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TABLE OF CONTENTS.

THE SURVEYS FOR THE PROPOSED BARGE CANAL, from Lake Erie to the Hudson River, for which an appropriation of $200,000 was made during the closing hours of the last session of the New York State Legislature, are being energetically prepared for by the State Engineer's office. On April 27 the board of engineers appointed by the State Engineer to investigate the various propositions and plans for lift locks for the proposed canal held its first meeting. This board consists of Mr. George S. Morison, M. Am. Soc. C. E.; Maj. Dan. C. Kingman, U. S. Engineer Corps; Prof. Wm. H. Burr, M. Am. Soc. C. E.; Maj. T. W. Symons, U. S. Engineer Corps, and Mr. Elnathan Sweet, M. Am. Soc. C. E. The Board organized by selecting former State Engineer Elnathan Sweet for Chairman and Mr. Henry Goldmark, M. Am. Soc. C. E., as Secretary, the latter having investigated the subject for the recent U. S. Deep Waterway Commission, and being, therefore, in position to give to the present Board the full benefit of these investigations. State Engineer Bond presented the general subject to the Board by saying that he wished the matter to be considered in the same practical way that would be used if some private company were about to construct a canal as a financial investment, and that it was desired that the interests of the state should be considered in order to find that style of lock which should give the best economy for the money invested, giving consideration not only to the facility for navigation but also to the interests of the people who are to pay for the canal if it is built. There were given to the Board for consideration descriptions and details of all the high-lift locks which have been designed or built. Among the designs which have been submitted for consideration are one by Mr. Chauncey N. Dutton and one by Mr. William R. Davis, Chief Bridge Designer, State Engineer office. Both of these designs are for a lift lock to overcome the 140 ft. rise at Cohoes Falls, where the Erie canal now has 16 double locks of the ordinary type. The survey, which is to be made by the State Engineer Department during the present season, will require a large number of civil engineers, levelers, rodmen, chainmen and helpers, all of whom have been, or are to be, selected under the Civil Service rules. To get the best results in this survey it is necessary to have a uniform method of records and field notes, and in order to decide upon the simplest and most effective method, the State Engineer has appointed a board of engineers to examine and consider the "instructions for survey parties" which have recently been prepared by the consulting engineers for the canal survey. The board of engineers thus appointed consists of Mr. Geo. S. Greene, Mr. Edward P. North, Mr. Geo. Y. Wisner, Mr. Palmer C. Ricketts and Mr. Nelson J. Stubbs, Mems. Am. Soc. C. E. This board held its first meeting on April 30.

AN ADVISORY BOARD OF ENGINEERS AT NEW Orleans is proposed by the Board of Sewerage and Water Commissioners, to consist of three local and two outside engineers. At a recent meeting it was decided to invite Messrs. Rudolph Hering, M. Am. Soc. C. E., and Geo. W. Fuller, Assoc. M. Am. Soc. C. E., both of New York city, to serve on the advisory board. One of the most difficult problems to be solved is the purification of the water from the Mississippi River.

AN INTERNATIONAL DAM ACROSS THE RIO Grande from El Paso, Tex., to Ciudad Juarez, Mex., is again proposed. The Mexican government has been interesting itself in behalf of its citizens below the proposed dam. It has been pushing claims for damages against the United States on account of the heavy diversions of water from the Rio Grande in Colorado and New Mexico. It is estimated that the dam and accessories would cost about $2,300,000.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the collision, near Phillipsburg, N. J., of a coal and freight train on the Central R. R. of New Jersey on April 27. One man was killed and a large number of freight cars badly wrecked.

A DESTRUCTIVE CONFLAGRATION swept over the cities of Ottawa and Hull, Ont., on April 27. The damage is summarized as follows in the latest press dispatches: Ottawa buildings destroyed, 2,000; Hull buildings destroyed, 1,800; total loss, both cities, estimated, $17,000,000; total insurance, both cities, estimated, $8,000,000; lives lost, seven; missing, four. More than 7,000 persons are homeless.

THE COLLAPSE OF A FOOT BRIDGE within the grounds of the Paris Exposition on April 29 caused the death of nine persons and the injury of 40 others, nine being seriously injured. This bridge crossed over the Aveuue de Suffren and connected one of the side shows with the exhibition grounds. It was built of cement, or concrete, and wire mesh, and seems to have fallen of its own weight, the ruins being precipitated upon the crowd in the aveuue below. At the time of its collapse the bridge had not been approved by the exposition authorities and was not open to traffic.

AN EXPLOSION OF BLASTING POWDER in the coal mines of the Pleasant Valley Coal Co., at Scofield, Utah, about 100 miles south of Salt Lake City, on May 1, killed probably 250 miners and injured many more. The latest press dispatches state that 150 bodies have been recovered.

THE CHISHOLM FUEL GAS PROCESS recently exploited in San Francisco and Oakland, Cal., and reviewed in our issues of Dec. 7 and Feb. 15 last, has been finally abandoned in both these cities. In our issue of March 29 we chronicled the remodeling of the San Francisco works to make water gas in the ordinary manner, and the Oakland "Enquirer" states that the plant at Oakland is now being also remodeled. It quotes one of the local stockholders as follows:

We have decided that the gas manufacturing process which we have proposed to put into operation is not a practicable one, and that is the reason the company will be reorganized. It will manufacture water gas under the old process, and the plant can be used for this purpose with but slight changes. We thought when we started in the business that the opinions of experts which we had secured justified us in believing the Chisholm process would be all right, but at the same time we made inquiries and learned that it would not cost much to change the basis of operations to water gas in case it should be found necessary.

STEPS TOWARDS MUNICIPAL OWNERSHIP of water-works have been taken by the Board of Supervisors of San Francisco, Cal. Under the new city charter (Art. 12), it is "declared to be the purpose and intention of the people of the city and county that its public utilities shall be gradually acquired, and ultimately owned, by the city and county." The first step to that end was a resolution passed March 26, inviting owners of existing water-works, and all others in a position to bid, to submit propositions for works capable of supplying a present estimated consumption of 25,000,000 gallons a day and an estimated future consumption of two or three times that amount. The first offer under this invitation was submitted by the Lake Tahoe & San Francisco Water-Works, of which Mr. A. W. Von Schmidt is President and Mr. Holland P. Smith is Secretary. The company states that it owns the right to stored waters in Lake Tahoe, together with a dam at the outlet to the lake, a diverting dam in the Truckee River, land on which the dams are located, and maps, plans and estimates for delivering water from Lake Tahoe to San Francisco. It proposes to rebuild the two dams named, construct a canal from the diverting dam to the Sierra Nevada Mts., a tunnel through the latter, a diverting dam across the American River, a canal from the latter dam to an intake reservoir in the Sierra foothills, 800 to 1,000 ft. above sea level; an intake reservoir, and a riveted steel pipe line or lines from the reservoir to the city, delivering water 300 ft. above the level of the sea. Various propositions as to quantities of water and other conditions are made, as follows: No. 1, 30,000,000 gallons a day, delivered through a single pipe line, $17,960,000; No. 2, same as No. 1, except with two pipe lines, $20,405,000; No. 3, works above the intake reservoir with a daily capacity of 100,000,000 gallons, otherwise same as No. 2, $21,215,000; Nos. 4 and 5, capacity of 100,000,000 gallons above intake reservoir, but 60,000,000 gallons below, $29,772,000 for a single, and $32,660,000 for a double pipe line. The works in any case would be finished in five years. All the propositions are made on the basis of 2½ cts. per lb. for pipe steel at tidewater on the Atlantic seaboard, prices to be raised or lowered in accordance with future market prices, presumably at the time of signing the contract. The same company offered, on Sept. 23, 1889, to build works capable of supplying 30,000,000 gallons a day for $15,000,000. It states that the increase in price in the present bid is due to an increased factor of safety and therefore thickness of plates in the proposed pipe line. It is expected that the Spring Valley Water-Works Co., which now supplies the city, will set a price on its works. We are informed that it values them at about $32,500,000, and that a valuation of $26,000,000 has been conceded by the city authorities as a basis for fixing rates at the annual readjustment. Mr. John A. Russell is Clerk of the Board of Supervisors of the City and County of San Francisco.

THE POLLUTION OF THE WATER SUPPLY of Cumberland, Md., by wastes from the mill of the West Virginia Pulp & Paper Co. has been in the courts for a number of years. An agreement designed to stop the litigation seems to have been reached. Under it the company will substitute the soda process for the sulphite process of pulp making and the city will withdraw its suits.

PAVING AND SEWERAGE WORK IN IOWA are greatly retarded by the present status of the law regarding assessments for benefits. The State and United States courts have each ruled on the matter quite recently, and the opinions appear to be very conflicting. The legislature has attempted to give some relief by a temporary act, which it proposed to replace two years hence by a more comprehensive one, after a special committee reports on the subject. We are indebted to Mr. M. V. Ashby, Acting City Engineer of Creston, Ia., for the above information.

A FAST ATLANTIC LINER has been ordered to be built by the North German Lloyd Line, which, it is stated, will exceed in size any steamship now afloat. According to the scanty figures which have been made public the new liner will have a length of 752 ft., and engines of 40,000 HP., and is to develop a speed of 24 knots. The new vessel is to be built by the Vulcan Shipbuilding Co., of Stettin.

THE GREATEST STEAMSHIP LINES of the world are summarized in a recent issue of the Liverpool "Journal of Commerce," as follows:

British.

Name of Company.	Gross Tonnage.	No. of Fleet.
Peninsular and Oriental	279,597	56
British India	277,711	105
Elder, Dempster & Co.	183,621	72
Thomas Wilson, Sons & Co.	170,709	87
White Star Line	126,940	22
Allan Line	124,785	34
Ocean Steamship (A. Holt)	122,091	49
Pacific S. N. Co.	117,969	38
Clan Line	117,368	39
Cunard Line	110,309	28
Anchor Line	108,402	31
T. & J. Harrison	102,549	28
Maclay & Macintyre (Glasgow)	95,200	45
Union Line	91,580	18
Prince Line	88,432	40
Johnson Line	84,781	25
Lamport & Holt	83,967	32
F. Leyland	82,584	24
R. Ropner & Co.	76,572	35
Castle Line	74,029	17
West India and Pacific	70,587	17
Other Lines.		
Hamburg-American Line	286,945	..
North American Lloyd	265,613	..
Hamburg S. Amer. S. N. Co.	100,646	..
Hansa S. S. Co.	84,867	..
Messageries Maritimes	229,837	..
Cie. Generale Transatlantique	166,701	..
Navigazione Generale Italiana	171,041	..
Austrian Lloyd	146,560	..
Compania Transatlantica	121,161	..
Nippon Yusen	161,698	..
American Line	116,950	19

This list includes ships owned and managed by these companies, but not vessels under construction. It will be observed that the names most familiar by no means rank the highest in this list.

PRICES OF THE RAW MATERIALS of foreign production used by American manufacturers continue to advance in the foreign markets from which these supplies are drawn. The following table shows the average value in foreign countries of the articles named during the fiscal years 1897, 1898, 1899 and the nine months ending with March 31, 1900, as shown by the figures of the Treasury Bureau of Statistics, which are based on the statements of importers of the cost of the goods in question at the foreign ports from which they are shipped to the United States:

	Fiscal year.			Nine months.
	1897.	1898.	1899.	1900.
Manila hemp, per ton	$73.68	$64.44	$116.62	$146.50
Sisal, per ton	60.60	74.59	128.12	151.30
India rubber, per lb.	.491	.551	.62	.65
Silk, raw, per lb.	2.84	3.05	3.19	3.94
Sugar, raw, per lb.	.0201	.0224	.0228	.0242
Tin, in bars, per lb.	.129	.1373	.1595	.269

THE FAILURE OF THE STAND-PIPE AT ELGIN, ILL.

By Wm. D. Pence, M. Am. Soc. C. E.*

The 30 × 95-ft. steel stand-pipe at Elgin, Ill., burst and fell about 8 a. m., on March 14, 1900. It is stated that the stand-pipe was full when the night engineer stopped pumping at 6 a. m., and pumping had not been resumed at the time of the accident. Reliable observations of two pressure gages by two men at the pumping plant near by just before the accident indicated that the water level was somewhat more than 20 ft. below the top of the stand-pipe.

Several reliable eye-witnesses state that there was first a crashing sound within the stand-pipe, resembling the sounds due to falling ice which have been heard almost every spring by persons living near the structure. This was followed almost instantly by a loud rending report and the rush of water and ice on the east side, and finally came a deep rumbling sound as the main upper section, containing several hundred tons of ice, struck the ground. About one-fifth of the plates, consisting of most of the four lower rings of the stand-pipe, tore loose from the upper section and from the bed-plate and was projected by the reaction of the escaping water to the southwest of the foundation, while the upper four-fifths or so, about 75 ft. in length, toppled to the east or northeast, fell vertically to the foundation, and finally landed in a flattened mass in a general northeasterly direction, free from the foundation, as shown in the photographic view, Fig. 2. Several of the plates in the ruins show by their brightened or curled up corners and edges the results of severe impact during the fall of the structure, and a deep circular furrow in the ground marks the path of the lower plates as they swung around to the westward. A careful examination indicates that the initial rupture occurred on the east or northeast side, about four courses from the base. The holding down bolts, 22 in number, failed mostly by direct fracture, usually in the eye. The injury to the masonry pedestal itself was comparatively slight, the stone water table being crushed and gouged out by falling plates and by the bent anchor rods. The bedplate remained in place.

The damage to surrounding property was surprisingly small, for aside from the leveling of trees and fences, only one house suffered much injury. Fortunately nobody sustained personal injury. The immunity from damage was due in part to the topography of the locality, the water passing quickly to the westward, and in part to the reduced amount of water in the stand-pipe when the failure occurred.

Fig. 1 shows the Elgin stand-pipe before its failure. Fig. 2 is a general view of the ruins taken several days after the accident. Fig. 3, taken immediately after the stand-pipe fell, is a view of the collapsed upper section, showing the extent of ice in the ruins. Fig 4 is a somewhat indistinct view of the interior of the upper section of the stand-pipe, which contained several hundred tons of ice after the fall. Fig. 5 is a sketch plan showing the location of the stand-pipe with reference to the pumping station. Fig. 6 illustrates several samples of the plate metal tested by the writer.

The stand-pipe, 30 ft. in diameter by 95 ft. high, having a capacity of 502,300 gallons, rested upon a concrete base faced with brick masonry, as shown in Fig. 1. This base has a height of 20 ft., making the total height of the stand-pipe 115 ft. above the adjacent ground surface. The plans of the Elgin stand-pipe are not available at the present time, but the details are very similar in a general way to those of two stand-pipes built at Peoria, Ill., some years since (Engineering News, Vol. XXVIII., p. 26, July 14, 1892, inset), and also, except as to roof and winding staircase, to those of the Des Moines, Ia., 30 × 100-ft. stand-pipe (Engineering News, Vol.XXVII., p. 347, April 9, 1892), the same engineer having designed and built the stand-pipes at all three of the cities named. The Elgin stand-pipe was built in 1887 at a cost of $14,287 for the superstructure alone.

Fig. 1.—View of Stand-Pipe at Elgin, Ill., Looking Northwest.

The bottom plate was ½-in. wrought iron, double riveted with butt joints, having ¾-in. rivets. The rings built 5 ft. each. The thicknesses of the plates were as follows: Course 1, 23-32 in.; No. 2, 11-16; No. 3, 21-32; No. 4, 19-32; No. 5, 9-16; No. 6, 17-32; No. 7, ½; No. 8, 7-16; No. 9, 13-32; No. 10, ⅜; No. 11, 11-32; No. 12, 9-32; No. 13, ¼; No. 14, 7-32; No. 15, 7-32; Nos. 16-19, 3-16. The details of the riveting given in the specifications were not followed in the construction, the pitch being about 2½ or 2⅝ ins. in the double riveting in the courses near the bottom where initial rupture occurred, and the holes being 1 in. in diameter. All horizontal joints were single riveted and vertical double riveted. The specifications for the plate metal will be given at the conclusion of this article in discussing the cause of the failure.

The Elgin water-works system was built in 1887-88 by the city. The supply is taken from the Fox River and filtered. There are two pumps, a 1,500,000-gallon Worthington and a 6,000,000-gallon Holly-Gaskill. The consumption of water per day, as given in The Manual of American Water Works for 1897, averages 1,000,000 gallons; maximum, 3,000,000; minimum, 700,440 gallons. As shown in the sketch plan, Fig. 4, the stand-pipe was located nearly 1,000 ft. from the pumping plant by the shortest line, although it is about 1,500 ft. by way of the 16-in. main. The usual service pressure in the mains has been 75 lbs. and the fire pressure 100 lbs. In case of fire it was customary to shut off the stand-pipe by means of a gate valve operated by an electric motor located in the gate chamber beneath the stand-pipe. This motor, which was controlled from the pumping plant, was damaged when the stand-pipe failed, the heavy door seen in Fig. 1 being burst inward by the rush of water and ice.

Twice each year since the stand-pipe was built it has been emptied and its interior carefully examined. The latest inspection was in October last, when the condition of the stand-pipe was said to be satisfactory. It is stated that there has been no trouble from leakage at least for ten years. The pitting action by the water has been quite marked, but perhaps no more so than is usual elsewhere under like conditions. The interior has been repainted twice since the stand-pipe was built. It has been found that very little of the interior paint has survived the first winter after repainting, owing to the rubbing action of the ice, an experience which is quite common to exposed stand-pipes with a low temperature water supply.

The pressure gage at the pumping plant showed 80 lbs. when the stand-pipe was full. An automatic gong alarm, which operated at about 79 lbs. pressure, served to notify the engineer in time to prevent overflow. It had been customary to fill the tank and then suspend pumping until the pressure fell to 65 lbs., representing a level about 34 ft. or so below the top of the stand-pipe. Unfortunately the gage was not self-recording, but, as already stated, it is claimed that two trustworthy men observing different gages at the pumping plant just before the accident, reported the pressure at 70 lbs., indicating a water level about 23 ft. below the top, or 72 ft. above the base of the stand-pipe.

It is said that pumping would probably have been resumed about 9 a. m. had not the accident occurred. Water service was cut off from the consumers until the valve at the stand-pipe could be closed and the pumps started. The works have, of course, been operated by the direct pressure system since the stand-pipe failed.

FIG. 2.—GENERAL VIEW OF RUINS OF THE ELGIN STAND-PIPE.

FIG. 4.—VIEW OF INTERIOR OF THE UPPER SECTION, SHOWING ICE.

*Professor of Civil Engineering, Purdue University, Lafayette, Ind.

The accompanying figures, Table I., relative to the weather conditions at Elgin during the ice-forming periods for the past two winters were obtained from the local weather observer.

TABLE I.—Comparison of Winter Temperatures at Elgin, Ill.

Year.	Month.	Sum of daily max.	Sum of daily min.	Mean temprture
1898.	December	908°	430°	21.6°
1899.	January	926°	414°	21.6°
1899.	February.	694°	208°	16.1°
1899.	March 1 to 15.....	598°	323°	....
1899.	December	1,062°	547°	25.9°
1900.	January	1,066°	602°	26.9°
1900.	February	775°	198°	18.5°
1900.	March 1 to 15......	521°	299°	....

Although the ground froze to less depth during the past than the preceding winter season, it is believed that ice has formed in lakes and rivers, and by inference in stand-pipes as well, in greater quantity this past winter. Recent observations by the superintendent showed the temperature of the water in the Elgin mains during the ice season to be little if any above 32° F. For several days preceding the accident the sun had been shining more or less and there was doubtless more or less thawing of the ice in the stand-pipe. However, it turned cold the evening before the failure and a film of ice ½-in. or more thick formed against the inside of the plates.

A careful study of the ice fragments and masses in the ruins showed that the great tube of ice commonly formed in exposed stand-pipes against the metal shell had in the Elgin stand-pipe a thickness of 6 ins. or so near the bottom and of 30 ins. or more in the upper section within the 30 or 35-ft. range of daily fluctuation of water level. It is commonly the case that the influx of warm water at the inlet pipe melts away or prevents the formation of this ice shell for some distance above the base of the stand-pipe, the extent of this action depending chiefly upon the temperature of the water supply. It would appear, however, that with the temperature of the water in the mains at about 32°, as above noted, this process of melting away the ice mass must have been very slight in the Elgin stand-pipe. Under these conditions the circulation of water in the stand-pipe by convection must have been insignificant. The increase in thickness of the ice walls from the base upwards was manifestly due to the increase in exposure toward the top of the stand-pipe.

The ice mass was, of course, originally molded close against the plates and rivets. It was evident, however, that a film of water had formed between the ice and metal shell, probably by the action of the sun and warmer winds for some days before the accident, for the imprints of the rivet heads and joints, while perfectly distinct, were not sharply outlined. This initial thaw is further evidenced by the thin layer of fresh ice,

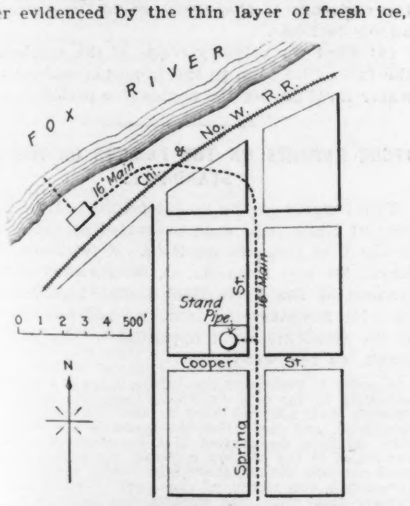

Fig. 5.—Sketch Plan Showing Location of Stand-Pipe and Pumping Station at Elgin, Ill.

already mentioned, which clung with surprising adhesion to the inner surface of the plates of the top section, notwithstanding its tremendous impact with the frozen ground. Although this ½-in. film of new ice held thus tenaciously to the metal sheets, no connection could be traced between the fresh film and the fragments of older ice. A careful examination showed the top of the ice mass in the upper section just even with the upper edge of the top ring of plates and the imprints of the rivet heads in the ice near the top continuously matching the rivets themselves, showing that the ice tube had not shifted longitudinally in the metal shell. Since the water level was below the point of buoyancy, it is certain that the ice mass was supported top to top with the stand-pipe either by the continuity of the ice shell to the bed plate, or by a frozen connection between the ice and the plates, or perhaps both. In any event, it seems absolutely certain that the main bulk of the ice molded more or less closely against the stand-pipe plates did not fall previous to the initial rupture near the base.

Among the countless fragments of ice were a number of very large sheets or chunks, two of which fell upon the bed plate and another immediately in front of the gate chamber door, Fig. 2. These masses and other boulder-like pieces of almost spherical form had unquestionably floated on the top surface of the water inside the ice tube, forming a broken sheet from 30 ins. to 3 ft. in thickness. With these masses floating at or near the top of the stand-pipe with the water surface held about stationary for a short time during the previous night, a very slight formation of ice, even less than that found on the plates, would weld them into a self-supporting sheet. The failure of this ice roof with the falling water level and consequent atmospheric pressure from above, accompanied by the morning rise of temperature, would account for the crashing sound within the stand-pipe heard the instant before initial rupture occurred.

The capacity of the stand-pipe free from ice was, as already stated, about 500,000 gallons. The estimated volume of ice, assuming a shell 95 ft. high with 18-in. average walls and a 30-in. top sheet, was 14,190 cu. ft., which would reduce the capacity of the full tank to about 400,000 gallons. With the water level say at 72 ft. above the base the volume of water in the stand-pipe when the failure occurred was not far from 300,000 gallons, indicating a consumption of perhaps 100,000 gallons or less from 6 to 8 a. m.. The total weight of ice in the stand-pipe, according to the above estimate, was say 800,000 lbs., or 400 tons, of which about 70,000 lbs. was in the top sheet whose fall is supposed to have preceded the failure.

A careful inspection of the ruins by the writer within a day or so after the accident revealed some interesting points relative to the plate and rivet fractures. Many of the plates showed by their curled and torn edges an ability to withstand severe abuse, but in various other places there appeared many unfavorable evidences in common with the ruins of other stand-pipes where poor material contributed largely to the cause of the failure. Among these indications were fractures of a more or less dead and laminated appearance, and evidences of brittleness, such as cracks and crystalline spots in the fractures. However, these indications were not so marked as in the ruins of the Peoria, Ill., stand-pipe, built under much the same specifications a year or two later than the Elgin stand-pipe, but by a different firm. While the rivet fractures themselves were satisfactory, as a general thing, many rivets indicated poorly matched holes and not a few had eccentric heads. Furthermore, there were many signs in the way of cracks about the rivet holes, which suggested damage in punching brittle plate metal. Many rivets were exceedingly loose; so loose, in fact, as to show that these holes must

FIG. 3.—VIEW OF UPPER SECTION AND OF ICE FROM THE STAND-PIPE.

have been greatly extended during the destruction of the stand-ipie, since the reported tight condition of the tank for the past ten years would not have been possible except with well-filled rivet holes. In view of the well-known influence upon the character of fracture with sudden rupture under impact, especially with low temperature, the writer withheld his conclusions as to the character of the plate metal until his laboratory tests were completed.

These tests included the usual tensile tests in duplicate, cold bend tests in duplicate, a quench bend test, and a test for phosphorus. The physical tests were made under the writer's personal direction in the Materials Testing Laboratory of Purdue University, and the phosphorus determination by Prof. W. H. Test, of the School of Chemistry. All the samples except D, Fig. 6, were taken from the plate which it was generally agreed gave way first. Considerable difficulty was experienced in preparing the specimens, the metal displaying a peculiar combination of toughness and brittleness. The results of the tests are given in Table II.

TABLE II.—Results of Tensile Tests of Material from Elgin Stand-Pipe.

	Sample	
	No. 1.	No. 2.
Original area, sq. ins.	.5625	.5754
Elongation in 8 ins., %........	22.5	23.5
Reduction of area, %...........	47.7	40.5
Elastic limit per sq. in., lbs.....	.....	37,020
Ultimate strength per sq.in., lbs.	58,490	55,960
Character of fracture.	Coarse, silky.	Laminated.

The yield point was not taken in sample No. 1. The elastic limit in No. 2 was determined from a card taken by the Henning instrument. The cold bend tests, A and B, Fig. 6, show the effect of bending the 9-16-in. strips nearly flat in the testing machine. Flaws or cracks developed on the outside of A when the inner radius was about 2 ins. or more and on B when the radius was ¾-in. The edges of strip A were somewhat rougher than those of B. Strip C was bent after quenching from a cherry red in water at about 80° F. The cracks began when the inner radius was about 1 in. The test for phosphorus was made from drillings taken from sample D, Fig. 6, which appeared to be unusually brittle and had an especially poor fracture. The fragment C was broken by a slight blow with a small hammer from a plate adjoining that from which the other samples were taken. The analysis showed .091% phosphorus.

The foregoing matter is devoted chiefly to the statement of available information relative to the Elgin stand-pipe and its failure. In the discussion as to the cause of the accident which follows, consideration will be given to the three phases—design, construction and operation.

Examining the list of plate thicknesses, it appears that the Elgin stand-pipe was designed with a safety factor of four, assuming 70% joint efficiency with 60,000-lb. steel plate. However, the spacing and diameter of the rivets in the lower rings was not such as to give the assumed 70%. In the fourth ring the rivets had a pitch of about 2½ ins. with 1-in. rivet holes which would reduce the efficiency of the joints to 60% or so, and increase the working stress with a full tank from 15,000 to 17,500 lbs. per sq. in. in the net section. With the water at the 72-ft. level at the time of the accident the stress due to hydrostatic pressure alone was, perhaps, 13,000 lbs. per sq. in. in the rings near the base where failure occurred.

The quite general practice of using a safety factor of four in stand-pipe design has doubtless been based upon the assumption of quiescence in the loading, as in building construction. In the case of a stand-pipe properly encased from the action of the ice and wind, this assumption is doubtless consistent, although the prevailing practice in good bridge work of using low working stresses for loads frequently applied might warrant the use, even in the protected stand-pipe, of safer unit loads than those obtained with a factor of four. In any event, the Elgin stand-pipe is open to severe criticism in that its metal has probably been subjected to as much as 17,500 lbs. per sq. in. under daily service, which represents a factor of safety of less than 3.5 as compared with an ultimate tensile strength of 60,000 lbs.; or if compared with the elastic strength of say 30,000 lbs. per sq. in., a "coefficient of security" of 1.7 or so. The latter is the more correct basis of judging of the safety of a stand-pipe, since total failure is almost certain to follow the opening up of the rivet holes, about which cracks or defects are most likely to occur.

The Elgin stand-pipe is, of course, open to the sweeping criticism which may be directed against the large number of stand-pipes which have no protection from the elements, especially those in icy latitudes. If, as must be conceded, intelligent design provides against a dangerous condition, which is certain to exist, then the Elgin stand-pipe was defective in design in that ice could form within it in dangerous quantities.

The specifications of the Elgin stand-pipe would have admitted, and in the writer's judgment did admit, steel plate of improper quality. The defects referred to are made evident by the following comparison in parallel columns between the tests specified at Elgin and those commonly prescribed by the better engineering practice, and by the physical and chemical tests already given:

Elgin Specifications.	Proper Specifications.
The metal of the plates must be of soft homogeneous steel, possessing a maximum tensile strength of 60,000 lbs. and a mimimum tensile strength of 55,000 lbs. per sq. in., and be officially and legally stamped; must be smooth, truly and evenly rolled, and uniform in size, and sufficiently ductile to admit of rolling, while cold, around a radius of 12 ins., without developing flaws, cracks, splits, or any other features which would render them unfit for the work in the opinion of the engineer.	The metal composing the stand-pipe shall be soft, open-hearth steel, containing not more than 0.06% phosphorus, and having an ultimate tensile strength of not less than 54,000, nor more than 62,000 lbs. per sq. in., an elastic limit not less than than one-half the ultimate strength, an elongation of not less than 26% in 8 ins., and a reduction of area of not less than 50% at fracture, which shall be silky in character. Before or after being heated to a cherry red and quenched in water at 80°F., the steel shall admit of bending while cold, flat upon itself, without sign of fracture on the outside of the bent portion.

While the tensile limits in the Elgin specifications are satisfactory, the cold bend test is obviously very absurd.

The results of tests by the writer, already stated, together with the appearance of the plate fractures in the ruins, show that the plate metal used in the Elgin stand-pipe was not suitable for such purposes. It is probable that common tank steel was employed, which, of course, is not a proper material to use in stand-pipes.

Finally, considering the operation of the stand-pipe, it is very generally believed that the failure would not have occurred had the stand-pipe been kept full of water. In many places it is regarded as of the highest importance to keep the pumps going practically without rest during the periods of alternate thaw and freeze, say during the months of February and March. It is during this period that the accidents from falling ice in various places have occurred. Although the ice has been heard to fall in the Elgin stand-pipe almost every spring since its construction, no injury seemed to result, so that no special importance was attached to the matter. The failure of the structure on March 14 came as an entire surprise to the authorities.

While it is practically certain that the initial rupture was induced by the fall of ice, it is argued by some that this could not be the case, since the automatic alarm of the pump failed to respond. It seems reasonable, however, that the impulse due to the impact or blow from the falling ice would find relief from the practically instantaneous rupture of the stand-pipe plates before it could travel through the 1,500 ft. or so of water main to the more or less sluggish alarm gage.

Again it has been asked, if ice caused the failure why has it not occurred during previous years when there may have been a greater mass of ice in the stand-pipe. To this it may be said that the danger is due less to the actual quantity of ice than to the peculiar combination of weather and improper control of the water level, which produces the serious effect. Furthermore, the testimony of those living in the vicinity of the stand-pipe indicates that the fall of ice during previous years may have weakened the structure and that the fall this spring was perhaps the "last straw." Had there been a fall of the entire mass of ice, weighing say 800,000 lbs., as in the stand-pipe at

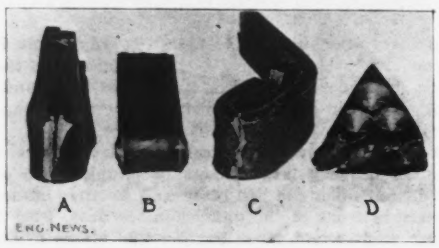

Fig. 6.—Test Samples from the Plates of the Elgin Stand-Pipe.

Maryville, Mo. (built by the same firm and about the same time as that at Elgin), the failure would be easily explained. But, as already stated, it is very likely that the only ice which fell previous to the rupture of the plates was the top sheet weighing probably about 70,000 lbs. The energy due to this fall of 20 ft. or so would be equal to 1,400,000 ft.-lbs. which acted chiefly upon the resilience of the metal shell, although a small portion was probably dissipated by the upward splashing of the water and through the outlet pipe into the system of mains. In view of the action of the ice shell, it is impossible to know just how this blow was distributed, but the total energy, if distributed uniformly over the lower 72 ft. of the stand-pipe, would give say 17 in.-lbs. per sq. in. of surface of the plates.

Now the elastic resilience of structural steel is 15 in.-lbs. per cu. in., and with the metal strained to 13,000 lbs. per sq. in. the surplus elastic resilience would be say 12 in.-lbs. per cu. in., or for the 9-16-in. plate in the fourth ring where initial rupture occurred, the available elastic resilience would be reduced to say 7 in.-lbs. per sq. in. of the inner plate surface. Thus the average energy per sq. in., due to the fall of the ice sheet, would be say 2½ times as much as the ability of the metal to receive shocks without passing the elastic limit of the metal. Considering the less thickness of the ice shell toward the bottom it seems very likely that the blow would be transmitted in more than average measure to the lower rings, and further, that the reduced plate section along rivet lines would suffer greater strain than the solid plate. Adding to these conditions the strong probability of an injury from ice action during previous years, the failure of the Elgin stand-pipe would seem to be fully explained. It is needless to add that the use of improper metal would increase the likelihood of such failure. It should also be noted that the foregoing somewhat hypothetical conclusions might be affected more or less by the possible high elastic ratio with brittle metal, indicated in the writer's tests, although this would be more than offset, no doubt, by the well-known liability of such metal to sustain damage, and suffer incipient fracture in the process of punching rivet holes. Furthermore, the supposed decrease in the resilience of steel under low temperatures would appear to be a very important factor, emphasizing still more the need of protecting stand-pipes from these critical elements.

Besides the fall of ice other possible dangers from the action of ice have been taken into consideration. One of these is the increased rivet shear due to the possible suspension of the 800,000-lbs. mass of ice from the top rim, which would amount to about 1,800 lbs. per rivet. Still another danger was in the formation of the ice cap by which the rivet shear might be greatly increased from the atmospheric pressure as the water was drawn off, or the stand-pipe might be overstrained by the sudden starting of the pumps. Should a perfect vacuum form beneath the ice cap, the increased vertical shear would be about 3,300 lbs, per rivet, which added to that due to the suspended ice, would produce a rivet shear of say 5,000 lbs. per rivet above that considered in the design. The danger from overstrain from pumping would, of course, be much reduced by the automatic alarm. Still another danger from ice is suggested by the existence of the water film due to thaw against the plates. In case the ice shell had a water-tight connection with the bed plate, as might appear possible with the low temperature of the supply, and be free from cracks so as to isolate the film from the main body of water, the dangers would be much the same as those which caused the failure of the stand-pipes at Asheville, N. C., and East Providence, R. I. These conditions are not unlike those which sometimes occur in a refrigerating plant when a breakdown for a few hours may allow a film of water to thaw between the ice mass and the sides of the freezing can. Under such circumstances the sides of the cans are sometimes seriously bulged when the refrigeration is resumed. These various possible or probable dangers from ice action merely go to enforce the importance of so encasing stand-pipes as to prevent the formation of ice within them.

To summarize, it is the writer's opinion:

(1) That the specifications for the Elgin stand-pipe were faulty in the tests for plate metal, and that improper material was used.

(2) That the working strains in the plate metal were excessive.

(3) That the failure would probably have occurred even with first-class material, owing to the exposure of the structure to the elements in an icy latitude.

(4) That the primary cause of the accident was the fall of ice, due to the improper control of the water level during the critical ice period.

OTHER REPORTS ON THE FAILURE OF THE ELGIN STAND-PIPE.

Two reports on the recent failure of the stand-pipe at Elgin, Ill., were presented at the meeting of the City Council, April 10. A brief one, dated March 20, was from Mr. C. W. Hawkes, Superintendent of the Springfield Boiler Manufacturing Co. He describes the material and workmanship of the structure as it appeared to him after the break, as follows:

> In order to determine the nature, I made a careful examination as far as a superficial inspection of the workmanship and material used in the construction of the stand-pipe, and found that the fractured plates showed a silky fracture, designating that the material in general was suited to the purpose intended, although a few fractured portions showed slight laminations which, however, were not in the portion of the tower in which the initial fracture took place; the workmanship likewise was good and even better than the specifications under which the tower was built; the contractors having deviated to some extent from the specifications, but for the better. The appearance of the plates showed that the general care of the tower had been good, although some of the plates were slightly pitted, but no weakness caused by such pitting. The thickness of the plates were ample thicknesses for the purpose intended under ordinary conditions.
>
> This substantiated the belief that the failure must have been by some sudden strain and undoubtedly by the ice and not by any apparent weakness of material or labor.

Mr. Hawkes noted particularly the evidences of large amounts of ice in the stand-pipe, which had been frozen to the shell, the latter being shown by the impressions of the rivets and seams in the ice.

As to rebuilding the structure Mr. Hawkes says:

I should recommend, that if a new tower be built, that the same be encased with brick or stone, allowing enough space between the pipe and casing for the circulation of air, likewise covered with a roof of proper design, which will prevent the formation of sufficient quantities of ice to ever cause any trouble. Also, should you decide to build a new tower, the bottom of the old one can undoubtedly be used and also the foundation, which is not injured to any extent and with slight additions for supporting casing, can be used.

A more extended report, dated April 7, was made to the city officials by Mr. Daniel W. Mead M. Am. Soc. C. E., of Chicago. Mr. Mead visited the ruins on March 15, the day following the accident. He thought the ice was thicker on the north and west than on the south and east sides, "and much thicker towards the top of the stand-pipe than in the lower portion." He also notes the large quantities of ice.

Regarding the character of the material and workmanship he says:

An examination of the fractured material shows, in some cases, slight laminations in the steel and evidences of brittleness was also noted at some points, but there are no indications which would point conclusively to defective material as the one cause of the accident.

At my request, your superintendent, Mr. Parkin, submitted pieces from two of the plates to Messrs. R. W. Hunt & Co., for physical and chemical tests. The results of these tests, while they do not show a material of as high grade as is desirable for this class of work, nevertheless do not show a quality which of itself would cause this accident.

The work on the stand-pipe seemed fairly well done; at least there had been no leakage on the pipe since it was first built. The rivets, however, did not fill the holes as completely as they should, and they could be readily driven out when one set of heads were removed.

After reviewing his computations of strains in the plates, assuming a joint efficiency of about 60%, against 70% for "good grades of double-riveted work," and also noting that the "maximum strain due to water pressure occurs every time the structure is filled," Mr. Mead discusses the causes of the failure and the rebuilding of the stand-pipe as follows:

For these reasons, I believe that this stand-pipe had only from 50 to 60% of the strength which it should have had for safety. The accident itself, however, I am convinced was due to no single cause, but to a combination of unfortunate conditions. The stand-pipe metal, already strained to an undue amount, was probably overstrained each winter by the effects of ice and of temperature strains. These excessive strains would find and affect particularly points where any weakness had been developed by imperfect riveting or by flaws in the metal. This weakness apparently developed at or near the fifth horizontal seam, which had, in my opinion, become so weakened at the point of rupture that it only required an unusual shock to produce failure.

I was informed that credible witnesses had first heard a crash as of falling ice, after which the tower was seen to slightly totter and the collapse followed.

The information at hand would seem to indicate that ice, either just broken from the side or floating ice that had lodged near the top, had fallen at this time and produced a shock which was the immediate cause of rupture in the vertical double-riveted joint in the fourth sheet, and that this produced the destructive results.

I do not believe that this fall of ice, of itself, would have caused the accident, but the condition of the pipe was evidently such that it only needed a strain slightly in excess of those already existing in the plates to cause rupture.

You have also inquired as to whether, in my opinion, a stand-pipe can be built which will be practically free from the danger of destruction which has overtaken the Elgin stand-pipe and, if so, what precautions are necessary to secure these results.

In reply to this question, I would say, that I believe it to be entirely feasible to design and construct a stand-pipe which will be safe from accidents of this kind. To accomplish this, the metal should not be strained by hydrostatic pressure above 10,000 lbs. per sq. in. of net section. The material of the pipe should be carefully selected, carefully inspected and tested, and great care should be taken to see that the work of manufacture and of erection is properly performed. With such precautions, I believe these structures to be entirely safe.

Under conditions such as exist in Elgin, other precautions than those stated can be easily taken. The lower half of the Elgin stand-pipe was practically of no value as far as storage was concerned, as when the water was drawn down more than about 35 ft. the pressure was inadequate to supply all portions of the city. For this reason it would be an easy matter to construct at Elgin, an elevated tank, by extending the masonry to the minimum height at which the head of water can be utilized. This would permit of the use in construction of light sheets, which are most easily and safely used in this class of work. In addition to this, the masonry tower can be readily extended so as to surround and protect the pipe itself and keep it practically free from ice.

After submitting proofs of these articles to various parties interested in the accident, we received some further comments on the failure, the first being from Mr. Mead, as follows:

From the measurements made by Mr. R. R. Parkin, Superintendent of the water-works at Elgin, and forwarded to me, the thickness of the sheets varied slightly from those given in the specifications. According to Mr. Parkin's measurements, sheet No. 1 was ¾-in. in thickness; No. 2, 11-16; No. 3, 21-32; No. 4, ⅝; Nos. 5, 6 and 7, 9-16; No. 8, ½; No. 9, 7-16; Nos. 10 and 11, ⅜; Nos. 12, 13, 14 and 15, ¼; Nos. 16, 17, 18 and 19, 3-16-in. In some cases these thicknesses were slightly less than those specified, which increases the tensile strain in the net section somewhat.

My own conclusions, as embodied in my report to the Water Commissioners of Elgin, seem to agree practically with those of Prof. Pence. The only point on which we seem to differ at all, is in his third conclusion, and in which we may or may not differ. As stated in my report, I do not believe that the fall of ice would have caused this collapse if the stand-pipe had been properly designed and built of proper material.

Mr. Parkin states as his belief that if the accident was due to ice, the ice in question must have been the floating fragments, which during the night preceding the break were connected by a sheet of ice extending over the surface of the water in the stand-pipe.

A PROPOSED WATERWAY FROM LAKE MICHIGAN TO THE MISSISSIPPI RIVER.

Ever since the inception of the idea for a main drainage canal to the Desplaines River to carry the sewage of Chicago westward by the Desplaines and Illinois rivers to the Mississippi River, there has been an ulterior design of developing this

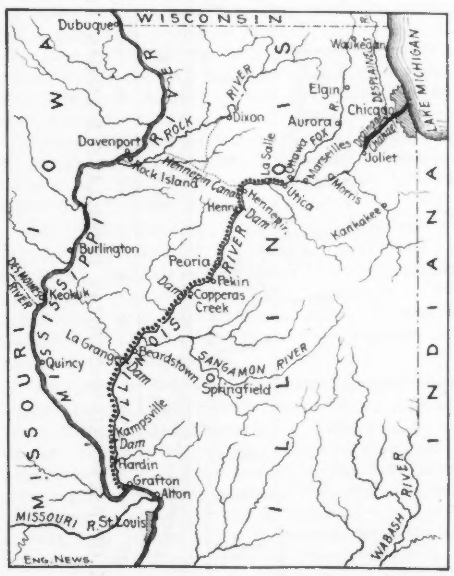

Fig. 1.—Map of the Route of the Proposed Waterway from Lake Michigan to the Mississippi River.

route as a deep waterway to afford navigation facilities between the Great Lakes and the Mississippi, and by the latter river to the Gulf of Mexico. The drainage canal, now completed and in service, was built with a view to navigation, and all bridges crossing it are drawbridges. This canal connects the Chicago River with the Desplaines River, and now comes the project of extending the navigable channel to the Mississippi.

In March, 1900, the Trustees of the Sanitary District submitted to Congress a memorial in favor of the construction of this waterway by the Federal government. A depth of 14 ft. is recommended, with a channel 300 ft. wide and a supply of 10,000 cu. ft. of water per second from Lake Michigan. The memorial sets forth that the most expensive part of the work has already been accomplished by the construction of the Drainage Canal, which extends the facilities of navigation as far as Lockport, 36 miles from Lake Michigan. This canal is 162 ft. wide in the rock sections, and 202 ft. wide on the bottom in the earth sections, with a normal depth of 24 ft. of water. In regard to the work required west of Lockport, we quote the following extracts from the memorial:

From Lake Michigan at Chicago to St. Louis the distance is 365 miles. Of this distance 34 miles are traversed by the Chicago Sanitary and Ship Canal and 42 miles by the Mississippi River. From the end of the canal at Lockport to the mouth of the Illinois River is 289 miles, of which distance 19½ miles are covered by the Desplaines River, which joins the Kankakee to form the Illinois. For purposes of description and estimate the total distance is divided into three characteristic sections: (1) the Joliet section, from the end of the canal to Lake Joliet, 8 miles; (2) the upper Illinois, from Lake Joliet to Utica, 54 miles, and (3) the lower Illinois, from Utica to the mouth, 227 miles.

(1) The Joliet section is a quite regular declivity over Niagara limestone (the same formation through which the canal was cut) through the city of Joliet, with an elevation of 12 to 15 ft. below Lake Michigan at the end of the canal and descending to 76 ft. below the lake at the pool known as Lake Joliet. There is little soil over the rock along these eight miles and the Desplaines River has formed only a shallow channel in the rock. The pools formed for the Illinois & Michigan canal and those created for water power were made chiefly by retaining walls and embankments. In geological history this slope was a great rapid in the ancient outlet of the lakes, and the pool known as Lake Joliet was formed in the softer rock at the foot of the rapids.

From the construction standpoint this stretch is the most expensive. Any waterway through this section must have ample prism to care for the flood waters of the Desplaines River, as well as the flow of the canal, and it will normally be constructed partly by excavation and partly by walls and embankments. It has been considered that this ample prism could be best constructed by giving it a depth equal to that of the canal. Several plans for treating the Joliet section have been studied for purposes of estimate, and it is believed that a project in harmony with the canal can be carried out for about $8,000,000. The pool known as Lake Joliet is five miles long and has ample depth when cleared of deposits. The project outlined contemplates an extension of the canal, and a part of the right of way needed has already been acquired, and all obstructions have been removed, except one dam and water power and the old Illinois & Michigan Canal.

(2) From Lake Joliet to Utica the distance is 54 miles, with a descent from 76 ft. below Lake Michigan to 142 ft. below. The river bed is deeply cut and is divided into pools and rapids, according to the nature of the resisting strata. Lake Joliet, already mentioned, Lake Du Page, above the mouth of the Kankakee, and the pool above Marseilles cover one-third the total distance. The average width of the river is from 500 to 600 ft. between banks. There are no artificial obstructions on the upper Illinois except the mill-dam at Marseilles. The tributary watershed varies from 6,400 sq. miles at the mouth of the Kankakee to 10,400 sq. miles at Utica, and gives rise to floods, which come in part during the season of navigation. Owing to the very considerable declivity, high velocities exist in localities, and this makes expedient a large and deep channel in the interest of navigation and without regard to the depth which may be utilized. The studies thus far made show that the upper Illinois can be treated on three levels or pools with a depth of 14 ft. by means of three dams or locks. This depth will require considerable dredging for a channel 300 ft. wide, though a part of this may be dispensed with, but at the expense of efficiency. A proper treatment will not injure any great area of bottom lands. Six highway and three railway bridges will require alteration. Trial estimates for actual projects show that a depth of 14 ft. with locks designed for larger depths can be produced throughout the upper Illinois for $10,000,000.

(3) The lower Illinois, or alluvial section, extends for 227 miles from Utica to Grafton, with a declivity which depends largely on the stage of water in the Mississippi. From the low water surface of the pool formed by what is known as the Henry dam at Utica bridge to the low water line of the Mississippi River, the descent is but 34 ft. Natural low water at Utica is but 31 ft. extreme or 28 ft. at ordinary low water, and for much of the year it is considerably less, owing to the longer periods of moderate stages in the Mississippi. This remarkable feature of low declivity is coupled with low banks (not averaging more than 12 or 14 ft. above low water) and extensive bottom lands of some 700 sq. miles, intersected by sloughs and marshes. These conditions make a stream of low velocity and occasion wide and deep overflows in the flood season.

The low water width is generally from 600 to 1,000 ft. and the ruling depth on bars at extreme low water is from 18 to 30 ins. Experience in dredging these bars has shown a reasonable permanence in the channel produced, but the extreme low water volume before the opening of the Chicago Canal was insufficient for a depth greater than 4 to 6 ft.

The river has been improved by four dams and locks, two built by the State at Henry and Copperas Creek and two by the United States at La Grange and Kampsville. These dams have been the subject of much protest by the adjacent land owners, who claim that they increase the liability of overflow by moderate rises in the river. It is also claimed that they raise the water plane, thereby provoking deposits in the beds of tributary streams as well as in the river itself. The deterioration of the pools seems to be well established and is naturally to be expected in a stream of the character of the Illinois River. In 1889 the General Assembly of Illinois passed an act making the removal of the dams Henry and Copperas Creek mandatory before the opening of the Chicago Sanitary and Ship Canal. The legislature at the same time requested the Federal government not to complete the works then in progress at La Grange and Kampsville and to change its policy to one of channel deepening in connection with the water supply from Lake Michigan. This request was repeated by the General Assembly in 1897.

The policy of the state of Illinois requires an open channel of not less than 14 ft. in depth and a width of 300 ft., to be secured by dredging, and a water supply of 10,000 cu. ft. per second from Lake Michigan. This would mean a volume sixteen times greater than that of natural low water at La Salle and eight times greater than at the mouth of the Illinois. Such a virile stream would better maintain the channel and such an improvement would make a better drain, so that an increased volume of flood water would be provided for. On the other hand, such increase of volume, without removing dams and deepening the channel, would cause widespread injury to material interests.

Official measurements have been made of the volume of water passing in the river at different stages. The bank-full stage, 12 ft. above low water, would indicate a flow of 18,000 to 22,000 cu. ft. per second from Utica to Havana; 30,000 cu. ft. at La Grange, and 40,000 at Kampsville. It is estimated that with the addition of 10,000 cu. ft. of water per second there would be a uniform depth of not less than 7 ft. on the natural bars throughout the lower Illinois, except near the mouth. An additional depth of 7 ft., making a total of 14 ft., would have to be secured by dredging. A dredging of the shoals for the most efficient results will materially lower the flow line. An estimate has been made for a navigable channel 300 ft. wide and 14 ft. deep which calls for the removal of from 60,000,000 to 70,000,000 cu. yds. of earth at a cost of $7,000,000. The material to be removed is easily handled and the recent improvements in dredging appliances would doubtless make the above figures cover the cost of removing 100,000,000 yds. In making these estimates the scouring action of the augmented volume is not considered, and there are special conditions which may make this an important aid.

From the mouth of the Illinois to St. Louis, a distance of 42 miles, no sufficient study has been made of the conditions to justify an estimate of the cost of improvement. This section forms the boundary line between two states and is less directly subject to the policy of the state of Illinois. It may be fairly assumed, however, as practicable to obtain 14 ft. of water in the Mississippi River from Grafton to St. Louis throughout the year, except when obstructed by ice.

Records kept at Morris, on the upper Illinois River, show that the ice season lasts on the average from 60 to 70 days, as against 120 to 140 days in the year on the lake routes from Chicago to Buffalo. During the past 12 years there would have been no interruption to navigation on the river route for two-thirds of the winters, and the stream could probably have been kept open in winter during the other years by the aid of ice boats.

In legislating for the Illinois & Mississippi Canal, better known as the Hennepin Canal, which provided for a channel from the Illinois River above Hennepin to the Mississippi River at Rock Island, Congress failed to make any provision for that part of the route required to reach Lake Michigan, which is absolutely necessary to make that canal useful. It may be assumed, however, that it was the intention of Congress to utilize the Chicago Canal when completed, and to improve the Desplaines and Illinois rivers from Lockport, the terminus of the canal, to the entrance of the Hennepin Canal, 19 miles below Utica. If this was not the case, the construction of the Illinois & Mississippi Canal could hardly be justified. However, that canal is only 7 ft. deep and is designed to reach points on the upper Mississippi. The Illinois River is susceptible of a far more radical improvement just as the lower Mississippi justifies a much greater depth than does the upper Mississippi. It would, unquestionably, be a great mistake to dwarf the Illinois River to the capacity of the Hennepin Canal. The larger depths and greater widths of the Illinois will serve the Hennepin better in permitting large navigation to and from its eastern terminus.

In conclusion, we sum up as follows:

(1) An available navigation of 14 ft. with locks for fleets of barges and so designed as to permit greater depths in the future may be had between the present terminus of the sanitary and ship canal at Lockport and the Mississippi River for $25,000,000. The channel improvements include five locks and dams in conjunction with a water supply of 10,000 cu. ft. per second from Lake Michigan, and it is not possible to produce such a waterway without this water supply.

(2) This depth will undoubtedly provide such a prism in the upper Illinois as will reduce the flood velocity to tolerable limits. It is believed that such a depth on the lower Illinois will avoid increased damage by overflow and produce a current strong enough to maintain itself against obstructive deposits. Its superiority for navigation needs no statement. This depth was determined upon as the least to be considered when the Chicago Canal was authorized, and has been formally expressed as the public policy of the state of Illinois.

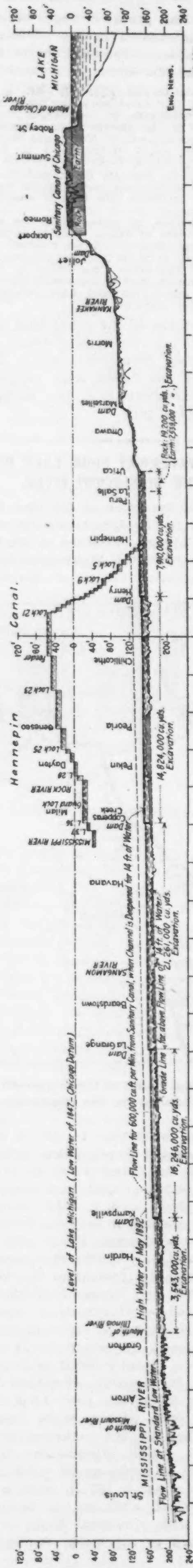

FIG. 2.—PROFILE OF PROPOSED WATERWAY FROM LAKE MICHIGAN TO THE MISSISSIPPI RIVER.

(3) The first effect of turning in the water from Lake Michigan after removing the dams is to extend the available steamboat and barge navigation as far up the Illinois River as Utica, which is only 62 miles distant from lake navigation at Lockport. Before the opening of the Chicago Canal, lake and river navigation, for practical purposes, were 320 miles apart.

(4) The plans made on which the foregoing estimates were based were to test the possibilities of the route and for purposes of calculation. They were not intended to determine a final design, but it is not assumed that a final design would lessen the estimate, although it might greatly improve its scope and make the work more efficient.

(5) A variety of plans for extending deep water from the mouth of the Illinois to St. Louis, have suggested themselves, but no estimate has been made. It is considered practicable to accomplish this improvement.

(6) That portion of the work between the end of the Chicago Canal and a point 19 miles below Utica, a distance of 81 miles, and covering all the structural and most expensive operations, is necessary to be done in order to form an outlet for the Hennepin Canal. This portion, in fact, practically covers all the work necessary to open the waterway as a whole, and subsequent work will simply be in the nature of betterment.

(7) A navigation of 14 ft. from Chicago to St. Louis is justified, without regard to any river connection at St. Louis, yet the fact will at once suggest itself that, as a connection with the Mississippi River, this depth can be carried through to the Gulf of Mexico, and maintained for enough months in the year to justify the expenditure. With the maintenance of 8 to 9 ft. minimum depth in the Mississippi River beyond St. Louis by the Mississippi River Commission, a depth of 14 ft. ought to be had for eight to nine months. The proposition is in harmony with such a natural development of the Mississippi as is believed to be not only possible, but in the highest degree desirable from every standpoint.

Since the above memorial was presented to Congress, a report has been made by a Board of Engineer officers, consisting of Col. J. W. Barlow, Major J. H. Willard and Major C. McD. Townsend, upon a proposed waterway from the terminus of the Hennepin Canal to a connection with the Chicago Drainage Canal at Lockport. The section covered will be seen to be practically the same as what is designated as the Joliet section in the above memorial of the Chicago Sanitary Commission.

The Board of Engineers has made careful surveys of the proposed route, and, while its estimates are only approximate, they are considered by the Board sufficiently large to provide for carrying out the work under the most unfavorable conditions that may be found. The estimates are for a canal 10 ft. deep, 100 ft. wide at the bottom, with 22 ft. clear head room, and with locks 40 x 260 ft., and such a canal would conform to the requirements of a river channel 8 ft. deep at extreme low water and would provide for the largest barge traffic likely to reach this route.

As seen by the accompanying profile, the Hennepin Canal terminates in the pool above the Henry dam, and an 8-ft. navigation already exists to Utica. At Utica a lock and dam with a lift of 15 ft., estimated at $460,000, must be construoted. From this lock to the head of the pool the depth increased by the flow from the drainage canal will be not less than 8 ft., but to insure this depth during the possible suspension of this flow an estimate for rock excavation at the head of the pool costing $200,000 is provided.

As the increased velocity of current in the river, due to the flow from the drainage canal, will cause a caving of the banks, thus widening the river and producing bars in the main channel, the Board also submits an estimate of $25,000 per mile for protecting the banks of the river. The Marseilles Canal, beginning at the head of the Utica reach, will have two locks, each with a lift of 15 ft., at an estimated cost of $460,000; the guard lock and dam at the head is estimated at $300,000, and 7.4 miles of canal are estimated at $1,052,500. From the head of the canal the route will follow the channel of the river to a point below the mouth of the Kankakee.

To decide whether to enlarge the Illinois & Michigan canal or construct a new channel from this point to the Lockport end of the Drainage Canal will require a careful and extensive survey, which the Board has undertaken to make. A provisional estimate for the enlargement of the present canal, however, is $100,000 per mile, exclusive of locks, culverts, etc. From the Joliet basin to the end of the drainage canal at Lockport the line requires three locks of 12 ft. lift each and a lock at the entrance to the canal, the estimated cost being $562,000.

The following recapitulation is made of the cost of a channel 8 ft. deep:

Utica to Marseilles, locks, dams, levees, rock excavations at head fall, bank protection, etc.	$960,500
Marseilles canal, dam and locks, excavation and embankment	1,812,500
Marseilles to Kankakee River, excavations, bank protection, etc.	650,000
Canal, Kankakee River to Joliet basin	2,525,000
Joliet basin to drainage canal, locks, excavations and embankment	1,332,000
Bridges	650,000
Right of way	800,000
Engineering contingencies	1,670,000
Total	$10,400,000

The final cost of the project to the United States involves not only an expenditure for lands and for works in river and canals outlined, but also the acquisition and use of public works of the state of Illinois and the Chicago sanitary district.

NOTES FROM THE ENGINEERING SCHOOLS.

Massachusetts Institute of Technology.—The following subjects have been chosen for Senior engineering theses: "Investigation of the Effect of Air in Water-Main," "Cantilever Crane Design," "Design for Ferry Landing Bridge," "Design for Bridge to be Erected Without False Works," "Experiments to Determine the Practicability of Measuring Flow of Water by Loss of Pressure at a Valve," "Design for Ferris Wheel," "Design for Grain Elevator," "Design for Dry Dock," "Determination of Coefficient of Discharge of Standard Tube," "Investigation of the Power to be Obtained at One of the Tide Mills Near Boston," "A Study of Recent Developments in Bridge Construction," "Design and Construction of Stand-Pipes," "Design for Steel Grand-Stand," "Design for Steel Dam," "Investigation of Different Forms of Dredges," "Investigation of Loss of Head at Bends in Pipes," "Design of Inverted Syphons," "Design for Cantilever Bridge," "Abolition of Grade Crossing at Everett, Mass.," "Design for Lift Bridge," "Special Test on Portland Polyphase Electric Power and Light Plant," "Investigation of Storage Batteries," "Current-Carrying Capacity of Aluminum Wires," "The Limiting Points of Harmful Resonance on Alternating Current Circuits," "Test on Electric Automobile," "Measurement of Energy on Three-Phase Alternating Current Circuits," "Efficiency Test of Two Direct-Connected Three-Wire Dynamos," "Harmonic Analysis of Alternating Current Wave Forces," "Induction Motors for Stroboscopic Study of Alternating Arc Lights," "Investigation of the Action of Air Lift Pumps," "Test on Ten-Wheel Compound Passenger Locomotive," "Design of Logging Locomotive," "Pneumatic Tools," "Some Effects of Hardening and Tempering on Steel," "Coefficient of Friction Between Leather Belts and Pulleys at Different Rates of Slip," "Investigation of an Axial Oil Machine," "Efficiency of Hancock Water Ejector," "A Study of a Shaft Governor," "Design for a Locomotive Repair Shop," "Design for an Ice-Making Plant," "Wave Force from Phasing Transformer," "Application of a Condenser to a Wool-Drying Machine," "Coefficient of Friction in Roller Bearings," "Effect of Pressure Upon Explosive Mixtures of Gas and Air," "Determination of the Line of Resistance in a Masonry Arch."

Mr. George C. Whipple, Director of the Mount Prospect Laboratory, Brooklyn, which is connected with the Water Department of the Borough of Brooklyn, has recently lectured to the students of the Institute on the microscopical organisms which cause tastes and odors in public water supplies. Mr. George W. Tillson, Engineer of the Bureau of Highways, Borough of Brooklyn, N. Y., recently gave three lectures to the students of civil engineering on the "Construction of City Pavements." Mr. Odin B. Roberts has lately addressed the students in the engineering courses on the "Nature and Function of Patents."

South Carolina Military Academy.—The state legislature, at its recent session, authorized the granting of the degree of Bachelor of Science by this school.

University of Michigan.—The annual tour of inspection of the Junior mechanical engineering students was made during the spring vacation under the guidance of Professor J. R. Allen. The cities visited were Toledo, Washington, Baltimore, Philadelphia, New York, Brooklyn, Bethlehem, Buffalo and Niagara Falls. There were 26 members in the party.

A debate was held on March 9 with representatives of the University of Pennsylvania on the subject, "Resolved: That the Formation of Trusts Should be Opposed by Legislation." Michigan won, upholding the negative.

Yale University.—The University will establish a Forestry School at Milford, Pa., upon a tract of land given for that purpose by the family of Mr. J. W. Pinchot. The total gift amounts to about $150,000.

University of Wisconsin.—A four years' course in "Applied Electro Chemistry" has lately been organized. This is intended to give students a training in the technology of chemistry, electro-chemistry and electro-metallurgy, together with instruction in the other branches of electrical engineering. For the first two years the work is exactly like that of the regular course in electrical engineering, but in the last two years a large part of the steam engine and machinery instruction is replaced by instruction in physical chemistry, analytical chemistry and electro-chemistry.

A new elective in "Illumination and Photometry" has been added to the work carried on in the electrical engineering department. This course is intended to deal with the useful distribution of light and the value of proper illumination.

Columbia University.—The School of Engineering has opened a new course in traction engines and automobile carriages, comprising detailed instruction in regard to self-propelling road engines, street railway engines, cars and automobiles. Prof. F. R. Hutton will have charge of the new course.

On March 22, Mr. J. Foster Crowell, M. Am. Soc. M. E., delivered before the Engineering Society a lecture on "Railroad Reconstruction Without Disturbing Traffic."

Ohio State University.—The Ohio Institute of Mining Engineers at its recent convention at Sandusky, O., decided to establish a scholarship in mining engineering at the University. The scholarship will pay $100 per year. It will be awarded to the one who stands the highest in a competitive examination.

University of Illinois.—The new Putman rotary engine, which was recently tested in the Laboratory of Mechanical Engineering, proved to be one of the most economical specimens of this type of engine which has been tested in the laboratory. The engine developed a brake HP. with the consumption of about 50 lbs. of steam.

Prof. I. O. Baker, of the University recently lectured on the "Distinguishing Characteristics of American Engineering." He gave particular cases in which American manufacturers of bridges, locomotives, and electrical appliances won over foreign competitors. The speaker explained the industrial, economic, and social reasons why the American engineer has been able to attain his present position as the leading engineer of the world. He ascribed his success to the following reasons:

1. The wide dissemination of popular education. 2. The superiority of American technical education. 3. The high price of labor. 4. The rapid settlement of the West. 5. The social and official conditions whereby young Americans may gratify their highest ambition. 6. The immigration in former years of the brightest and strongest young men of many European nations. 7. The absence in America of the excessive conservatism of many European countries.

Prof. Baker explained that American engineering education is much superior to that of any European country. In England, properly speaking, there are no engineering colleges. Engineers receive their education through the apprenticeship system. In Germany engineering education consists largely of undue refinement in mathematical and scientific analysis, with little or no attention to a study of economic conditions of engineering problems. The American method of instruction by means of laboratory and field practice is practically unknown in Europe.

Mr. F. H. Newell, Hydrographer of the United States Geological Survey, recently delivered an address to the students on the investigations of the water resources of the country being made by the division of Hydrography of the survey.

Other non-resident lecturers for the current year are: Mr. Walter B. Snow, of the B. F. Sturtevant Co., Boston, Mass., on "Mechanical Ventilation and Heating;" Mr. H. G. Prout, Editor of the "Railroad Gazette," on "Engineers and the Railroads;" Mr. A. V. Abbott, Chief Engineer of the Chicago Telephone Co., on "Electrical Highways;" Mr. F. W. Willcox, of the General Electric Co., Harrison, N. J., on "The Evolution and Economic Use of Incandescent Lamps;" Mr. W. A. Layman, of the Wagner Electric Manufacturing Co., St. Louis, Mo., on "Transformers in Modern Electric Power Transmission;" Prof. R. B. Owens, McGill University, Montreal, Canada, on "Most Recent Developments in the Applications of Electricity."

Purdue University.—Mr. C. F. Scott, Chief Electrician of the Westinghouse Electric & Mfg. Co., of Pittsburg, Pa., recently delivered before the Engineering students a lecture on "Modern Methods for the Distribution and Long Distance Transmission of Electric Power." Mr. A. V. Abbott, Chief Engineer of the Chicago Telephone Co., has lectured at the University twice, once on "Wireless Telegraphy" and lately on "The Construction of Electrical Distribution Circuits."

New York University.—The School of Applied Science announces a four years' course in Marine Engineering, examinations for which will take place next June. The appointment of Mr. Carl C. Thomas, M. E., late Chief Engineer of the Globe Iron Works of Cleveland, O., is also announced. Mr. Thomas was educated at Leland-Stanford and Cornell Universities and has had an extensive experience in the design and construction of a large number of vessels, including Government and passenger and freight steamers. There are now three torpedo boat destroyers under construction for the Government at the Sparrow Point Works of the Maryland Steel Co., of which company Mr. Thomas is at present Designing Engineer. This course is the fourth to be organized in the new School of Applied Science; the others being civil, mechanical and chemical engineering.

The Iowa State College.—The state legislature, which has just adjourned, made direct appropriations amounting to $102,000 for new buildings, and also voted a tax of $55,000 per year for five years for the same purpose. A new Engineering Hall, to cost about $150,000, besides furniture and equipment, is to be commenced as soon as the architect's plans can be perfected and the contract let. It is also proposed to erect and equip a new Ceramic Laboratory in the near future. The legislature also voted an increase in the annual appropriation for running expenses of $25,000 per year, and it is expected in the near future to add several members to the engineering faculty.

University of Pennsylvania.—Mr. Joseph W. Harris lectured April 12, before the Mechanical Engineers' Club of the University, on the manufacture of incandescent lamps.

Lehigh University.—The Physical Laboratory which was recently destroyed by fire will be immediately rebuilt, and will be ready for occupancy, fully equipped for the departments of Physics and Electrical Engineering, at the opening of the college year in September.

A MOTOR CARRIAGE RELAY STATION ROUTE is to be established during the coming season to embrace the sea shore resorts from Seabright to Atlantic City, N. J. Stations are to be established at these two places and between them at Long Branch, Allenhurst and Spring Lake. At each of these stations there will be motor carriages of various styles for sale and to hire, and also means for recharging and caring for both gasoline and electric vehicles of the Columbia type. The stations are to be operated by the New Jersey Electric Vehicle Transportation Co., with principal offices in New York city.

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

The city of New Orleans seems to have an exceptional opportunity to provide itself with a subway system for pipes and wires, in certain sections. It is about to enter on the construction of a sanitary sewerage system, and to extend or build water-works. According to the "Times-Democrat," Mr. Geo. C. Earl, M. Am. Soc. C. E., Engineer to the Water and Sewerage Commission, is reported as stating that in some parts of the city, particularly in narrow streets, it will be difficult to find space for the new water and sewer pipes, the space being already largely occupied with underground furniture. By placing all the underground conduits in a subway space might be economized and future disturbance of the streets greatly reduced. In a soil and climate like that of New Orleans, a minimum disturbance of the street surface and underlying material is highly desirable. In fact, we understand that street openings are practically prohibited during the hottest part of the year. Under such conditions it would be doubly valuable to have water, sewer, gas and other conduits in a readily-accessible subway. To keep such a subway dry might present a problem unusual in such work, but it is well worth considering whether this difficulty would not be small in view of the great benefits that would result from a subway system.

Before any railroad company in the state of New York can begin the construction of its road, it must obtain from the Railroad Commission a certificate that public convenience and necessity require the construction of the proposed road, and without such a certificate the road cannot be built. Similar statutes have been in force for many years in Maine, Massachusetts and Texas, and have been of great benefit in cutting off wild-cat railroad schemes and schemes for paralleling existing roads before their promoters could defraud the public.

The New York Commission has just rendered a decision in what is probably the most important case ever brought before it under this law—the application of the Delaware Valley & Kingston R. R. Co. for permission to build a double-track railroad from a deep-water terminal on the Hudson River at Kingston, N. Y., along the line of the abandoned Delaware & Hudson Canal to a connection with the Erie & Wyoming Valley R. R., at Lackawaxen, Pa.

When the Delaware & Hudson company abandoned its famous old canal a year or two ago, it sold the property outright to the Cornell Steamboat Co., of Kingston, N. Y., and that corporation, with some of the largest independent producers of anthracite coal and those interested in the Erie & Wyoming Valley Ry., has organized the Delaware Valley & Kingston R. R. Co., to build the road above described. The topographical advantage of this new outlet from the anthracite coal fields to tidewater is noteworthy. From the Delaware River to the Hudson, the only adverse grade is one of 15 ft. per mile, four miles in length, near Summitville. The heaviest grades in the opposite direction are 40 to 45 ft. per mile; and it is said that a locomotive can take a trainload from the mines to Kingston and haul back the empty cars with the average percentage of loads in the reverse direction, and thus dispense entirely with the use of helper engines. A large advantage in the construction is that the bed of the old canal is utilized for practically the whole distance, and grading thus becomes a very small item. The entire cost of construction is estimated at only $40,000 per mile.

The coal producing companies interested in the proposed road are said to have a total output of nearly 14,000,000 tons per annum; and with such facilities for delivering coal from the mines to deep water at low cost, the new road is likely to obtain a very heavy traffic.

The application of the company was opposed before the State Railroad Commission* by representatives of the principal anthracite carrying roads, chiefly on the ground of the diversion of traffic, which would result to their lines from the operation of the new road. The application was granted by the Railroad Commission, however, and the long-talked of new outlet from the anthracite fields seems certain to become a reality in the near future. Whether it means larger profits for the mine operators, high profits to the transportation line, or cheaper coal to the consumer, time alone will demonstrate, but it may very likely result in all three things.

*An account of the proposed road and of the testimony before the State Railroad Commission is given in the April "Letter" of the Anthracite Coal Operators' Association. Any of our readers interested can probably obtain copies from Mr. H. S. Fleming, Secretary of the Association, 26 Cortlandt St., New York.

The proposed waterway from Lake Michigan to the Mississippi River, described elsewhere in this issue, is said to be likely to receive a cold shoulder in the present session of Congress; yet it is pretty certain to be heard from again; and there is not a little to be said in its favor. Chicago is exceedingly interested in having the Federal government undertake the improvement of the lower Illinois, not only because of advantages which she expects to gain from the use of the river as a waterway, but to save her from damage suits brought by the owners of bottom lands along the lower Illinois. The additional volume of water which Chicago has turned into the Illinois through its new drainage canal will increase the height and duration of floods all along the lower Illinois for a distance of over 200 miles; and also the general level of the water in the navigation pools. That this will result in a multitude of suits for land damages seems altogether likely; and Chicago and the residents of the Illinois Valley are anxious that the Federal government should undertake the deepening of the channel on a scale extensive enough to drain the Illinois bottom lands, some 700 sq. miles in extent, and relieve Chicago from the threatened suits from the owners of these lands.

Whether the provisional estimate of $25,000,000 for a 14-ft. waterway from the Mississippi River to the present terminus of the Drainage Canal is at all adequate, will require careful surveys to determine. It is fair to say, however, that if this estimate is found to be a safe one, the project has at least far more to recommend it than the absurd Hennepin canal, with its 7-ft. depth and its multitude of locks.

THE INFLUENCE OF THE ROTARY KILN ON THE DEVELOPMENT OF PORTLAND CEMENT MANUFACTURE IN AMERICA.

By its production of over 5,000,000 barrels of Portland cement in 1899, the United States assumes third place among the cement manufacturing countries of the world. The significance of this statement is fully appreciated only by going back to the beginning of the decade and observing the figures of Portland cement production at that time. In 1890 the total domestic output of this important engineering material was less than 500,000 barrels. This output was exceeded by practically all European cement manufacturing countries, except probably the Scandinavian states in the north and Spain and Italy in the south; it was only about one-fifth of the total consumption of the United States, the remaining four-fifths being imported from Germany and England. Before 1897 the domestic production had grown to exceed the imports of Portland cement, and in 1899 it was over twice as great as the imports. When we remember that Portland cement had been manufactured in England since 1824, and to the exclusion of natural cement since 1860, and that Germany and France had for more than 20 years previous to 1890 produced it in great quantities, the question one naturally asks is: why was this country so late in developing its manufacture and, also, what were the conditions which led to such a rapid development all at once?

In answer to the first part of our question, it is evident at the outset that one very cogent reason why the United States was slow to take up the manufacture of Portland cement was its well-established natural cement industry. In no other country in the world had this industry reached such great proportions. This was, of course, due primarily to the fact that in no other country were there available such widespread deposits of uniform high quality natural cement rock. The natural cement rock deposits of France rank next perhaps to those of the United States, there being produced from them annually some 7,000,000 to 8,000,000 barrels, of which probably no more than 2,000,000 barrels are true natural cements of a class at all comparable with American natural cements. Compared with the present total American production of about 8,500,000 barrels annually these figures are small. The natural cement industry of other European countries is insignificant compared with that of France. In quality and reliability the discrepancy between American and European natural cements is greater even than in the relative extent of their production. America's great wealth of natural cements and the justifiable confidence which American engineers had in their merits for structural purposes were, therefore, it is only fair to say, accountable in a large measure for the slowness with which the manufacture of the artificial material was taken up.

A little study will show, however, that the entire onus of the delay mentioned cannot be laid at the door of a preponderating natural cement industry nor to the entire satisfaction of American engineers with the natural product for all purposes. The fact alone that large quantities of Portland cement were imported annually into the United States precludes this assumption and makes it necessary to seek for some further reason. It will throw some light upon this search and also be interesting in other respects if we review briefly the early history of Portland cement manufacture in America.

It is quite generally conceded that the first American Portland cement plant was developed by Mr. David O. Saylor, at Coplay, Pa. Mr. Saylor first established his works in 1865 for the manufacture of natural cement, but his interest was soon attracted to the possibility of making Portland cement, and he began to make experiments to this end. The process which he finally developed was substantially that now used all through the Lehigh region which turns out the great bulk of the Portland cement manufactured in this country. Briefly described, this consisted

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John F. Stevens, M. Am. Soc. C. E., Chief Engineer.

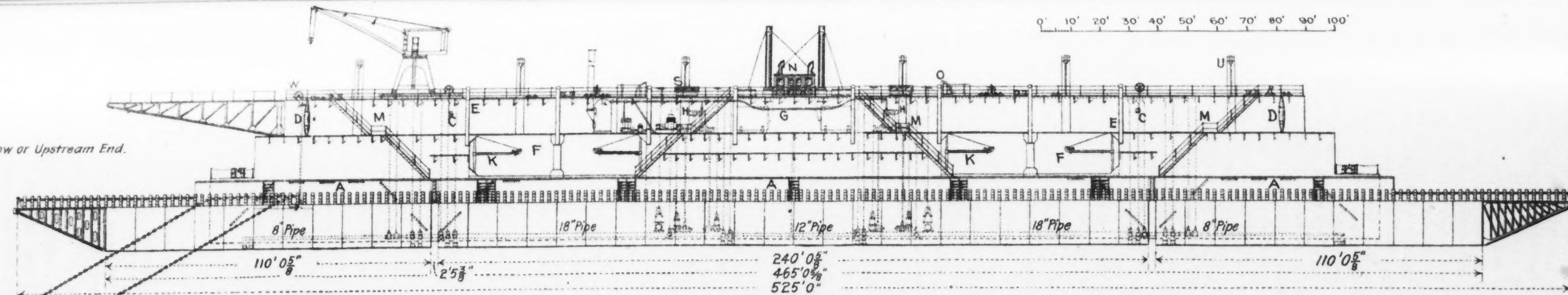
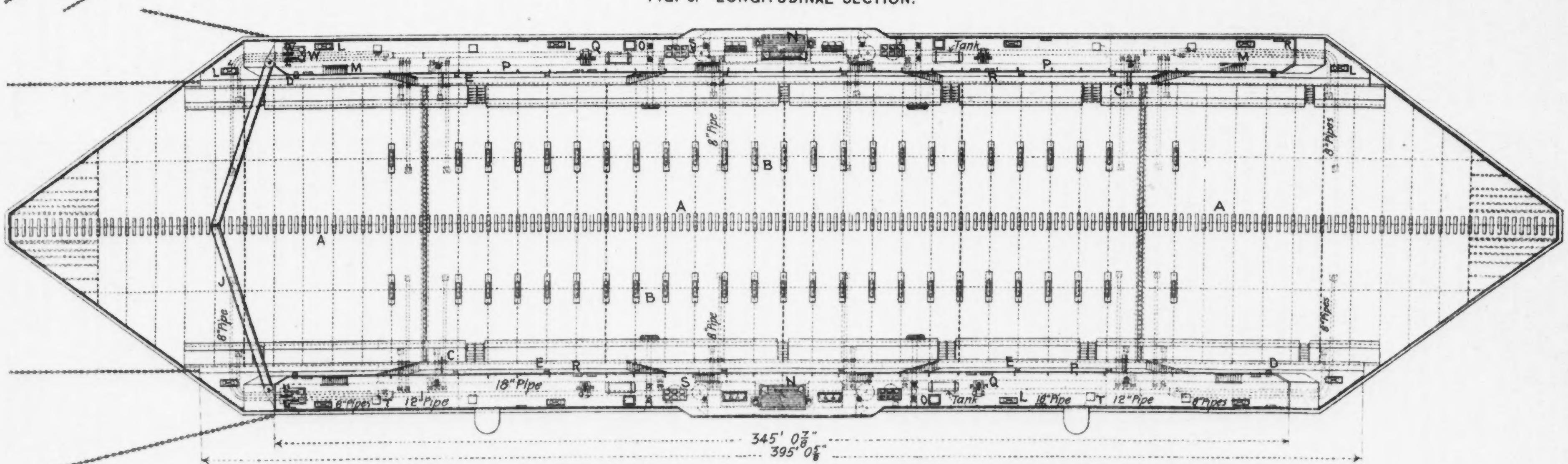


FIG. 6. LONGITUDINAL SECTION.



Keel Blocks ... A	Gangway Openings ... F	Bollards ... L	Winches ... Q
Sliding Bilge Blocks ... B	Boiler Rooms ... G	Accommodation Ladders ... M	Fairleads ... R
Mechanical Side Shores ... C	Engine " ... H	Valve House ... N	Skylights ... S
Roller Fenders ... D	Flying Gangway ... J	Companion ... O	Hatches ... T
Spring Timbers ... E	Hand Cranes ... K	Belaying Cleats ... P	El. Arc Lamps ... U
		Windlass for Moving Gear ... W	

FIG 7. GENERAL PLAN.

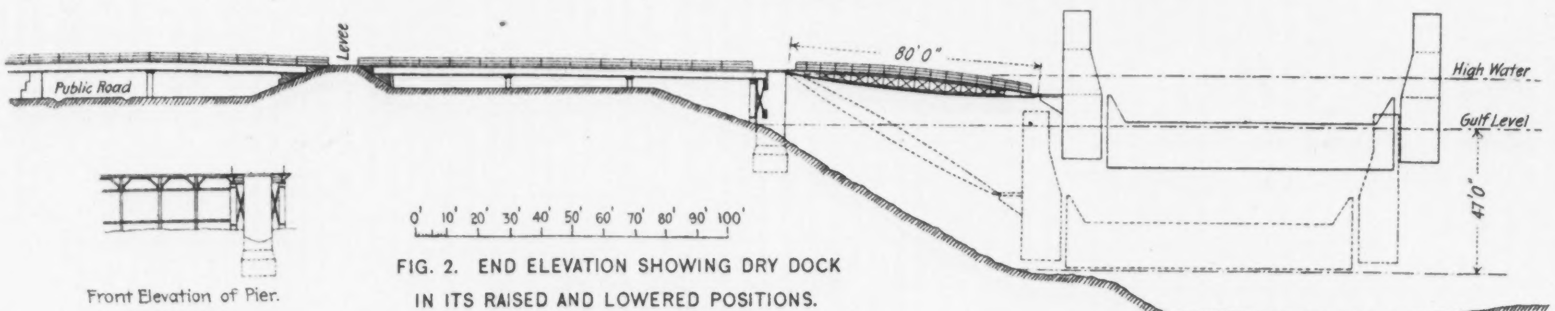
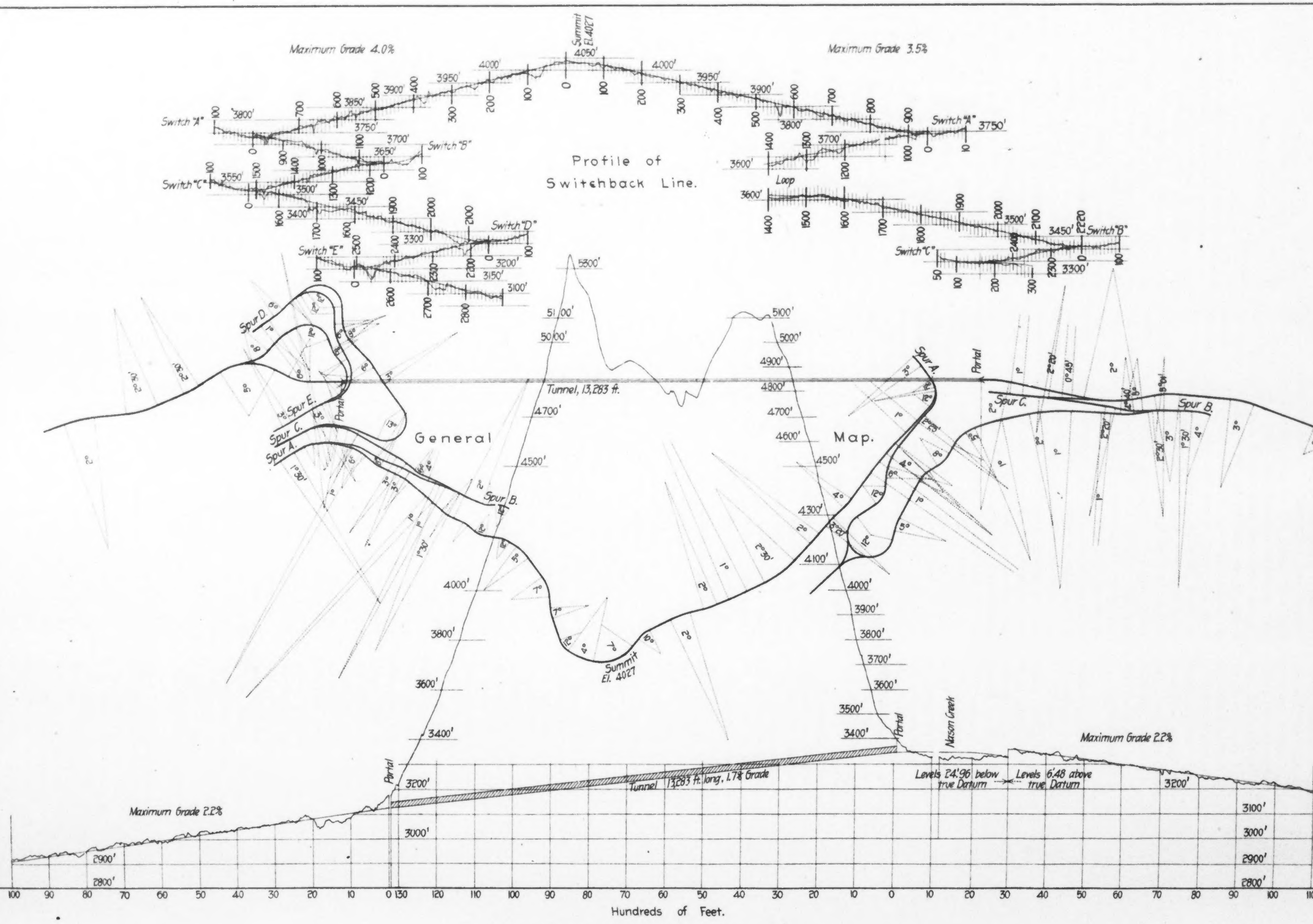


FIG. 2. END ELEVATION SHOWING DRY DOCK IN ITS RAISED AND LOWERED POSITIONS.

15,000 TON FLOATING DRY DOCK AT THE ALGIERS, LA., U. S. NAVAL STATION.

Admiral M. T. Endicott, Chief Constructor, U. S. N. Clark & Stanfield, London, England, Designers. Maryland Steel Co., Sparrows Point, Md., Builders.

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



Profile of Tunnel Line.

MAP AND PROFILES OF THE SWITCHBACK AND TUNNEL LINES OVER THE CASCADE RANGE; GREAT NORTHERN RY.

John F. Stevens, M. Am. Soc. C. E., Chief Engineer.

in grinding the natural rock in proper proportions to an impalpable powder and molding this powder with water into bricks which were burned in kilns. The final grinding of the calcined clinker to a fine powder completed the process. So successfully had Mr. Saylor's experiments progressed that he exhibited Portland cement at the Centennial Exhibition in 1876, which compared favorably with the best imported brands of this material which were exhibited there. In the light of these facts it is not too much, we think, to say that to Mr. Saylor more than to any other one man is due the development of Portland cement manufacture in the United States.

While Mr. Saylor's experiments were being carried on to success at Coplay, a number of other cement works were started in different sections of the country. In 1872 a small works was established near Kalamazoo, Mich., but owing to the character of the raw material and the high price of labor and fuel—coke being the fuel almost universally employed in intermittent dome kilns—the cost of making the cement was too great to make its manufacture a commercial success, and the works shut down. A similar fate also overtook for the same causes works established at Rockland, Me., in 1879, and at a later date in the celebrated Rosendale cement district of New York state. A somewhat better success was had with works established at Wampun, Pa., in 1875, and at South Bend, Ind., in 1877. Both of these plants are still in operation. Altogether, therefore, of the six Portland cement works started in America previous to 1881, three were failures; certainly not a very encouraging outlook for the investor who was asked to put his money into Portland cement manufacture. The great difficulty seemed to be the cost of getting the raw material into powder, then into paste, then into bricks and then into the kiln, with sufficient economy, and the inventors turned their attention to its solution.

About 1884 patents were taken out for a process in which certain liquid hydrocarbons were mixed with the ground raw material. In this way a paste was made which, when molded into balls, could be at once placed in the kilns and thus many of the intermediate drying processes saved. The new invention proved successful, but, with the introduction of water gas and the consequent advance in the price of coal tar, it was put aside. Meanwhile other methods of arriving at the same purpose were being developed. It is out of the question at this time even to catalogue the numerous different experiments which were made, nor would it be of much importance to our discussion to do so. The experiments of greatest importance were those which were carried on in the development of the rotary kiln.

The invention of the rotary kiln was the development of a logical attempt to reduce the cost of cement manufacture. Laboratory experiments had shown that it was possible to calcine powdered raw material in a crucible and produce perfect cement clinker. The question at once arose whether it was not practicable to accomplish the same thing on a commercial scale. If it were, it was plain that the necessity of molding the raw mixture more or less accurately into balls or bricks would be avoided and also that the cost of crushing the clinker into fragments small enough to be easily ground would be likewise done away with. These possible economics made the problem a tempting one, and after some study Mr. Frederick Ransome, an English engineer, brought forward the rotary kiln as the solution.

Mr. Ransome secured his English patents in 1885 and the following year he had his invention patented in America. Briefly described, his kiln consisted of a metal cylinder lined with fire-brick and set at a slight inclination on roller supports. A rotary motion was given to the cylinder by a worm gearing with teeth on the circumference of the cylinder. The powdered raw material was fed into the upper end of the cylinder and the flame from a gas burner entered at the opposite end. The interior of the cylinder was fitted with longitudinal ribs made by setting the fire-bricks forming the lining on edge at intervals to keep the powder in constant motion and so give the heat free access to it from all directions. As the cylinder revolved the raw mixture was gradually fed forward until it dropped out at the lower end as calcined clinker.

The first rotary kiln was erected at Grey's works in Essex in England, and was about 15 ft. long and 18 ins. in diameter. The size of the cylinder was too small to produce good results and in succeeding furnaces the diameter was increased to 24 ins., then to 36 ins. and then to 48 ins. With this last diameter and a tube 30 ft. long, good cement clinker was successfully produced. In the course of a short time rotary kilns were installed at several other English works.

Despite the favorable outlook at the beginning, however, the rotary kiln failed to gain favor in England. In the first place it involved the necessity of drying and powdering the slurry produced by the wet and semi-wet processes of reduction, which were almost universally employed, since it was not thought possible at that time to handle wet mixtures as is now a common practice in America. Besides the objection to this preliminary drying it is probable also that the English cement makers were somewhat frightened by the large expense for fuel which the kiln entailed. These faults were, however, not the only ones which English manufacturers charged against the rotary kiln as it was employed in their factories. Trouble was had from the balling of the clinker on the lining of the kiln, owing to an incipient fusion of the silicates. The clinker produced is also stated not to have been uniform in quality. Altogether these objections were sufficient to discourage the further use of the rotary kiln in England.

Theoretically, the process offered many advantages, however, which prevented its being entirely cast aside, and the work which had been abandoned in England was taken up in America with far greater success. It is only fair to say that American cement makers were greatly assisted in their early experimental work by possessing raw materials in the hard, dry cement rocks of eastern New York and Pennsylvania which were especially suited to the rotary kiln process. The first rotary kilns used in America were erected by the Atlas Cement Co. at their works near Rondout, Ulster county, New York. In 1889 the same company built two rotary kilns at its Coplay, Pa., works, where it took up still more energetically the extensive and costly work of experimentation which finally placed the rotary kiln upon a successful basis.

We need not enter into the changes in detail which were made in the original device further than to say that they consisted chiefly in remedying the mechanical defects in construction, setting and operation which apparently did much to make a failure of the early experiments carried out in England. Comparing the original and the present kiln along more general lines, however, it should be noted that the size of the kiln has been greatly increased and its construction simplified. The fins or stirrers on the inside of the original kiln have been abandoned. The gas fuel originally employed has given way to crude petroleum and that in turn to powdered coal, with a resulting economy in fuel for each change.

It was not long after the success of the rotary kiln in handling dry materials was demonstrated before attempts were made to adapt it to the calcination of wet mixtures. In the original English installations the wet slurry had been dried and pulverized by processes entirely separate from the calcination process. This method was improved upon as soon as American manufacturers took hold of the work, by utilizing the waste gases of calcination for drying the slurry. The next step in the development of the rotary kiln process with wet mixtures was to admit the wet slurry directly into the cylinder of the kiln. This simple scheme was not adopted until after some years of experimenting, and its development and first adoption must be credited to the Sandusky Cement Co., just as the successful development of the rotary kiln for dry mixtures is to be credited to the Atlas Cement Co., as previously indicated.

From what has been said, it will be readily seen that although the original patent for the rotary kiln was taken out in England the device to all intents and purposes is American, since its only successful development has been in this country. How successful this development has been will be evident upon presenting a few statistics showing the use of the rotary kiln, in America. According to the report of the U. S. Geological Survey the total production of Portland cement in the United States for 1898 was 3,692,284 barrels, of which 2,170,782 barrels were calcined in rotary kilns. According to the best available figures the cost of calcination by rotary kilns is less than by any other form of kiln under the conditions prevailing in America. In quality the best product of rotary kilns in America has been found equal, if not superior, to the best domestic or foreign product of other forms of kilns. With the hard, dry materials used in Eastern Pennsylvania, which are comparatively free from fluxing salts, the rotary kiln is at its best. It is quite possible, however, that it would not succeed so well with the raw materials which are commonly employed in Europe and which are considerably higher in fluxes. As previously stated, one of the chief sources of trouble in the early tests of the rotary kiln in England was the balling of the slurry on the kiln lining, owing to the fusion of the silica.

Whatever the possibilities of the rotary kiln may be in Europe there is no doubt that it is now enjoying a popularity possessed by no other type of kiln in America. In point of mere numbers dome kilns stand ahead of rotary kilns in this country, but in amount of production the rotary kiln not only leads any of the other types but they produce more cement than all the other types combined.

In what has been said we have the essential facts explaining the delay in developing a Portland cement industry in America and why, when once started, it has grown so rapidly. At the outset there were the competition of a great natural cement industry and full confidence of engineers in the superiority of imported Portland cements, particularly the German brands, to be overcome. To these were coupled the difficulties encountered in the earlier attempts to manufacture Portland cement in America. These difficulties were due very largely to ignorance of the best method of handling the raw materials and to the great cost of reducing them to a shape ready for calcination. These difficulties were gradually overcome one by one, the greatest single improvement being doubtless the successful development of the rotary kiln. With each improvement the Portland cement industry moved a step ahead. The rotary kiln was, however, the device needed to place American raw materials and costs of production on an equal footing with those of European countries. This condition being secured and the market being already at hand it only required the necessary energy and capital to give Portland cement manufacture in America the thriving growth which it is now exhibiting.

Thirteen states produce Portland cement. A great variety of raw materials are employed. In Pennsylvania and New Jersey argillaceous limestones are chiefly used; at Glens Falls, N. Y., the material is Trenton limestone; marls and clays are employed at Sandusky and Bellefontaine, O., at Warners and Jordan, N. Y., and at Bronson and Coldwater, Mich.; in Western Pennsylvania and Eastern Ohio hard limestones are used with clay, and at Yankton, S. Dak., and White Rocks, Ark., chalks and clays provide the raw materials. By far the larger part of the Portland cement produced in the United States, however, is made from limestone of the natural cement rock variety. As found in the Lehigh valley this rock resembles the famous "natural Portland cement" rocks of Belgium, it being a clayey limestone with but a slight excess of clay over the amount required. A small proportion of pure limestone is ground with the natural cement rock to make up for this excess of clay. In 1898 the amounts of Portland cement produced in America from limestone and from marls and other soft materials were as follows:

Twenty factories using limestone.........	3,112,492 bbls.
Eleven factories using marl, etc...........	579,792 "

In conclusion it may be pointed out that the United States is the second greatest cement consuming country in the world, the exact figures for 1898 being:

Kind and source of cement.	Barrels.	Per cent.
Natural rock cement	8,418,924	59.6
Imported Portland cement	2,013,818	14.26
American Portland cement..........	3,692,284	26.14
Total of all kinds	14,125,026	100.

Germany produced about 18,000,000 barrels of Portland cement in 1898, of which 15,000,000 barrels were consumed at home and 3,000,000 barrels were exported.

LETTERS TO THE EDITOR.

Failure of the Austin Dam.

Sir: In 1890 I occupied the chair of geology at the University of Texas, and as a citizen of Austin voted with the people of that place for the issuance of bonds to construct the dam. At that time I felt that in the building of this dam certain geological factors should have important bearing upon its location and construction. These opinions have been accentuated by a minute survey of the Austin quadrangle since made by the United States Geological Survey and by the sad catastrophe which has recently overwhelmed my fellow-citizens. The results of my professional observations were not sought at the time, but I think that if the dam is reconstructed, as is now proposed, the geological questions bearing upon the location and material for constructing it should be seriously considered.

As stated by Prof. T. U. Taylor in your issue of April 19, the present site of the dam is located at the exit of a canyon, where the river debouches from a deeply canyoned plateau country upon the low plain of the Black Prairie region of Texas. In the plateau country, which begins about a mile above the present site of the dam, the strata are firm and horizontal and the river flows over ledges of firm and solid rock, which would have made a suitable and durable foundation for the construction. Just below this point and within a belt of country upon which the dam is located, the strata are excessively jointed and faulted, constituting what is technically known as the balcones fault zone, as shown in the section, Fig. I. The geological formation is also different, consisting of the limestones of the Edwards formation, which are exceedingly porous and soluble, while to the west of the fault zone the strata are less soluble and more durable. The action of subterranean waters upon the Edwards limestone results in dissolving it into caverns and crumbling strata, even where at the surface it appears perfectly solid and durable. Furthermore, artesian springs of great volume and pressure well up the joint planes and fissures in this formation. The site of the dam chosen crossed the river sub-parallel to one of the most conspicuous of the fault lines, at the northern end of which, after the excavation and construction had well advanced, a spring of the character mentioned developed, which greatly endangered the tie-on at that end and cost many thousand dollars to circumvent. Unfortunately, I did not have an opportunity to observe the nature of the excavation for a foundation, which, however, from a geological consideration, should have been upon the face of a flat stratum plane, which I know from the character of the dislocation could not have been obtained along the line of the dam. Had the dam been located less than two miles above its present site this structural condition would have been avoided. (Fig. 2 illustrates the general faulty character of the rock at the dam site.—Ed.)

A second geological consideration in the construction of the dam, and one to which sufficient attention was not, in my opinion, paid was in the choice of material. Within 60 miles of Austin, by rail, are some of the most superb granite quarries in the world. This material was used to face the dam, but its center was built of the same soluble limestone as that previously mentioned, which was obtained from a quarry at the mouth of Bee Creek, on the south side of the river, less than half a mile from the dam. (See Figs. 3 and 4.—Ed.) An examination of the face of that quarry shows the character of the material taken from it for use in the dam, and a glance is sufficient to show that its solubility was such as to render it utterly untrustworthy.

I send you herewith some pictures showing the geological character of the dam site. Yours very truly,

Robert T. Hill,
Geologist, U. S. Geological Survey.

Washington, D. C., April 23, 1900.

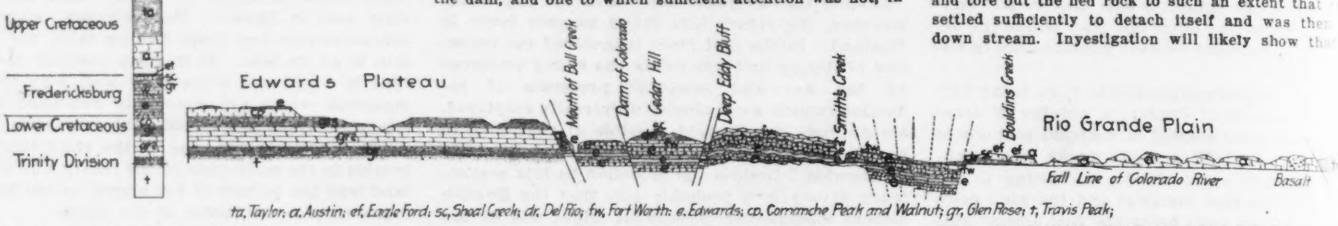


FIG. 1.—GEOLOGICAL SECTION EAST AND WEST ALONG THE COLORADO RIVER AT AUSTIN, TEX., SHOWING THE BALCONES ZONE OF FAULTING.

Sir: I was connected with the work at Austin, Tex. from the time the preliminary surveys were made until the final completion of the dam, and am familiar with the conditions which existed during construction. For two years I was assistant engineer under Mr. Frizell (during which period the foundation for the east end of the dam was put in), and for one year I served as chief engineer, with Mr. J. T. Fanning as consulting engineer.

While on this work I kept a diary, and from it, as well as from memory, I note that when putting in the foundation we found the rock very good for about 150 ft. from the east bluff. At this point we encountered a fault, which extended about 75 ft. After passing this fault the rock was poor for about 350 ft. further, when it began to get better, and under the portion of the dam now standing the rock is good.

In the fault there was no semblance of stratified rock, except occasionally a detached piece. Most of the material was adobe, or pulverized rock, with an occasional streak of red clay. The excavation at this place, as I remember it, was carried down 8 to 10 ft. in the up-stream trench, and the trench widened from 4 ft. to 10 to 15 ft. The fault extended down indefinitely.

After being appointed chief engineer (July 1, 1 and believing this to be a weak place, I obtained permission from the board to puddle the up-stream face and had a large quantity of clay hauled in. Soon after the dam was completed springs were discovered just below the and opposite that portion which failed. No doubt these springs had their origin in the lake above.

I consider it probable that water rushed under the dam and tore out the bed rock to such an extent that the dam settled sufficiently to detach itself and was then floated down stream. Investigation will likely show that where the fault existed the foundation is cut out to a great depth. I do not anticipate that any of the foundation masonry remains in its original position. The dam did not break horizontally nor slide on its base, but was floated.

The people of Austin have my sincerest sympathy, knowing, as I do, that they undertook this work in the best of faith and carried it through against the strongest opposition.

While it is gratifying to me to know that the portion of the foundation put in while I was chief engineer is still intact, yet I claim no especial credit, since that portion of the dam rests on very good rock foundation.

Fig. 3.—Quarry from which Limestone for Center of Austin Dam was Taken.

I wish to state that the attitude of the president of the board of public works toward Mr. Frizell was not such as should exist, if the best results were to be obtained during construction.

Yours,
E. W. Groves.

New Baltimore, Mich., April 23, 1900.

FIG. 2.—VIEW SHOWING FAULTY NATURE OF LIMESTONE ROCK AT THE SITE OF THE AUSTIN DAM.

Sir: Viewing the immense limestone bluffs and rock bottom of the Colorado River at the Austin dam, it seemed that it would require an earthquake to move that large dam, but the accounts of the failure and a study of the views in Engineering News of April 19 seems to bear out the impression that the water found another fault in the limestone formation similar to the ones in the east bank and under the power-house foundations shown by the break of June, 1893. The writer was in Austin at that time, also during the repairs of the headgate masonry and rebuilding of the power-house foundations following it. In reference to this limestone formation note is made in my article of August 2, 1894 (Engineering News), as follows: "It was found that the break was due to a fault in the limestone formation, the original stratum built upon having been a shelf about 20 ft. thick, resting upon a soft stratum from 4 to 8 ft. thick, which was washed out by the pressure with the lake full. This stratum was at elevation + 21." Further on in this same article reference is made to a soft stratum 2 ft. thick at elevation — 10 found in the excavation for replacing the power-house wall.

Prof. T U. Taylor, in Engineering News for Feb. 22, 1900, mentions that water was found disappearing in the east bank just above the dam in 1899, indicating previously undiscovered seams. Proof prior to this was that springs showed up in the east bank for some distance below the dam when the lake was first filled.

Mr. Fanning's letter in your issue of April 19 offers a pertinent suggestion as to the character of limestone formation in that section of Texas which I had occasion to verify in sinking foundations for some bridge piers about 30 miles from Austin, near the same valley. Soft seams, sometimes only 4 to 6 ins. thick, were found underlying strata of 2 to 4 ft. thick.

It is evident that the volume of water represented by a section 1,100 ft. across by 11 ft. deep, pouring over this dam would find a weak spot anywhere within a reasonable distance and develop a fault in the river bottom which might have escaped detection by the soundings prior to beginning work.

Except the discussion of municipal ownership of the plant at Austin, there were conditions which made Austin considerably different from other cities of its size as to public improvements. A great part of the bonded debt of Texas cities has gone into street pavements, on account of a soil that offers little naturally, but which, in Austin, is a succession of limestone hills and gravel slopes. This item of public expense was reduced at Austin, so that with equal taxation there was opportunity of using money for a better water supply, lighting and improved sanitary conditions—necessities in such a warm climate.

Very truly, Frank E. Snyder,
Principal Asst. Engr. on Track Elevation.
[illegible] E. 22d St., Chicago, Ill., April 23, 1900.

Notes and Queries.

L. J. C., Jacksonville, Fla., desires information as to the use of artificial gas in brick kilns on a large scale.

WATER PURIFICATION AT VINCENNES, IND.

A mechanical filtration plant, combining coagulation, subsidence and filtration, was put in operation at Vincennes, Ind., in the latter part of October, 1899. The most notable features of the plant are the comparatively long period of subsidence, the automatic control of the inflow and outflow of both the tanks and filters and the use of air in place of rakes for agitating the filtering material during the process of washing.

The population of Vincennes was 7,680 in 1880 and 8,853 in 1890, showing a slow growth. It is claimed that the population is now 15,000. A public water supply was introduced in 1885 by the Vincennes Water Supply Co. Aside from private

Fig. 4.—View Showing Soluble Character of Edwards Limestone, Used for Center of Austin Dam.

sewers on the two main streets, the city is without sanitary sewers.

The water supply is taken from the Wabash River, through a 20-in. intake pipe laid into the river, its outer end being left open. Two 2,000,000-gallon Deane compound duplex pumps now lift the water to a stand-pipe. This structure is 22 ft. in diameter and extends to the unusual height of 220 ft. It is not covered.

The natural water of the Wabash River at this point is very unsatisfactory at times, and presumably is rarely an ideal supply. As far back as 1887, and probably when the works were built, there were two large wells in the gravel near the river, designed to furnish the supply at high water. To what extent these wells reduced the periods of roily water we cannot say, but evidently they were of comparatively little account, for when the franchise was renewed, in the spring of 1899, the city stipulated that the supply should be purified. Accordingly, a contract for purification works was made by the Water Company with the Continental Filter Co., of New York, providing for a daily capacity of 2,000,000 gallons, the water to be perfectly clear and the plant to remove at least 96% of the bacteria present in the raw water.

The conditions to be met by the plant are those found in river water from a rather large, generally flat, drainage area, with loamy soil and much limestone. From such a drainage area, as might be expected, the stream is fed largely by ground water, which is very hard. At the time of the spring and fall freshets the water is laden with loam, much of which is finely divided; besides this, it receives organic matter in other forms. The water, coming so largely from the ground and having so sluggish a flow, is very low in dissolved oxygen, thus giving rise to decomposition of its organic contents, on standing, accompanied by a decidedly objectionable odor. The color of the water is also unpleasantly dark.

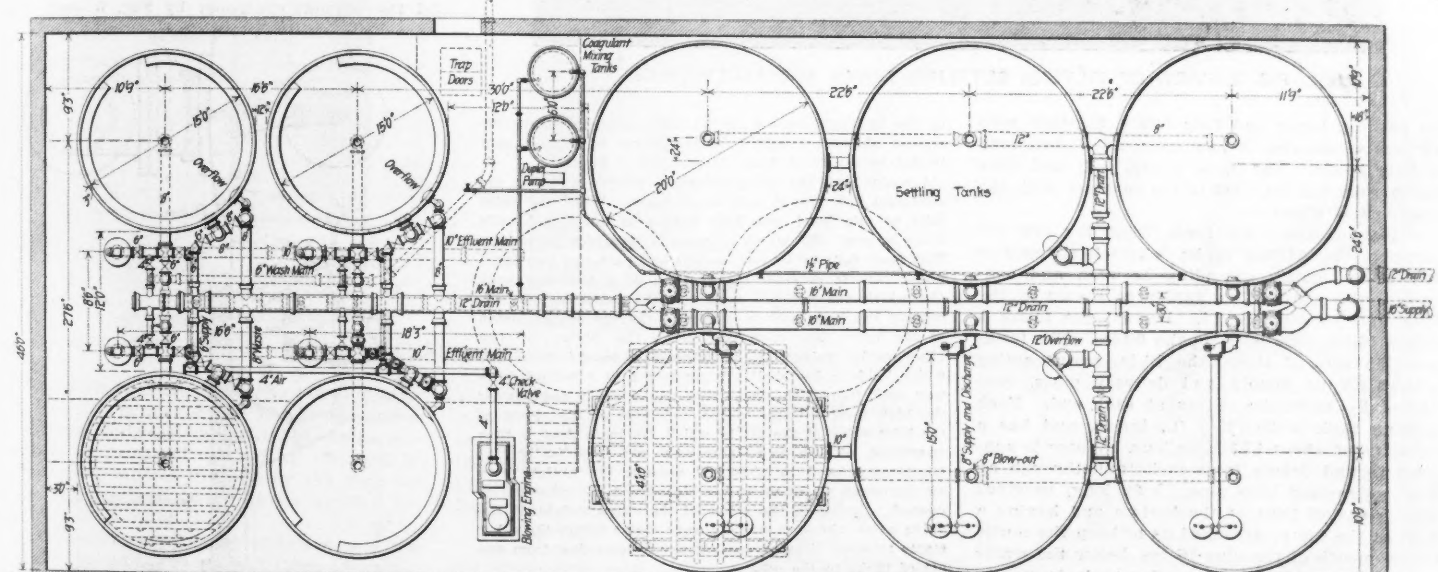


FIG. 1.—PLAN AND SECTION OF MECHANICAL FILTER PLANT AT VINCENNES, IND.
Continental Filter Co., New York City, Contractor.

The characteristics noted suggested the desirability of providing ample facilities for coagulation and sedimentation, in order to remove both the suspended matter and color. The odor, it will be understood, need not be feared, after the water has once been thoroughly purified.

The works installed to effect the desired changes include a low lift horizontal Snow pump of 2,000,000 gallons capacity, to supply the filters; six settling tanks and four filters, together with various accessories; a new clear water well; and a filter house. The Snow pump, well and filter house were not included in the contract with the Continental Filter Co.

FIG. 2.—VIEW OF FILTERS, SETTLING TANKS AND ACCESSORIES.

A 16-in. force main leads from the low lift pump to the settling tanks, where it changes to two 16-in. mains, extending between and connected with the settling tanks, as shown in the plan and section, Fig. 1. Beyond the tanks a single 16-in. main leads to the filters. The tanks work in sets of three, the 16-in. mains acting alternately as supply and delivery pipes, controlled by hydraulic valves at each end. Each settling tank is 20 × 15½ ft., inside, and has a capacity of about 37,300 gallons. Water is supplied to and drawn from each tank through an 8-in. galvanized iron pipe, 15 ft. long, provided with a swivel joint at the bottom and having a float at the top so arranged as to keep the center of the mouth of the pipe 16 ins. below the water surface, except that when the tank is nearly empty the water is only 2 ins. above the top of the pipe. It was found on trial that with the center 10 ins. below the surface so much air was drawn in when the tanks were full, and therefore the pipe nearly vertical, as to cause a movement of the pipes and a disturbance both of subsidence and the flow to the filters.

The tanks in each set are connected near their tops and there is a waste weir 6 ft. long and 4 ins. deep in the center tank of each set. The concrete floors of each tank slope towards the center on a grade of 1 in 15, where there is a 12-in. outlet, all for convenience in washing out sediment.

Before describing the system of feeding and drawing from the settling tanks a few words may be said regarding the introduction of coagulant, just before the water reaches these tanks. A brass pump, located between the filter and settling tanks, forces the coagulant, in solution, through a small pipe connected to the force main just above the first hydraulic valve, where it is discharged through a perforated brass pipe, the jets being at right angles to the force main. The solution of sulphate of alumina is prepared in two 4 × 6-ft. wooden tanks, having their tops 6 ins. above the floor. The solutions range from 0.5 to 4% in strength and are made by spraying water over the chemical.

The operation of the settling tanks can best be made clear by quoting a description kindly supplied to us by Mr. Chas. L. Parmelee, Chief Engineer of the Continental Filter Co., as follows:

The subsiding tanks are operated on the fill, quiescent-subsidence and draw plan. Their operation is controlled by the hydraulic valves on the main branches above described and the supply to these valves is in turn controlled by a pair of floats in each set of tanks.

A main float (A) of considerable weight is set at the minimum flow line of each set of tanks. When the water falls to this level this float begins to lower and pulls down a pawl (B) which releases a weighted lever (C). This lever falls by its own weight and performs two functions: (1) It reverses the position of a four-way cock (D) which controls the supply to the outlet valves, admitting the high service supply to the top of the piston of the valve then open, and below the piston of the other outlet valve; (2) it releases a second pawl (E) which holds a float ball (F) connected to a second four-way cock (G). This arm drops and opens a passage for the high service water to the underside of the piston of the inlet valve of the set in which the main float is then operating. These two operations are practically instantaneous, and in about 30 seconds the outlet valve on the empty set of tanks has closed and the other outlet opened. Owing to the effect of the extra weight of the valve gates, the open valve always closes before the other starts to open, thus preventing any reverse flow from one set of tanks to the other.

The pipe supplying the high service water to the inlet valves passes by the outlet valves, and on each line (both inlets have a separate supply) there is a lever valve. This valve is so set that it is opened during the last inch of movement of the outlet valve, when closing, and is closed during the first inch of movement, when the outlet starts to open and remains closed so long as the outlet is open. By this arrangement, the main inlet valve is prevented from operating when the outlet valve is open, thus preventing any direct flow to the filters of water which had not been treated by subsidence. As soon, therefore, as the outlet valve closes, the high service supply is admitted to the inlet valve and the latter opens. In opening, it relieves the pressure in the main supply line and steam is admitted to the main supply pump and to the chemical feed pump, the steam on both of these pumps being controlled by a steam governor, which closes at 20 lbs. pressure in the main water supply line.

Both pumps start at once and the set of tanks is filled as rapidly as the pumps will operate. When the tanks are nearly full the rising water lifts the float arm operating the inlet four-way cock, and at a certain point this lever reverses the position of the four-way cock and the high service water closes the inlet valve. As it closes the pressure in the main supply increases, and when the valve is closed it quickly reaches 20 lbs., when the steam governors close and stop the pumps. During filling the main float lifts the weighted operating lever back to its original position, and also sets the trip lever of the inlet cock, so that when the float lever for this cock rises it again locks, thus preventing the inlet valves from opening while the tanks are being emptied.

After the tanks are full the water stands quiescent until the other set is empty, when the operation is repeated. This period of quiescence is from 10 to 20 minutes, depending on the suction-lift on the main pump which affects its speed. The arrangement for feeding and drawing furthermore disturbs the body of water in the tanks very little, and subsidence, therefore, proceeds at all times. Each set of tanks holds 101,900 gallons of water, of which 88,400 gallons are drawn out. At the normal rate of operation of the filters, 1,389 gallons per minute, there is, therefore, available about 63 minutes' supply in each set of tanks. The average period of subsidence is, therefore, 24 minutes during filling, about 15 minutes quiescence on an average and about 32 minutes during drawing, making a total period of 71 minutes.

These basins are cleaned about once a week. The water is drawn down, and unless the deposit is very heavy most of it is washed out by the water drawing down on the conical bottom. The remainder is readily flushed out by a stream from a 1½-in, hose, which is operated from the platform above the tanks.

The four filter tanks are each 15 × 7½ ft., built, like the settling tanks, of 3-in. clear cypress staves. The available filtering surface in each tank is 15 ft. in diameter, or 176.7 sq. ft. in area, giving a total area of 707 sq. ft. The contract capacity of 2,000,000 gallons per day, therefore, contemplates a rate of filtration of less than 125,000,000 gallons a day.

The filtering material consists of 3 ft., in depth, of sand, with an effective size of 0.34 mm., resting on 6 ins. of buckshot gravel. Beneath the latter is the collecting system of brass strainers and pipes, which also serves for a reversed current used to wash the filters. A similar but smaller pipe system is used to introduce the air used in washing, as explained later.

The filter influent regulator is shown by Fig. 4 and the effluent controller by Fig. 5, each consisting of damper valves, operated by floats. The effluent controller is provided with a tell-tale, which shows when the filters are becoming so badly clogged as to need clearing. The location of these devices is shown by Fig. 1.

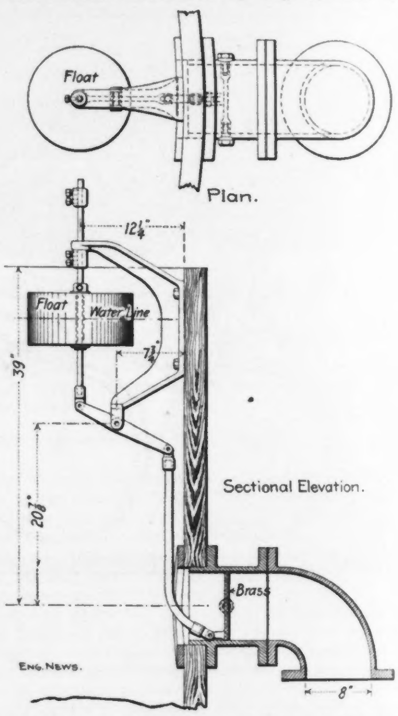


Fig. 4.—Influent Regulator on Filters at Vincennes, Ind.

When a filter is to be washed, the water on the bed is drained down to a level about 6 ins. below the top of the gutter. The outlet is then closed and air is driven through the bed and the water at the rate of 4 cu. ft. per min. per sq. ft. of bed. A rotary blower of the Root type with a capacity of 700 cu. ft. per min. is used for this purpose. The air is left on for about a minute, meanwhile, it is said, thoroughly agitating the sand and even driving the gravel to the top of the bed. After the air is shut off water is forced upward through the bed at the rate of 8 to 9 gallons per sq. ft. per minute. This continues two or three minutes, after which the air is again turned on. On con-cluding the second application of air, washing with water is resumed, and continued until the bed is clean, the dirty water, of course, wasting all the while. The filter is then refilled from the top, after which the outlet is opened and filtration resumed. It is said that although the gravel from the bottom of the bed is forced up through the sand by the air blast it returns to place by the time the washing is completed, owing to its greater hydraulic subsiding value.

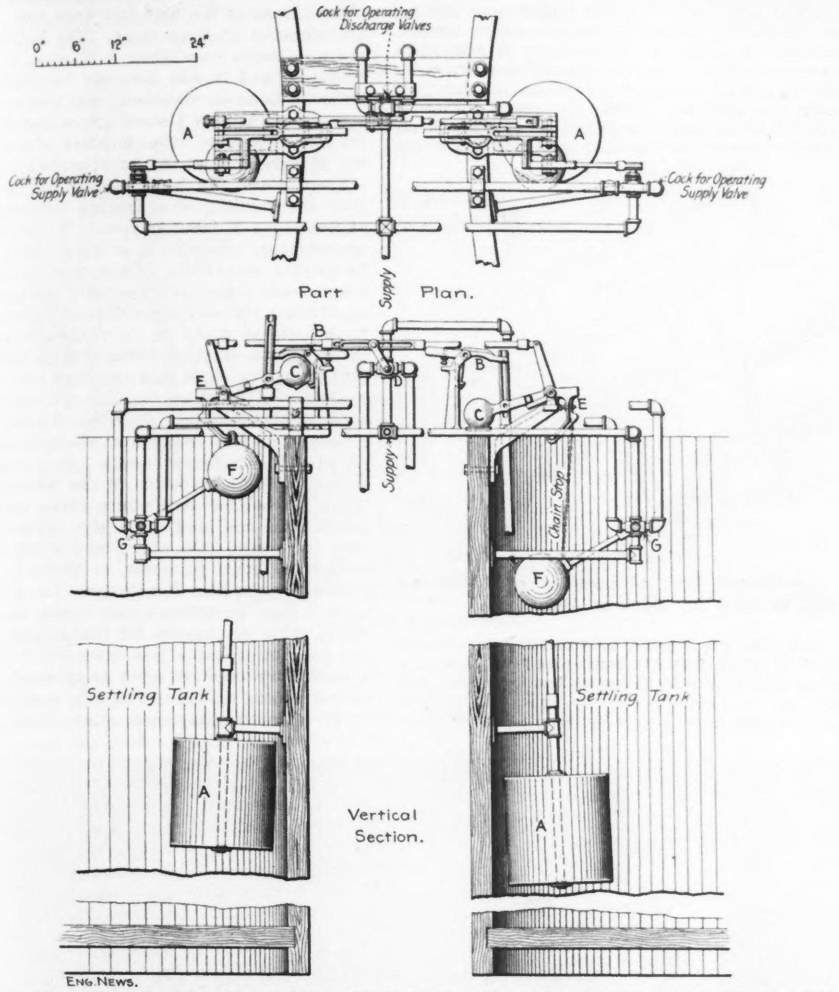


FIG. 3.—AUTOMATIC DEVICE FOR REGULATING SUPPLY AND DELIVERY OF SETTLING TANKS.

As to the results obtained by filtration very few figures are available, and some of those are rather indefinite, but the superintendent and pumping engineer express satisfaction with the plant. The following chemical results were reported to the Continental Filter Co. in December, 1899, by Mr. Wm. H. Warren, Professor of Chemistry in the Medical Department of Washington University, St. Louis, Mo.

I have examined two samples of water sent to me from Vincennes, Ind., by Mr. Chas. L. Parmelee, and at his request I send to you my report for the same. The results are expressed as milligrams per liter, or parts per 1,000,000. They are as follows:

	Water—River.	Water—Filtered
Date of examination	Dec. 26.	Dec. 27.
Turbidity	Marked.	None.
Sediment	Heavy.	None.
Color	Decidedly yellow.	Practically none.
Odor (cold)	Stagnant.	Slight.
Odor (hot)	Increased.	More mrkd
Total solids	593.0	287.0
Loss on ignition	123.0	60.0
Fixed residue	470.0	227.0
Suspended matter	244.6	0.3
Free ammonia	0.172	0.172
Albuminoid ammonia (solution)	0.232	0.148
" " (suspens'n)	0.670	0.040
" " (total)	0.902	0.188
Nitrogen (as N_2O_3)	0.020	0.008
Nitrogen (as N_2O_5)	3.6	6.4
Oxygen cons. unfiltrd (5 mins.)	5.64	2.0
Oxygen cons. filtered (5 mins.)	3.0	....
Chlorine (unfiltered)	33.54	11.9
Chlorine (filtered)	24.89	....
Temporary hardness	169.0	114.0

It will be seen that practically all the suspended matter and color were removed, and that the albuminoid ammonia was greatly reduced. In January, 1900, Messrs. L. J. Weisenberger and Henry Schwartz, Superintendent and Pumping Engineer of the works, respectively, reported to Mr. Walter Wood, Treasurer of the company, that during two months' operation the filtered water had always been "perfectly clear and bright, and free from objectionable tastes and odors;" also that while the daily bacterial results "fluctuate to a considerable degree, the following figures are believed to be representative of the operations:

	Per cu. cm. Range.	Per cu. cm. Average.
Bacteria in river water	25,000 to 100,000	40,000
Bacteria in filtered water	500 to 1,200	750
Average bacterial efficiency		98.1%"

As to coagulant, it was stated in the same report that the "amount of chemical required will apparently range from 10 to 40 lbs. per 100,000 gallons of filtered water, on the basis of the best grade of sulphate of alumina." This is equivalent to from 0.7 to 2.8 grains per gallon.

A report from Messrs. Weisenberger and Schwartz, dated March 29, 1900, and addressed to the Vincennes Water Supply Co., contained a statement of pumpage from Jan. 21 to March 27, 1900, with comments thereon, as follows:

		Pumpage, gallons—Total.	Pumpage, gallons—Av. rate per 24 hours.
Jan. 1 to 31	149 hrs. 5 mins.	13,791,298	2,220,000
Feb. 1 to 28	155 hrs. 15 mins.	12,939,104	2,000,000
Mch. 1 to 27	166 hrs. 5 mins.	12,843,778	1,856,000
Totals	470 hrs. 25 mins.	39,574,180	2,009,000

There were three filters in operation at all times, and the fourth one was used not more than one-fourth of the time. This would show that the average actual rate of filtration for the entire plant for the past three months was 2,485,000 gallons per 24 hours. It is to be noted in this connection that the high water did not reduce this rate, the subsiding basins removing most of the heavy mud.

The filters require from 12,000 to 15,000 gallons of water per filter for washing. As they require washing not more than twice in 24 hours, the amount of wash water ranges from 96,000 to 120,000 gallons per 24 hours.

The above figures show a minimum net capacity of the filter plant of 2,365,000 gallons per 24 hours, or 18¼% in excess of the guarantee.

The filtered water has been uniformly clear and bright and free from suspended matter even in the muddiest stages of the river water. Mechanically the plant is entirely satisfactory, the filter company having remedied at once the few minor defects which have appeared.

The computations following the pumpage figures are based on the assumption of 24 hours' continuous work at the rates actually maintained during an average daily period of pumping of about 5½ hours, for the 86 days covered. The actual pumpage averaged about 460,000 gallons a day. In the report made early in January of this year, mentioned above, it was stated that the filters were washed daily, the quantity per filter being given as 12,000 to 15,000 gallons, as in the second report, the operation taking 15 to 20 minutes. If the statements in the two reports mean that each filter is washed daily, then, allowing for the fourth filter being in actual use only one-quarter as much as the others, and, therefore, washed only once in four days, the actual amount of wash water would be:

$$\frac{12,000 + 15,000}{2} \times 3\frac{1}{4} = 43,875 \text{ gallons.}$$

This is almost one-tenth the net amount filtered Of course, with the filters in constant use, the percentage of wash water would be greatly reduced, the figures, as given in the report, being an average of 108,000 gallons of wash water to 2,485,000 gallons gross, or 2,365,000 gallons net yield, or well towards 5%, in either case.

It should be noted that the filtered water is pumped to the stand-pipe and the high service pumps shut down as soon as the pipe is full; also that water from the stand-pipe is used for washing the filters. We are indebted to the officials of the Vincennes Water Supply Co. and of the Continental Filter Co. for most of the information on which this article is based.

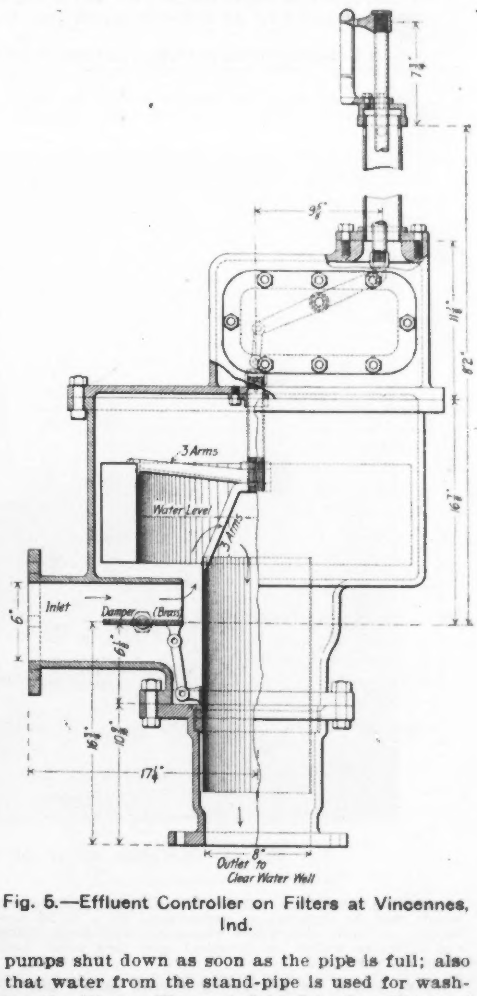


Fig. 5.—Effluent Controller on Filters at Vincennes, Ind.

THE WIDTH OF CITY STREETS in some of the large cities of the world is compared in a summary published by the "Canadian Contract Record," from which we abstract the following items: Berlin—Under den Linden (includes a broad walk with two rows of trees for nearly half of the whole length), 196 ft.; Leipziger Strasse, 72 ft.; Friedrich Strasse, 72 ft.; Friedrich Strasse, from the corner of Behren Strasse to Unter den Linden, 41 ft.; Konig Strasse, 57 ft. The width of the pavements on both sides of the street is included. Brussels—Le Boulevard Circulaire, between les Places de Namur and Louise, 220 ft.; L'Avenue Louise, 183 ft.; L'Avenue du Midi, 118 ft.; Le Boulevard Ansbach, 91 ft.; Le Boulevard du Nord, 78 ft.; Le Rue de la Nord, 65 ft.; Le Rue Royale, 65 ft. Paris—Rue de Rivoli, 88 ft.; Rue Montmatre, 72 ft.; Avenue de l'Opera (Boulevard St. Germain), 98 ft.; Grands Boulevards, 114 ft.; Avenue des Champs Elysees, 229 ft.; Avenue de Grande Armee, 295 ft.; Avenue Bois de Boulogne, 393 ft. Vienna—Ringstrasse, 187 ft.; Karntnerstrasse (Upper), 62 ft.; Karntnerstrasse (Lower), 121 ft.; Praterstrasse, 118 ft.; Rennwegg, 65 ft.; Hauptstrasse, third and fourth districts, 65 ft. each; Hauptstrasse, fifth district, 72 ft. New York—The streets vary in width from about 60 ft. to 150 ft. The ordinary residence streets—beginning at First St. and extending across the island of Manhattan from east to west, up as far as 220th St.—are 60 ft. wide, excepting at intervals of about half a mile, when they are 100 ft. The avenues which run north and west at right angles with the cross-streets are 80 to 150 ft. wide. Below Houston St. or First St., on Manhattan Island, the streets and thoroughfares are of irregular widths, following for the most part lines of paths, lanes or roadways originally followed for the convenience of the early colonists or settlers. Washington—Most of the avenues named after the different States are 160 ft. wide from building line to building line, with 50 to 107 ft. roadway respectively.

BOOK REVIEWS.

ELECTRIC WIRING.—By Cecil P. Pool. New York: The Power Publishing Co. Leather; 4½ x 6½ ins.; pp. 101; 46 illustrations, and 28 tables; $1.00.

This hand-book seems to be complete and well arranged. Its scope is indicated by the following extract from the preface:

This book is designed to serve both as an instructor for practical wire-men who have occasion to lay out their own work, and as a convenience and general reference book for electrical engineers whose work includes the calculation of transmission circuits, etc. With this object in view the author has included formulas and instructions which may be regarded as superfluous by a technician, because of their elementary character, and some tables and formulas which the practical man may never have occasion to employ.

Wiring tables for alternating-current motors are included and tables showing the corrected drop in inductive circuits are given. The formulas from which the various tables are calculated are given and, in the case of alternating currents, are illustrated graphically. Diagrams are given for wiring lights, motors, call-bells, transformers, etc.

THE ORE DEPOSITS OF THE UNITED STATES AND CANADA.—By James Furman Kemp, A. B., E. M., Professor of Geology in the School of Mines, Columbia University. Third edition, entirely rewritten and enlarged. New York, 1900: The Scientific Publishing Co. Cloth; 9 x 6 ins.; pp. 481; illustrated. $5.

In the present edition Prof. Kemp has included the mines of Canada in his descriptions of ore deposits, has added about 100 pages of new matter, has doubled the figures in number, and has rewritten much of the original text to bring it fully up to date. The chief purpose of this book is to give a condensed geological and statistical description of the principal ore deposits of this country and Canada; including in these the producers of iron, silver and gold, silver and lead, copper, zinc and the lesser metals of aluminum, antimony, arsenic, bismuth, chromium and manganese. These condensed descriptions are accompanied by a complete bibliography referring the reader to original sources of information and fuller accounts, when these are desired. The second purpose of the author is to stimulate investigation and study of the interesting phenomena connected with the origin and nature of these ore deposits, by permitting an extended view of the whole field. In both cases Prof. Kemp has done his work well. The geological descriptions are very minute and these are illustrated by maps, cross-sections and photographs taken largely by himself. On the more speculative side of attempting to ascertain the origin of certain deposits, he quotes and discusses all that has been previously written on these topics, and disposes of a considerable amount of published nonsense in so doing.

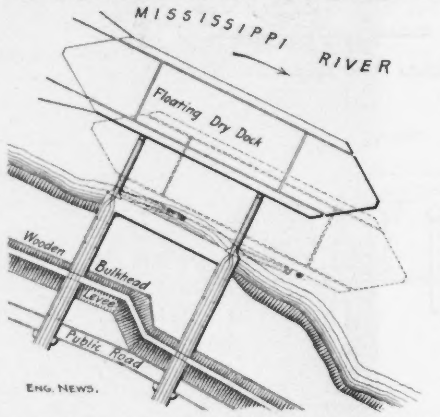


Fig. 1.—General Plan of Location of 15,000-ton Floating Dry Dock at Algiers, La.

THE 15,000-TON FLOATING DRY-DOCK FOR THE U. S. NAVAL STATION AT ALGIERS, LA.

(With full-page plate.)

We illustrate in the accompanying cuts and on our inset sheet this week the general details of the 15,000-ton floating dry-dock now being built by the United States Government for use at its naval station at Algiers, La. With the possible exception of the floating dry-dock built some years ago for Blohm & Voss, shipbuilders, of Hamburg, Germany, and which is reported to have a capacity of 17,500 tons, this new American dock is the largest of its type in the world. The Havana floating dry-dock, which was towed across the Atlantic to Havana, Cuba, just previous to the outbreak of the war with Spain, had a capacity of 10,000 tons. At the close of the war this dock was sold to the Government of Vera Cruz. The builders of the Havana docks were Swan & Hunter, of Wallsend, England, and it was designed by Clark & Stanfield, of London, England, who are also the designers of the new United States dry-dock which we illustrate here. The builders of this dock are the Maryland Steel Co., of Sparrows Point, Md.

From what has been said it will be observed that the building of a floating dry-dock, capable of floating a 15,000-ton vessel, is not entirely unprecedented, although it is quite unusual enough to attract attention. While there has not been very much practical experience in building and operating such very large floating dry-docks, there have been, as many of our readers know, a great many smaller floating docks of from 2,000 to 3,500 tons capacity, built and operated with success in America. A brief examination will show that for such small vessels at least the floating dry-dock presents several important advantages as compared with stationary docks. It is plain, for instance, that the adoption of the floating dock relieves the builder at the very outset from any demand upon his land for a site, which may be a very important gain where land is expensive or is needed for other purposes, or where it is of such a nature that the foundations for a stationary dock would be difficult and costly to construct. There being no expense for foundations, the floating dock is probably less expensive to build than a stationary dock of wood or masonry, having a corresponding capacity. The only conditions, probably, where the stationary dock might prove less costly, are where the dock is of the largest size, or where the land required for its site is available at a very small cost. For example, the contract price of the new 15,000-ton floating dock which is illustrated here is $810,000. The new timber dock of approximately similar capacity at the League Island Navy Yard was $749,000, but this did not include the cost of the land for the site.

The most important advantage of a floating dock is, however, that it is portable property. If desired it can be shifted from one position to another in the home yard at slight expense, or, if necessary, it can be towed from one port to another. The Havana dock, it will be recalled, was safely towed across the Atlantic to Cuba, and

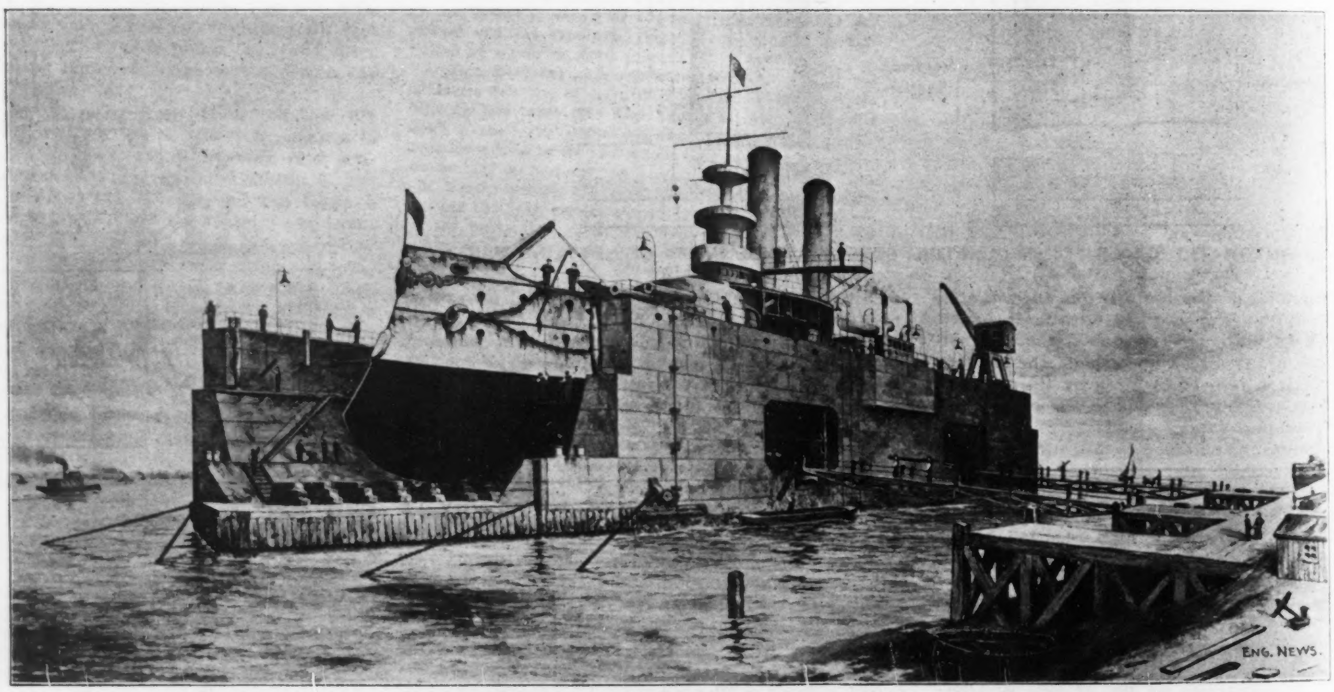


FIG. 3.—GENERAL VIEW OF U. S. 15,000-TON FLOATING DRY DOCK, WITH VESSEL IN POSITION FOR WORK.

thence to Vera Cruz. This portability renders the floating dry-dock a salable asset, since it can be removed by a purchaser to the new location where he desires to use it. As an illustration, the United States Government, at the outbreak of the war with Spain, was able to purchase a floating dock of 2,200 tons capacity from private owners, and transfer it to the Pensacola Navy Yard, where it was at once available for all the vessels within its lifting capacity then operating in Southern waters. The new dock when completed will have to make

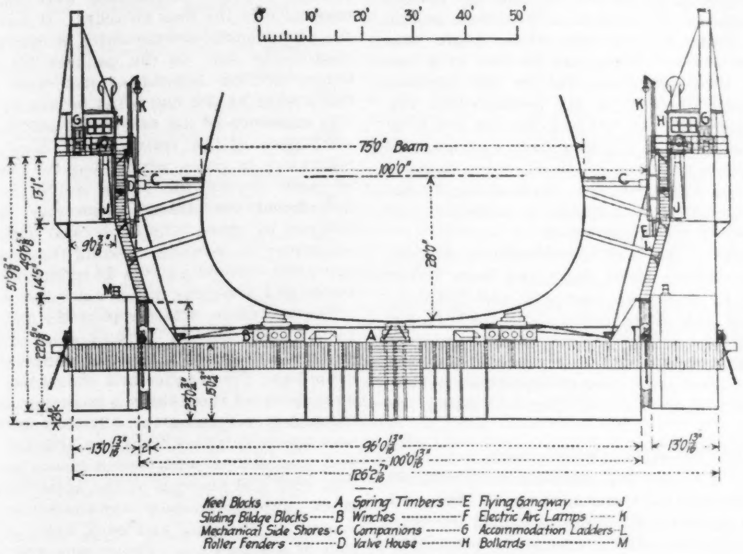


FIG. 4.—END ELEVATION.

a journey by water from Baltimore to New Orleans before it is put into use.

The preceding remarks necessarily state the case of the floating dry-dock very briefly, but they indicate quite clearly the reasons which influenced its construction. As already stated, it is to be located at the naval station at Algiers, La., which is located on the Mississippi River, just below New Orleans. Fig. 1 is a plan of the immediate location. It will be seen that the dock is approached by two trestles carrying tramways which terminate with support piers just at the water's edge. Between these piers and the edge of the dock are hinged two bridges. Figs. 1 and 2 indicate the construction and operation of these bridges quite clearly, and also show the manner in which the dock is maneuvered in operation. A perspective drawing of the dock, with a battleship inside, is shown by Fig. 3. Figs. 4 and 5 are, respectively, an end elevation and a transverse section of the dock, and Figs. 6 and 7 are a longitudinal section and plan.

Referring to the drawings, it will be observed that the dock consists of five pontoons, three of which compose the bottom of the dock, while two form the side walls. The center pontoon of the three forming the bottom is rectangular in form, and is 240 ft. long, but the two end pontoons are rectangular for only 80½ ft. of their length, the remainder being finished off in the form of a blunt point or bow. Only 55 ft. of the end pontoons are buoyant, the remaining or outside 30 ft. forming the bow, being composed of a series of plate and lattice girders strong enough to support the ends of a ship, but which do not give objectionable buoyancy to the ends of the dock when short vessels are being raised by it. These end platforms, however, have a water-tight deck plating and are surrounded by a water-tight end plating or bulwark.

The deck pontoons are divided into 32 pumping divisions, of which 24 are absolutely water-tight and distinct. The side walls have four water-tight divisions each. Each of these 40 compartments has a separate drain pipe controlled by a separate valve. All the drain pipes in the starboard half of the dock lead into a main drain pipe in the starboard side wall, and all in the port half to a similar drain in the port side wall. These main drain pipes are continuous the whole length of the side walls, and the four pumps in each wall are seated directly on them, so that any one pump can empty all the compartments in its half of the dock. Connections are also available by which in case of a breakdown of half of the pumps the other half can empty the whole dock. A separate engine is provided for each pair of pumps, and there is a separate boiler for each engine, but the steam pipes are so arranged that either engine of a pair can take its steam from either boiler. This duplication makes a complete breakdown almost impossible. Steam is the only motive power used in the dock.

Although, as stated above, the dock is divided into 40 compartments, each having its own regulating valve, the operation of the whole dock is controlled from two central positions on the top of the towers. Each valve-house is in direct communication by speaking tubes with its engine rooms, so that the man in charge can manipulate every valve, both water and steam, for the maneuver of the dock without quitting his post.

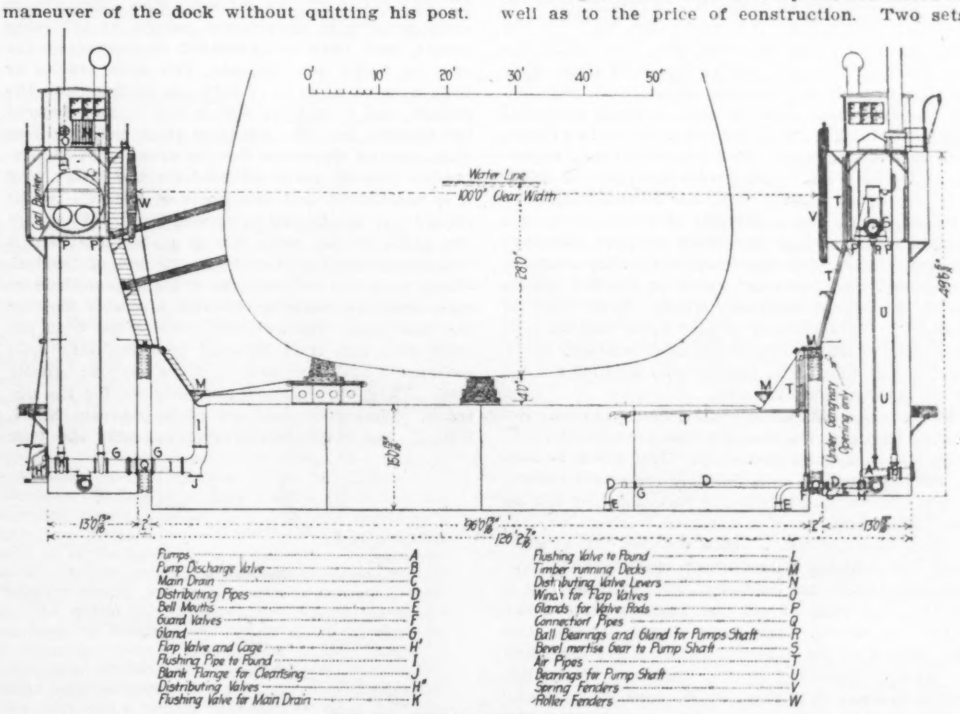


FIG. 5.—TRANSVERSE SECTION.

The operation of raising a vessel with the dock is substantially as follows: When all compartments of the dock are empty it floats at a draft of 4 ft. To sink it, the valves are opened, admitting water to the various compartments. It may be sunk to such a depth that it will take in a vessel of 30 ft. draft. The vessel is floated in and carefully centered over the keel blocks, and the pumps are then set to work to remove the water from the compartments. In pumping out the water the chief care is to see that the dock keeps level. This is accomplished by altering the speed of pumping from the different compartments to suit the conditions. As the dock raises the vessel out of the water, shores are inserted between the vessel's hull and the side walls, and the pumping is continued until the floor of the dock is raised above the water level. The keel blocks are high enough to raise the bottom of the vessel some 4 ft. above the floor of the dock at the point next the keel, giving space enough to work underneath the vessel, as shown in Fig. 4. One of the most notable features of the dock is the fact that it is self-docking. It will be readily understood that a floating dry-dock, like any other floating vessel, will occasionally require repairs to its underwater parts, and on account of its size it is, of course, out of the question to dry-dock it as can be done with smaller vessels. The only resource, therefore, was to design it so that it would be self-docking. This is accomplished as follows:

If it is desired to dock the middle pontoon, the fastenings connecting it with the other pontoons are removed, and it is allowed to float loosely. Water is then admitted to the end pontoons and side walls and the middle pontoon floats up, until a set of lugs on its bottom corresponds to the upper connecting lugs on the side walls. This brings the middle pontoon entirely out of water. The middle pontoon in turn has sufficient capacity to dock both end pontoons at once, and one of the side walls can be tilted out of water by filling the other one. By these various means the entire underwater surface of the dock is made accessible for repairs.

The dock is complete in itself, having its own engines, boilers and operating machinery, and complete quarters for its crew. As already stated it can be towed anywhere. With its lifting capacity of 15,000 tons, and lateral dimensions of 525 × 100 ft., it will dock any vessel now in the United States Navy. In calling for the construction of the dock the Navy Department prepared general specifications upon which it asked for competitive plans and bids, the competition thus extending to the merits of the plans submitted as well as to the price of construction. Two sets of plans and bids were received, and after careful comparison those of the Maryland Steel Co. were accepted. The designs submitted by this company were prepared by Messrs. Clark & Stanfield, Engineers and Naval Architects, London, England. Work is now in progress on the dock at the plant of the Maryland Steel Co., at Sparrows Point, Md. It only remains to be noted that while the dock is nominally of 15,000 tons' capacity, it has this capacity when the deck is 2 ft. out of water. With the deck awash the buoyancy is 3,000 tons more, or 18,000 tons altogether.

THE SWITCHBACK LINES OF THE GREAT NORTHERN AND NORTHERN PACIFIC RAILWAYS OVER THE CASCADE RANGE.

(With full-page plate.)

One of the notable features of American railway engineering has been the rapidity with which great lines of communication have been opened, leaving to the future the work of improving the lines as the traffic develops. This feature has been specially prominent on some of the lines crossing the Rocky Mountains, and in the present article we describe the bold "switchback" lines built across the Cascade Range of these mountains by the Great Northern Ry. and the Northern Pacific Ry. for their transcontinental routes, to avoid the delay incident to the construction of tunnels for lines of more favorable location. One of these has already been superseded by a tunnel line, and the tunnel on the other route will probably be finished this year.

The Great Northern Line.

In the construction of the Pacific Extension of the Great Northern Ry., in 1890-92, the Cascade range of the Rockies, in Washington, was crossed by a switchback line going over the Stevens Pass, The pass was discovered in 1890 by the late C. F. B. Haskell, M. Am. Soc. C. E., and named for Mr. J. F. Stevens, M. Am. Soc. C. E., who was in charge of the exploration surveys under Mr. E. H. Beckler, then Chief Engineer. Mr. Stevens is now Chief Engineer of the Great Northern Ry. A general description of the line, with the switchback and tunnel, was given in our issue of May 18, 1893. The plan of building a "switchback" crossing was adopted in order to ensure rapid construction, and a prompt opening of the line for traffic, but it was intended from the first that this part of the line should be eventually replaced by a tunnel. Work on the tunnel was commenced in August, 1897, and is expected to be completed this year.

Fig. 1 is a plan and profile showing the location and grades of the switchback and tunnel lines. On the switchback line, the grades are 3½% on the east side and 4% on the west side, with maximum curves of 12°, except that on the west slope there is one curve of 13°, turning an angle of 149° 14'. On the east slope is a 12° curve having a central angle of 218° 24'. There is a Y-spur on this curve, but this is not used. The curves have a superelevation of 5 ins. The grades are equated 0.04% per degree of curve. All the switchbacks are equipped with non-automatic stub switches. No special arrangements have been made to take care of runaways, and it has been found that none are necessary, the reversing grades on the tail tracks being considered sufficient. There have been no runaways or accidents of any kind, and in fact this piece of line is considered as safe as any other part of the line. The bridges and trestles are all of timber cut along the line.

Passenger trains are given 1¼ hours to make the run of 12 miles, but the trip has been made in 45 minutes on special occasions. The track is said to ride as steadily as is possible for a line having sharp curves, and meals are served in the dining car, as on other parts of the road, without any inconvenience. When a train reaches the switchback, two 110-ton consolidation engines with driving wheels 54 ins. diameter, and cylinders 20 × 39 ins., are coupled on, one at each end of the train. A special train crew takes charge, and movements at the different switches are governed by whistle signals from the engines. Passenger trains average nine cars, or 350 tons, and freight trains average 18 cars, or 700 tons, behind the tenders. During the winter, there is considerable trouble on account of snow. To keep the line open, two of the consolidation engines are coupled together, back to back, with a Leslie rotary snow plow ahead of each. These are run over the line as frequently as is necessary, to excavate the deep snow and to keep the snow cuts open and the track clear.

The total length of the line is 12.15 miles, including the spurs, the summit being 6.40 miles from Cascade station on the east, and 5.75 miles from Wellington at the west end. The summit elevation is 4,055 ft. above sea level, 674 ft. above Cascade, and 939 ft. above Wellington. From the map it will be seen that there are three switchbacks (or reversing stations) and a horseshoe loop on the east side, and five switchbacks on the west side, the location on the east side being arranged to avoid the great snow slide indicated on the map.

The curves are not laid out with transition curves, and are not fitted with guard rails. The gage is widened ¾-in. on the 10° and 12° curves, and 1 in. on the 13° curves. The track is laid with 80-lb. rails, spliced with 36-in. angle bars and sig-bolt joints. There are 16 ties to a rail length, the rails being secured by six common spikes in each tie, and by six pressed-steel rail braces to each rail. All the switchbacks are level for 100 ft., or between the frog and headlock, and then rise with a grade of 1% to 5% for a distance of 1,000 ft. on the spur, the grade being so arranged as to assist materially in stopping and starting the train without shock.

Work on the tunnel was commenced in August, 1897, and in March, 1900, there had been driven about 4,700 ft. from the east end and 5,000 ft. from the west end. This leaves about 3,400 ft. yet to be driven, and at the present rate of progress of 8 ft. per day at each end, it is expected that the headings will meet some time in September. About 750 men are now at work, driving and lining the tunnel.

The Northern Pacific Line.

The Northern Pacific Ry. adopted the Stampede Pass route through the Cascade range in 1884, and in 1886 it awarded to Mr. Nelson Bennett the contract for the tunnel, which was to be completed in 28 months. In order to expedite the opening of the transcontinental line, a switchback line was built, crossing the range by the Stampede Pass, which had been discovered in 1881 by one of the exploring parties, and has an elevation of about 3,675 ft. above sea level. The switchback was opened in July, 1887, while the tunnel was completed in May, 1888. The length of the switchback line was about seven miles, with maximum grades of 296 ft. per mile (5.6%) on the east side, and 275 ft. per mile (5.2%) on the west side. The grades were practically continuous, except at reversing points, and were compensated on curves at the rate of 0.04% per degree. The stub tracks or tails were on a grade of 0.2%, ascending from the switch, and were from 400 to 500 ft. long beyond the headblocks. The grade on these tails was less than that on the main line, on account of the excessive rate of grade adopted for the latter, and it is considered that the grade of the tail tracks should not be allowed to exceed 2½%. Whenever the grade of the main line is under this rate it can be extended uniformly to the end of the tail. There were two switchbacks and a loop on the east side, and two switchbacks and a double loop on the west side. The switches were of the Wharton type, although it is believed that ordinary split switches would have answered the purpose equally well. They were always normally set for the uptrack. They were laid out as in diagram No. 1, Fig. 2, the track being level between the frog point and headblock. A method which is considered preferable by Mr. E. H. McHenry, M. Am. Soc. C. E., Chief Engineer of the Northern Pacific Ry., is shown in diagram No. 2. This can be operated to much better advantage, but has the objection of sacrificing distance, and thereby increasing the cost. This method, however, would be worth adopting where the increased cost was not excessive.

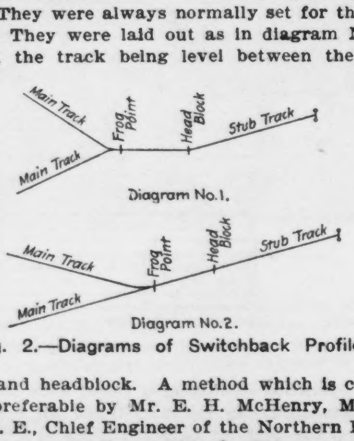


Fig. 2.—Diagrams of Switchback Profiles.

A very heavy traffic was carried over the line during the period in which it was operated. The average speed was from 7 to 10 miles per hour in ascending, and from 12 to 20 miles in descending. The line was operated by consolidation mountain engines with a weight of 120,000 lbs. on the driving wheels; and there were also two special decapod engines, having 130,000 lbs. on the driving wheels; cylinders, 22 × 20 ins.; driving wheels, 3 ft. 3 ins. diameter. These dimensions account for the slow speed in ascending the grades. Special switchmen were stationed permanently at the four switches. It was found that the switchback was far safer in operation than a continuous line, as the chances for disaster by trains getting beyond control were very much diminished by the line being broken up in sections. The existence of the tail tracks also increased the confidence of the train crews, thus preventing runaways in cases where, but for the knowledge of these tracks, the crews would probably have abandoned the trains. Runaway trains were stopped by these tails on several occasions without injury or damage. During the whole period of operation, extending over 18 months, the company never had a serious disaster nor lost a life.

The operation, while apparently difficult, was in reality very simple. Trains were operated with engines on each end, to avoid danger from broken couplings. By practice and experience the enginemen operated their engines in perfect unison. The method of reversing the direction at the switches was specially noteworthy, on account of the ease and smoothness with which it was accomplished. The stop and reversal at the upper end of the tail track were practically simultaneous; the train swung up the stub and back again with the motion of a pendulum. Steam was shut off just before passing over the switches and the train was allowed to stop and reverse its direction by gravity, the enginemen working steam in reverse motion as soon as sufficient velocity was attained. All the engines were fitted with water brakes, which added very much to the ease and safety of operation.

The tunnel is 9,850 ft. long, partly in basaltic rock, but largely in shale with timber lining. The swelling of the shale under exposure made it necessary to put in a masonry lining soon after the tunnel was completed, and this consists of concrete side walls and a brick roof arch. It is 16 ft. 6 ins. wide in the clear and 22 ft. high, with 12.36 cu. yds. of excavation per foot of tunnel in solid rock, and 15.70 cu. yds. where the timber lining was put in. It was driven by the top heading system, and the average rate of progress for the entire work was 18 ft. per day. The headings met on May 3, 1888, and the first train passed through on May 27, 1888. The cost was about $1,600,000. There is an ascending grade of 0.74% from the west portal for 5,000 ft., and then a descending grade of 0.2% to the east portal. The elevation of the east portal is 2,827 ft., and that of the west portal is 2,800 ft. above sea level. By this tunnel, the railway secured a permanent line with maximum grades of 116 ft. per mile (2.19%), this being the grade of the approaches for some miles on each side of the tunnel. The distance is about three miles, instead of seven miles by the switchback. The construction of the tunnel was described and illustrated in our issues of Oct. 3, 10 and 17, 1891.

In this connection it may be of interest to make brief reference to the Zigzag switchback and tunnel of the New York, Ontario & Western Ry. The tunnel line is about one mile long with grades of 0.75% and 1.25% for northbound and southbound trains; and replaces a switchback line with four inclines about three miles long, with grades of 1.8% and 1.98%, respectively. It also effected a saving of about $30,000 per annum formerly expended in helping trains over the summit, this amount being more than three times the interest on the cost of the tunnel line. This was described in our issue of Jan. 10, 1891. The Hagerman Pass line and the Busk tunnel line on the Colorado Midland Ry. form a similar case, but the "outside" line is carried through the Hagerman Pass without the use of switchbacks. The tunnel line on this road saves seven miles in distance, 530 ft. in elevation, and 2,000° in curvature, as described in our issues of Nov. 24, 1898, and April 6, 1899.

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