similar to that which the New England Association removed at its last meeting. Thus far nearly the whole membership and all the officers have been from Ohio, due largely, it is presumed, to the fact that the original idea was to form an association of Ohio men alone.

The convention opened Wednesday afternoon with the usual addresses of welcome, the President, Mr. Jerry O'Shaughnessy, of Columbus, O., being in the chair. The report of the Secretary, Mr. John Fisher, of Hamilton, O., showed total receipts of $360, and a balance of $134 in the treasury.

Electrolysis and Quality of Water Supplies.

A paper dealing with these two subjects was presented by Mr. Joseph J. Pater, of Hamilton. He urged that the association should investigate the subject of electrolysis.

TABLE OF FORMULÆ FOR SOLVING THE PROBLEM OF VOLUME INCLOSED BY TWO INTERSECTING CYLINDERS.

Formulæ submitted by	Formulæ (a = smaller radius. r = larger radius.)
F. W. Salmon, Burlington, Ia.	Lay out to scale on paper; develop intersection of cylinders in a plane; determine area of this figure; multiply by average height obtained with planimeter, as with indicator card.
John Peterson, Montclair, N. J.	Divide upper cylinder into slices by planes intersecting axis of large cylinders, get area of each segment of large cylinder thus formed, and subtract from area of rectangle formed by chord tangent and side of upper cylinder; average the area between adjacent sections and multiply by distance apart. The sum of these products equals volume.
George N. Linday,* Chicago, Ill.	$\frac{2}{3} d_0^3$; d_0 being a medium of the diameters if they are nearly alike.
Ward Baldwin,† Cincinnati, O.	$\frac{a^4}{r} \pi \left\{ \frac{1}{8} + \frac{1}{64} \left(\frac{a}{r}\right)^2 + \frac{5}{4 \times 256} \left(\frac{a}{r}\right)^4 + \frac{35}{64 \times 256} \left(\frac{a}{r}\right)^6 + \frac{147}{256 \times 256 \times 2} \left(\frac{a}{r}\right)^8 + \text{etc.} \right\}$
L. K. Sherman, Lockport, Ill.	$\frac{4}{5} a^2 (r - \sqrt{r^2 - a^2})$.
J. H. Serviss, Closter, N. J.	$4 a^2 \left\{ \frac{r}{4} \pi - r + \frac{a^2 + r^2}{6 r} - \frac{2 a^2 r^2 - a^4 - r^4}{40 r^3} - \frac{(a^2 + r^2)(2 a^2 r^2 - a^4 - r^4)}{112 r^5} - \frac{4 (a^2 + r^2)(2 a^2 r^2 - a^4 - r^4) - (2 a^2 r^2 - a^4 - r^4)^2}{1{,}152 r^7} + \ldots \right\}$
Charles W. Comstock, Golden, Colo.	$4 \pi r a^2 \left\{ \frac{1}{32} \left(\frac{a}{r}\right)^2 + \frac{1}{256} \left(\frac{a}{r}\right)^4 + \frac{5}{4{,}096} \left(\frac{a}{r}\right)^6 + \frac{35}{65{,}536} \left(\frac{a}{r}\right)^8 \ldots \right\}$.
C. F. Peterson, Edge Moor, Del.	$r a^2 \left\{ \pi - \left(\frac{a}{r}\right)^2 0.3955 - \left(\frac{a}{r}\right)^4 0.0500 - \left(\frac{a}{r}\right)^6 0.0157 - \left(\frac{a}{r}\right)^8 0.0069 - \ldots \right\}$
S. W. Frescoln, Reading, Pa.	$a^2 r \left(\pi - \frac{1}{30} \left\{ 97 - 14 \left(\frac{a}{r}\right)^2 - 3 \left(\frac{a}{r}\right)^4 \right\} \ldots \right)$.
Fred'k M. Thomas, Skaneateles, N. Y.	$0.4 a^3 P \left[1 + \frac{P^2}{8} + \frac{5 P^4}{128} \right]$ In which $P = \frac{a}{r}$. This is an approximate formula for practical use.
A. N. Talbot,§ Champaign, Ill.	$\frac{\pi}{8} \times \frac{a^4}{r} \left\{ 1 + \frac{1}{8} \left(\frac{a}{r}\right)^2 + \frac{5}{128} \left(\frac{a}{r}\right)^4 + \frac{35}{2{,}048} \left(\frac{a}{r}\right)^6 + \ldots \right\}$.
George R. Dean, Rolla, Mo.	$\frac{\pi a^2 r}{8} \left\{ \left(\frac{a}{r}\right)^2 + \frac{1}{8} \left(\frac{a}{r}\right)^4 + \frac{5}{128} \left(\frac{a}{r}\right)^6 + \ldots \right\}$.

*1323 Monadnock Block. †University of Cincinnati. §University of Illinois.

The discussion indicated that the subject was new to many of the members, although some pointed out that it had been exhaustively treated before similar societies in past years. A special report on the subject, being a study of the conditions at Dayton, O., by Mr. Harold P. Brown, of New York city, and other experts, was presented in printed form, by Mr. Chas. E. Rowe, of Dayton, and is abstracted at length elsewhere in this issue. Mr. J. R. Cook, of Toledo, said his city was one of the first to have electric railways, but they had never had an instance of injury to the water mains. Great care had been taken so to connect the tracks and the water mains as to maintain a positive current in the latter. Mr. Rowe cited an instance of a cast-iron welded joint where a test showed the rails were not carrying more than 5% of the return current. The subject of electrolysis was referred to the Executive Committee, to report to the next regular meeting, with power to pay the expenses to the next convention of some one who had made a study of the subject and would give them an address.

The other division of Mr. Pater's paper, the quality of water supplies, was designed to awaken the interest of the members in the subject. On request, Mr. B. H. Flynn, an inspector employed by the Ohio State Board of Health, outlined some work he has been doing on stream pollution. He had found that on the Sandusky River, for instance, Crestline, Bucyrus, Upper Sandusky, Tiffin, Fremont and Sandusky, located in the order named, are taking water from the river and discharging it back again as sewage for the towns below to drink.

The Additional Water Supply for Columbus, O.

Mr. O'Shaughnessy described briefly what is being done in his city in this line. About 8,000 ft. of 42-in. perforated cast-iron pipe is to be laid, of which 3,000 ft. is now down, for an infiltration gallery. Near by and connected with this pipe are 18 driven wells, 6 ins. diameter, 75 to 80 ft. deep, and 32 ft. apart. The water in the wells rises to the surface of the ground. The formation here, in a typical section, consists of 12 ft. of clay, 24 ft. of gravel, 6 ft. of boulders, 12 ft. of sand, 8 ft. of blue clay and 8 ft. of yellow clay, below which is rock. The perforated pipe is in the gravel, from 15 to 18 ft. below the surface of the ground. Bids for a concrete dam 52 ft. high, across the Scioto River, were to be received Oct. 3, the site being 5½ miles above the wells. It is thought that the effect of the water stored by the dam will be to keep the water level along the wells more constant than it would be otherwise. If water is taken directly from the river the State Board of Health expects the city to filter it.

Mr. Pater stated that where galvanized iron well points are used the perforations should be made before galvanizing, to prevent them from filling with rust.

The Purity of Public Water Supplies.

This paper was read by Mr. J. J. Hoppes, M. Am. Soc. M. E., of Springfield, O. He referred to the fact that the comparatively few recent deaths from typhoid fever in the army had stirred up the newspapers to much comment and criticism, while they scarcely mention the fact that 40,000 deaths from this disease occur annually in the United States, and many times that number of cases. The last analysis of the water from the filter gallery at Springfield, O., showed only 45 bacteria per cu. cm. He urged the members to work for legislation against the pollution of streams.

Idiosyncracies of Some Water Consumers.

In a very brief paper on this subject Mr. C. W. Wiles, of Delaware, O., cited instances of alleged bad odors in water from certain services, which odors, he said, were really due to bad plumbing in the sinks at which the water was drawn.

Sanitary Sewers and Automatic Flush Tanks.

Mr. H. C. Stilwell, of Marion, O., stated that his company was obliged, by its franchise, to furnish water free of charge for certain public purposes, including 2,500,000 gallons per year for sewer flushing. In 1894 sewers were put in operation, with automatic flush tanks. After a struggle, meters were secured on the services for the tanks. The first year afterwards the city paid nearly $200 for excess flushing water. The next year it kept under the limit. Last year the city began extra cleaning on the sewers, without notifying the company, and for the year used 5,000,000 gallons, or double the amount allowed free of charge. He was convinced that the regulating apparatus of flush tanks is not reliable, and that such devices are a menace to good fire protection.

A member stated that his works supplied 225 flush tanks, it was supposed, through orifices. The consumption running up to a high point, it was found that ½-in. faucets had been put in and were running full stream. On regulating the tanks the consumption fell 500,000 gallons a day.

Repairs to a Submerged River Crossing at Hamilton, O.

This work was briefly described by Mr. John Fisher, of Hamilton, O. On March 23, 1898, a freshet damaged a 20-in. submerged pipe, 600 ft. long. About 100 ft. of the main was undermined and a break occurred. A coffer-dam and centrifugal pumps were used in making the repairs. It was found that there were eight leaky joints, besides the broken ones. The injured portion of the pipe has been protected by piling, cut off at the top line of the pipe. It is proposed to continue this protection across the whole length of the submerged pipe. Calking with cold lead would not stop the leaks, so bands were used in addition.

Mr. J. R. Cook, of Toledo, O., said he had a 16-in. main, 1,300 ft. long, beneath the Maumee River. A leak occurred in 28 ft. of water at a ball and socket joint. Sand blast action made a large hole. A hand-hole plate was used as a temporary repair and a sleeve and lead joint as a permanent repair.

Closing Business.

The following are the principal officers elected for the ensuing year: President, Mr. T. R. Cook, Toledo, O.; Secretary, John Fisher, Hamilton, O.; Treasurer, Chas. E. Rowe, Dayton, O.; Editor, J. J. Pater, Hamilton, O. For the next place of meeting Cincinnati was chosen, it receiving 22 votes, against 15 for Put-in-Bay, O.

Excursions.

Besides several interesting trolley rides, there were excursions to the State Masonic Home, the shops of Warder, Bushnell & Glessner, manufacturers of reapers, binders and mowers, and to the pumping station of the local water-works. A lunch was served at the pumping station by the water department.

An account of the exhibits of water-works appliances will be found under Industrial Notes.

OHIO HAS 1,228 COAL MINES, according to the annual report of Chief Mine Inspector R. M. Haseltine. Most of these are small, however, only 413 employing more than ten men. The total production in 1897 was 12,448,822 tons, a decrease of nearly half a million tons over 1896 and 1½ million tons over 1895.

Of the year's coal production 4,106,124 tons were mined by machinery, a gain of 737,775 tons as compared with 1896. 732 hands were engaged in operating the machines, as against 579 in 1896, and there were 5,001 men engaged in blasting down and loading out the coal after being undermined by the machines. Coal is produced by machinery in 53 mines, as compared with 44 during last year. At the close of the year there were 166 electric machines and 67 which used compressed air.

There were 277 casualties reported, of which 40 were fatal, 142 were serious, and 95 were of minor consequence. There were 311,220 tons of coal mined to each life lost, as compared with 314,942 tons during 1896. There were 87,667 tons produced to each serious injury received and 44,841 tons were secured to each casualty that occurred as compared with 64,563 tons during 1896. 35.4% of the accidents were due to falls of roof, 17.3% to falls of coal, 25.3% to contact with mine cars, and 5.8% to premature explosions of powder.

Light carburetted hydrogen gas (fire damp) was present in 34 mines as compared with 38 during 1896, 4 serious and 1 minor accident are reported as emanating from this source.

COTTON PRODUCTION, in the United States, has shown a remarkable increase and a coincidental fall in price. U. S. Treasury statistics show that since 1872 the United States has quadrupled its cotton production, and the price is now about one-fourth of what it was then. In 1872 the cotton crop was 1,384,084,494 lbs., with an average price of 22.19 cts. per pound—with paper money at some discount. In 1898 the crop was 5,667,372,051 lbs., and the average price was 6.23 cts. per pound. Twenty-five years ago the United States produced 70% of the cotton of the world, and now produces 85% of all that is used. The cotton crop of other cotton-producing countries was an average of 1,618,000 bales per year between 1872-78 inclusive, and 1,924,000 bales for the average of the years 1890-97. The price of cotton cloth is also reduced at about the same rate. In 1872 "cotton printed cloth" was quoted at 7.38 cts. per yd.; in 1898 the same grade of goods bring 2.17 cts. per yd.

THE EXPORT TRADE OF THE UNITED STATES, as shown in an article on the world's export trade in the Antwerp "Journal of Maritime Interests," has increased nearly 150% since 1872, and has passed from fourth to the second place in the list of nations. In the interval, 1872-1898, the exports of England increased $207,475,000, while those of the United States gained $620,109,000. France, since 1872, has changed places with the United States, and is now fourth instead of second; she has lost $69,673,000 in this time. Germany holds third place and Russia fifth, with Austria-Hungary and Belgium holding sixth and seventh places. The total amount and relative rank of different nations at the two periods is shown in the following table:

Countries.	—Amount of exports.— 1872.	1896.	Increase.	Relative rank. '72.	'96
England ...	$1,235,200,000	$1,422,000,000	$207,475,000	1	1
United Sta's	430,583,000	1,050,692,000	620,109,000	4	2
Germany ..	559,700,000	994,156,000	384,456,000	3	3
France	726,066,000	656,393,000	*69,673,000	2	4
Russia	270,586,000	513,908,000	261,322,000	5	5
Aust-Hngry	250,900,000	369,016,000	118,116,000	6	6
Belgium ...	193,000,000	283,324,000	90,324,000	7	7

*Decrease.

A PROCESS FOR MAKING LEVEL GLASSES which is a decided improvement over old methods is described in "Iron Age" for Sept. 29. This process has been adopted by the Stanley Rule & Level Co., of New Britain, Conn. The level glass is centered properly and brought into contact with a 6-in. cast-iron wheel running at 2,500 revolutions per minute. The wheel has a sharp ridge on its circumference, and the friction between this and the glass melts the glass and small particles of iron are fused into the glass, leaving a sharply defined permanent mark without weakening the glass, as in the ordinary method of marking by scratching.

TESTS OF THE STRENGTH OF FLAT HEADS for cylinders subject to internal pressure were recently made by Prof. C. Bach and reported in the "Zeitschrift des Vereines Deutscher Ingenieure." The heads tested were over 2 ft. diameter. For cast-iron heads the author deduces from his tests the following formula:

$$K_b \geqq 0.8 \left\{ \frac{r}{s} + \left(\frac{a - 0.5\,r\left(1 + \frac{r}{a}\right)}{s} \right)^2 \right\} p.$$

For riveted flanged heads with a good sized radius for the curve at the junction of flange and head he proposes the following:

$$K_b \geqq \left\{ \frac{1}{2}\,\frac{r}{s} + \varphi \left(\frac{a - 0.5\,r\left(1 + \frac{r}{a}\right)}{s} \right)^2 \right\} p.$$

In these formulas—

K_b = assumed working stress for bending.
a = diameter of head in inches.
φ = percentage of elongation of metal in ultimate tensile test.
r = radius of curve at junction of flange and head.
s = thickness of metal in inches.
p = internal pressure on head in pounds per sq. in.

Prof. Bach states that his tests indicate that the strength of flat heads varies not as the thickness, as D. K. Clark supposed, but as the square of the thickness.

RAINFALL IN INDIA is variable. English engineers report as follows concerning the rainfall in the Midnapur and Howrah districts of Lower Bengal: The average annual rainfall in this section is about 70 ins.; but observations made at Ban Kura record a rainfall as follows for the four days ending at 8 a. m. on the dates set down:—

June 16	0.90 ins.	June 18	12.48 ins.
June 17	6.45 "	June 19	2.40 "
Total			22.73 "

THE UTILIZATION OF OLD RAILS in railway track is a very important matter, in order to increase the service life of the rails and several methods have been tried to make old rails again available for use in the main track. Many rails are removed from the track on account of worn, battered or depressed ends, and the Holland Co., of Pittsburg, Pa., has a plant for cutting off the ends and re-drilling the rails. A sufficient length is cut off to remove any marking due to the old splice bars, so as to get a good bearing for the new bars. The rails are calipered and arranged in regard to height, being graded to 1-32-in. in height, so that they go together well in the track. This method was described in our issue of Aug. 18 (p. 102). Rails which have been in service for 15 years have been treated in this way and put back in the main track. The plant has a capacity of 200 tons per day, and the company has several contracts on hand. The Holland Co. also re-rolls old rails to smaller sizes. This practice was introduced a few years ago by the McKenna Rail Re-Rolling Co., of Joliet, Ill., which has treated large quantities of rails.

BOOK REVIEWS.

CAMBRIA STEEL.—A Handbook of Information Relating to Structural Steel, Containing Tables, Rules and Formulas for the Use of Engineers and Architects. Cambria Iron Co., Johnstown, Pa. Leather; 4½ × 7 ins.; pp. 350; illustrated; $2.

This is the fourth edition of the Cambria Iron Co.'s pocket-book, and it shows considerable improvement over preceding editions. In place of the tables of weights and dimensions of the earlier editions it includes plates of sections, complete tables of weights, dimensions and properties of the principal structural shapes manufactured by the company, together with numerous tables and formulas useful to the structural engineer. It is stated that the tables pertaining to structural shapes were especially prepared for this edition. Those giving the properties of I-beams, channels and angles, safe loads of channels and I-beams and spacing I-beams are given in detail for each section, so that the required information can be obtained without interpolation. The various mathematical tables, formulas and other information have been compiled from authentic sources and revised and corrected to bring the information up to date. Altogether the book is very creditable in contents and make-up, and every engineer having structural work in charge can profitably add it to his list of manufacturer's pocket-books. A good index is provided.

OUTLINES OF PRACTICAL HYGIENE.—By C. Gilman Currier, M. D., Assoc. Am. Soc. C. E., Fellow of the New York Academy of Medicine, etc. Third edition, revised and enlarged. New York: E. B. Treat & Co., 242 West 23d St. Cloth; 6 × 8 ins.; pp. 461; 86 illustrations; $2.

This book treats a great range of subjects, and on the whole in a very satisfactory manner, considering the necessary limitations of space. The principles laid down seem to be well in accord with the best ideas and practice. The greatest faults of the book seem to be the failure, in the latest revision, to bring some of the sections wholly up to date. Thus, under garbage disposal, no mention is made of utilization or reduction processes, which have been prominently before the public of late and deserve some words both of praise and caution. Under water, more might well have been said regarding mechanical filtration, while it would help many readers to know that slow sand filtration is now being used in this country with notable success at a number of places. Besides the subjects already indicated the book discusses soil, climate, clothing, bathing, diet, exercise, lighting, heating, ventilation, plumbing, infectious diseases, disinfection, and many other vital matters affecting the health of the individual and the community.

EXPERIMENTAL MECHANICS.—Tests and Experiments made by the Class of '99 of the Stevens Institute of Technology during the Supplementary Term, June and July, 1898. By D. S. Jacobus, M. E., Professor of Experimental Mechanics and Engineering Physics, Stevens Institute of Technology, Hoboken, N. J. Press of the Stevens Indicator. 8vo.; cloth; pp. 67, with blank pages for notes. $1.50.

This book was printed for the use of one class in the Stevens Institute, but we understand that a few copies are for sale. It consists of brief directions for making tests, formulae for calculating results, and tables to be filled out by the students when the tests are completed. The preface states that experience has shown it to be necessary to modify from year to year, tables and directions such as those given, and it has been decided, therefore, not to issue a number of books to be used by succeeding classes, but only enough for one class each year, so that any desired changes may be made. The tests, concerning which directions are given, all of which with many others are required to be made, comprise tests of two steam boilers, of a condensing engine with independent vacuum pump and with a jet condenser, of a compound engine, of a simple non-condensing engine, of a rotary engine, of a steam turbine, of a gas engine connected direct to a dynamo, of a hot-air engine, of a steam pump, of a centrifugal pump, of ejectors and injectors, of air-compressors, fans and blowers of different kinds, of dynamo meters, of a water wheel, flow of water, and of steam in pipes, of lubricating oils, of a steam radiator, of non-conducting coverings, etc.

A large number of blank pages are bound in the book for additional notes and sketches. We commend the idea of this little book to the professors of mechanical engineering in other technical schools. It is the result of many years of experience in testing work in Stevens Institute.

THE NEW ROADMASTER'S ASSISTANT.—A Manual of Reference for those having to do with American Railroads. By George Hebard Paine. New York: "The Railroad Gazette." Limp cloth; 4¾ × 7¼ ins.; pp. 253; illustrations, 259. Price, $1.50.

This book is the successor to the "Roadmaster's Assistant," written by William C. Huntington in 1871 and revised by the late Charles Latimer in 1877. The arrangement and treatment of the subjects follow mainly upon the lines of the former work, but while the new book is more comprehensive than the old one, it is much less thorough, the style being general and brief rather than detailed. This is necessary in view of the variety of subjects included in this small book, but it is in many cases unsatisfactory, as it allows of but very little information being given on any one subject. As an example, the man looking for information as to the once much discussed "miter joint" for rails, finds only a diagram plan which "shows what is called the mitered end, a plan that has been largely followed on the Lehigh Valley R. R." There is no reference to the merits or demerits of, or the results of experience with, this joint, and as a matter of fact the Lehigh Valley R. R. some years ago abandoned the use of this joint. In the same way frogs are disposed of in a little more than one page of type, and the brief description of the automatic switchstand states that if the switch is "set wrong it will be thrown by the train itself whether going over the main track or side track route." This might be understood to mean that a train approaching the toe of a misplaced switch will throw the switch right, which is, of course, incorrect. The book nevertheless contains a considerable amount of information and is a useful addition to modern literature on railway track. It is well printed in large type, but considerable space is wasted by wide margins with unnecessary marginal paragraph headings.

PRISMOIDAL FORMULÆ AND EARTHWORK.—By Thos. U. Taylor, C. E., University of Va.; M. C. E., Cornell University; Assoc. M. Am. Soc. C. E. John Wiley & Sons, New York. Cloth, 9 × 5½ ins.; pp. 102; diagrams. $1.50.

This is not a book of earthwork tables, but an historical and practical treatise on prismoidal formulæ and their application to earthwork under many varying conditions of surface. Mr. Taylor, in Chapter I., takes up the formulæ of Newton, Hirsch, Koppe and Kinklin, proves and extends them and shows their limitations. He proposes no new formula, but points out that the term "prismoidal formula" is misleading, inasmuch as in another chapter on two-term formulæ he shows that there are an infinite number of formulæ more characteristic of the prismoid than that formulated by Newton. But the rules of Newton and Kinklin apply to the prismatoid and cylindroid, and they will thus apply with exactness to all forms of earthwork that fall in the class of ruled surfaces. As the burden of the work of finding the volume of earthwork cuts or fills consists in obtaining the areas of cross-sections, Mr. Taylor devotes himself to developing methods by which these areas can be found correctly, and with the least labor. To this end he explains the construction of a diagram which applies to all three-level sections and renders the work easy. He illustrates this by a number of problems worked out, including five-level, or very irregular surface sections, borrow-pits, etc. The cost of earthwork is discussed, chiefly based upon data taken from Trautwine; and included in this section are drag and scraper work, steam-shovel work, overhaul, etc. In another chapter he treats of correction for curvature, giving also Rankine's and Henck's methods. He concludes with the chapter on two-term formulæ, before referred to. The treatment of this subject is necessarily mathematical; but it is simple in form and easily understood, and according to the bibliography appended, on both the prismoid and earthwork, Mr. Taylor gives us a very complete and satisfactory resume of all authorities.

AMERICAN CEMENTS.—By Uriah Cummings. Boston: Rogers & Manson. Cloth; 6 × 8½ ins.; pp. 299; illustrated; $3.

In his preface the author of this book, who by the way is a manufacturer of natural cement, states that the chief motive which has animated the work "has been a desire to an adequate consideration paid to the claims and merits of American rock cements." In this connection he says:

> It has always seemed to the writer that scant justice has been done to natural hydraulic cements and that the tendency to regard artificial products as, in some mysterious manner, much superior to all others has no sufficient justification in the facts of the case, and that when all the evidence is heard it will be found and conceded, that for enduring qualities, for excellence in places of trial, for permanence and for worth, no artificially made cement can be found to compare with that mixed in the molds of nature.

As the author, on p. 192, states that what he should consider an ideal cement would

> consist in a selection of the raw materials which were found to be best adopted for the purpose (especial care being taken at least as to the quality of the clay) and then to be thoroughly and finally commingled in correct proportions, then calcined to a mild clinker, sufficiently vitrified to produce a medium weight, and then ground exceedingly fine.

It is evident that he refers in his prefatory statement to artificial cements as they are generally made and not to such cements as they might or should be made. In a word, the gist of the author's argument throughout the book is that the modern methods of Portland cement manufacture which produce a high short-time testing product are entirely faulty. That he succeeds in proving this is perhaps doubtful, but be at least presents evidence strong enough to be worth pretty careful study, and any cement user trained in modern doctrines in this matter will do well to read Chapters III., IV., VI. and VII. of this book. Outside of these chapters the book is not to be extravagantly commended, to say the least, and in some parts reads much like a trade catalogue. With these parts improved or cut out entirely and the really important chapters written in a more temperate tone the author's argument would have carried much more conviction to his readers than it is likely to do with the book in its present shape.

AMERICAN STREET RAILWAY INVESTMENTS.—A Supplement to the Street Railway Journal. Published annually for the use of bankers, brokers, capitalists, investors and street railway companies. 1898. The Street Railway Pub. Co., Havermeyer Building, New York. Cloth; 12¾ × 9½ ins.; pp. 279; maps. $3.

This excellent publication adds several new features to its annual exhibit of the mileage, equipment and financial condition of the street railways throughout the United States and Canada. The preface makes a comparison of gross receipts in 1896 and 1897 that has a general interest. According to this statement, 26 properties earned over $1,000,000 each in 1897; 19 earned from $500,000 to $1,000,000; 46 properties earned from $100,000 to $500,000; 51 earned from $50,000 to $100,000, and 33 properties earned from $25,000 to $50,000. In the first group the average rate of increase over 1896 was 2.20%; in the second group there was a decrease of earnings amounting to 0.11%; in the third an increase of 1.87%; in the fourth an increase of 1.61%, and in the fifth group the average decrease was 0.67%. This table rates 175 properties in all, and the total receipts from these were $113,394,903, with 75.2% of this amount credited to the 26 companies in the first group. The proportionate receipts of the other groups respectively were 11.3, 9.4, 3.0 and 1.1%. The gross receipts of the 175 companies in 1897 were 1.9% higher than in 1896. The various street railway companies are then taken up in alphabetical order; and in every case, where accessible, the statement covers the population in 1880, 1890 and 1896; date of charter or consolidation; plant and equipment at latest possible date; capital stock, funded debt, liabilities and earnings and operating expenses; officers of the road, etc. A new and useful feature is the presentation in tabular form of operating expenses and receipts and a balance sheet for four or five years past. This table enables comparisons to be made without referring to previous issues of the annual. There is also an increased number of excellent maps showing the street railways of principal cities throughout the United States.

SOME COMMON ERRORS IN IRON BRIDGE DESIGN.—By W. C. Kernot, Professor of Engineering, Melbourne University. Ford & Son, Melbourne, Australia. Cloth; 6 × 9 ins.; pp. 49; illustrated.

The trite saying that an engineer learns more from his failures than from his successes receives considerable substantiation from this little volume, in which Prof. Kernot has collected and analyzed something over a score of the most common errors made in designing iron and steel bridges. These errors are considered by the author under the following headings: Disproportion of Foundation Area to Load Carried; Excessive and Disproportionate Size of Columns; Girders Supported in an Unfavorable Manner; Imperfect Expansion Apparatus; Insufficient Depth of Girders; Unfavorable Disposition of Material for Enduring Bending Moment; Insufficient Connection Between Chord and Web; Vertical Stiffeners Absent or Wrongly Placed; Incomplete Triangulation; Redundancy; Curvatures of Members; Eccentricity; Unscientific and Wasteful End Pillars; Unduly Numerous Systems of Triangulation; Inefficient Forms of Compression Members; Imperfect Joining of Tension Members; Local Weakness at Intersection of Web Members; Arrangements Involving Serious Secondary Stresses; Arrangements Involving Severe Temperature Stresses; Insufficient Lateral Bracing; Cross Girders Not Placed in Proper Relation to the Web System of Main Girders; Improperly Designed Cross Girders; Unscientific Forms of Footpath Brackets; Faulty Parapets.

In each of these cases the author defines the error in a general way, then follows by quoting and describing several actual examples in which it occurs, and, finally, points out the best method of remedying or avoiding it. Generally the examples selected are legitimate ones and the criticism is well taken, and if once in a while the author dwells upon errors of old practice now generally avoided or selects cases which are purely local it does not come at all amiss to remind engineers that they are examples to be avoided. It will repay bridge engineers to obtain and read this book to refresh their memories concerning some of the errors which have been made in the past, and which are to be avoided in the future.

A POCKET-BOOK FOR MECHANICAL ENGINEERS.—By David Allan Low, M. I. Mech. E., Professor of Engineering, East London Technical College (People's Palace), London. With over 1,000 illustrations. Longmans, Green & Co., London, New York and Bombay. Cloth; 4¼ × 6¾ ins.; pp. 740. $2.50

This new addition to the long list of "pocket-books" for engineers is a very creditable production. It differs from all other recent books of its class in the great number of its illustrations, and in the unusual amount of space given to details of design of power transmission appliances, such as pillow blocks, hangers, keys, pulleys, etc. We notice, for example, two pages of illustrations of different styles of lock nuts, a page of spanners or wrenches, with proportions of sizes, a page of wire rope fastenings, 2½ pages of details of connection of iron or steel roof trusses, two pages of types of cross-heads, etc. Over a dozen forms of steam boilers are illustrated, more than 20 pages being devoted to them, including their descriptions and lists of sizes. The most notable differences between this pocket-book and the American books of Trautwein, Haswell and Kent, are the large proportion of space given to illustrations, the smaller size, the smaller number of pages and the larger type used. The book, therefore, contains probably less than one-third of the amount of text that is given in either of the other books named. The subjects treated and the amount of space given to each are approximately as follows: Mathematical tables, weights and measures, notes on geometry, algebraic and trigonometrical formulae, etc., 203 pages, of which about 25 are devoted to tables of comparison of Metric and British measures. Center of gravity and moments of inertia, 14 pages. Statics, kinetics, friction, efficiency of machines, etc., 28 pages. Sizes, weights and strength of materials, 98 pages. Stress diagrams for framed structures, 17 pages. Screws, bolts, nuts, keys, cotters, pipes and pipe joints, 25 pages. Shafting, coupling, bearings, 32 pages. Belt, rope, friction, and toothed gearings, and wire rope transmission, 36 pages. Cranks, eccentrics, connecting rods, cross-heads, pistons, stuffing boxes, valves, 31 pages. Heat, combustion, fuel, properties of steam, factors of evaporation, 37 pages. Steam boilers, riveted joints, boiler details, 62 pages. Steam engines, 43 pages. Locomotives, permanent way, 49 pages. Gas and oil engines, 19 pages. Compressed air, hydraulic transmission of power, hydraulics, 25 pages. Miscellaneous notes and data, 8 pages. Index, 18 pages.

The author states in his preface that the preparation of the work has occupied the whole of his spare time during the past five years, and he has had the services of several assistants in the calculation of tables and the preparation of the illustrations. The older tables have been checked by comparing them with those given by the best authorities, English, American and German. So far as we have been able to examine it, the work seems to have been exceedingly well done. Since the book contains so much less matter than the standard American works of its class, it can by no means be considered as a substitute for them, but since it contains much matter which they have omitted, chiefly in relation to details of design, such as are found in works on machine design, it may prove to be a useful companion to them.

RESERVOIR SITES IN WYOMING AND COLORADO.—Report from Capt. H. M. Chittenden of a Preliminary Examination Made by Him of Certain Reservoir Sites in the States of Wyoming and Colorado. House of Representatives, Document No. 141. Paper; 6 × 9 ins.; pp. 110; illustrated. Address Members of Congress or the author, care of Missouri River Commission, 1515 Locust St., St. Louis, Mo.

This investigation originated in an appropriation of $5,000 in the River and Harbor bill of June 3, 1896:

For the examination of sites and report upon the practicability and desirability of constructing reservoirs and other hydraulic works necessary for the storage and utilization of water, to prevent floods and overflows, erosion of river banks and breaks of levees, and to re-enforce the flow of streams during drought and low-water seasons, at least one site each in the states of Wyoming and Colorado.

The report discusses briefly but quite comprehensively the various phases of water storage and stream flow regulation mentioned in the above quotation, reviewing some classic French studies of flood prevention made in the middle of this century and giving especial attention to the storage of water for irrigation. Among the appendices to the volume is a monograph by Mr. Jas. A. Seddon, Assistant Engineer, "On Reservoirs and Their Effects on the Floods of the Mississippi System." Sites for five reservoir systems, including seven reservoirs, were surveyed under Captain Chittenden's direction, and estimates of their cost were made and are included in the report. Three of these systems are in Wyoming, the Laramie, Sweetwater and Piney Creek systems, and two in Colorado, the South Platte and Loveland systems. The character of the dams recommended are straight and curved masonry, and combined rock-fill and earth structures. The primary function of these reservoirs would be the storage of water for irrigation and power. Possibly they would also alleviate flood conditions in the rivers. Captain Chittenden is convinced that the cost of a reservoir system for the Mississippi large enough to materially diminish the height of floods would be too great to warrant the expenditure, "unless it is called for by other and more direct causes." He is strongly of the opinion that reservoir construction is essential to the wisest development of the arid West, and that it should be carried out by the general government, which should control all the water rights involved and own and operate the reservoirs, holding "the stored waters absolutely free to public use under local regulations, subject only to the right to close the reservoir whenever flood protection or other emergency should require."

The report is illustrated by good half-tone reproductions of a number of handsome photographic views of reservoir sites, by several diagrams, and by seven large folding maps of the reservoir sites examined.

FORESTRY CONDITIONS AND INTERESTS OF WISCONSIN.—By Filibert Roth, Special Agent. With a discussion by B. E. Fernow, Chief of the Division of Forestry, U. S. Department of Agriculture, Washington, D. C. Paper; 9×6 ins.; pp. 76; map.

In an introduction, Mr. Fernow describes the object of and the methods followed in ascertaining forest conditions; while Mr. Roth enters into the detail of the investigation, by counties, and describes the principal timber growing in Wisconsin. A summary of Mr. Roth's report shows that Wisconsin, with a population of 2,000,000 and taxable property worth about $600,000,000, annually consumes over 600,000,000 ft. B. M. of lumber, besides enormous quantities of other wood materials. In the northern part of the state, with a land surface of more than 18,000,000 acres, only 7% is under cultivation, and the rest is a continuous body of forest and waste land. From this area in the last 60 years over 85,000,000,000 ft. B. M. of pine lumber alone has been cut, with an annual average of 3,000,000,000 ft. for the last ten years. The lumber industries of the state employ 55,000 men, receiving $15,000,000 in wages per year, and the value of the product is $35,000,000; to this $25,000,000 more must be added as coming from wood manufactories. The standing timber is estimated as follows: Of pine, 17,000 million feet; hemlock, 12,000 million feet; hardwoods, 16,000 million feet; the present annual growth amounts to about 900 million feet, of which only 250 million feet is marketable pine, and this growth is largely balanced by natural decay in over-ripe timber. At present nothing is being done to restock 8,000,000 acres of "cut-over" land, and Mr. Fernow recommends that the state of Wisconsin in its own interest, establish a permanent forestry commission, and control the manner of exploiting forests under state ownership.

NOUVEAU TRAITE DES BICYCLES ET BICYCLETTES.—Equilibre et Direction; Le Travail. Par C. Bourlet, Docteur Es-sciences Mathematiques, Etc. Encyclopedie Scientifique des Aide-Memoire. Second edition. Paris: Gauthier-Villars et Fils. Two volumes. Paper; 7½ × 4⅝ ins.; pp. 180, and pp. 186; illustrated.

The first edition of these two volumes on the design of and the work done by bicycles was published in 1895; but the rapid development and radical changes made in these machines render a new edition necessary. Mr. Bourlet calls those machines bicycles which have the motor wheel in front, and is thus at the same time a motor and a directing wheel; and terms those having the motor wheel behind, bicyclettes. In succeeding chapters of the volume on "Equilibrium and Direction," he treats of the trajectories of the two wheels, the analytical conditions of equilibrium upon the level and upon inclined ground, or the security of the machine; and finally discusses effects of a change in direction. In this volume he devotes a chapter to the construction of bicycle race-tracks. He handles this from a mathematical and a practical point of view, and discusses gradients and curves for semicircular, elliptical and parabolic tracks.

The second volume, that on "Le Travail," is devoted to a mathematical discussion of the resistances to be overcome by the cyclist, or the friction in transmitting gear, the rolling friction, resistance of the air, etc. A chapter is also given upon the measure of work performed on the level and on grades, by the pedal, etc., and the influence of weight. The final chapter is upon the product of work; a study of pedal and crank pressure and the choice of gear. In the latter connection he argues that the maximum work, under the best conditions, is obtained with 115 revolutions of the crank per minute. Mr. Boulet compares the work done by a pedestrian and by a cyclist and concludes with a number of tables giving air-resistances at various speeds; the resistance and work performed at varying speed on a level or an inclined road, on the race track and on a mountainous route. The two works combined are a careful mathematical and theoretical discussion of bicycle design and operation.

MECHANICAL HEATING AND VENTILATION.—An Exhaustive Analysis of All Systems. Second edition. By M. C. Huyett, Heating and Ventilating Engineer, 66 Piquette Ave., Detroit, Mich. 8vo.; morocco; pp. 155; $3.50.

The author of this work is a man with a grievance—several grievances, in fact—and therefore his book is forcible and interesting, although his style is not above criticism, and his statements sometimes lack in technical precision. His two chief grievances are that "text-books, so called," do not give the kind of information concerning heating and ventilation that he thinks they should give, and that manufacturers of fan blowers tell falsehoods in their catalogues concerning the capacity of their fans and the horse-power required to drive them. The book is addressed "To Architects," and he tells them

The following pages present the essentials of heating and ventilation; the tables are original and are given to aid in the development of your part of plans on a scientific basis. It is information which has been withheld by manufacturers and engineers.

A sample of the author's method of treating technical questions is the following. On p. 13 be says:

The subject has been treated from a theoretical standpoint by most writers; in no "text-book," so called, can anything he found helpful or even suggestive which will aid architects in proportioning flue areas required for heating and ventilation.

This certainly encourages us to hope that in this book at least something helpful and suggestive on the subject will be found, and here it is on p. 25, under the heading, "Proportioning Areas of Heat Risers and Ventilating Flues."

Conditions are seldom alike, consequently no iron-clad rule can be stated for initial velocities. The judgment of a heating and ventilating engineer, based on practical experience, is the ony safe guide. Velocities must base on size and exposure of rooms, kind of occupancy, and location and distribution of displacement openings.

Then follows a "rule for computing pipe and riser areas for heating and ventilation based on changing air times per hour," given in a most complicated form, but which may be translated into a simple form as follows: Multiply the capacity of the room in cubic feet by the number of times the air is to be changed in an hour; divide the product by the velocity the air is to have in the flue in feet per second, and the result will be the area of the flue in square feet. Following this are several pages of tables of figures giving flue areas for different capacities of rooms and different velocities of air.

With all this how much has the architect learned that is helpful or suggestive in proportioning flue areas? Why, simply that he must first call in a heating and ventilating engineer of practical experience who will use his "judgment" in determining the number of times the air should be changed and the velocity to be given the air in the flue, and then with these data given be may by reference to Mr. Huyett's tables and rules compute the area required. There is not a word in the book so far as we can find by means of which a student of the subject of heating and ventilation may arrive at a "judgment" as to the velocity, or by which be may check the "judgment" of the "practical man."

Mr. Huyett's criticism of the fan manufacturers for publishing false information in their catalogues is no doubt deserved. He gives examples from the lists of four makers whom he calls A, B, C and D, showing that the actual capacity of their fans is only about half, and in some cases less than half of that claimed, and that the horse-power required to drive them at the stated number of revolutions is often understated by about half. A disk fan rated at 25,000 cu. ft. per minute was found by anemometer test to deliver less than 7,000 cu. ft. He has done a public service in thus protesting against this evil, and it is to be hoped that fan manufacturers will pay attention to it and mend their ways.

The book contains some good suggestions in regard to specifications for heating and ventilating apparatus, from which we quote the following:

Any seller who fails to specify the actual quantity of 1-in. steam pipe, diameter of fan wheel, and its width at the periphery, r. p. m. and speed of engine, does so with the intent to get a contract that shall be definitely indefinite—except they hedge behind "we are responsible" and "we guarantee." Responsibility and guarantee never yet warmed and ventilated a building. That requires a definite quantity of steam pipe and volume of air contact therewith.

NORTHWARD OVER THE "GREAT ICE." A Narrative of Life and Work Along the Shores and Upon the Interior Ice-Cap of Northern Greenland in the Years 1886 and 1891-1897. With a Description of the Little Tribe of Smith Sound Eskimos, the Most Northerly Human Beings in the World, and an Account of the Discovery and Bringing Home of the "Saviksue," or Great Cape York Meteorite.—By Robert E. Peary, Civil Engineer, U.S.N., M. Am. Soc. C. E., M. Am. Geographical Society. With maps, diagrams and about 800 illustrations. In two volumes. Frederick A. Stokes Co., New York. Cloth, 9 × 6¾ ins.; pp. 520 and 625.

This story of adventure and discovery in North Greenland is remarkable among narratives of its kind, as illustrating what one man can do, almost unaided by others, in extending our common knowledge of geography, and of a remote and peculiar people. Though Mr. Peary has devoted twelve years of his life to Arctic explorations, has made six expeditions to the North, and for nearly four years of that time remained within the Arctic Circle, the government has never appropriated, nor been asked to appropriate one dollar towards this purpose, nor has any scientific or geographical society, as a body, provided funds for furthering his efforts. Fully two-thirds of all the money expended has been earned by Mr. Peary and by his wife, by lectures and publications issued. Some few individuals have been generous in their personal contributions, though none of these latter exceeded $1,000, except the aid extended by Mr. Morris K. Jesup, in assisting to send a ship after Mr. Peary in 1895. Mr. Peary, evidently, did not propose to be open to the charge of "wasting other people's money on useless Arctic exploration," and he reduced the risk of human life to a minimum, the chief risk being to himself.

In the introduction to this work, Mr. Peary gives full credit by name to those who assisted him in his efforts, describes his outfit, and gives a sketch of those who accompanied him to the North. He then takes up in detail his several expeditions, from the reconnoissance of 1886 to his latest voyage. In the first volume the chief interest centers upon his 1,200-mile march across the Greenland ice-cap to Independence Bay and back, with but one companion—the faithful Eivind Astrup. Aside from the details of camp-life and the experiences on the ice-cap and the rocky moraines, very considerable information is given relating to the geological structure of the region visited, and to the peculiar Smith Sound tribe of Eskimos and their manners and customs. The many illustrations are chiefly reproduced direct from photographs, and in their way tell a graphic story of the difficulties encountered and surmounted and the curious and interesting people met with.

The second volume is devoted to the North-Greenland expedition of 1893-94, and 1894-95, and to the summer voyage of 1896-97 after the Cape York meteorites. Here again we have detail, but very interesting detail, of the almost daily doings of the party in building and fitting out their winter home, in passing the weary winter in preparing for the long marches across the ice-cap and in actually making the several journeys towards the North. This part must be read to be appreciated as no abstract will do justice to the strange conditions encountered.

Mr. Peary gives a detailed history of the Cape York meteorites, of exceptional size, purity and homogeneous composition. He traces this history to 1818, when Captain Ross found the natives in possession of rude implements edged with iron which they said came from an "iron mountain" near Cape York. Various expeditions sought this iron mountain, but it remained for Mr. Peary to discover the true source of these nickel-alloyed fragments of iron. Having gained the confidence of the Eskimos, in 1894, he was led to the long-sought-for "mine" and found it to be three great masses of true meteoric iron, the "Woman," the "Dog," and the "Tent," as the natives termed them. The first named weighed 5,500 lbs., and this was secured in 1895 after much trouble in getting it aboard the "Kite," and it and the "Dog," a smaller mass of 1,000 lbs., were transported to New York. The great meteoric stone, the "Ahnighito," or the "Tent," was partly removed from its bed in 1896 and finally secured in 1897. This mass, the largest of the meteorites, was irregular in shape and had a maximum length of 11.2 ft., a maximum width of 7.6 ft., and a maximum thickness of 6 ft.; its estimated weight is between 90 and 100 tons. Etchings show the characteristic Widenannstätten figures, and analyses show the typical meteoric nickel-steel alloy of about 92% iron and 8% nickel. Final analyses of the three masses indicate that they were three fragments of one original mass. In answer to objections made that the specimens obtained were not of meteoric origin, Mr. Peary produces certificates from three of the highest authorities upon this branch of mineralogy—Prof. L. Fletcher, of the British Museum; Dr. E. A. Weinschenk, of the Institute of Minerals of Munich, and Professor Bezina, Director of the Natural History Museum of Vienna. The book itself is handsome in appearance and it includes a map of the Arctic regions, showing the most recent explorations of Robert E. Peary, Fridtjof Nansen and F. Jackson; the map being made by Prof. Angelo Heilprin, who accompanied Mr. Peary.

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