ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

VOL. XLI. No. 19.

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A LIFT LOCK FOR THE ERIE CANAL at Cohoes, N. Y., may be built by a private company. At the last session of the New York state legislature a bill was passed by which the Canal Board is authorized to permit the construction of a canal, with the necessary locks and appurtenances, near Cohoes, N. Y., and by which it is provided that:

Such canal, locks and appurtenances shall be of dimensions and according to plans and specifications approved by the state engineer and surveyor, who shall supervise its construction. The connections of such canal with the existing canals shall be so constructed as not to interfere with the operation of the existing canal system. The canal board may, at its option, lease the canal and locks so constructed, and contract for their operation during seasons of navigation, conditioned upon the successful operation of the same, at an annual rental which shall be fixed by the canal board and which shall not in any event exceed 5% on the actual cost of the construction of the said new canal, locks and appurtenances, together with the sum now annually expended in maintaining and operating the present Erie canal from lock three to lock eighteen, inclusive, known as "the sixteens," or such part of the present state canals as the new canal, locks and appurtenances herein provided for, shall replace and be a substitute for, for purposes of navigation and commerce. The state may at its option at any time acquire such canal, locks and appurtenances by purchase, if able to agree with the owners thereof, and otherwise by condemnation. After the canal herein provided for shall have been completed and put in successful operation, and leased or acquired by the state, it is hereby declared to be, for all public purposes, a part of the Erie canal; and the canal board is hereby empowered thereupon to discontinue the operation and maintenance of the present Erie canal between its junctions with the Champlain canal and the proposed new canal.

It is unofficially reported that capitalists interested in the pneumatic lock system of Chauncey N. Dutton are ready to undertake the work provided for in the bill. The total lift to be overcome is about 140 ft., and it is probable that it will be divided between two locks.

A NEW CAPE COD CANAL SCHEME is projected by the Massachusetts Ship Canal Co., which has been favorably reported upon by the Committee on Harbors and Public Lands, of the Massachusetts Legislature. The company is given until Dec. 1, 1900, to secure subscriptions for $500,000 of its capital and to pay $100,000 to the state, otherwise the charter is void. The incorporators of the company are Henry W. Armstrong, R. G. F. Candage, W. F. Humphrey, Nathan Appleton, Robert Rantoul, B. F. Peach, Jr., E. B. Hayes, W. L. Ramsdell, W. B. Burgess, W. F. Baker, J. C. Whyman, H. N. Berry, J. T. Wilson, C. A. Campbell, C. P. Mudge, S. W. Eldredge, A. W. Hurd and B. J. Berry. The capital is $7,500,000, and the canal must be completed within five years, under penalty of losing the charter. A deposit for land damages is not required, and the bill is generally a liberal one. The route of the canal is from the mouth of Bass River, on Nantucket Sound, through the towns of Dennis and Yarmouth to a point on Massachusetts Bay, or Cape Cod Bay, generally following the Bass River. The canal is to be 75 ft. wide at bottom, 200 ft. wide at top, or 150 ft. wide if it has vertical walls, and it is to be not less than 23 ft. deep at low water. The company will have the right to build all necessary docks, etc., and to operate tugs to assist vessels through the canal. The same company was incorporated in 1895, but did no work; and the Boston "Transcript" is uncertain whether the route is preferable to the Buzzard's Bay route, or practicable at all. Since 1870, seven Cape Cod canal companies have been incorporated with no results. In another bill which was reported to the Massachusetts legislature on May 4, Alexander Dow and Walter Clifford, of New Bedford; De Witt C. Flanagan, of New York, and others, ask permission to build and operate a ship canal beginning at Buzzards Bay, running through the towns of Bourne and Sandwich, and ending in Barnstable Bay. The capital stock is $6,000,000, and the canal is to be 25 ft. deep at mean high water, and not less than 100 ft. wide on the bottom and 200 ft. at the surface. The bill is supposed to provide for a forfeit of $25,000 each to the towns of Bourne and Sandwich if the canal is not located within three months of granting the charter, and a deposit of $200,000 is to be made with the state as an evidence of good faith and to cover land damages. The canal will have to be completed in five years, ready for use.

THE SAULT STE. MARIE WATER-POWER CANAL, now under construction, has been causing some apprehension among vessel owners as to its possible effect upon lake levels. It was feared that the great canal would draw off so much water from Lake Superior that the depth of water in the harbors would be insufficient for large vessels. Mr. Alfred Noble, M. Am. Soc. C. E., was retained some time ago to examine into the conditions existing and likely to exist, and he came to the following conclusions, as reported in the Chicago press:

1. The withdrawal of 30,000 cu. ft. of water a second—this being the amount required for the contemplated development—would lower Lake Superior's level probably 2 ft. in the course of years.
2. That a reduction of the Soo rapids section for an area equal to that which now passes 30,000 cu. ft. of water a second, by an ordinary dike constructed from either shore, would prevent the lowering of the low level, but would raise the high level to an extent resulting in damage to existing dock and shore improvements.
3. That the construction of a submerged weir about 630 ft. long would not only accomplish the reduction of the present overflow area in an amount equal to the volume to be withdrawn, but would also leave a sufficient section for the safe outflow for the higher stages of Lake Superior level. Such a structure, within a limit of about 4 ins., would regulate the level of the lake as between the ranges of extreme low and high water.

The proposed canal is to develop about 140,000 HP. The submerged weir recommended by Mr. Noble is included in the final plans, and these plans have been approved by the U. S. Engineers. Preliminary work on the canal was commenced last summer, and it is expected that about 2,500 men will be employed this season, on day and night shifts. This canal was described and illustrated in our issue of Aug. 4, 1898.

WATER POWER on the Chicago Drainage Canal is to be developed by the Economy Light & Power Co., of Joliet, Ill., according to report. There will be 30 turbines, 68 ins. diameter, arranged in groups of five, each group driving a dynamo of 1,000 HP. The turbines will work under a head of 14 ft., which is the fall from the canal tail-race to the Desplaines River. Another project, in which Mr. Maurice T. Moloney, Mayor of Ottawa, Ill., is interested, is to build a steel and concrete dam across the Illinois River at Ottawa, giving a 16-ft. head of water, and developing about 10,000 HP.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Great Northern Ry., near Saunders, Wis., on May 8. Press reports state that while a heavy ore train, consisting of 40 ore cars and several box cars, was crossing a 1,200-ft. timber trestle, the structure failed, owing to water undermining the foundations of some of the piers, and the entire train fell to the ground 100 ft. below. The engineer was killed and the fireman mortally injured.

A HEAVY COAL TRAIN was recently run on the Baltimore & Ohio R. R. from Cumberland to Brunswick, Md., a distance of 100 miles. It consisted of 50 Schoen steel cars of 50 tons capacity (Eng. News, Jan. 19, 1899), each car weighing 34,000 lbs. empty and carrying an average load of 98,000 lbs. of coal. This train was hauled by a consolidation engine, with cylinders 22 × 28 ins., and driving wheels 54 ins. diameter. The total weight of the train was as follows:

Cars	1,700,000 lbs.
Coal	4,900,000 "
Engine	168,700 "
Tender	75,000 "
Total	6,843,700 "
Per cent. of coal to total	71.6%

A FAST RUN WAS MADE on the Terre Haute & Indianapolis R. R., between Indianapolis, Ind., and East St. Louis, Ill., on April 21. The distance between these two places is 235.75 miles, and it was covered in 263 mins. (4 hrs. 23 mins.), which was at an average speed of 53.76 miles per hour, including all stops. There were 14 stops altogether, consuming 23 mins., which made the actual running time 4 hours, and the average speed, not including time lost in stops, 58.9 miles per hour. The train which made the run consisted of one baggage car, one combination car, one passenger coach, one sleeping car and one dining car.

AN ORDER FOR 20 FREIGHT LOCOMOTIVES for England has been received by the Baldwin Locomotive Works, of Philadelphia, Pa., from the Great Central Ry., the new English trunk line. The Baldwin company is also building 20 passenger locomotives for the same railway, the order for which was received some time ago.

THE SAFETY OF THE MANHATTAN ELEVATED R. R., which has been questioned in a recent report made by a committee of Sanitary Inspectors of the Board of Health of New York city, is asserted in the report of the Expert of State Railroad Commission, which has just been made public. This inspection was commenced March 14 and completed April 13, during which time every part of the structure was examined. In view of the rather alarming claims made in the Board of Health report (Eng. News, May 4) the following excerpt from the report of the Railroad Commission's expert is of interest:

No weak or defective foundations were discovered. A few castings at foot of columns show cracks at the top, but they were not found to extend far, and the fact that the lead calking has not been disturbed shows that no weakness has resulted therefrom and that the cracks were doubtless made previous to or during the erection. Roadmaster Black, who saw the erection of the structure, states that the cracks were made at that time by the insertion of iron wedges to plumb the columns. Arrangements are now made for banding those not already banded to prevent possibility of the cracks extending. Some of the cast-iron fenders at the foot of columns placed in the street are broken, but they were placed there only to prevent trucks and wagons from striking the columns, and have nothing to do with supporting or strengthening the columns. The columns used are of various kinds, but all indicate abundant strength, and no defects affecting their safety were discovered. The anchorage has proven efficient. Only one column was found loose at the foot, and the movement of that was less than 1-16-in. The transverse girders on all lines, excepting the suburban, are mainly of lattice design and are in good condition, showing no indication of excessive deflection or bending, and are very free from loose rivets. Some plate, lattice and truss transverse girders are used; and all are in good condition and of sufficient strength. The suburban line, excepting on private ground, where brick piers are used in place of columns, is all plate girder construction, of excellent design and great strength. The longitudinal girders on all the other lines are mainly of the open-webbed type, and are of a great variety of weights and depths, to meet local requirements, and an almost constant variation in lengths of span. Nearly all the lighter girders of this type have been strengthened by the addition of another set of diagonals. Two large gangs are now at work strengthening the light girders on the Ninth Ave. line. These girders I do not calculate weak, nor do they show indications of weakness; the rivets do not appear to work loose, nor do the girders deflect under loads beyond the allowable safe limit.

To determine the quality of metal and whether any deterioration had taken place during the 20 years' service to which the iron in the Ninth Ave. structure has been subjected, a diagonal brace at the end of one of the lightest girders was removed and tested, showing a very high grade of iron.

A few lattice girders are used, and quite a proportion of plate. Pin-connected deck trusses are used on the high portion of the Sixth Ave. line near 110th St. All are in good condition and of sufficient strength. At various places on the Ninth Ave. line, through Greenwich St., the old-style 24-in. plate girders have been doubled by placing one above the other. The connections of these girders are somewhat crude, but they hold their position and are abundantly strong. A few expansion bolts were found bent, broken or missing, but upon attention being called to them they were promptly replaced.

On the Ninth Ave. line, through Greenwich St., the most thorough examination was made, on account of the soundness and safety of that portion of the road having been questioned. Not a loose rivet in main girder members was found and but a few in lateral connections. The deflection under trains was measured in a great many places, and the greatest found was 7-16-in. in center of a 53-ft. span. The lateral movement or sway was also measured at top of girders, where it would be greatest, and in no case did the total movement exceed 5-16-in. (or 5-32-in. each way from the normal position). These tests were made on the single-column structure, where there was no connection between the tracks excepting at stations and on curves.

A DUAL SYSTEM OF WATER SUPPLY FOR NEWARK, N. J., is recommended by Mayor Seymour in his message to the new city council. He states that he made a similar suggestion twelve years ago, when a member of the old Aqueduct Board, and that he is more firmly convinced than ever of the wisdom of the plan. He would use the Passaic River for fire, sprinkling and manufacturing purposes, introducing the new system at once, but on a small scale at the start, with gradual extensions.

THE JERSEY CITY WATER SUPPLY CO. has been incorporated to carry out the contract for a new supply for Jersey City recently awarded to Mr. Patrick H. Flynn, of 189 Montague St., Brooklyn. The company has an authorized capital stock of $1,000,000, and the incorporators are Michael J. Kennedy, Fred. C. Cocheu, Nicholas K. Connolly, John McCarty and Louis H. Meht, of Brooklyn; Henry Belden, 31 Broadway, New York city; and Wm. D. Edwards, of Jersey City. It is said that most or all the Brooklyn men named are business associates of Mr. Flynn. Both Mr. Belden and Mr. Edwards have been connected with water supply matters in Jersey City for many years, especially with the Jersey City Water Co. The new company has organized by electing Mr. Meht as President, Mr. Kennedy, Secretary, and Mr. Belden, Treasurer.

THE REDUCTION IN THE PRICE OF GAS in New York, announced last week, has been met and exceeded by the New Amsterdam Co., which is now supplying customers at 50 cts. per 1,000 cu. ft., or 15 cts. lower than the two companies that started the rate war.

INTERLOCKING PLANT AT PACIFIC JUNCTION; CHICAGO, MILWAUKEE & ST. PAUL RY.

The track elevation work on the Chicago, Milwaukee & St. Paul Ry., within the city limits of Chicago, includes Pacific Junction, and the tracks at this point have not only been raised, but have been rearranged in such a way as to facilitate train movements, while the entire junction has been equipped with a new and complete signal and interlocking plant. The traffic is very heavy, and as no diversion could be allowed, the raising and rearranging of tracks and the installation of the interlocking equipment had all to be done with little or no interference with the traffic. The interlocking plant was put in service on March 20.

The junction is a complicated one, and is in the form of a diamond, with four curved sides and two diagonals. This is shown by the plan, Fig. 1. From the Union station to Pacific Junction there are four main tracks. Four tracks then turn west to the Council Bluffs and Omaha Division, while two tracks continue northward to the Milwaukee Division. The old Bloomingdale line runs eastward from the junction to North Chicago, and is a very busy terminal freight line, passing through a manufacturing district, while it also offers an alternative route to the Union station in case of any block on the main line south of Pacific Junction. The four-track curve to the west and the double-track line to the north are main lines; the others are freight and connection lines. The total distance between the outermost signals is about 5,150 ft. north and south and 3,470 ft. east and west.

At the center of the junction is a double-track grade crossing, and in addition to the regular interlocking signals there are semaphore block signals governing the crossing. Both the block and route signals must be clear before a train can start to pass over the crossing. These block signals have pointed ends, to distinguish them from the interlocking signals, as shown to the right in Fig. 2. It has been decided to put in electric automatic block signals between Pacific Junction and the Union station, but the type to be adopted has not yet been settled.

The interlocking machine has a frame for 108 levers, with 100 working levers and eight spare spaces. The distribution of the levers is as follows:

19	levers for	32 switches.
9	" "	11 derails.
2	" "	4 crossing bars.
5	" "	5 switches and 5 derails.
1	" "	1 high and 1 dwarf signal.
17	" "	32 facing point locks.
16	" "	16 dwarf signals.
31	" "	36 signals.

The locking frames are placed horizontally, on the main floor of the tower, behind the lever frame, and only the rods and wires to the lead-outs are beneath the floor. Two forms of lead-outs are used: (1) the usual arrangement of reciprocating rods or pipes, operated by bell-cranks and supported on roller carriers; (2) rocking shafts or tumblers, operated by cranks inside the tower and having outside crank arms to which the pipe lines are attached. Fig. 3 is a good view of the lead-out arrangement, and a group of ten rock shafts may be seen passing through the base-board of the tower. Another peculiar feature of the plant is the use of heavy box cranks for changing the direction of groups of pipe lines. One of these is seen at the left in Fig. 3, and a larger one is shown in Fig. 2. This latter view also shows the crossing block signals (at the right) and the long guard rail beyond the derail, which is intended to prevent a derailed train from wrecking the pipe lines and going down the bank. On the left is the terminus of the Humboldt Park branch of the Metropolitan Elevated Ry.

The views reproduced from photographs give an excellent idea of the amount of piping used, and Fig. 4 shows the form of subway construction used for carrying the pipes and wires underneath the tracks, so that repairs can be made without disturbing the tracks. Heavy timbers, 8 × 16 ins., and 8 to 10 ft. long, form the foundation for the subway, and upon these are laid lines of 9-in. I-beams 27½ ins. apart, the beams being spiked to the timbers. The track ties are laid upon these beams and bolted to them, and the pipes are laid in the spaces between the beams. The subway shown in Fig. 4 has 24 pipes and 10 wires.

All the signal posts are of steel, the larger ones being built up, while the smaller ones (carrying a single arm each) are of heavy pipe, like trolley poles. The large poles, shown in Fig. 5, were designed by the signal department of the railway company. The post itself is composed of four corner angle irons, connected by lacing bars, and the top carries a deep, stiff bracket frame in which are seated two or three pipe poles, on which the semaphore blades and spectacles are mounted. These posts are of very neat design, and are exceptionally stiff.

Fig. 5, which is a view looking northward, includes some interesting details. In the first place it shows the monolithic concrete abutments used by this railway in all its track elevation work, and shows also the solid floor of the plate girder bridges. Each rail is secured to an oak filler (protected by tie plates), laid in a 9-in. inverted channel by means of U-bolts, and no guard rails are used. It also shows how the pipe lines are carried across the bridges by means of cantilever floor beams riveted to the girders.

The interlocking plant was built by the Union Switch & Signal Co., of Swissvale, Pa., under the direction of Mr. W. H. Elliott, Signal Engineer, and Mr. C. O. Tilton, Assistant Signal Engineer of the Chicago, Milwaukee & St. Paul Ry. We are indebted to Mr. Elliott for the plans and photographs made use of in this article.

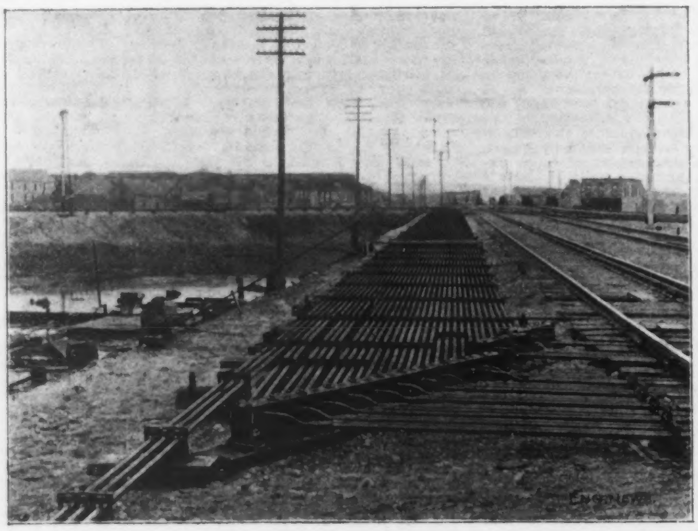

FIG. 2—BOX CRANKS FOR SWITCH AND SIGNAL RODS.

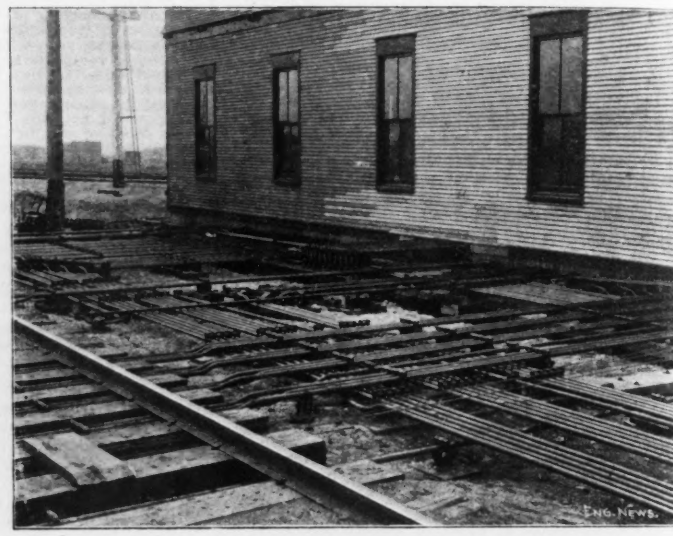

FIG. 3.—VIEW OF LEAD-OUT FROM TOWER AT PACIFIC JUNCTION.

SEWAGE ANALYSIS AND THE CHEMICAL TREATMENT OF SEWAGE.*

By Prof. Leonard P. Kinnicutt.**

Sewage has been aptly defined as the water supply of a city after it has been used, containing the refuse of man's habitations, the street-washings and the waste products of every branch of industry. In speaking of sewage it is customary to divide it into two kinds, domestic and manufacturing sewage: Domestic sewage being the sewage of a town or city where no, or very few, manufacturing processes are carried on; manufacturing sewage, the sewage of a town or city whose existence depends upon large industries. The disposal of these waste products so that they shall not become a nuisance either to the city where they are produced or to other towns or cities, is a problem which has caused more trouble to chemists and engineers than any other one question.

In a few favored localities sewage can be disposed of by carrying it into the sea, or into a large water course. This is, however, exceptional, and as a rule the sewage, to prevent its becoming a nuisance, has to be so treated that those substances which by their decomposition would produce a nuisance, are destroyed or removed. There are at present three ways by which this is attempted: Chemical Precipitation; Broad Irrigation; Intermittent Filtration.

In treating the question as to what is accomplished by each of these methods, it is necessary to have a clear idea of what sewage is. In domestic sewage we have a great variety of complex organic compounds, vegetable and animal, which by the process of putrefaction are broken up into similar substances, and which, during the process of decomposition, give off odors which are the cause of complaint. These substances may either be suspended in the sewage or in solution.

In manufacturing sewage we not only have the organic compounds that are contained in domestic sewage, but also other organic substances such as come from wool washings, tanneries, dye works, woolen and cotton mills, and other industries, also the mineral substances and free acids which are found in the largest quantities in cities engaged in any branch of the iron industry.

Besides the substances above mentioned, and which may be called dead matter, there is in all sewage living matter, the so-called micro-organisms, bacteria, moulds, or what in ordinary language are called germs. This living matter, as the name micro-organism implies, is not visible to the eye, but exists in very large quantities; or, rather, the number of micro-organisms in a given quantity of sewage is very large, one liquid ounce often containing 25,000,000. The greater number

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of these micro-organisms are not harmful to man, but in sewage there is, as a rule, and may be at any time, bacteria which, if they enter the human system, produce such diseases as dysentery, cholera, typhoid fever, and the other so-called germ diseases; and in a perfect treatment of sewage, although they are harmless, unless the sewage enters a water supply, their removal, as well as that of the decomposing organic matter, must be accomplished.

The Chemical Analysis of Sewage.

Having thus seen, in general, what sewage is, is it posible, by any method of analysis, to tell exactly what any given sewage does contain? Roughly speaking, it is possible. It can easily be determined by chemical analysis the amount, by weight, of the total organic and inorganic matter present in a given volume. Also what kind and what amount of mineral matter, including free acids, the sewage contains. Further, particular dye-stuffs can often be identified, and it can be told whether or not there is in the sewage refuse from tanneries, woolen and cotton mills, and other well-known industries.

As regards the greater part of the organic matter, it is not yet possible to say what substances are present, although it can be told whether or not the organic matter is such as will readily undergo putrefaction, and what stage such decomposition has already reached.

The chemist, in making an analysis of sewage, besides determining the total amount of solid matter and the amount of mineral matter, makes certain other determinations which are called Free ammonia; Albuminoid ammonia; Total Nitrogen; Nitrogen as nitrites; Nitrogen as nitrates; Oxygen consumed; Chlorine.

What do these terms signify, and what deductions are made from their determinations? Organic matter contains, as a rule, four elements: Carbon, Hydrogen, Oxygen, Nitrogen, united in the most varied and complex manner, most of the nitrogen existing in compounds which more or less resembles albumen, a substance familiar to us in the white of an egg.

When the sewage undergoes putrefaction these complex compounds are first broken up, simpler substances being formed, carbon dioxide and ammonia escaping. The ammonia which is thus formed remains in greater part in the solution of the sewage and the amount when determined is called the free ammonia, which shows the amount of putrefaction which has taken place.

When the first process of decomposition has taken place, and which is brought about in nature by a class of bacteria called anaerobic, living best in the absence of light and air, a second process of decomposition takes place. The simpler organic compounds formed by the first process are further broken up, this being accomplished in nature by another class of bacteria called aerobic, their life depending upon the presence of oxygen, which they obtain from the air. By this second process, called nitrification, the nitrogen of the simpler organic compounds is changed first into nitrites and then into nitrates. After this change is complete, all the organic matter in the sewage is destroyed and there is left only mineral matter, and the sewage is now no longer sewage, but a mineral water, water containing only mineral or inorganic substances.

The chemist determines the amount of nitrogen that exists in the sewage both in the form of nitrites and nitrates. If any quantity of nitrogen as nitrites is found it is a sign that the second stage of decomposition has begun, and as in this stage very little odor is given off, it is also a sign that very little trouble may be expected from the sewage by the giving off of foul gases. If much of the nitrogen exists as nitrates it shows that this second stage is well advanced, and if all of the nitrogen is found in the state of nitrates and none as nitrites, the purification is complete, all the organic matter having been changed into mineral matter.

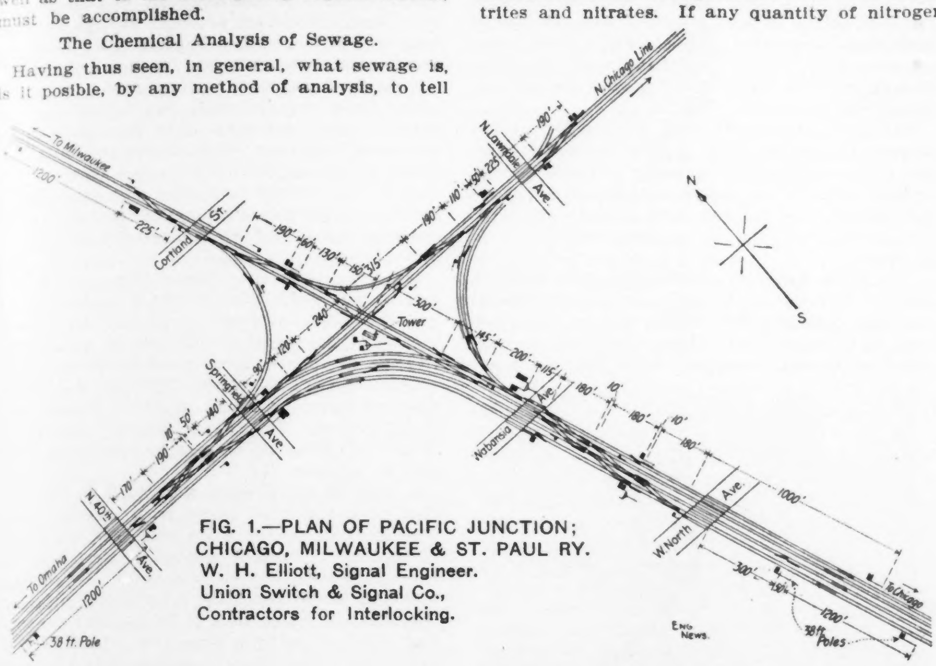


FIG. 1.—PLAN OF PACIFIC JUNCTION; CHICAGO, MILWAUKEE & ST. PAUL RY.
W. H. Elliott, Signal Engineer.
Union Switch & Signal Co., Contractors for Interlocking.

Albuminoid Ammonia.—This is the measure of the nitrogen that is united to the carbon, hydrogen, and oxygen, in compounds similar to albumen, but which, as decomposition proceeds, will be changed into ammonia, into nitrites and nitrates. It signifies the amount of organic matter that remains unchanged, but which will go through the two stages, putrefaction and nitrification. The larger the amount of the so-called albuminoid ammonia obtained by the chemist, the greater is the amount of putrescible matter.

Total Nitrogen.—This is the nitrogen contained in the albuminoid substances, in the free ammonia, in the nitrites and nitrates. If from the total amount of nitrogen, that which exists in the free ammonia, in the nitrites and nitrates be deducted, the exact amount of nitrogen existing in the albuminoid and other decomposable substances is obtained. It is a more exact measure of the decomposable organic matter than the "albuminoid ammonia." It is, however, comparatively speaking, a tedious and difficult determination, and the common measure of organic matter in sewage is still the "albuminoid ammonia."

Oxygen Consumed.—As the name implies, this denotes the amount of oxygen necessary to burn up or destroy the organic matter. Its determination is fairly simple, and in domestic sewage the results show the relative amount of organic matter. But in the manufacturing sewage the results are much less trustworthy. In testing the purity of treated sewage, the determination of the oxygen consumed is of importance and takes equal rank with the determination of albuminoid ammonia. The English test for sewage satisfactorily purified is that it does not contain more than 0.1428 parts albuminoid ammonia in 100,000 parts, and that 100,000 parts does not absorb over 1.428 parts oxygen in four hours.

Chlorine.—The chlorine in domestic sewage comes mostly from urine, and its determination serves chiefly in domestic sewage as an index to the total amount of impurity. It is not changed by any process of sewage treatment and the same amount of chlorine should be found in the treated and untreated sewage. Its determination, consequently, serves the useful purpose of showing whether the sample of treated sewage analyzed corresponds to the sample of crude sewage taken.

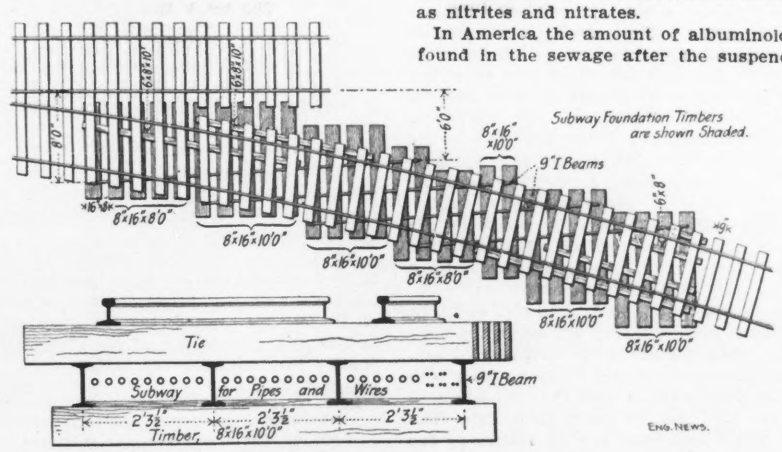
In fresh sewage, as can be seen from the above statements, albuminoid ammonia, free ammonia, chlorine, are found, but no nitrogen as nitrites or nitrates. As sewage undergoes putrefaction and nitrification, the albuminoid ammonia and free ammonia decrease; the nitrogen as nitrites and nitrates increases, and in perfectly purified sewage all the nitrogen has been changed into nitrates excepting the nitrogen of the free ammonia, which as ammonia gas has escaped into the air.

The strongest sewage is the one which contains the most albuminoid ammonia and consumes the largest amount of oxygen. The sewage which contains the greatest amount of nitrogen as nitrates and consumes the least amount of oxygen, is the one which approaches most nearly to pure water.

The amount of purification, therefore, which has been accomplished by any process of treatment, is calculated, by determining the percentage of albuminoid ammonia removed, the difference in the amount of oxygen consumed before and after treatment, and in the amount of nitrogen found as nitrites and nitrates.

In America the amount of albuminoid ammonia found in the sewage after the suspended matter has been removed by filtering the sewage through filter paper, is often determined. From the results so obtained an idea is gained of how much of the polluting substances are in suspension and how much are in solution, and this may be of decided importance.

It is now evident that from the results of the analyses of sewage of various cities conclusions regarding the comparative amount of polluting matters in each can be drawn; and from the an-



Enlarged Cross Section of Subway.

FIG. 4.—SUBWAY FOR SWITCH AND SIGNAL RODS AND WIRES.

there being a more than sufficient quantity of this salt in the sewage itself, except on holidays and Sundays, to bring about the best results. In order to supply copperas to the sewage on holidays, Sundays, and the few other occasions when there may not be enough of this compound in the sewage, a large basin is used for storing up the sewage containing copperas.

A portion of the plant was in working order in 1890, but it was not until July 15, 1893, that the entire sewage of the city was treated. Since then analyses of the sewage and effluent have been made daily. The samples for analysis are made up of 24 hourly portions, an effluent being thus obtained which corresponds very closely to the sewage. The results are tabulated, the average composition of the sewage and effluent determined for each month, and the percentage of impurity removed, calculated.

The following table, from the reports of Mr. Harrison P. Eddy, Superintendent of Sewers, gives in an abridged form the results obtained from Dec. 1, 1893, to Dec. 1, 1898:

Year ending Dec. 1,	Lbs. lime per 1,000,000 galls. of sewage treated.	Per cent. albuminoid ammonia removed. Total.	Dissolved.	Suspended.
1894	945	50.78	10.48	89.54
1895	1,030	51.63	8.43	91.11
1896	1,212	53.92	15.04	92.02
1897	1,130	53.02	10.75	93.46
1898	1,074	51.82	11.77	92.62
Avg. for 5 yrs.	1,078	52.62	11.29	91.75

The average result for the six years shows that the practical working of the lime and copperas treatment removes 52.62% of the total organic matter; 11.29% of the dissolved organic matter; and 91.75% of the suspended organic matter.

From a very intimate knowledge of the Worcester plant, together with personal observations and study on the ground of the principal plants for chemical treatment of sewage in Great Britain and Germany, I believe the above results are as good as, or better than, have been elsewhere achieved, and that though on an experimental scale, as shown by Dibden and Hazen, all of the suspended matter and 30% of the organic matter in solution may be removed, the best we can expect from a practical working of the process is the removal of not more than 95% of the suspended matter, and 15% of the soluble organic matter.

The most important question of all now awaits an answer: Can treated sewage, where practically all the suspended matter and from 10% to 15% of the soluble organic matter has been removed, be emptied into a water course? By chemical treatment no radical change has been brought about in the organic matter in the sewage; the nitrogen present is still all in the form of free ammonia, or united to the carbon, hydrogen, and oxygen, and though undoubtedly a large number of micro-organisms have been carried down by the lime, and hydrates of iron and aluminum, a sufficient number always remain, so that after a few hours the effluent will contain as many, if not more, than the original sewage.

Practically no decomposition has taken place and no nitrites or nitrates have been formed. All that has been done is to remove a certain portion of the putrescible matter; that remaining, about seven-sixteenths of the original organic matter, being all in solution. That this must also, some time or other, undergo decomposition, is self-evident, and all that has been gained by the chemical treatment is that the treated sewage can be emptied into a smaller stream than could the original sewage, both because it contains less organic matter and because it contains no floating or suspended matter. If crude sewage is emptied into a stream, the floating matters are apt to lodge along the banks, especially at bends in the stream, and if the stream is used for mill purposes the floating matter is apt to settle down to the bottom of the ponds behind the dams, forming a putrefying mass. Keeping this point in view, namely, that all the suspended matter has been removed so that no trouble will be experienced from floating decomposable substances, what proportion must the volume of the stream bear to the volume of the treated sewage? If the stream is used as a source of water supply, the safe rule is that the effluent from the chemical treatment of sewage should not be allowed to enter the stream on account of the micro-organisms the effluent contains. If the stream is only a water course, the effluent can, I believe, under certain conditions, be safely allowed to flow into the stream. What are these conditions? Possibly the best study of this subject is by Professor Adeney, of Dublin.* He has made a most careful study of the process of putrefaction and nitrification. In the process of putrefaction he shows that carbon dioxide, water and ammonia, are formed while in the second stage, nitrification, nitrates, water, and a very small amount of carbon dioxide are the chief products. He determines the purity of an effluent, therefore, by the amount of oxygen it will use up and the amount of carbon dioxide formed. If there is sufficient oxygen dissolved in the water of the stream to supply all that is required for the organic matter which remains, to undergo the first change, he shows that there is very little danger of any odor arising from the mixture of the effluent with the river water. If there is enough oxygen in the river water for the organic matter that is present to undergo both changes there is absolutely no danger. If Adeney's conclusions are correct, the required conditions can easily be determined for any given case.

Another way of determining the necessary conditions is pointed out in a paper by Mr. F. P. Stearns.**

In this paper it is shown that if the albuminoid ammonia in a stream is above 0.0278 parts in 100,000, the stream contains so much organic matter that it is offensive, and that if it contains only an amount of organic matter so that the water gives only 0.0070 parts albuminoid ammonia, it is certainly not offensive, and that between these two limits the question may be considered a debatable one. Taking these figures, and knowing the average amount of albuminoid ammonia in a sewage effluent, and knowing the average volume of that effluent and the minimum flow of the stream, whether or not the effluent can be emptied into that stream is a simple matter of calculation. If, for instance, the sewage effluent contains 0.3 parts of albuminoid ammonia, which is a general average, to reduce this to 0.0278 parts in 100,000 the dilution must be at least as 7 to 1, and to reduce the amount of albuminoid ammonia from 0.3 to 0.01 parts, which would be considered as a very safe limit, the dilution must be as 27 is to 1. Or, in other words, if the stream into which the purified sewage is to flow is a fairly quick-running stream, there would be, as a rule, very little danger of it becoming offensive if its minimum flow was 10 to 15 times greater than the effluent; and there would be no danger if the minimum flow was 27 times greater than the volume of the treated sewage. These deductions are made upon the supposition that the chemicals which remain in the effluent do not retard the decomposition of the organic matter in solution. There may be a difference of opinion on this subject, and I have made many experiments mixing treated sewage with river water, where the dilution has been much less than 10 to 1, and failed to obtain the slightest sign of decomposition, keeping the mixture, in many cases, over a week at a temperature of 80°. Yet from all the experiments and investigations I have made at various times and places, I am led to believe that if purification by chemicals is ever advisable, it is only under the conditions where the effluent from the process can at all times be diluted with at least 10 times its volume of running water.

There is one very important point in the chemical treatment of sewage that has not as yet been mentioned, and that is how the substances thrown out of the sewage by the chemicals, and known as sludge, can be handled.

The sludge is usually a thin black mud, containing not only all the organic and mineral matter removed from the sewage, but also a greater part of the chemicals that were used; it contains a very large amount of water, 95 to 98 per cent., and amounts on the average to about 40 tons per million gallons of sewage. It must be dealt with at once, for through decomposition it quickly becomes offensive, and the question of how this large mass of semi-liquid putrescible matter can be disposed of is the most difficult part of the whole problem of chemical treatment.

For cities on the sea coast, the best method is to pump it into especially constructed tank steamers, as is done in London, which carry it out to sea, and discharge it through outlet valves at the bottom of the tanks.

As to inland cities, it was thought that after allowing the sludge to become sun and air-dried, so that it could be handled with shovels, it could be sold to the farmers as a fertilizer. It has been found, however, that the farmers not only refuse to buy it, but after a short time refuse to accept it as a gift, and it is now conceded that filter presses are a necessary part of a chemical precipitation plant. By their use the amount of water that the sludge contains can be so diminished, that the forty tons of sludge as it comes from the basins will weigh about eight tons after having passed through the presses, and is formed into solid cakes that can be easily handled. The expressed liquor, however, is very foul, and ought to be treated with chemicals in a special basin; though in many works it is run into the untreated sewage. The pressed sludge has at first very little odor, and undergoes putrefaction comparatively slowly, yet its manurial value is so low, that it will only be taken away in small amounts by the farmer, and eventually must be disposed of by digging it into the ground in the neighborhood of the works, or burning it in a refuse destructor. The cost of thus disposing of the sludge must be carefully considered by the sanitary engineer when dealing with the question.

In the above pages I have tried to give a careful summary of what I consider to be the best information we possess regarding the chemical treatment of sewage, and to state it in such a manner that an engineer can form an opinion whether or not the process is an advisable one, when taken in connection with the local conditions that exist at the place where its adoption is contemplated.

*Transactions Royal Dublin Society, v. 5, pp. 539-620; v. 6, pp. 260-281.

**"The Pollution and Self-Purification of Streams," published in the report of the Massachusetts State Board of Health Report, Examination of Water Supplies, 1890, pp. 785-802.

A LARGE ARTESIAN WELL PLANT AT CAMDEN, N. J.

One of the largest artesian well plants in the country was put in operation at Camden, N. J., a few months ago. The contract capacity of the plant was 20,000,000 gallons.

The contract for the wells, connections, a pumping station of 20,000,000 gallons capacity, a 36-in. cast-iron force main 19,280 ft. long, a 30-in. branch 12,780 ft. long, a 20-in. branch 12,780 ft. long, and also a 30 x 110-ft. steel stand-pipe, was let to Mr. Geo. Pfeiffer, Jr., of Camden, for $525,000, to which was added, before construction was begun, $36,500, for changing the 20-in. branch to 30-in., making a total of $561,500. The contract was dated June 24, 1896, and the city took possession of the plant a few months ago.

The exact sources of the artesian waters of the Delaware valley at and near Camden and Philadelphia have not been fully settled. It is well known that in the portion of New Jersey south and east of a line drawn from Trenton to Jersey City many successful artesian wells have been sunk to various levels. Much detailed information regarding these wells is given in the reports of the Geological Survey of the State of New Jersey.

For some years prior to 1894 it was felt that the water supply of Camden taken from the Delaware River, near the city, was polluted by the sewage of Camden and Philadelphia, besides which it carried an objectionable amount of suspended matters. In that year Mr. J. T. Fanning, M. Am. Soc. C. E., of Minneapolis, was engaged to report on a new supply for Camden. After considering various sources, including artesian wells, he recommended a new intake further up the river, an 80,000,000-gallon settling basin, a new 20,000,000-gallon pumping station, a standpipe and a 36-in. force main, all at an estimated cost of $645,260. But the advocates of artesian wells carried the day, arguing from the success of isolated examples in Camden and Philaalyses of the sewage after treatment the percentage of polluting matters which have been removed can be calculated.

It is well to state at this point that a single analysis of sewage is absolutely of no value, for the sewage varies greatly from hour to hour and results so obtained may lead to very inaccurate, not to say absolutely false, conclusions. To obtain results that are of any value, samples of the sewage before and after treatment must be taken half-hourly, or at least hourly, for a period of about 72 hours. Attention is called to this point because it is often thought that from a single analysis an idea of the character of the sewage can be obtained, and because in very many published papers on the treatment of sewage, analyses are given which are absolutely of no value, owing to the fact that they have been made on a single sample, or from samples collected in such a way as not at all to represent the character of the crude or treated sewage.

Having seen what sewage is, and how an idea as to its character and strength can be obtained, and how the amount of purification accomplished by any method of treatment can be calculated, we can deal more intelligently with the three methods of treatment.

The Chemical Treatment of Sewage.

This method consists in the adding of certain chemicals to the crude sewage, allowing the sewage to run into large open or closed tanks, through which it flows with such slow velocity that the substances which have been thrown down by the chemicals, subside, leaving the supernatant liquid as it runs from the last tank free from any suspended matter.

Innumerable chemicals have from time to time been tried, but the aim in all cases has been the same, to make the sewage alkaline, to form a heavy, insoluble substance in the sewage which as it falls through the sewage will carry down with it the suspended polluting matters; and to remove a part of the soluble matter by forming with it substances insoluble in water. As the chemicals must be used on a large scale their cost must be taken into account, and from numerous experiments it has been generally agreed that lime with sulphate of iron or sulphate of aluminum best answers the requirements. Other chemicals can be used, and if the question of cost did not enter into the problem there are some, as, for instance, ferric sulphate, that might be substituted with advantage for the ordinary sulphate of iron or for the aluminum sulphate. In all large cities, however, the three chemicals which are first named are the ones which are in use.

What takes place when these chemicals are added to the sewage? First of all, the lime unites with the carbonic acid, forming carbonate of lime, or chalk, and with any other free acid that may be present, such as sulphuric acid, forming sulphate of lime or gypsum, and the sewage is rendered slightly alkaline. Chalk and gypsum are both insoluble in water, and in settling to the bottom of the tanks carry down part of the insoluble matter in the sewage. Iron sulphate, or aluminum sulphate, which are usually added to the sewage after it has been rendered alkaline by the lime, form a large, bulky precipitate of hydrate of iron or hydrate of aluminum, which act in the same way as the chalk and gypsum, carrying down the remaining suspended matter in the sewage, leaving, when the process is well carried out, a clear, bright-looking liquid to flow from the tanks. It is often claimed that the iron sulphate or aluminum sulphate do more than this, that they unite with part of the soluble matter of the sewage, in the same way that they unite to certain soluble dyes, and thus remove not only the insoluble polluting substances, but also a part of the soluble polluting matters. What are the facts in the case?

The question can best be answered by examining the work that has been done on the subject. The best experimental work on a small scale is that done by W. J. Dibden in England and by Allen Hazen in America. Dibden's experiments are reported in his book on "Purification of Sewage and Water," London, 1898. The table given on page 35 of this book shows the results of the examination of 23 series, each consisting of 25 effluents obtained by the addition of various chemicals in varying amounts to a given sample of London sewage. The best results were obtained with lime and copperas, 10 grains of each to an English gallon, 30% of the soluble organic matter being removed. The best results with lime alone, using 15 grains to the gallon, was the removal of 25% soluble organic matter; lime and alum, 5 grains of each to the gallon, removed 18%; 10 grains of lime, 2 grains of iron sulphate and 10 grains aluminum sulphate removed 24%, while lime, copperas and aluminum sulphate in the very large amounts of 700, 100 and 500 grains, respectively, to the gallon, removed 52%.

The few experiments with sewage from other sources showed that with certain kinds of sewage, the character of which he omits to state, a much greater removal of soluble organic matter could be accomplished; in one case, using 5 grains of lime and 10 grains of copperas, 69% were removed.

Mr. Allen Hazen's experiments were made in 1889, he at that time being Chemist to the Massachusetts State Board of Health. The sewage taken was that of Lawrence, Mass., which can be classified as domestic sewage, containing on the av-

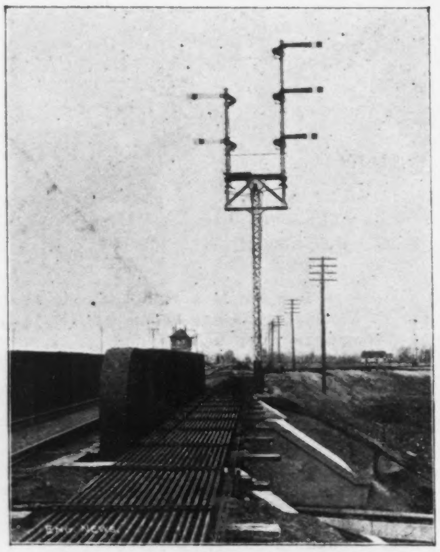


Fig. 5.—Steel Signal Post; C. M. & St. P. Ry. W. H. Elliott, Designer.

erage 0.66 parts of albuminoid ammonia in 100-000 parts of sewage. A full report of his work is given in the Massachusetts State Board of Health Report, "Purification of Sewage and Water," 1890, pages 737 to 791. In this report it is shown that a definite amount of lime gives a result as good as, or better than, either more or less lime; which Dibden's experiments, quoted above, confirm. That the more copperas, ferric-sulphate or alum used, the better the result, and that no lime is necessary with alum or ferric-sulphate if the sewage is alkaline.

All of these chemicals remove all of the suspended organic matter, and, judging from the albuminoid ammonia determinations, a small portion of the soluble organic matter, varying with the nature and the amount of the chemicals used, as is shown by the following table:

Chemicals used per 1,000,000 gallons of sewage.	Soluble organic matter removed.
1,800 lbs. lime	22%
700 " lime, 1,000 " copperas	29%
270 " ferric-sulphate	32%
650 " aluminum sulphate	20%
360 " ferric-sulphate	41%
870 " aluminum sulphate	29%

Mr. Dibden and Mr. Hazen thus seem to have proved that a certain amount of the soluble organic matter in sewage does unite with lime and copperas, forming an insoluble compound, and they both agree that when lime and copperas are used 30% of the soluble organic matter can be thus removed. Allowing this to be a fact, is this amount of soluble organic matter removed when sewage is treated with chemicals on a large and practical scale?

The first plants for the treatment of sewage by chemicals were constructed in England, and this method has been tried by all the large inland cities, London, Manchester, Birmingham, Leeds, Sheffield, Bradford, Salford, etc., and it would be thought that a careful examination of the work that had been done in these cities would give a direct and conclusive answer to the question. Such, however, is not the case. All these works have been constructed as practical working plants and very little attention has been paid to the scientific side of the question. Analyses of the sewage and effluent in all these places have been made from time to time, but not in any systematic way, and very little exact information can be derived from the published results. A close study of a great many reports and analyses leads only to the general conclusion that about 50% of the total organic matter, most of which is in suspension, is removed by English chemical precipitation plants.

Experiments on the effect of chemicals on London sewage were made by W. J. Dibden in 1883, and the results obtained by him are given in the Report of the Royal Commission on Metropolitan Sewage Discharge, Minutes of Evidence, Vol. 2, pp. 201-206. This report, however, only shows that by using lime and copperas a removal of about 50% of the organic matter could be obtained, but gives no data as to how much of this was in solution.

In 1889-90, experiments were made at Salford to determine which of many rival methods would give the best results when used with the sewage of that city. Various companies were asked by the city authorities to construct experimental plants at Mode Wheel, the main sewer outfall, the operations of which were to be carefully examined and reported on by a committee of sanitary experts. The report of these experiments, which was published in 1891, is most disappointing, for what should have been a most valuable contribution to sewage literature has very little real scientific value. A careful study of the report shows some astounding results, in some cases the treated sewage appearing to contain more organic matter than the crude sewage, showing plainly that the samples of raw sewage taken for analysis did not represent that which was treated, and there is no proof that this was not usually the case. The only conclusions to be derived from the report are that lime and copperas were as effective as any other chemicals, and that a purification of about 50% was obtained.

If we look to Germany, the country where it might be expected the most careful work would be done, for an answer to the question, we are again disappointed. Very little attention, on the whole, has been paid to sewage purification, and there are only nine large cities that attempt to treat the sewage. Frankfort, Halle, and Essen are the only large cities using chemicals, and of these the Frankfort plant is by far the largest. The sewage of this city is between 15,000,000 and 16,000,000 gallons per day, and to purify it about 1,300 lbs. of aluminum sulphate and 300 lbs. of lime are used per 1,000,000 gallons. An examination of the sewage and effluent was made in 1889 by Lepsius.* The samples of sewage and effluent were taken at the same moment, consequently the sample of effluent came from a sewage of unknown impurity, and the results are almost worthless as data.

Turning to America, we find the largest chemical precipitation plant at Worcester, Mass., and from the reports of the work done there, valuable data and information can be obtained, and it is the only case where investigations as to what can be accomplished on a large scale by chemical treatment have been carried on systematically.

Worcester is a manufacturing city of 100,000 inhabitants, with a dry weather flow of sewage of about 16,000,000 gallons, the sewage containing a large amount of free acid and iron salts, and, as regards organic matter, might be considered as rather dilute, the albuminoid ammonia averaging 0.5 parts in 100,000.

The treatment consists of simply adding milk of lime, 1,100 lbs. of lime per 1,000,000 gallons of sewage. The addition of copperas is unnecessary,

*Zeitschrift angewante chemie, 1889, p. 152.

facture, and the development of the commercial testing laboratory from its first small beginning to a business and engineering position of recognized standing and merit. The recognition of the value of the deceased man's professional work by the various scientific and engineering societies was prompt and generous. He was a member of the American Society of Civil Engineers, of the American Institute of Mining Engineers, the American Society for the Advancement of Science, American Society of Mechanical Engineers, the American Chemical Society, the Institution of Civil Engineers of London, and the Iron and Steel Institute of Great Britain. He contributed largely to technical literature, and was awarded the Norman gold medal by the American Society of Civil Engineers for a paper written for the International Engineering Congress, held in Chicago in 1893.

Capt. Hunt gained his military title from the fact that for over twelve years he was the commander of Battery B of the National Guard of Pennsylvania; and when the late Spanish-American war broke out he went to the front with this battery, leaving Pittsburg on April 27, 1898. He went to Porto Rico with his battery, and it was in this service that he contracted the disease which eventually caused his death. Capt. Hunt was married in 1878 to Miss Maria T. McQueston, of Nashua, N. H., who, with one son, 17 years of age, survives his death.

CHINESE RAILWAYS are discussed in a publication of the U. S. Bureau of Statistics, entitled "Commercial China in 1899." There are now open to trade in China 6,000 miles of waterway navigable by steam vessels, 3,000 miles of telegraph, about 350 miles of railways in operation and over 3,000 miles projected. The first Chinese railway was opened in 1876, between Shanghai and Wusung, 14 miles apart; but native prejudice and superstition caused it to be torn up soon after. About 1881, Mr. Claude W. Kinder, M. Am. Soc. C. E., and now Chief Engineer of the Imperial Railways of China, was then in charge of a Chinese coal mine near Tientsin. He improvised a locomotive and fought native opposition until he gradually developed the little coal line into one of general traffic, and extended it to Tientsin and the treaty port of Shan-hai-Kwan; it was later extended to near Pekin and Paoting, and is now being extended to the iron and coal regions. This system of about 350 miles is the first and only one in actual operation. The projected railways include the Russian Manchuria system, terminating at Port Arthur, on the Gulf of Pichili, and ultimately connecting with the Pekin system. Between Pekin and Tientsin and the Yangtze valley in Central China, several lines are laid down. One would extend from Tientsin to Shanghai, 700 miles long and running from 100 to 350 miles from the coast, following the general line of the Grand Canal. This line passes through territory claimed by England and Germany as "spheres of influence," and British and German capital will probably combine for its development. The Pekin-Hankow line lies west of these spheres and is about 650 miles long; it is in the hands of a Belgian syndicate, and work has been commenced. Still west of this are several other projected lines leading to the iron and coal districts of Northwestern China. South of Shanghai is a British line proposing to connect Wenchow, Ningpo and Hangchow, all treaty ports, with Shanghai. This line may be finally extended to Hong Kong, though an English syndicate is now building a 200-mile line from Hong Kong to Canton. A short line is also located, connecting Shanghai with Soochow and Nankin. The Canton-Hankow line is the only American concession. This line is about 600 miles long and it has been surveyed by Mr. W. B. Parsons, M. Am. Soc. C. E. In the extreme south of China, French interests are proposing railways to connect Tonkin with important Chinese cities on the navigable streams, or the treaty ports of Woochow, Pokhoi, etc. West of the American concession several hundred miles is a British line to connect the Province of Szechnan with Canton and Hong Kong; and England is also planning to connect China with the railway system of British India, by extending the existing Mandalay line, in Burmah, to the Chinese border at Kunlong, and finally to the city of Yunnan, to Chunking and to the head of navigation of the Yangtze River.

THE READING RAILWAY SUBWAY in Philadelphia is nine-tenths completed, and by Aug. 1 next two tracks will be in operation. It was commenced in September, 1894, and since then the sewerage system has been rebuilt; about 1,000,000 cu. yds. of material have been excavated; 175,000 cu. yds. of masonry laid; 4,000 tons of steel have been erected in 13 bridges; and ten miles of temporary and five miles of permanent track put down. The total cost will be about $6,000,000 and 50 contracts were let.

THE ORDINANCE AUTHORIZING THE EMPLOYment of three experts to investigate the Philadelphia water supply, and appropriating $25,000 for the purpose, has been passed by the city councils and approved by the mayor. The mayor has appointed the following experts: Rudolph Hering, of New York; Joseph M. Wilson, of Philadelphia, and Samuel M. Gray, of Providence, R. I. The investigation will be carried on jointly by these men and the Director of the Department of Public Works and the Chiefs of the Bureaus of Water and Surveys.

THE LOWEST BIDDER FOR THE NEW SETTLING reservoirs at Cincinnati, prices for which were given in our Construction News columns for May 4, have withdrawn their bid. Folz, Willard & Co., the lowest bidders, offered to do the work for $1,039,232, which was about $130,000 below the next highest bidder and some $200,000 below the engineer's estimate. Folz, Willard & Co. have written a long letter to the trustees of the new works stating that on request of the engineers the company conferred with the latter and found that the engineers intended to insist on a more rigid interpretation of the specifications than the company had figured on. It is stated that the contract will probably be awarded to the next highest bidder, A. J. Henkel, for $1,171,744.

AN ELECTROLYTIC PROCESS OF PRESERVING wood is described by United States Consul E. T. Liefeld, at Freiburg, Germany. In this process the positive pole of a dynamo is connected with a lead grating, upon which the wood to be treated is placed. A solution, which is kept at the uniform temperature of 100° F. by means of a steam pipe underneath the grating, is poured into the vat so as almost to cover the log of wood treated. At a public demonstration, the solution used contained 10% of borax, 5% of resin, and 0.75% of carbonate of soda, the borax being used on account of its antiseptic properties and the carbonate of soda to help dissolve the resin. A porous tray, the bottom of which consists of two sheets of canvas with a sheet of felt between, is placed over the log, and a sheet of lead connected with the negative pole of the dynamo is placed above this. When the current is turned on, the solution is drawn from the bottom and the sap is driven out, and its place taken by the borax and resin. The time required to impregnate a 10-in. log is about 7 or 8 hours, and then the wood is slowly dried, which takes in the open air in summer several weeks or even months. It was stated that a unit of electrical energy was required for every 6 cu. ft. of timber treated. This is said to be the first industrial application of the principle of electric osmose, viz., if the electrodes in an electrolytic solution are separated by a porous partition and a current passes, the volume of the liquid in contact with the positive pole diminishes, while that in contact with the negative pole increases.

FLOODING A BURNING MINE-SHAFT by a new method has been employed with success by the Pennsylvania Coal Co., says "Mines and Minerals." On Dec. 13, 1898, fire was discovered in the timbering on an inside slope in the 14-ft. vein, near Shaft No. 6. After an ineffectual effort to put out the fire by hose, it was at first proposed to flood the entire mine, with 200 acres or more of workings. On further consultation it was suggested that large tanks be erected near the head of the slope and the water from them discharged on the fire through troughs or sluices. But it was quite as difficult for the workmen properly to place these sluices as it was to handle the hose. A dam in the slope, just above the fire, was finally built, and in this dam was a door which was closed by long ropes extending up the slope. The dam was located 250 ft. down the slope; the door opening was 4 x 5 ft., and this was closed by heavy folding doors 7 ins. thick and overlapping in the center by mitered joints faced with sheet-rubber. To these two doors were attached eight 1¼-in. wire ropes taken up the slope and secured with the doors shut. In 12 to 15 hours 150,000 to 200,000 gallons of water accumulated behind this dam; the doors were then opened by letting go on the wire ropes and the water was discharged down the slope. This was repeated until the workmen fighting the fire backward on the gangway had reached the foot of the slope. The last fire was seen on Jan. 27, 1899, just east of the foot of the slope, and the men removed the heated and burned coal and rock until they had surrounded it and could attack the fire with three hose streams. The fire was completely extinguished by Feb. 18.

THE NEW CARNEGIE STEEL CO., which was incorporated at Trenton on May 4, with a nominal capital of $2,000, is understood to be the first step in the much-talked-of consolidation of all the big iron and steel combinations in the East. The Carnegie plant is said to be already purchased at a price estimated above $100,000,000; and the final total capitalization of the new company may reach $550,000,000. While the deal is still in progress and no details are made public, the combination is supposed to include the Carnegie interests, the National Steel Co., American Tin Plate Co., and National Stamping & Enamel Ware Co. The position of the Federal Steel Co. and the American Steel & Wire Co. is as yet unknown. Mr. H. C. Frick, John D. Rockefeller and H. H. Rogers are the leading spirits in the new movement.

THE SPANISH-AMERICAN WAR, according to the last report of the U. S. Treasury, cost about $266,000,000, including the $20,000,000 paid to Spain and the $3,000,000 to Cuban soldiers. This includes the expenditures for 14 months, and is in excess of normal expenditures for the army and navy. From March, 1898, to April, 1899, inclusive, the total expenditure on the army was $258,944,569, and on the navy, $92,020,798. For the same period in 1897-1898, the corresponding expenses were $65,502,964 and $39,434,518, respectively.

THE LEAD PRODUCTION FOR 1898, says a preliminary statement of the U. S. Geological Survey, was 310,606 net tons, as compared with 289,598 tons in 1897, and 264,994 tons in 1896. This includes hard and soft lead and the product from smelting foreign base bullion and ores in bond.

THE ELECTROLYTIC MARINE SALTS CO., which was organized to operate the Rev. P. F. Jernegan's "process" of extracting gold from seawater has received a report from Prof. Henry Carmichael, the expert appointed by the liquidation committee to make an investigation after Mr. Jernegan's abrupt departure. Prof. Carmichael reports that the process was fraudulent. The directors are said to have recovered a considerable sum from Jernegan, which, together with the sale of machinery, etc., has realized enough to pay a 20% dividend to the stockholders.

THE CONSUMPTION OF COPPER IN 1898, says U. S. Consul Stern, of Bamberg, amounted to over 400,000 tons; the United States, England and Germany using 115,935, 106,000 and 101,518 tons, respectively, chiefly in connection with electric installations. The world's production of copper in 1898 is estimated at 420,000 tons, of which 234,272 tons came from the United States. The "Revue de la Semaine" for March 22, 1899, gives the statistics for copper production for the years 1895-98, inclusive. This table shows an increase in total productions from 334,562 tons in 1895 to 424,126 tons in 1898, and a steady increase in price per ton, on quotations for Jan. 1 of each year, from $208.40 to $250.08, for 1895 and 1898, respectively. The supply of copper comes from 21 different countries; but the following lead in 1898, with the amounts given: United States, 234,261 tons; Spain and Portugal, 53,225 tons; Japan, 25,175 tons; Chile, 24,850 tons; Germany, 20,085 tons; Australia, 18,000 tons; Mexico, 10,435 tons; Canada, 8,040 tons; Russia, 6,000 tons. All other countries are far below these figures, Algeria being set down for only 50 tons.

THE U. S. CIVIL SERVICE COMMISSION, in its fifteenth annual report, says that it has examined 45,712 persons in the last year, and passed 30,600 of these. In the departmental branch of the service, 2,100 were appointed through educational examination, and 2,336 through non-educational, or registration examination; in the custom service 202 persons were appointed; 2,758 in the post-offices; 229 in internal revenue; 225 in the government printing office.

THE ANNUAL REPORT OF THE GENERAL ELECTric Co., for the year ending Jan. 31, 1899, gives the total income of the company from sales, royalties and sundry profits as $16,472,022, and the total expenses, including only cost of goods sold, general expenses, taxes, sundry losses, as $13,094,534. The total income from all sources, including dividends on stocks owned, etc., amounted to $17,260,859. Patents and patent expenses cost $269,440. Accumulated dividends were paid to the amount of $1,609,552, covering the period from July 1, 1893, to Jan. 31, 1899. The surplus for the year, after deducting all expenses, was $156,571. The various factories of the company cover about 160 acres of ground, and contain approximately 1,800,000 sq. ft. of floor space all free from mortgage or other lien. The total valuation of the land, buildings, and machinery contained is estimated the same as last year, at $3,400,002, notwithstanding the fact that $897,740 were expended during the year in additions and improvements. At the time the books were closed there were 315 uncompleted installations of finished apparatus in progress at various places, valued at $774,966, which were not included in the report. The report shows the company to be in excellent condition.

THE OSTEND, BELGIUM, TRAMWAY, operated on the accumulator system, is 2½ miles long, says "The Engineer." In 1898, 17,000 car-miles were traveled and the expenditures per car-mile are given as follows, in English pence: Inspectors, 0.360; man at charging board, 0.142; engineer and fireman, at station, 0.114; maintenance of motors, 0.047; maintenance and repair of batteries, 0.171; drivers on cars, 0.408; switchmen and track-cleaners, 0.190; fuel, 0.346; oil, 0.066; waste, 0.015; total, 1.859d., or 3.718 cts. per car-mile. As no renewals of battery plates have been required, this does not figure in the total.

delphia, and the feeling that the Delaware River water would have to be filtered sooner or later.

The location of wells was fixed, after examining records of old wells and putting down test wells, on meadow land about six miles northeast of the city, at the junction of Delaware River and Pensauken Creek. The surface of the meadow being at about mean tide, dikes were built to prevent overflow at high tides.

The wells are in four groups, and are 6, 8 and 10 ins. in diameter, but mostly 8-in. The strainers average 24 ft. in length. Eleven of the wells terminate in water-bearing strata 50 to 70 ft. deep and 92 in strata 90 to 125 ft. deep.

Twelve wells, 6 ins. in diameter, were sunk by Kisner & Bennett, of Belmar, N. J. The strainers for these wells are of galvanized iron pipe, with ⅜-in. holes covered by brass cloth, soldered on. They were sunk by hydraulic jets. The lower end of the strainers were plugged, while the upper ends carried lead washers which were expanded against the inner side of the casing proper.

The remaining wells, 91 in number, were sunk by the Cook Well Co., of St. Louis. They are provided with the usual Cook strainers, formed by circumferential or longitudinal slots in the pipe, larger on the inner than the outer side. They were sunk by driving and the use of sand buckets.

Each well casing is stopped at its upper end by a removable air tight cover, which is fitted on the upper end of a T, leaded onto the casing below, and connecting at the side with the branch of the collecting main, these branches being at angles of 45° with the mains. There are two mains, increasing in size as wells are added until a diameter of 30 ins. is reached. The mains have a rising grade to the receiving well, where they bend downwards, forming siphons. The summit of each main is provided with an air chamber, connected to an independent air pump in the pumping station. The mains may thus be used as siphons, or through the agency of by-passes, as suction mains, or both methods may be employed.

Ten wells, 8 and 10 ins. in diameter, are provided with air lifts. The air pipes are 1½ ins. in diameter and have about 60 per cent. submergence, the air escaping through holes drilled in the pipe. Air is furnished by an Ingersoll-Sergeant air compressor, working under an average pressure of 47 lbs. The steam cylinders are 18 × 22 ins. and the air cylinders 22 × 22 ins. in diameter. The air receiver is 4⅜ × 10½ ft., and a 7¼-in. air pipe leads from it to the wells. The wells are connected to a 20-in. main 4,596 ft. long, which delivers water by gravity to the receiving well. This main does not run full. It is provided with a 10-in. Y bend and stand-pipe at its upper end. In the bottom of the connecting well are two 10-in. flowing wells.

The water in the various wells stood at about mean tide level, before being pumped, but a few wells with casings terminating near the ground level were overflowing. The fluctuation of the tide level averages 5.8 ft. and the water in the wells rises and falls 15 to 20 ins., with the rise and fall of the tide. The outcrop, or gathering ground, is believed to be across the Delaware River in Pennsylvania, from a limited area located along the river; it is also believed that there is some infiltration from the river and from Pensauken Creek, while possibly some water comes from fissures in the underlying crystalline bed rock. The general character of the strata pierced by these wells is as follows: Meadow alluvium, 5 to 20 ft.; sand, 5 to 6 ft.; clay, 1 to 2 ft.; yellow or white sand, 5 to 8 ft.; clay, 2 to 5 ft.; water-bearing gravel with little sand, about 20 ft.; clay, 5 to 20 ft.; white sand, 5 to 15 ft.; yellow gravel 5 to 20 ft.; clay, 0 to 1 ft.; water-bearing gravel and sand, 25 to 60 ft.. Below the latter is about 40 ft. of clay and decomposed rock, on crystalline schist or bed rock, dipping from N. W. to S. E.

There has been a controversy between the city and contractor over the yield of the wells. The pumping records show that 72 of the siphon wells yielded an average of 6,860,000 gallons a day during a period of 80 days, and that the full number of siphon wells, 93, yielded 10,500,000 gallons a day during 150 days. These figures are based on plunger displacement, with no allowance for slip. A later test, for 17 days, 15 hours, gave an average result of 18,203,000 gallons a day, with a 2% deduction. The deduction was based on measurements over a 10 ft. weir during two runs of 41 and 22 hours, respectively. After the latter test the city put the plant in regular service. With a 26-ft. lift the amount of water pumped was between 15,000,000 and 16,000,000 gallons. About this time the demands for water became very great, owing to a severe cold weather spell, and the old pumping plant was started up again. This being followed by numerous cases of typhoid fever, stringent measures to reduce waste were taken, which, with the return of mild weather, made it possible to shut down the old pumps.

The first step towards the reduction of waste was the appointment of four inspectors. These men have found hundreds of defective house services, which have been or are being repaired. The use of hose has been restricted to the hours of 5 to 8 a. m., and 6 to 9 p. m. The average pumpage is now (May 4) about 12,000,000 gallons a day, which the new plant yields. A contract for meters has been let which, it is expected, will still further reduce the waste. The need of reform of some sort is shown by the fact that the average daily water consumption was previously about 250 gallons per capita.

Pending final settlement with the contractor of all matters pertaining to the alleged failure to fill the contract requirement of 20,000,000 gallons a day, the city has retained 20% of the contract price. The contractor has presented a large claim for extras.

The receiving well is 30 × 35 ft., brick lined, with a concrete bottom. The lining wall was sunk on an iron cutting shoe.

The pumping plant includes two 10,000,000-gallon Holly-Gaskill high duty, horizontal compound pumping engines and six National water tube boilers with an aggregate capacity of 750 HP.

The general scheme of the works described above was laid down by the city, Mr. L. E. Farnham being city engineer. The detailed engineering work was done by Mr. Wm. H. Boardman, Engineer for the contractor, and Mr. Cook, of the Cook Well Co. We are indebted to Mr. Farnham for assistance in the preparation of this article.

ALFRED EPHRAIM HUNT.

Capt. Alfred E. Hunt, M. Am. Soc. C. E., one of the most prominent metallurgical engineers of this country, and the leading personality in the development of the aluminum industry to its present position, died at Philadelphia, Pa., on April 26, 1899. The immediate cause of Capt. Hunt's death was a hemorrhage of the bowels, complicated with weakness of the heart, but these were only indirect causes which were themselves the result of a fever contracted while he was in command of Battery B, of Pittsburg, Pa., at Chickamauga Park, and later in the Porto Rico campaign of the Spanish-American war. The deceased man, accompanied by his wife and mother, was on his way to Atlantic City, N. J., in search of improved health, when he was taken sick on the journey and compelled to stop off at Philadelphia, where he died. To all but his relatives and a few personal friends the fact that Capt. Hunt was seriously ill was unknown, and the news of his sudden death came as a shock to the greater number of his many business and professional friends and acquaintances.

Alfred E. Hunt was born at East Douglass, Mass., on March 31, 1855, and was a descendant of William Hunt, who came from England to Concord, Mass., in 1635. His father, Leander B. Hunt, was the owner of the long-established Hunt Axe Works, at East Douglass. Capt. Hunt was educated at the Roxbury High School and the Massachusetts Institute of Technology, graduating from the latter institution in metallurgy and mining engineering in 1876. For some time after graduation he was in the West with the U. S. Geological Survey; and he later became connected with the Bay State Iron Works, in South Boston, where the second open-hearth furnace in America was set up under his direction. For this company he also went to Michigan to explore for iron ore, and upon the samples brought back by him the first report was made on the Michigamme mines, the first of the famed ore discoveries in Northern Michigan. From 1877 to 1879 he was manager and chemist of the open-hearth steel works at Nashua, N. H. Capt. Hunt then came to Pittsburg as superintendent and chemist with Park Bros. & Co.; but in 1882 he resigned, and with George H. Clapp, of Park Bros., he formed the firm of Hunt & Clapp, and established a chemical laboratory, and did the chemical work of the Pittsburg Testing Laboratory for the physical and chemical testing of materials and the inspection of iron and steel structures, which had been established in the same year by Wm. Kent and Wm. F. Zimmermann. Two years later Messrs. Hunt & Clapp bought out the original owners of the laboratory. The business so prospered that in 1892 it was incorporated, under the above name, with $75,000 capital, by buying out Hunt & Clapp.

It was while in active management of the Pittsburg Testing Laboratory that Capt. Hunt became interested in Charles M. Hall's process for the reduction of aluminum, which he, in company with the inventor, finally developed into the important works of the Pittsburg Reduction Co. Mr. Hall had invented his process over two years before, and a year previous had been associated with the Cowles Co., of Lockport, N. Y. This company experimented with the process under an option from the inventor, but abandoned it, not thinking it of value as compared with their own process. Mr. Hall shortly afterward made the acquaintance of Mr. Hunt, and naturally brought the process in whose success he was so much interested to the attention of the latter. Mr. Hunt's education and intimate knowledge of chemistry made him at once recognize the merit of the scientific principles involved in the process, and as soon as he had familiarized himself with its details, he set about organizing the Pittsburg Reduction Co., raising the capital among his personal friends in Pittsburg. The further development of the manufacture of aluminum by this company is familiar knowledge to engineers, and need not be mentioned here, but the lesson of liberal-minded enterprise, based upon sound technical knowledge, which this little scrap of early history teaches may well be taken to heart by young engineers. At the time that Mr. Hunt and his associates began the manufacture of aluminum by the Hall process, that metal was selling at $15 per pound. It now sells at from 30 to 40 cts. per pound.

The manufacture of aluminum, however, may be considered as only one of the important enterprises of Capt. Hunt's work as an engineer. The others were the opening of the Michigan iron mines, the adoption of the open-hearth process in steel manu-

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

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

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - VICE-PRESIDENT.
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ALFRED E. KORNFELD, New York, F. A. PECKHAM, Chicago, S. B. READ, Boston, C. F. WALKER, Cleveland, } ADVERTISING REPRESENTATIVES.

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

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

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The excellent quality of material and workmanship specified for the steel work of the Boston Elevated Railway, which we describe elsewhere in this issue, will make that road perhaps the best built structure of its kind in the country. For all metal work, except rivets and adjustable members, open hearth medium steel, sub-punched and reamed, is demanded. Considering the general favor in which soft steel is held nowadays for nearly all kinds of structural work, this is, perhaps, the most striking requirement of the specification. The choice of the harder metal was based upon the well-known opinion of the consulting engineer, Mr. J. A. L. Waddell, M. Am. Soc. C. E., that it is just as cheap to employ a reamed medium steel at a high intensity of working strain, as it is to employ unreamed soft steel at a lower intensity, when the saving in weight because of the higher working strength of the former is considered, and that the better quality of the sub-punched and reamed work is thus clear gain. To state the argument more particularly, a medium steel can be strained legitimately some 10 per cent. higher than soft steel, which allows a saving of about 7 per cent. in weight for designs in the former metal. The cost per pound of the two metals at the rolling mills is practically the same, as is the cost of erection, also. This leaves the saving in weight to counterbalance the extra cost of reaming, which it will a little more than do in the average run of work. As far as the total cost is concerned, therefore, it is immaterial whether unreamed soft steel or reamed medium steel is adopted, but there is an important advantage in the superior quality of the work obtained by using the reamed material.

The requirement that all reaming shall be done with rigid cylindrical reamers or drills, is also an old contention of Mr. Waddell. In a paper read before the American Society of Civil Engineers in February, 1897, he made the assertion that in his opinion the use of flexibly-connected, tapered reamers is nothing more than a means of making it practicable to get rivets through badly-punched holes that assemble irregularly, and is not true reaming at all. Whatever the general opinion of engineers may be regarding the justice of this assertion, there is no reasonable question about the excellence of the workmanship, which requires all rivet holes to be sub-punched ⅛-in. smaller and then reamed, with the members assembled, and using rigid, cylindrical reamers, to 1-16-in. larger than the rivets. Except solid drilling, no other method probably would secure so good work, and solid drilling is as yet out of the question in the great majority of structural and bridge work, because of its high cost. The remaining requirements of the specifications for material and workmanship do not call for particular mention, except to note that the same high standards have been maintained throughout every detail. Another feature of the specifications which may also be mentioned in closing is the section governing the methods of erection in streets having overhead trolley electric lines occupying the space below. So far as we recall, no similar specification has heretofore been published.

The great importance to the engineer who aims to keep abreast of progress in his profession, of keeping in close touch with the work of the leading engineering societies, has made the task of reporting the proceedings of these societies one of the principal duties of an engineering journal. For some years Engineering News has been gradually enlarging and perfecting this branch of its work, and it may not be out of place at this time, when the paper is starting on the second quarter century of its life, to point out briefly the large amount of space and editorial attention which "society proceedings" receives in its columns. Taking the 52 numbers of the calendar year of 1898 as the basis, an examination shows that announcements and reports of the proceedings of 200 different technical societies were regularly presented in our columns. As most of our readers have probably observed, the system which we have adopted for handling this great mass of engineering society news, is, first, to record in a special department in our "Construction News Supplement" each week the dates, and, so far as possible, the subjects of approaching meetings, together with a brief summary of the papers and discussions at meetings recently held. The brevity of these announcements prevents, of course, any abstract of the papers. What we aim to do is to present in this department an "index" to current technical literature as presented before technical societies, so that the reader who follows it from week to week may learn of any paper whose subject is of especial interest to him, and may take his own measures to obtain a copy of it, from the Secretary of the Society before which it is read or from the author. Besides this, a large proportion of these papers come sooner or later before the editors, and such of them as are deemed to be of greatest value to the readers of Engineering News are selected for separate publication, in full or in abstract.

In the second place, an extended report of the annual and semi-annual meetings of the national engineering societies, and of other national societies most closely affiliated with engineering, is presented in the main body of the paper, where it will be preserved and available for reference in binding.

Referring again to our examination to determine the amount of space devoted to reports of technical societies in the issues of this journal for 1898, we find that the average space occupied by society proceedings in our Supplement during 1898 was two columns in each issue, or, altogether, 104 columns, or over 22 pages of nonpareil (the smallest type used in Engineering News). In the body of the paper full reports were published of 36 different annual or semi-annual conventions, which aggregated 132 columns, or 44 pages of nonpareil matter. This does not include the numerous papers read at the meetings, which were published in full or in abstract under separate titles, nor the editorial discussions of society work which appeared from time to time. Of the 36 conventions, 23 were attended and reported by members of the regular editorial staff of the paper, and the reports of the others were obtained through the secretaries, official stenographers, or other persons attending the meeting by special arrangements made in advance of the meeting. These figures are a pretty good indication not only of the enormous growth of engineering society work, but also of the breadth of the field which Engineering News is aiming to cover for its readers.

"Engineering is the Art of Making a Dollar Earn the Most Interest," is the heading with which Mr. E. H. McHenry begins his instructions to engineers engaged in railway location in the service of the Northern Pacific Ry. Co.* This definition of engineering is new to us. Whether it is original with Mr. McHenry or not we do not know; but it condenses so much wisdom in such a small compass that it deserves a place in the memory of every engineer. It is perhaps not so broad as some other definition of the engineer's work, but it is none the worse for that. The broader definitions include a good deal of work which in these days does not deserve to be called engineering work at all. In the work of railway location for example, to which Mr. McHenry's terse definition was intended especially to apply, there are a great many men who can lay down a line of railway to run from somewhere to somewhere with grades and curves over which trains can be run with safety at fair speed. But how many are the men who can lay down that line which shall so unite the elements of small first cost, low operating expense and best facilities for collecting traffic that the dollars invested in it shall earn the most interest? It may be said with truth that such a problem is impossible of definite solution, since it depends upon elements which the future has yet to determine. An approximate solution must be made, however, and is made in every case, although it is often only the roughest sort of guess at the final result. It is the province of the engineer to replace rough guesses by careful estimates. It is his business to ascertain the probabilities as to the future volume of traffic and other unknown factors, and to use this knowledge in solving the problem of making the dollar earn the most interest.

We have used railway location only as an illustration. The definition is as true of the design of a boiler plant, a mining outfit, an ocean steamer, or any other class of work which the engineer has to do. In all these varied fields the engineer finds himself in competition with men who can do the same things and reach the same results; the difference is that the engineer will aim to reach not only results but the best results.

We are aware that there was an older type, an older school of engineering not yet quite extinct, to which this definition did not at all apply. Judged by the practice of this school, engineering was the art of building strong and monumental works, designed according to precedent, built to endure. This type of engineering still continues to a certain extent on the other side of the water. The type of engineering which Mr. McHenry has defined has in large measure especially characterized the work of American engineers. It is engineering of this sort which is putting an American bridge across the Nile and sending American locomotives to India, and American steel and iron all over the world.

RAILWAY COMPETITION WITH CANALS IN NEW YORK.

The expert commission appointed by Gov. Roosevelt to investigate and report upon the question: What shall the State of New York do with its canals? has issued a circular letter asking for the presentation to it of data and opinions upon this subject. We quote from this letter as follows:

Sir: The Governor of New York has requested this committee to report to him before the next meeting of the legislature what is best to be done about the canals. Briefly, the facts in the case are as follows:

The tonnage on the canals has steadily diminished from 6,673,370 tons in 1872 to 3,360,063 tons in 1898. Until within the last few years the diminution has been chiefly on the smaller canals. The Erie Canal, which carried 3,500,000 tons in 1871, had 3,235,000 tons in 1893; and the Champlain Canal, which had 1,100,000 tons in 1871,

*Eng. News, April 20, p. 251.

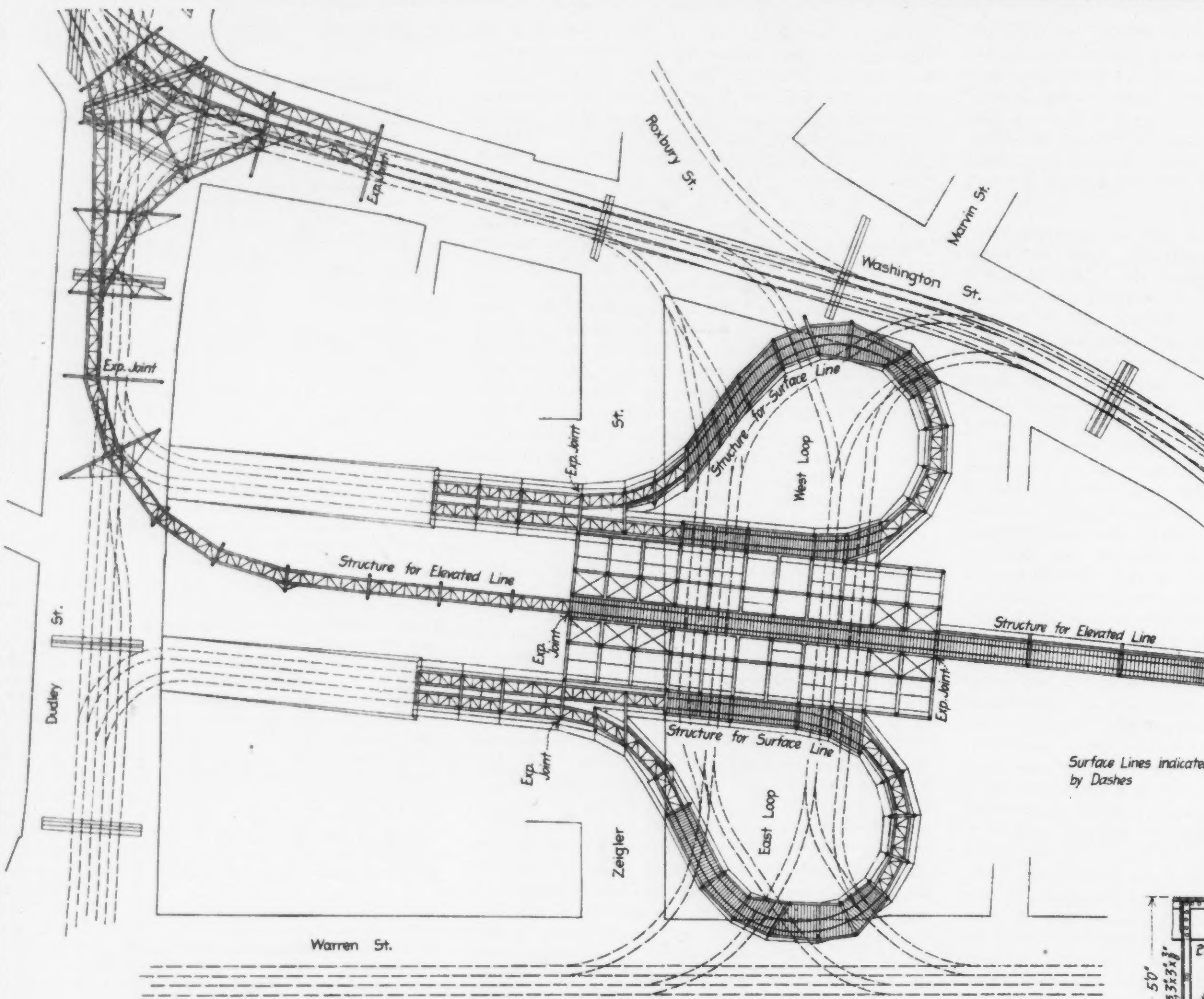


FIG. 8. GENERAL PLAN OF DUDLEY ST. TERMINAL.

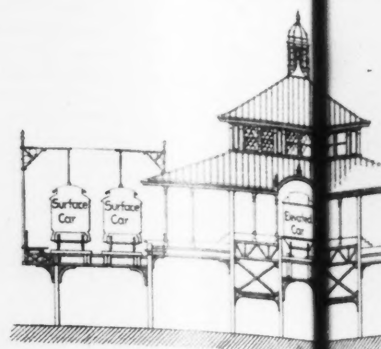


FIG. 11. SOUTH EN[D] ELEVATIO[N]
DUDLEY ST. TERM[IN]AL STATI[ON]

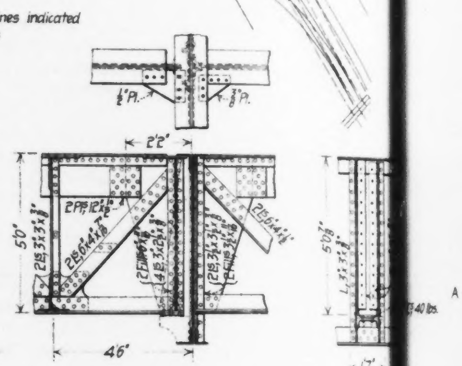


FIG. 6. FIXED AND EXPANSION END CONSTRUC[TIO]N OF LONGITUDINAL GIRDERS.

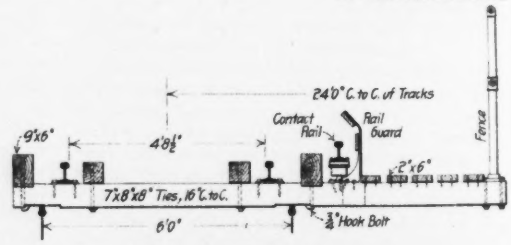
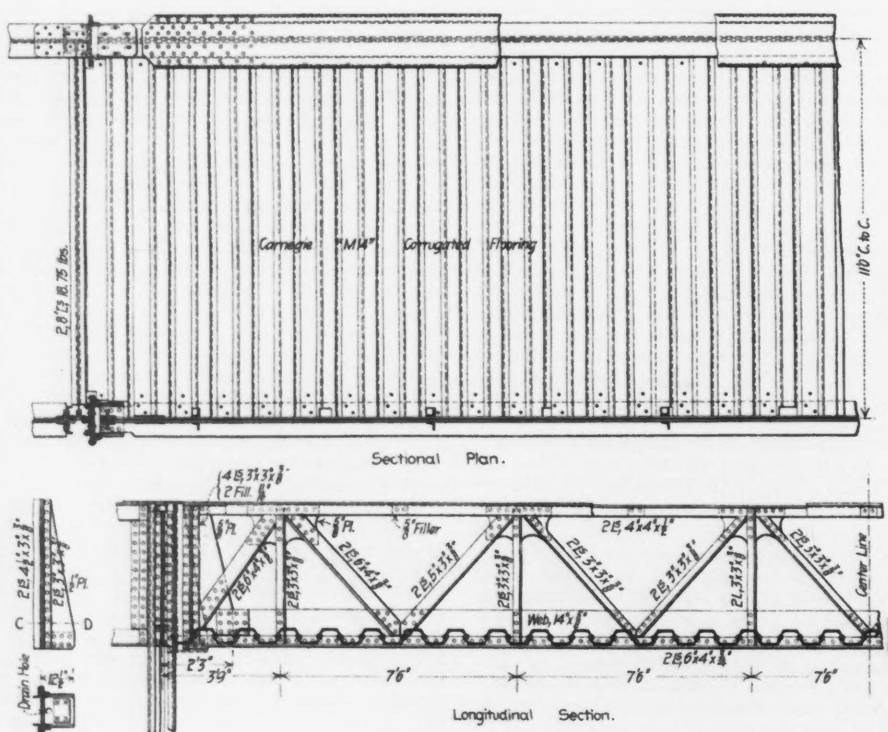


FIG. 12.
PROPOSED STANDARD TRACK CONSTRUCTION.



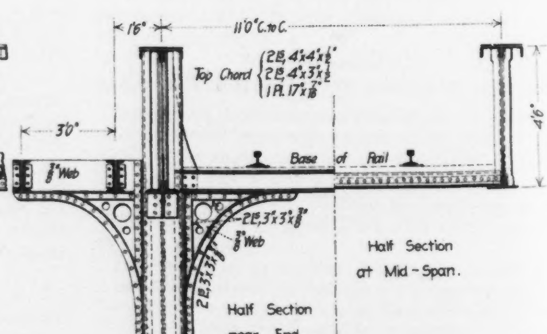
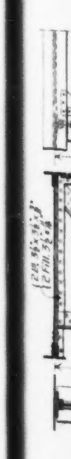


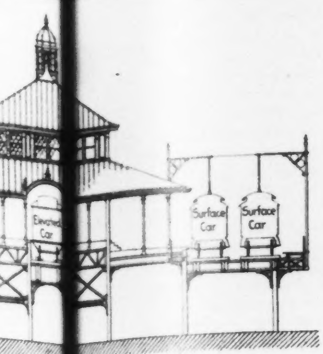
FIG. 7. SPECIAL LONGITUDINAL THROUGH GIRDERS
WITH SOLID FLOOR CONSTRUCTION.



BOSTON ELEVATED RAILWAY, BOSTON, MASS. (ROXBU[R]Y TER[MINAL]

Geo. A. Kimball, M. Am. Soc. C. E., Chief Engineer.

Pencoyd Iron Works, Philadelphia, Pa., Penns[ylv]ania St[eel]



OUTH E[...] ELEVATION OF
ST. TERM[...]AL STATION.

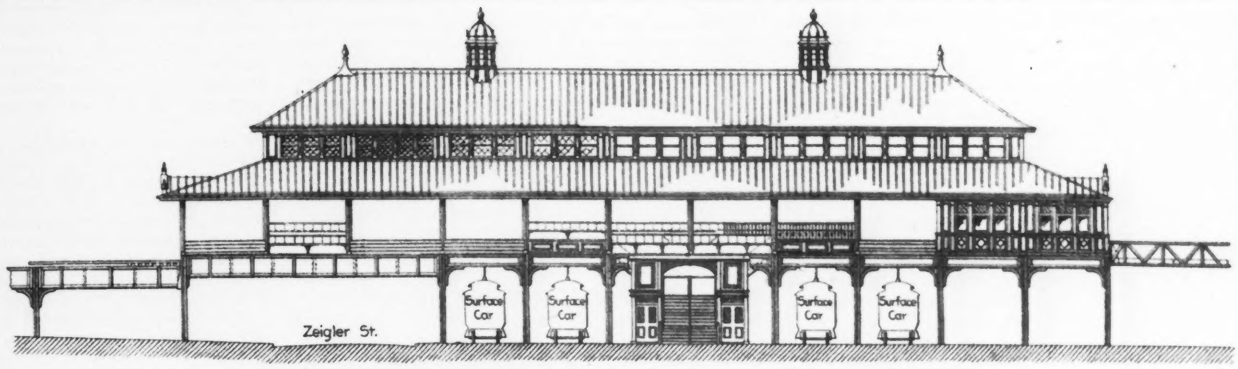


FIG. 10. EAST SIDE ELEVATION OF DUDLEY ST. TERMINAL STATION.

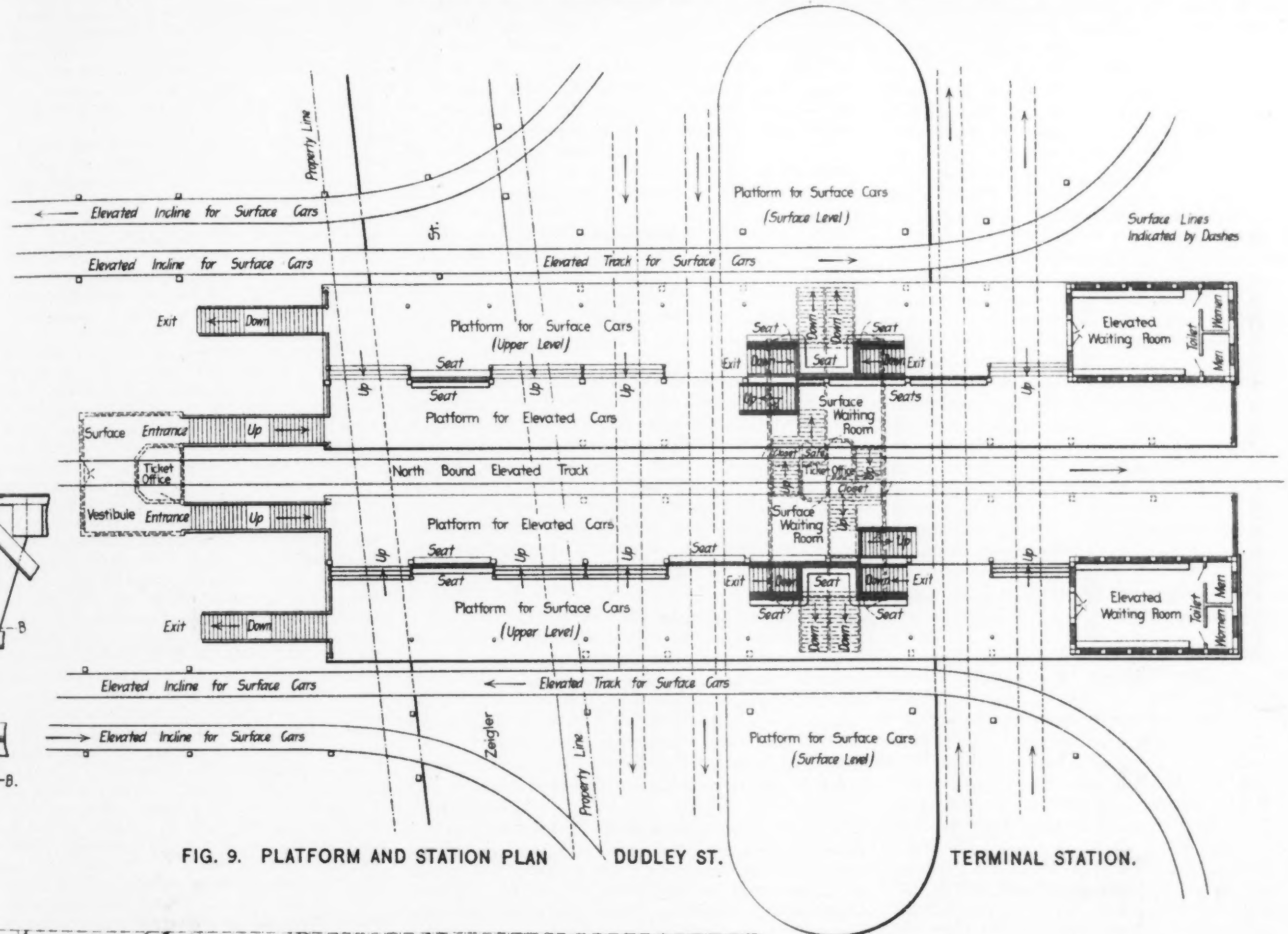
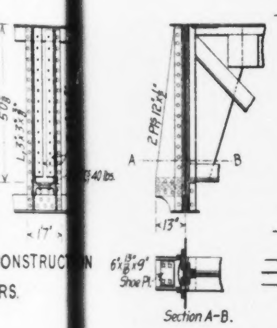


FIG. 9. PLATFORM AND STATION PLAN DUDLEY ST. TERMINAL STATION.



CONSTRUCT[...]N
[...]RS.

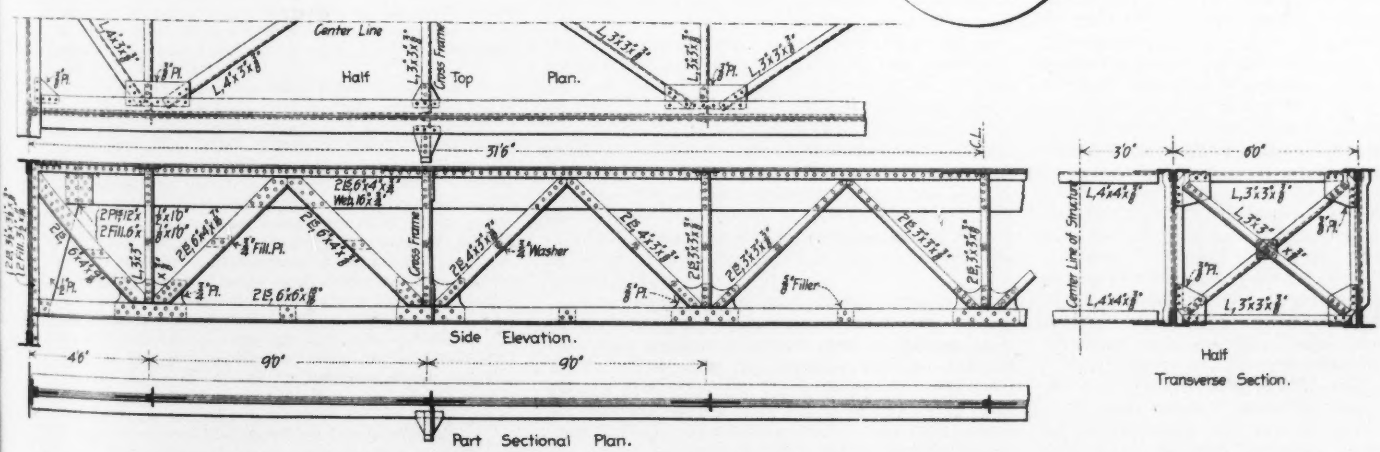


FIG. 5 STANDARD LONGITUDINAL DECK GIRDER CONSTRUCTION.

(ROXBU[...] TERMINAL AND GENERAL LINE CONSTRUCTION.)

J. A. Ostrup, Assoc. M. Am. Soc. C. E., Designing Engineer.

[...]a., Penns[...]ania Steel Co., Steelton, Pa., Contractors.

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

carried 1,020,000 tons in 1892. Since 1893, owing to the improvements on the railroads and the reduction of rail rates and the lack of improvements on the canals, the tonnage on these canals has also diminished; in 1898 the Erie Canal carrying 2,300,000 tons and the Champlain Canal about 800,000 tons.

In 1895 the legislature authorized, and the people by vote approved, the expenditure of $9,000,000 for increasing the depth of the Erie and Oswego canals from 7 ft. to 9 ft. in the canal bed and 8 ft. in the masonry structures, and 2 ft. less in the Champlain Canal. The appropriation is exhausted, and the work is stopped. The commission appointed last year by Governor Black has reported that 36% of the work is completed and 64% is yet to be done, and that to complete this project, including suitable modern locks at Cohoes, Little Falls, Newark and Lockport, will cost approximately $15,000,000.[2] Our task is to study the question in the light of existing facts and recommend to the Governor the best course to pursue under the circumstances as he found them on taking office. We shall endeavor to obtain and present in an intelligible form the necessary statistics of commerce and freight rates in order to form an intelligent judgment, and, in addition, we desire to have the opinion and advice of those who are competent to give them.

It seems to us that there are five possible solutions of the problem:

(1) To complete the present project of enlarging the Erie, Oswego and Champlain canals at a further cost of $15,000,000 (or $24,000,000 in all). The benefits to be derived from this project are estimated by competent engineers at a saving of 1.11 cts. per bushel of wheat from Buffalo to New York, or a reduction from the present cost of 1.8 mill per ton per mile to 1.0 mill per ton per mile, and a corresponding reduction in other traffic, on its capacity of about 15,000,000 tons per annum. It is understood that this present project includes the construction of pneumatic locks at Lockport and Cohoes, the lengthening of all other locks on the Erie and Oswego canals so as to take in two canal boats, each 115 ft. in length, and these two canals made suitable for boats of a draft of 8 ft. This project provides for the Champlain Canal draft of 6 ft., and a possible substitution of slack water navigation on the Hudson River wherever practicable between Fort Edward and Troy in place of the existing canal structure.

2. To enlarge the present locks on the Erie Canal at once to a length of 200 ft., a width of 26 ft. and a depth of 11 ft., making them suitable for boats 25 ft. wide, 125 ft. long and 10 ft. draft. The project would cost about $6,000,000. It would permit the use of boats of 6 ft. draft, as at present, but with increased width and length, and having a capacity of about 420 tons or 14,000 bushels of wheat, in place of 240 tons or 8,000 bushels of wheat, at present carried. It is estimated that the use of such boats would result in a saving of 1 1-10 cts. per bushel of wheat, or a reduction to 1.0 mill per ton mile.

With the locks thus enlarged, the question of increasing the size of the prism could be considered separately with the following results:

(a) With the size of the canal prism increased so as to complete the existing project, making it suitable for boats of 8 ft. draft, and of the length and width above stated; these would have a capacity of about 620 tons or 20,667 bushels of wheat, instead of 240 tons or about 8,000 bushels of wheat, as at present. It is estimated that the use of such boats will result in a saving of 1¼ cts. per bushel of wheat, or a reduction to 8-10 of a mill per ton mile. The cost of this work on the prism, outside of the locks, is estimated at about $14,000,000, and its adoption would utilize and make available the work that has been done under the $9,000,000 Act.

(b) With the size of the canal prism increased so as to make it suitable for boats of 10 ft. draft, and of the length and width above stated, these would have a capacity of about 820 tons or 27,333 bushels of wheat, instead of 240 tons or 8,000 bushels of wheat, as at present. It is estimated that the use of such boats will result in a saving of 1 4-10 cts. per bushel of wheat, or a reduction to 0.7 mill per ton mile. The cost of this work on the prism, outside of the locks, is estimated at about $24,000,000, and its capacity at 20,000,000 tons per annum.

3. To construct a barge canal continuously descending all the way to the Hudson River from Lake Erie, with a depth of 12 ft., and suitable for barges of 1,200 to 1,500 tons, which can be towed on the lakes if desired. The cost of this is approximately estimated at $50,000,000, and the saving at 1.55 cts. per bushel of wheat from Buffalo to New York, or a reduction over present cost of 1.8 mills per ton mile to 0.6 mill per ton mile. Its capacity is estimated at 25,000,000 tons per annum.

(4) To construct a ship canal with a depth of 20 to 30 ft. suitable for lake and ocean vessels of 5,000 to 10,000 tons capacity. The cost of such a ship canal, depending upon its size and the route adopted, is estimated at from $200,000,000 to $500,000,000. This ship canal project is under consideration by the Federal government, Congress having appropriated $240,000 for surveys and authorized the appointment of a Deep Water Way Commission, which is now vigorously prosecuting surveys along the Oswego-Mohawk and the Champlain routes with a view to forming an accurate estimate of the cost.

5. To abandon the canals entirely, as has been done in some other states, and dispose of the property interests therein to private individuals or corporations on the best terms which can be secured, or to make some other use of the property for the benefit of the state.

It will be understood, of course, that the figures which the committee presents are merely such approximations as they have been able to make from their present knowledge. At least one member of the committee, however, has already given exhaustive study to the problem, so that these figures are not by any means to be taken as mere wild guesses.

The committee has before it an exceedingly difficult task. It would be difficult enough if present conditions were all that needed to be studied; but the committee must not only ascertain present conditions, but approximate those of the future as best it can. The canal in its present condition is admittedly obsolete. It can no longer compete with the railways in handling even the cheapest bulk freights. It seems to us, therefore, that one of the first questions which the commission ought to determine is, the extent to which the railway is likely to compete with the canal in the future. Will the canal, when each or any of these improvements are completed, be able to carry goods at less cost than the railways with which it will be in competition?

In order to answer this question, we must ascertain what railway companies are doing at the present time in the movement of freight at low rates and low cost, and also try to see, if we can, what further reductions in the cost of freight carriage by rail are likely to be made in the near future.

If the reader will turn to our issue of two weeks ago (April 27, p. 257), he will find a statement of the rates fixed by the Trunk Line Association for grain freights by rail from Buffalo to New York for the present season. The rate on wheat is equivalent to 2.3 mills per ton mile. The rate on corn is equivalent to 1.8 mills per ton mile. Last week announcement was made of the shipment of oats from Chicago to New York by the Lake Shore & Michigan Southern at 12 cts. per 100 lbs., or 2.4 mills per ton mile.

The Chesapeake & Ohio Ry. has become noted for its achievements in the carriage of soft coal over a mountain road at astonishingly low cost. In our issue of Sept. 9, 1897, we reviewed some of the work which this road has done, and recorded an average rate of only 2.53 mills per ton mile for the carriage of soft coal. We believe the Pennsylvania has carried coal at rates as low as this or lower, although we are now unable to quote exact figures.

We have selected these cases almost at random as examples of what railways can accomplish at the present day in the cheap movement of bulk freights. It is to be noted that all these cases are examples from the traffic of solvent roads, which are doing business for the profit there is in it, and which do not pretend to claim that they are carrying traffic at cost. Nor is there any reason to suppose that these rates, low as they are, do not afford a fair profit to the railway company handling the traffic. What makes them possible is, first of all, an enormous volume of freight to be hauled between terminals, and, second, a long distance to haul it. Given these essentials and a track with easy grades and curves, proper terminal facilities and rolling stock, and freight can be moved by rail at a profit even at the low figures which are quoted above.

Actual computation may make this a little clearer. Suppose we have a train of forty 30-ton cars (the present standard modern freight car), all loaded to their full capacity, or 1,200 tons of paying load. At only 2½ mills per ton mile such a train will earn $3 for the company every mile that it runs. It need hardly be said that this is far above the average earnings of freight trains, even on the roads of heaviest traffic. For example, the average earnings of all freight trains on the Lake Shore & Michigan Southern Ry. in 1898 were $1.78 per mile run. The expenses of moving such a train, on the other hand, are only a trifle more than for moving a short way freight of a dozen cars. The locomotive takes considerably more fuel and water and oil; but these are small items in the cost of train movement. The engine crew and train crew cost little, if any, more. The cars can be leased for ½-ct. per mile. The wear of rails and ties due to the increased traffic, represents, so far as is at present known, but a small figure.

Railway managers know that the trains which earn money for the company are the long heavy through freights, even though they do carry bulk freights at prices which seem incredibly low.

All their efforts have been directed in recent years toward increasing the train load; building more powerful locomotives, cutting down grades and easing curves, and the result in the economical movement of freight is one of the greatest wonders that Nineteenth Century engineering has accomplished.

We need only refer here to the enormous reduction in railway freight rates that has taken place. The Lake Shore & Michigan Southern Ry., already instanced, had an average freight rate in all classes of goods moved of 1.504 cts. in 1870, 0.75 ct. in 1880, 0.626 ct. in 1890, and 0.502 ct. in 1898. These, of course, are average rates, and the high rate charged on high-class merchandise, local shipments and short-haul traffic, must be remembered in estimating from this the average ton mile rate charged by these roads on long-haul bulk freight such as coal, ore and grain.

So much for the present; and now what of the future? Railways are now, in some cases, actively competing for the privilege of carrying bulk freight at 2 to 3 mills per ton per mile. How much lower than this will they be able to move freights ten years or twenty years hence? Is it reasonable to suppose that we are at the end in the reduction of the cost of carriage by rail?

The chief factor in the reduction of rates in the past has been the increase in the tonnage and speed of freight trains. Rates per ton mile have gone down, but earnings of freight trains per mile run have gone up. There is still room for further saving, and large saving, too, by increasing the weight of trains. Very recently there has been a noticeable tendency toward increasing the size and hauling capacity of locomotives. The consolidation locomotives which were deemed extraordinarily powerful machines ten or fifteen years ago, are being replaced by larger and more powerful engines.

The "record" train is growing rapidly in size. For example, last summer the Pennsylvania hauled a train of 130 cars, carrying 3,692 tons of paying load, with a single locomotive, a distance of 161 miles on its main line. Since this article was begun word has reached us of the eclipse of even this remarkable performance, through the use of the new 100,000-lb. steel cars. The Baltimore & Ohio recently hauled a train of 50 of these cars, carrying a net load of 4,900,000 lbs., a distance of 100 miles on its road with a single locomotive. The 100,000-lb. steel car is beginning to be looked forward to as the coming standard vehicle for the movement of bulk freights of great volume. These cars greatly reduce the percentage of dead load to paying load, and they are expected to be far more durable than wooden cars, and to effect a large reduction in the cost of car repairs. A train of 40 such cars, all fully loaded, will not be longer than many freight trains now run in regular service; yet it will carry a paying load of 2,000 tons. The hauling of such a train presents no difficulties on any railway of light grades and easy curves. Locomotives now in service can accomplish it without difficulty. The running expenses of such a train need be very little in excess of those of an ordinary freight train, and its successful operation is merely a matter of suitable terminals for receiving and distributing the freight, and proper yards for handling the train at the end of engine stages while on its journey.

We have made it plain, we hope, that the cost of moving bulk freights in large volumes over long hauls depends primarily on the size of the train load. It is also beyond dispute that a further great increase in the train load is entirely practicable and certain to be made, where traffic conditions permit. What limits can we set, then, to the further reduction of freight rates, and what possibilities or probabilities in this direction are already in sight? As we have seen above, the rates are already recorded below 2 mills per ton mile. Does it seem unreasonable to suppose that larger cars, heavier locomotives, and the heavier train loads which these will make possible, will yet bring about a rate of one mill per ton mile, and that many now in mature life may survive to see it? Even this low rate would give earnings of $2 per train mile, with an average train load of 2,000 tons; and in view of the remarkable performances of the Pennsylvania and the Baltimore & Ohio above recorded, we see no reason to doubt that such average train loads may even, under present conditions, be moved with success in the regular course of traffic.

Perhaps a railway freight rate of 1 mill per ton mile may seem incredible; but it is no more incredible than the reductions which have taken place in freight rates in the past quarter century would have seemed to those who looked forward at that time.

Of course, it will be clearly understood that what has just been said applies only to the special conditions of enormously heavy traffic and long hauls; but these are exactly the conditions which exist in the case under discussion. Nowhere in the world, probably, is there such a vast volume of through traffic to be hauled a long distance as that which is collected at the lower Lake ports, and the cities on the Atlantic seaboard. It is this great volume of traffic which has extended the life of the old Erie Canal after nearly all the other large canals built in the early part of this century have been abandoned, and it is this great volume of traffic which makes possible a lower ton-mile rate for freight movement by rail than has been anywhere else attained.

If it be granted, as we think it must be, that any future artificial waterway from Lake Erie to the Hudson may have to face railway competition at 1 to 2 mills per ton mile, the serious question for the State of New York is whether any waterway can be made which will meet such competition. The figures assumed by the committee for the various waterways which they propose are: For a canal improved according to present plans, 1 mill per ton mile. For a canal with widened locks, 1 mill per ton mile; widened locks and 8-ft. draft, 0.8 mill per ton mile. Widened locks and 10-ft. draft, 0.7 mill per ton mile; 12-ft. barge canal, 0.6 mill per ton mile.

These figures, however, represent the mere cost of running the boats. They do not represent the real cost of the traffic, for the cost of maintenance of the canal itself and the interest on the investment that must be made for its improvement are entirely omitted. To compare them with the railway rates we should omit from the latter all that part of the earnings which go to pay for maintenance of the roadway and interest on the bonds. If, on the other hand, we make reasonable assumptions for the volume of traffic on any of the proposed waterways, we find that when we include the cost of their maintenance, and the interest on the investment, the total cost is nearly or quite equal to what we may be fairly assumed as the probable cost of carriage by rail.

It must be remembered, moreover, that nearly all freight will go by rail rather than canal, even at a somewhat higher rate. It seems to us, therefore, that New York must face the prospect that no matter what improvements she may make in the Erie Canal, the railways which compete with it will still carry the bulk of the traffic.

There is, however, one aspect of this question which should not be overlooked, and that is, the influenece of the canal as a competitor in compelling the lowering of railway rates. We have pointed out that the railways can, if they are compelled to do so, carry the traffic at a total cost as low or lower than any waterway; but will they do this if the influence of the canal as an independent competitor is removed? Will the competition of other routes to the seaboard, of the Canadian waterways and rail lines, of the railways terminating at Philadelphia, Baltimore and the Gulf ports, be sufficient to compel the trunk lines between Buffalo and New York to continue the improvement of their facilities and the reduction of their rates, as would an improved waterway on the line of the Erie Canal?

From this point of view the moderate improvement and maintenance of the Erie Canal may be worth all it costs, even if it carries no more freight in future years than at the present time. Legislation can compel the lowering of exorbitant railway rates; but it cannot compel the introduction of improved methods of operation and economies to reduce the cost of railway service. We must look to competition to effect this.

There are other aspects of the problem before the New York Canal committee which space does not permit us to consider. We believe, however, that the point of view we have set forth is the correct one; and that, if New York decides to improve and maintain its canal, it should do so with the full understanding that their office is to serve as a potential regulator of railway rates, rather than actually to handle any large volume of traffic.

LETTERS TO THE EDITOR.

Concrete Chimneys.

Sir: Though having replied once to A. D. R., whose query was published in the Engineering News of March 16, 1899, I wish to ask your indulgence of a second reply, the material for which came to my notice to-day. Mr. Fr. von Emperger, in Paper No. 703, Trans. Am. Soc. of C. E., 1894, treating of highway bridges, says:

> Two concrete structures which give the best proof of the elastic properties of this material (concrete) may be mentioned. One is a chimney 160 ft. high, in Ireland, in one piece of concrete, which has stood the heaviest storms; and another example, which is cited by Mr. A. Relia, are wine tanks of a capacity of 80,000 gallons (of concrete only), in Agram, Hungary, which stood the last earthquake without cracking. A further proof is the use of concrete in railroad structures directly below the tie.

In the discussion of the above paper it is brought out that Mr. Thaddeus Hyatt, in a book published by himself in 1877, mentions a factory building of his in Farringdon Road, London, as being built of re-enforced concrete, and also states that in a letter addressed to Mr. Hyatt, by the "eminent American experimenter, R. G. Hatfield, and who tested combination" concrete beams as early as 1855, he, Mr. Hatfield, from his investigations, concludes that the method of combining iron and steel with concrete "should be applicable also to bridge construction," and urges its use in the construction of lighthouses, chimneys, stairways, etc. The dates and authorities given are of value. Yours respectfully,

Paterson, N. J., May 6, 1899. Wm. Wallace Christie.

The Calculation of Stresses in the Bonn Bridge.

Sir: As regards the formulas for the calculation of the stresses of statically indeterminate arches, there are engineers who consider that the various methods are not all they could wish for from a scientific standpoint. The calculation is tedious, and after the results are finally obtained misgivings arise as to their practical value. It is one thing to theorize where no responsibility is attached. It is quite another thing for those who have charge of responsible work to use formulas which are considered theoretically and practically uncertain. This applies to all three methods of calculation in use:

(1) Maxwell's method, which is briefly treated in Prof. Greene's "Graphical Statics," and is the method used by American engineers; (2) Weyrauch's method, which makes use of the neutral axis and applies strictly only to trusses whose chords are parallel, and which has been very fully treated by Prof. Mueller-Breslau and recently by Prof. Howe, in his book on arches, and (3) Mohr's method, which was developed by Dr. Winkler, and which is the best in use. This method is treated in an article by Prof. Mueller-Breslau in the "Zeitschrift des Architekten und Ingenieur Vereins zu Hannover" for 1881. He states the principles very clearly and gives examples with original approximate methods.

Besides the uncertainties due to design, there are those due to workmanship and to erection, which the formulas cannot take into account. These uncertainties have a much more serious effect than in the case of statically determinate trusses. For instance, take the Bonn arch, concerning which Mr. Fritz Mueller von der Werra has written such an admirable account for the Engineering News. The large center span was first erected and left standing all winter. During this time there was a horizontal reaction on but one side of the piers. Could anyone foretell how much the piers would give so as to allow for it in the calculation? A slight change in span would alter all the stresses materially. However, as a matter of fact, the piers spread but little. Again there is the question of connecting the two parts in erection so that the chords shall have the prescribed initial stresses. Can this be done so that the stresses will be as determined by the calculations?

Mr. Fritz Mueller von der Werra, in his communication in Engineering News of May 4, states that the curving of the chord members "has a purely local effect on the respective member, and does not complicate or render more statically indeterminate the framework as a whole, and can, without involving objectionable statical complications in the rest of the truss, be readily taken care of by a handy and perspicuous formula, such as given." In the first place, Mr. Fritz Mueller von der Werra misunderstood the article which he criticises. I did not intend to consider the curving of one member in its effect on the others, not because there is no such action, but because it is generally too small to be considered. When, however, he states that there is no such action, I beg to differ. Any cause which changes the length of any member, affects the stresses in all the other members. There are three such causes acting, namely, temperature, the direct stresses of tension and compression, and bending. As regards the last, whatever increases the bending increases the stresses produced by this action, and a curved piece on account of its eccentricity will change its length more than a straight piece. Generally, it is very true, this action is so slight that it may be neglected as affecting the other members. Nevertheless, it does exist, and trusses should be so designed, as regards the eccentricity of the loading at the joints, the section chosen, the radius of curvature, etc., as to reduce it as much as possible. The curving of the chords adds a new factor to the already uncertain calculated amounts, increases the weight, increases the expensive elements of cost in shop labor considerably, and absolutely necessitates the process of annealing, which process must be done in an exceptionably thorough and careful manner.

In the second place, as regards this "handy and perspicuous formula, such as given." Where is it to be found? The only practical methods I know of are the three mentioned above. Of course, I do not mean that there are no others. Only that I should be delighted to find an easy and accurate formula for the calculation of arches of this nature. Very truly,

Alex. Rice McKim.

106 East 23d St., New York, May 6, 1899.

Concerning the Prismoidal Formula.

Sir: Mr. "X.," in yours of April 13, referring to the question "how many cubic yards are there in a 400-ft. rock-cut having vertical sides 27 ft. apart, and the cuttings of which at the regular 100 ft. stations are 5 ft., 33½ ft., 43 ft., 33 ft. and 3 ft.?" shows the well-known fact that where there are no side slopes in an excavation the result will be the same whether obtained by the so-called prismoidal formula or by average end areas. But the ordinates being those of two parabolic curves, the contents of the rock cut can be easily shown to be 12,000 cu. yds. instead of 11,350 cu. yds., as by the prismoidal formula and average end areas.

As Mr. "X." seems to object to 100-ft. intervals, there is no objection on my part to reducing them from 100 ft. to 10 ft. each, which makes the true result 1,200 cu. yds., as against 1,135 cu. yds. by prismoidal formula.

If we go further, and divide all dimensions by 10, and assume that we ask some good marine architect to compute the weight of a rocker keel of lead for a yacht giving dimensions as follows: 40 ft. long, to side 2.7 ft., depth at 10-ft. intervals to be 5 ft., 3.35 ft., 4.3 ft., 3.3 ft. and 3 ft., his answer will be, calling lead .41 lbs. per cubic inch, 102.47 gross tons, being 5.5 tons in excess of the result by prismoidal formula, and the very considerable discrepancy of 5.7% from the "X." result—quite too great a margin for shipwork, as it would make $100 to quarrel about in the price of the keel; it would give a wrong displacement for the yacht, and would ruin all of the carefully made calculations of her stability under sail.

In the example as first given, the "prismoidal formula" would do the rock-man out of perhaps one thousand dollars, for which, if the affair came into court, the engineer might, like the unjust steward, be commended—and he might not.

The true answer can be found by using Section 4,153 of the "Revised Statutes of the United States." This formula is used at least one thousand times where the so-called prismoidal formula, as set forth in 1883 by J. Macneill, Esq., C. E., is used once, and besides being, as far as I am aware, the only rule for such measurements established by statute in this country, is also the legal guide in every civilized country in the world.

To go back of the legal history of this rule, we find it used by Moorsom, and by all writers on naval architecture as far as the time of Jacobo Stirling, whence it is often called in England, Stirling's rule, and it is not too much to say that it is universally used with slight modifications in all calculations of the displacement and stability of ships, both vessels of war and commerce.

To do away with the mystery with which many regard the prismoidal formula as enveloped, let us consider that, when used as it ought to be, it is simply one of the parabolic rules, and will measure all solids and spaces having a fair claim to regularity of shape, and is not by any means confined to the rather simple case of a prismoid.

The "prismoidal formula," as commonly understood by the engineer in this country, may be described thus, as applied to a single "section" of railroad work:

Let

b = the area of one end section,

t = the area of the other end section,

m = the area of a section midway between the two ends and deduced from them,

S = the solidity.

Then the forumla is $S = \overline{b + 4m + t} \times \frac{1}{6} h$.

The rule habitually used in all marine work is precisely the same in form, the only difference being in the fact that the midway section, instead of being "deduced," is measured. This means in effect that if the area of the mid-section is found by measurement to be either more or less than that of a prismoid bounded by straight lines, then that plus or minus difference is shown in the resulting solidity, instead of being totally disregarded.

The error arising from the use of a deduced mid-section is quite too large, in our rock-cut example, but is far greater in measuring a hemisphere of, say, 100 ft. diameter. Here the base or one end section is 7,854 sq. ft., and the vertex or other end section is zero. The "deduced" mid-section is 1,963.5 sq. ft., and the solidity 130,900 cu. ft., but by Stirling's or any of the parabolic rules, the measured mid-section is 5,890 sq. ft., and the solidity 261.800 cu. ft., which is the true volume of a 100-ft. hemisphere, and just 100% more than the "prismoidal" rule gives, and 33.3% more than by the poor old average end area rule.

If some young—or old—engineer, who takes a real interest in the study of his profession would, before using deduced mid-sections, try plotting by the "curve of areas" the sections not only of prismoids, but cones, pyramids, spheres, and different solids of revolution, etc., he would be apt to come in view of some amusing things. Or, if that should be too much trouble, let him open some rudimentary treatise on shipbuilding,and read a few pages on the calculation of displacement. I would not ask him to go too far into the various rules, such as Stirling's (first and second), Weddle's, Durand's or the five-eight rule, but only enough to get a general idea of the measurement of solids, as the full literature of the subject is too much for any one busy man to fairly cope with. In the meantime, it might be well for him to allow me to pass on to him Mr. "X.'s" advice to "let the prismoidal formula alone;" at least, until he is sure he can make it measure a rock cut a hundred feet long in 25 ft. stations without a blunder of over five per cent.

Certainly an average engineer, professional or unprofessional, ought to be taught as much of the mensuration of solids as a draftsman in a mould-loft usea every day.

Yours truly, "W."

New York, April 27, 1899.

A Sectional Third-Rail Electric Street Railway System.

Sir: I have read with a great deal of interest your article on "The Sectional Third-Rail System at Manhattan Beach" (Eng. News, April 27). With regard to your criticism of the system in the last paragraph of your article, I think that perhaps some of the following data will interest your readers and trust you will find space for the same in your columns.

In the Murphy system there are about 180 switches per mile of single track, and these switches constitute about one-third of the total cost for outside construction. The switches are of course the first item of depreciation that the engineer anticipates. The rest of the outside construction may justly be considered to be of a most permanent character and liable to only slight depreciation, perhaps 1 or 2%. In short, its permanent character will very closely approach that of the actual track itself. If, then, the item of depreciation of the switches be written at 10%, the total depreciation on outside construction, allowing 1% for the track, would only be a total of 4⅓%, which is by no means an excessive figure, especially as the depreciation of overhead trolley construction is written at 15% by conservative engineers.

Anything exposed to rain storms, ice storms, wind storms, lightning and the like, is bound to depreciate very rapidly and to such destructive influences the sectional conductor system will, I think, be conceded to be practically impervious.

The Safety Third-Rail Electric Co. are now considering and will doubtless adopt a guarantee to maintain their switches on any road they may construct for a yearly sum equivalent to 10% of the first cost of the switches. This, it seems to me, should, in a measure, dispose of the maintenance problem.

Regarding the matter of leakage I trust you will pardon me if I venture to state that I think the amount of leakage has been somewhat exaggerated, and in substantiation of my objection I submit the following figures obtained by actual experiments at Manhattan Beach, N. Y. An exposed section on one of the third rails was made live by blocking up one of the switches, and a milli-ammeter was placed in series with the track. The following tests were then made to determine what would be the leakage current.

Leakage From Live Section to Ground.

Conditions of track.	Current leaking in amperes.
Full length of one section of 15 ft. covered with water	0.05
While water was being poured on	0.0875
When entirely covered over with thoroughly-mingled mud and water	0.5
Rock salt (3 lbs.) liberally sprinkled over entire length, leakage after ten minutes	1.

An attempt was next made to produce extraordinary conditions in order to make the leakage current sufficient to hold up the automatic switch. The track was flooded with salt water from the ocean, which dissolved the rock salt already sprinkled on the track and made a strong solution of salt, mud and water. In this case the leakage current varied from 8 to 12 amperes and the switch stayed up. These conditions, however, were so severe that it is fair to assume that they would never obtain in practice. It was also interesting to note under these conditions that there was no doubt to the casual observer that the section was live. The mud and water boiled, arced and sputtered violently.

The present switches on the system are set to hold up at 12 amperes. The minimum current required to operate a car of the ordinary type varies from 16 to 20 amperes and it is intended to set the switches for a minimum holding up current of higher value, thus practically eliminating the possibility of the severest conditions that obtained in this test from making a section live.

In view of the foregoing I think it is not unreasonable to say that the chances of damage from 500-volt currents due to falling overhead wires in the trolley system are much greater than are the chances of a live section of this system being left in the roadway.

I also venture to enclose you some further data on leakage tests made independently, which are quoted from a paper on "Electric Traction by Surface Contacts," by Miles Walker, which appears in the April issue of the "Journal of Institution of Electrical Engineers" (England). These tests practically substantiate those already made, and are just as pertinent, though they were made on a sectional conductor system of a different character from that at Manhattan Beach. The difference between the two sets of tests are doubtless due to different areas of exposed conductor.

Data on Leakage Tests.

Conditions of road.	Current leaking in amperes.
Track covered with very wet mud, and water ½ to ¾-in. deep, so as to make the very worst street condition. The skate resting on two studs at 500 volts above earth. The mud between the studs touching the skate at intervals along its length. Total leakage from the two studs.	3.9
The same after standing 5 min.	4.5
After one stroke of a brush so as to reduce the depth of mud and water to ⅛-in.	2.3
One stud with short skate resting on it. Wet mud about ¼-in. deep	1.2
The same with mud deeper. Very bad road conditions	2.5
The same with thin mud and water as it would be on an ordinary wet day	0.4
The same dry	Practically none

It must also be remembered that in the Murphy System each car carries a brush which sweeps away the slush and mud before the contact shoe impinges upon it, so that the worst conditions that could be created with natural resources would be very much mitigated before the car began to take current from the section.

It is further to be noted that the leakage rated would obtain only for the very brief interval during which the car was over the section. Respectfully yours,

E. V. Baillard.

5 Beekman St., New York city, May 1, 1899.

SAFE LOAD ON SOIL AT NEW ORLEANS, LA.

For the purpose of testing the bearing capacity of the soil in New Orleans, La., preliminary to erecting a steel water-tower, Mr. F. J. Llewellyn, M. Am. Soc. C. E., Vice-President and Chief Engineer of the Gillette-Herzog Manufacturing Co., of Minneapolis, conducted a series of experiments in December, 1898. The point selected was on the outskirts of New Orleans, at the commencement of the swamp. In Minneapolis it is commonly assumed that the soil will support from 1,000 to 1,500 lbs. per sq. ft. without subsequent compression, or settlement under the load. But as a result of the test in New Orleans it was concluded that 650 lbs. per sq. ft. was the greatest permissible load. As this would have required a very large footing-area, it was deemed more economical to use piles; and 5 30-ft. piles were, therefore, driven under each of the four piers, capped below water-level, and these supported brickwork for the anchorages only.

The ground was tested near the works of the Standard Cotton Seed Oil Co., and three pits were dug, each 5 ft. deep and 4 ft. square. The water was found 18 ins. below the surface, and the bottom of the pit was in blue clay. This bottom was well probed for stumps to a depth of 8 ft., and none were found. On the bottom of each pit was laid a cypress wood foundation, 3 ft. square, and made of 3 × 12-in. timbers, doubled and crossed. On this foundation was placed the test load; scrap iron being used to the water surface and brick above that surface. The test pits were loaded as follows, allowance being made for displacement:

Pit.	Total per sq. ft., lbs.	Total load, lbs.
No. 1	650	6,100
No. 2	1,000	9,280
No. 3	1,300	12,000

Immediately after loading, the vertical distance was carefully measured between the top of the center of the foundation timbers and the lower edge of a strip stretching across the center of the test load. In the three cases this distance was 82¼, 118, and 111⅛ ins., respectively.

The tests were commenced on Dec. 13, and on Dec. 17 the settlement for No. 1 was found to be ⅛-in.; on Dec. 19, it was the same; but it was 1-32-in. more on Dec. 24. For No. 2 it was 5-16-in. on Dec. 17; 1-16-in. more on Dec. 19, and ⅛-in. more on Dec. 24. For No. 3, the settlement was ⅜-in. on Dec. 17; 1-16-in. more on Dec. 19, and 1-16-in. more on Dec. 24. The weather was clear and cold for the first two days; then became cloudy and damp on Dec. 15, and rained on Dec. 18; it became clear and warm on Dec. 20, and remained so until Dec. 23, when it became cloudy and rained on Dec. 24. The necessity for getting to work prevented longer observations on the test pits; but enough was learned to make the course outlined above advisable.

THE BOSTON ELEVATED RAILWAY.

(With two-page plate.)

The Boston Elevated Ry. Co. was incorporated in 1894, and in 1897 the Massachusetts State Legislature amended the original act by giving to the company additional powers and locations. As the law now stands the company has the following powers:

(1) To construct lines of elevated railway to be operated by electricity or other motive power except steam, according to such routes and plans as the State Board of Railroad Commissioners may approve.

(2) To have the Boston Transit Commission, upon compliance by the railway company with certain requirements, construct a subway under or near Cambridge St., and under Bowdin Square and Court St., to connect with the existing subway; also to construct a tunnel or tunnels of sufficient size for two railway tracks from a point on or near Hanover St., or such other point as the Commission may deem proper for suitable connection with the subway, to a point at or near Maverick Square, in East Boston, where a suitable connection with the surface tracks may be made. Finally, the Transit Commission is to lease this new subway and tunnel line to the Boston Elevated Ry. Co., for 25 years, at an annual rental of 4⅞% of the gross receipts of all lines owned, leased, or controlled by the railway company.

(3) To lease and operate the lines, property, etc., of the West End Street Ry. Co., and other street privileges. The lease of the West End St. Ry. Co. has already been made.

Broadly summarized, the Boston Elevated Ry. Co. thus controls, besides its own elevated lines, all the vast network of street railway lines formerly controlled by the West End Street Ry. Co.; the rapid transit subway already built and additional subways and tunnels ordered to be built in the future, and also possesses a free field to buy or lease any other street and elevated lines it may desire, subject to the approval of the State Railroad Commissioners. Some idea of the great extent of this transit system may be obtained by examining the accompanying map on which are shown all the lines of the West End Street Ry. Co., the route of the new subway, and the proposed route of the elevated line proper.

Another preliminary matter which needs to be noted is that the law incorporating the elevated railway company, as amended, provides that the fare charged shall not exceed "five cents for a single continuous passage in the same general direction upon the roads owned, leased or operated by it," and, therefore, the terminal stations at Roxbury and Charlestown are made transfer stations, at which passengers can be transferred from the surface to the elevated lines or vice versa. The means adopted for accomplishing this will be described further on.

Route.—The route of the elevated line in Boston proper is shown by the map, Fig. 1. As will be seen, it connects with the subway to form a loop line in the business section of the city. The total length of the line between terminals, not including any of the subway, is about seven miles, and along this distance there will be eleven stations, located at an average distance of half a mile apart. The general character and appearance of these stations were illustrated in Engineering News of March 31, 1898. Besides the line shown on the map, the charter of the company provides for two branch lines, one extending east into South Boston, and the other running west into Cambridge, but neither of these are to be constructed at present.

The line actually under construction, therefore, is that shown on the map, and the state of the work at the present time is about as follows: The interfering buildings along the right of way are being torn down, and work is progressing on the column foundations, many of which are completed, and the contracts have been let for practically all of the superstructure except the Sullivan Square Terminal. The contracts for the metal work have been divided between the Pencoyd Iron Works, of Philadelphia, Pa., Carnegie Co., and the Pennsylvania Steel Co., of Steelton, Pa., the first concern having the bulk of the work. According to the contracts all of the work is to be completed early in 1900.

Foundations.—The foundation work consists principally of the piers on which the columns rest, and is being done entirely by the railway company. These are of concrete founded upon solid rock or compact earth without piles and upon pile clusters where the ground is soft. Fig. 2 shows two of these piers uncovered, so as to display the three courses of concrete, while Fig. 3 shows the top of another pier with the cast pedestal and holding down bolts in place. The cost of these piers runs from $200 to $300 each.

Superstructure.—The superstructure is of the regular elevated railway deck type, in which the columns are connected by cross girders, which carry four main longitudinal girders, two under each track. Fig. 4 shows the column and cross girder construction in detail, but, being located on a curve of the Dudley St. loop there is of course a difference between the longitudinal girder connections as shown here and those for the ordinary tangent line. About the only feature of the column construction proper, which merits especial notice, is the use of especially rolled channel sections having the form shown by Fig. 4a. The standard longitudinal girder construction is shown by Fig. 5, which shows a girder for a maximum span of 63 ft. For spans of 54 ft. a girder differing from this only in minor details is employed, and Fig. 6 shows the details of the expansion and fixed end construction of one of these girders. The two illustrations, Figs. 5 and 6, show all the essential main characteristics of the longitudinal girder construction, on the regular line work. At the Dudley St. terminal, where a minimum elevation of the tracks was desired, with the standard head-room below for street cars, and where it was necessary to prevent drippings, a special through girder and solid floor construction was employed, which is fully shown by Fig. 7.

Material and Workmanship.—The character of the metal-work is best described by quoting from the specifications. These are in abstract as follows:

Inspection.—The inspection and tests of material will be made at the mills promptly on its being rolled, and the quality will be determined before it leaves the mills. The inspection of workmanship will be made at the shops and site at as early a period as the nature of the work will permit.

Metal.—Unless otherwise specified all metal shall be of medium steel, but soft steel shall be used for rivets and adjustable members. Cast-iron may be used only for pedestals, wheel fenders on columns or posts exposed to wagon traffic and for ornamentation. All steel shall be manufactured by either the acid or the basic open-hearth process, and must be uniform in character for each specified kind. A chemical analysis of every melt shall show not over .05% of sulphur; of phosphorus, not over .04% in basic steel or .08% in acid steel will be allowed, except in rivet steel in which the phosphorus shall be limited to .03%.

Tensile Tests.—The ultimate tensile strength of all steel, except that used for rivets and adjustable members, shall be 64,000 lbs. per sq. in. Steel for rivets and adjustable members shall have an ultimate tensile strength of 52,000 lbs. per sq. in. All test bars must have a tensile strength within 4,000 lbs. per sq. in. of that specified; and for medium steel an elastic limit of not less than one-half on the tensile strength of the test bar, an elongation not less than 22%, and a reduction of area not less than 40%. In determining the ductility, the elongation shall be measured after breaking on an original length of 8 ins., in which length must occur the curve of reduction from stretch on both sides of the point of fracture. For rivet steel the elastic limit shall not be less than 30,000 lbs. per sq. in. The elongation in 8 ins. shall not be less than 28%, and the reduction of area not less than 50%. All broken samples must show a silky fracture of uniform color.

Bending and Drifting Tests.—Specimens of medium steel when heated to a cherry red and cooled in water at 70° F., shall be capable of bending 180° around a circle whose diameter is equal to the thickness of the test piece, without showing signs of cracking on the convex side of bend. Specimens of rivet or soft steel shall be capable of bending cold 180° to a close contact without any signs of cracking, and when nicked and broken, or when rivets are cut-out after having been driven, the metal must show a fibrous, silky structure with no crystalline appearance. Punched rivet holes in medium steel, pitched two diameters from a sheared edge, must stand drifting until their diameters are increased 50%, and must show no signs of cracking the metal.

Variation in Weight.—A variation in cross section or weight of more than 2½% from that specified shall be cause for rejection; and no excess of metal above that computed from the drawings exceeding 2½% will be paid for.

Workmanship.—The ends of all lacing-bars shall be cut to a neat curve concentric with the rivet hole. All idle corners on plates or angles exposed to view shall be neatly chamfered off at an angle of about 45°. The interior curves in gusset plates, brackets, etc., shall be punched or cut with dies corresponding to the radius of curvature so that when finished the edge will be smooth and even. No sharp or unfilleted re-entrant corners will be allowed. In all cases where a steel piece, in which the full strength is required, has been partially heated or bent, the whole piece must be subsequently annealed. In pieces of secondary importance where the bending is slight, said bending is to be made cold and no annealing will be required. Crimped web stiffeners will not require annealing.

Rivets when driven must completely fill the holes, have full heads concentric with the rivet holes, and be machine driven whenever practicable. The machine must be capable of retaining the applied pressure after the upsetting is completed. Whenever possible the work shall be shop riveted. The following rule will generally govern the location of rivets: The pitch in the direction of the main stress shall never exceed 6 ins., except in members composed of only two angles, where connecting rivets may he spaced not exceeding 18 ins. At right angles to the line of stress, rivet lines shall not be further apart than 30 times the thickness of the thinnest plate connected, nor shall the outside row of rivets be further from the edge than 8 times the thickness of the outside plate. The distance between the edge of any piece and the centre of a rivet hole must never be less than 1½ ins., excepting for lacing-bars, small angles, fillers and where especially shown otherwise on the drawings; and whenever practicable this distance shall be at least two diameters of the rivet. Rivet holes must be accurately spaced; the use of drift pins will be allowed only for bringing together the several parts forming a member, and they must not be driven with such force as to distort the metal about the holes. If the holes must be enlarged to admit a rivet, it must be reamed.

All rivet holes in steel work, if punched, shall be made with a punch ⅛-in. in diameter less than the diameter of the rivet intended to be used, the die being as nearly the same diameter as the punch as possible for each thickness of metal, and they shall afterwards be reamed by means of cylindrical drills or reamers to a diameter 1-16-in. greater than that of the rivet. Before this reaming takes place all the pieces to be riveted together shall be assembled and bolted into position, then the reaming shall be done; for one of the principal objects of this clause in relation to sub-punching is to ensure correct matching of rivet holes and the avoidance of holes of excessive diameter.

All holes for field rivets, excepting those for lateral and sway bracing, shall be enlarged by reaming after erection, unless they have been drilled to an iron template or temporarily assembled and reamed in the shops.

All abutting surfaces of compression members, except flanges or girders, when the joints are fully spliced, must be planed or turned to even bearings so that they shall be in as perfect contact throughout as can be obtained by such means; and all such finished surfaces must be protected by a thick coating of white lead and tallow before being shipped from the shop.

The ends of all web plates that abut against other web plates must be faced true and square or to exact bevel, and the end stiffeners must be placed perfectly flush with these planed ends, so as to afford a proper bearing for the ends of the attaching girders. Web plates must not project beyond the flange angles or be more than ⅛-in. back from the faces of same.

FIG. 1.—MAP OF BOSTON, MASS., SHOWING ROUTE OF NEW ELEVATED RAILWAY, AND ITS CONNECTIONS WITH THE RAPID TRANSIT SUBWAY AND THE SURFACE STREET RAILWAYS.

The lower ends of posts must be planed off square and true, so that they may bear properly against the base plates or pedestals. The base plates must also be true and absolutely perpendicular to the axes of posts. The upper ends of posts, where cross girders rest upon them, shall be machine-faced perpendicular to their axes.

All stiffeners on plate girders are to have their ends milled to fit the horizontal legs of the flange angles. Any stiffeners which after being riveted are not in contact at these points, must be cut out and replaced.

When members are connected by bolts which transmit shearing stresses, as may be the case at points where it is impossible to drive rivets, the holes must be reamed parallel and the bolts must be turned to a driving fit. After

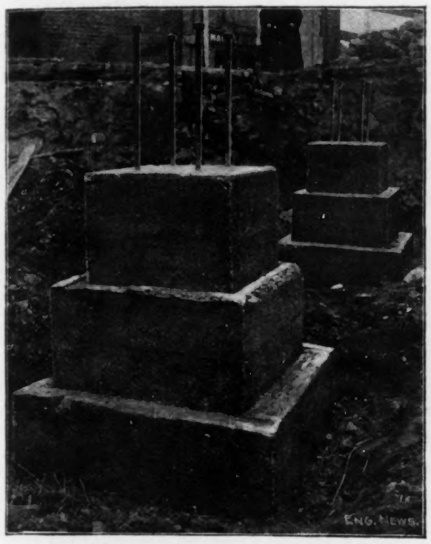


Fig. 2.—Column Foundation for Boston Elevated Railway, Uncovered, to Show Masonry.

the nut has been tightly screwed on, the thread will be cut across with a chisel to prevent loosening. The dimensions of all square and hexagonal nuts shall be such as to develop the full strength of the body of the bolt or adjustable member. Washers and nuts must have uniform bearings.

Painting.—Before assembling the component parts of any member, all faces coming in contact, or inaccessible to paint after being riveted up, shall receive a good coat of paint. Before the structure is erected, all surfaces which will come in contact at erection, or which will be inaccessible after erection, shall receive two coats of paint. One of these coats may be applied before the metal leaves the shops; the other, however, must be applied in the field immediately before erection. After the shop work is completed, and before leaving the shop, all metal work shall be thoroughly cleansed of all scales, rust, etc., preparatory to being painted, and as soon as possible after any portion of the structure is erected and completed, the contractor shall thoroughly cleanse the metal work of all accumulations of dirt, cinders, grease or other objectionable materials that may be found thereon, and in every way prepare the structure for final painting.

Erection.—The contractor shall furnish all staging, false work, travelers, derricks, tackle and tools necessary for fulfilling his duties under this contract, all of which shall be of modern design and such as will facilitate the rapid erection of the structure. They shall be constructed of sound materials and shall at all times be subject to the approval of the engineer. The contractor shall erect, adjust and rivet the structure and cleanse all metal work ready for painting.

Nearly all of the metal work is to be erected over the lines of surface cars run by electricity by the overhead trolley system. The contractor must so arrange his work as not to interfere with the running of the surface cars, and where surface cars are in operation he will be required to do the raising or hoisting of all material in the night time between the hours of 12 o'clock midnight and 5 o'clock in the morning, and during those hours the trolley wires will be removed by the company for such a distance on the street as the contractor may require, provided, however, that at the intersection of streets and other places where the wiring is of a special character, the company instead of removing the wires altogether will cause them to be cut dead between said hours, and adjusted so as to occasion the contractor as little inconvenience as possible. As soon as the parts are raised they shall be temporarily connected together with bolts, a sufficient number as the engineer may determine being used to safely carry all the dead weight of all parts of the structure which may come on them, together with the derricks, rigging and hoisting machinery which the contractor may wish to use on top, for the erection of the adjoining spans. As rapidly as possible after the erection the work shall be riveted. Before riveting the longitudinal girders to the transverse, and the transverse girders to the posts, the fitting-up bolts shall be sufficiently slacked up to make sure that the supported members rest on the shop-riveted seats provided for them.

The company shall have the right to attach its trolley, and feed wires, as well as telegraph, telephone, electric light or other wires, to any part of the structure during construction, and the contractor must so conduct his work that the trolley wires may be attached to each transverse girder as the traveller passes over it, and so that the surface car line can be opened at 5 o'clock in the morning. The riveting of the structure may be performed during the day. The company will not be responsible for any accidents caused by the trolley, feed or other wires,

Fig. 3.—Column Foundation, Boston Elevated Railway, Showing Shoe and Holding-Down Bolts in Place.

to men or materials upon or about the work in connection with the performance by the contractor of his work hereunder, and the contractor agrees to hold the company harmless and indemnified from any claims in respect to such accidents.

On that portion of the line occupying narrow streets, or where the posts are set on or near the curb lines, no materials will be allowed on the surface of the streets except during the night, that is, between 7 p. m. and 5 a. m., without special permission from the engineer. On the remaining portions of the streets only such materials shall be placed in the streets during the day as may be permitted by the engineer.

Dudley St. Terminal.—As already stated, the two terminal stations at Roxbury and Charlestown will also be transfer stations, between the surface and elevated lines. Figs. 8 and 9 show the plan of the Dudley St. terminal, at Roxbury. The elevated line coming south on Washington St., turns to the left on Dudley St. and loops back on itself, passing through the terminal station on the route, as shown by the general plan, Fig. 8. Surface cars coming from a generally southern direction east and west on Dudley St., ascend to the elevated railway level by inclines terminating in east and west loops. Another set of surface cars pass under the elevated platform at right angles to its length, where they load and unload at a surface platform. Fig. 9 shows the relative locations of the elevated and surface platforms, and the means of communication between the two levels. One ticket office and the surface car waiting-room are on the surface level, but the elevated railway waiting-rooms and the other ticket office are at the upper platform level. Figs. 10 and 11 show a side and end elevation of the station, which also help to explain the construction and method of transferring passengers, and show the general architectural appearance of the station.

Track Construction.—The type of track construction has not been finally decided upon, but the construction which is now planned is shown by Fig. 12. This drawing needs no explanation except to state that every fourth tie which extends outside of the girders to carry the sidewalk is 7 × 8 × 12 ins., instead of 7 × 8 × 8 ins., as are the regular track ties. The Railroad Commissioners require the ties to be notched over the girders. The ties, walk and general timbers are to be of long-leaf Southern pine, and the rail joints of the "Continuous," or "Weber," pattern; the track rails are to weigh 85 lbs., and the contact rails 50 lbs. per yard, both of the American Society of Civil Engineers recommended sections; and the bolts, spikes and tie-plates are to be of steel.

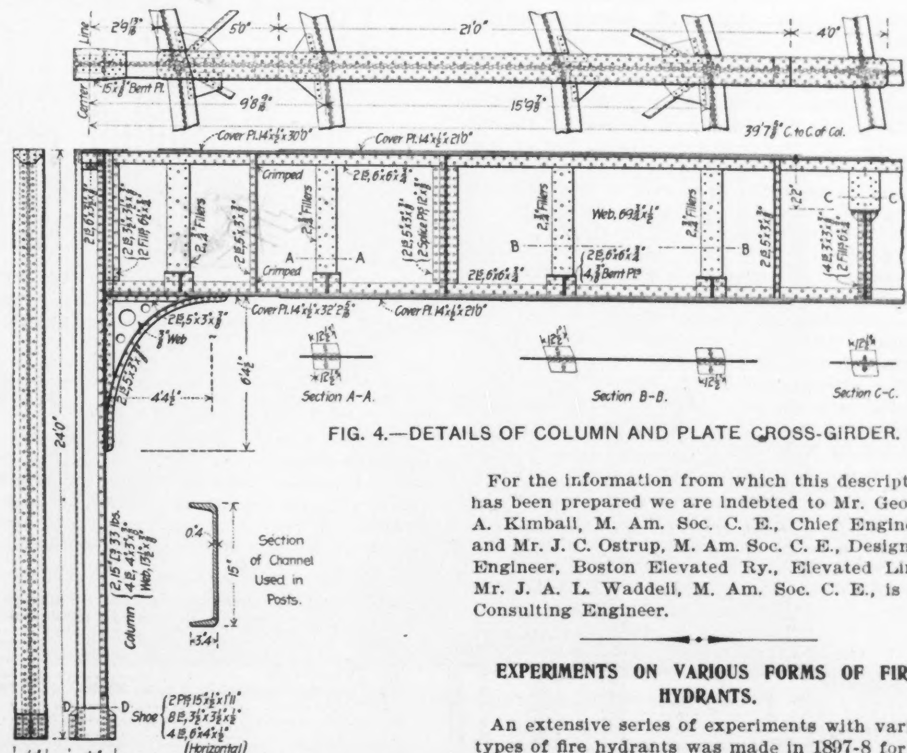


FIG. 4.—DETAILS OF COLUMN AND PLATE CROSS-GIRDER.

For the information from which this description has been prepared we are indebted to Mr. George A. Kimball, M. Am. Soc. C. E., Chief Engineer, and Mr. J. C. Ostrup, M. Am. Soc. C. E., Designing Engineer, Boston Elevated Ry., Elevated Lines. Mr. J. A. L. Waddell, M. Am. Soc. C. E., is the Consulting Engineer.

EXPERIMENTS ON VARIOUS FORMS OF FIRE HYDRANTS.

An extensive series of experiments with various types of fire hydrants was made in 1897-8 for the water department of the city of Holyoke, Mass. by Mr. Chas. L. Newcomb, M. Am. Soc. M. E., of Holyoke. The results of these tests have been embodied in a lengthy paper by Mr. Newcomb, read at the meeting of the American Society of Mechanical Engineers, at Washington, D. C., this week. The following is an abstract of some of the most important results presented. Part of the tests were under the direct charge of Mr. Ezra E. Clark, of Springfield, and the balance were in charge of Mr. A. L. Kendall, of the Factory Mutual Fire Insurance Co. Mr. John R. Freeman, M. Am. Soc. C. E., made valuable suggestions regarding the work.

Mr. Newcomb states that so far as he can learn no other fire hydrant tests of importance have been made, or published, except a few in 1886, by Prof. Selim H. Peabody, of the University of Illinois, and observations on the nozzle or butt discharge of one hydrant, by Mr. Freeman.

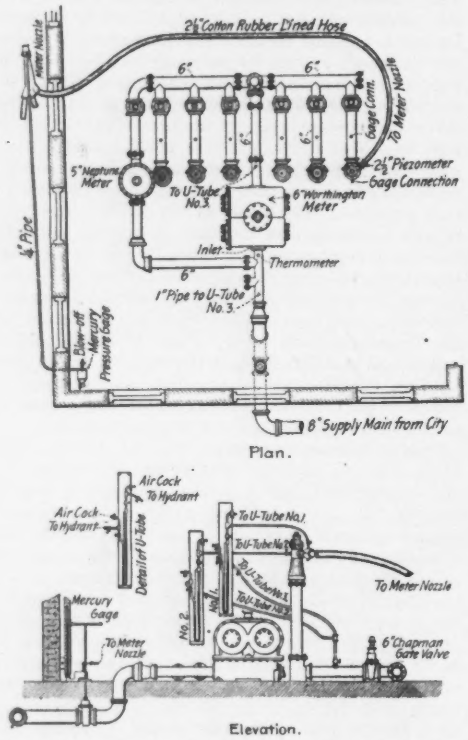


Fig. 1.—Arrangement of Apparatus for Testing Hydrants at Holyoke, Mass.

The object of Mr. Newcomb's tests was to make a complete investigation of the fire hydrants in most common use, the work being classified as follows: (1) Friction losses caused by the hydrants. (2) The discharging capacities of open hydrant nozzles under different pressures. (3) Water hammer due to quickly closing the main gate. (4) General features of construction, certainty of action, strength and durability. A total of 22 hydrants were tested, there being from 1 to 7 different hydrants from nine manufacturers, principally to include variations in size and number of outlets, or to include both gate and compression valves. Each hydrant tested is described in detail in the paper.

The arrangement of the testing apparatus is pretty fully shown by Fig. 1. The methods of conducting the tests for friction losses is thus described by Mr. Newcomb:

In all the tests observers were placed at the different gages and took readings simultaneously at the sound of a bell, a warning bell being struck five seconds before the time for reading. The majority of the tests were of ten minutes' duration, and readings were taken each minute. A few of the tests were of five minutes' duration, and in these half-minute readings were taken.

The following programme was adopted for all the friction-loss tests:

Condition.	Size of meter nozzle, ins.	Approx. pressure at nozzle, lbs.	Approx. gallons per min. flowing.
One-hose outlets	¾	66	130
" "	1¼	46	250
" "	1½	33	350
" "	1¾	24	450
" "	2	19	550
Two-hose outlets	1½	65	375
" "	1¾	30	500
" "	1¾	45	625
" "	2	34	750
" "	2½	17	850

In all cases after the water was started ample time was allowed before the readings were commenced to make sure the water had come to a steady condition of flow.

Before or after each series of tests the zero readings of the mercury column was obtained by filling the gage connections with water and holding the end level with the center of the nozzle and then reading the gage.

At the end of a series of tests the averages were quickly computed and checked, and the gross loss in pounds, and the gallons per minute discharged for each condition, were plotted on cross-section paper and a curve drawn through the points. This gave a constant check on the work and quickly showed up any error. The occasional prompt finding of a discrepancy tended strongly to impress the observers with the need of care in taking readings and handling the apparatus. For this reason and for the greater ease with which any trouble is located and remedied, and for the chance of studying the results and investigating at once while the apparatus is in place any special feature, this method of carrying the computations along with the work is believed to be of the greatest benefit to the experimenter. The chance of false readings was carefully guarded against by liberal blowing off of all connections before each test. For a number of hydrants series of tests were repeated to try the accuracy of the work, and it was almost invariably found that the two series agreed well within practical limits.

The question was raised as to whether the velocity of water through the 2½-in. hydrant butt might not cause such a contraction of the stream as to affect the readings of the U-tube. Two series of tests were therefore made on one hydrant, one with the 2½-in. piezometer next to the hydrant outlet, which was the usual arrangement, and the other with a piece of 2½-in. pipe about 2 ft. long between the hydrant and the piezometer. A special test for the friction loss in this 2½-in. pipe was then made, and, correcting for this loss, the results were found to be practically the same in the one case as the other, showing that the piezometer screwed directly to the hydrant could be relied upon for accurate results.

The most notable thing brought out by the whole investigation, to our mind, is the small range of friction losses in the various makes of hydrants under conditions similar to those of actual service. For instance, with one stream flowing at the rate of 300 gallons per min., the minimum total loss was 0.59 lbs., and the maximum total loss was 2.40 lbs. With one stream at 500 gallons, the range was from 1.72 to 6.25 lbs. The friction losses for two streams, flowing at the rate of 500 gallons per min., are shown by the diagram reproduced herewith, Fig. 2, which is one of four so-called pyramid diagrams used to present the friction losses graphically. It will be noticed that the friction is divided into barrel and nozzle losses, the latter here meaning hydrant nozzles.

A 4-in. barrel is too small for a two-way hydrant. The differences in barrel losses for hydrants, having about the same dimensions,

must be accounted for largely by differences in the design of the gate and the water passages in the immediate vicinity. Sharp corners, restricted sections, and sudden changes in the area of the passages all tend to produce eddyings, which use up pressure.

The high nozzle losses are attributed to "sharp, jagged corners at the outlets," and the low ones to rounded and smooth outlets.

Regarding the total losses in the hydrant, the following observations may be quoted:

It is desirable that the waste of pressure through a hydrant should be as small as it is practicable to make it. In high-pressure systems the losses found for the average hydrants are perhaps tolerable, but in lower-pressure systems—and many systems having a nominally high pressure become low under heavy draughts—every avoidable loss is objectionable. In the hydrants without independent gates, a simple rounding of the corners of the core at the outlet will make a material improvement in the nozzle losses. Reduction of loss for independent gate hydrants is more difficult, but some improvement is probably possible without serious trouble. The fact that some makers have found out how to reduce the barrel losses, so called, to comparatively small amounts is good working ground for improvements in those hydrants now having rather large losses.

It is not to be understood that this friction loss is the criterion for a perfect hydrant. Certainty of action under all conditions is of the greatest importance, but, other things being equal, the hydrant having the smallest total friction loss when working at its full capacity is the best.

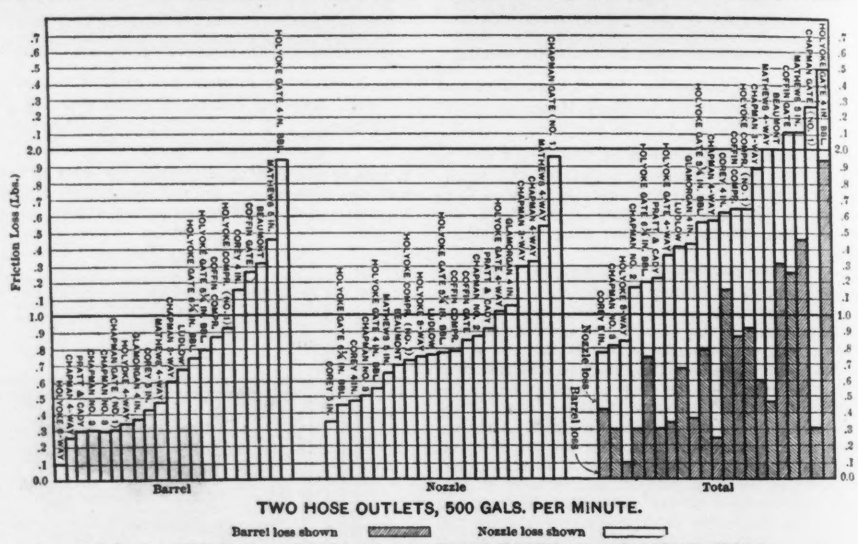


FIG. 2.—FRICTION LOSSES IN HYDRANT TESTS AT HOLYOKE, MASS.

While we agree heartily with the author, in the main, we must again say that we think the differences between the several hydrants is remarkably small. But there is every reason why the loss should be reduced to a minimum, especially if it is principally a matter of designing and finishing the curved portions of the waterways.

Characteristics of Hydrants and Tests for Strength.

Name of hydrant.	Weight, lbs.	Inside volume, cu. ft.	Time to drain, mins. secs.	Hydrostatic test of— Main valve. Pressure, lbs.	Main valve. Result.	Hydrant barrel. Pressure, lbs.	Hydrant barrel. Result.	Result of test of valve stems.
Beaumont	290	0.69	2 30	180	Valve tight	300	Drip leaked very little...	Stems twisted off.
Chapman No. 1.	435	1.39	7 30	180	Pressure dropped in ¼ min., 80 lbs.	150	Caps leaked...	Stem twisted out of shape.
Chapman No. 2.	425	1.44	7 15	...	...	...	...	...
Chapman No. 3.	734	2.29	5 11	...	...	...	...	...
Chapman 3-way	577	1.63	7 01	...	...	...	...	...
Chapman 4-way	580	2.24	.. ..	...	...	...	...	...
Coffin Gate	467	1.59	.. ..	180	Pressure dropped in 1 min., 80 lbs.	240	Caps leaked.	Not injured.
Coffin Compression	506	1.44	7 30	180	" " " 1 " 75 "	280	" "	Stem strained, but not broken.
Corey 4-in.	418	1.55	2 20	180	" " " 1 " 80 "	200	" "	...
Corey 5-in.	560	2.24	3 40	180	Pressure dropped in 40 secs., 80 lbs.	300	" "	Not injured.
Glamorgan, 4-in.	531	1.22	2 05	180	Valve tight	280	" "	Top of stem broken off.
Holyoke Gate, 4-in.	356	1.02	.. ..	...	...	...	...	...
Holyoke Gate, 6¼-in.	500	2.16	9 00	180	Pressure dropped in 1 min., 80 lbs.	300	Caps leaked...	Stem twisted off.
Holyoke Compression No. 1.	669	1.20	4 30	180	" " " 1 " 80 "	220	" "	Bottom of hydrant pushed out
Holyoke Compression No. 2.	538	0.77	.. ..	...	...	...	...	...
Holyoke Gate, 4-way	580	2.24	.. ..	...	...	...	...	...
Holyoke Gate, 6-way	...	....	31 06	...	...	...	...	...
Ludlow	497	1.87	3 40	180	...	280	Caps leaked...	Stem twisted out of shape.
Mathews 5-in.	750	1.42	5 30	180	Pressure dropped in 50 secs., 80 lbs.	280	Flange at bottom leaked.	Top of stem broken off.
Mathews 4-way	757	1.50	.. ..	...	...	...	...	...
Pratt & Cady	688	2.28	15 ..	70	Valve leaked badly.	220	Caps leaked.	Yoke, bottom of hydrant broken

The water hammer tests showed that the gate hydrants generally gave considerably less hammer than the compression type. Regarding the claim urged by some that firemen desire to obtain the full hydrant pressure as speedily as possible, it is urged

that in the long run it will be very much better to insure the safety of water mains by avoiding heavy water-hammer effects than to gain a few seconds of time at the risk of crippling the distributing system, very likely at the critical point of a fire.

The results of the tests for strength are given in the accompanying table. In two hydrants without positive drips the drips got out of order and failed to close when the main valve was open.

The hydrostatic tests were designed to show how the hydrant would act under abnormal pressures. The greater part of the discussion of the results shown in the table is given in the following quotation:

A broken or twisted valve stem is not an uncommon result of the excitement of a large fire. Sometimes a hydrant sticks, or a mistake is made in the direction to turn for opening or closing. Often, in such cases, if one man cannot start the hydrant, two or more men take hold. In this connection it is somewhat surprising that so far as known no one has yet made a hydrant which is not liable to serious damage if a forcible attempt is made to turn it in the wrong direction, either opening or closing; something accomplishing what the ratchet on a stem-winding watch accomplishes seems possible and greatly preferable to the simple limit of breaking strength. Such a device might also give the fireman immediate evidence that he was wrong, thus saving time. A hydrant cannot be expected to stand unlimited abuse, but to get some idea of the ability of the hydrants to withstand such usage the following tests were made: Two ordinary men were instructed to open each hydrant, using the regular hydrant wrench, which is 17 ins. long, exerting their maximum strength in an effort to open the hydrant beyond its natural limit. If no injury resulted they closed the hydrant, exerting again their maximum strength after the hydrant was completely shut. These tests, therefore, took the strength of two ordinary men using a wrench of definite length as the measure of the force applied. It is not exact in any way, but gives some results which, in a practical way, are somewhat useful. In most instances some injury was done to the hydrant, the stem generally being the point to give way, though in one case the bottom of a hydrant was actually pushed out by attempting to open it beyond its natural limit. (The results of these tests are given in the last column of the table.—Ed.)

Time did not give a chance for any complete tests on the durability of the working parts of the hydrant, but starting with the assumption that a hydrant might be opened on an average ten times a year, and should be good for a service of twenty years, each hydrant was opened and closed 200 times. No special derangement of wear resulted, except in two cases, in which the stuffing-box nut on top of the hydrants showed a tendency to work loose.

In a number of the hydrants the design has been made with the idea of facilitating repairs. In some cases this resulted in considerable restriction to the waterways. It is believed that in most cases, by keeping the desirability of free waterways in mind, ability to make quick repairs can be combined with smooth, free waterways. In this connection the friction-loss tests will be of value in showing what can be done and what should be avoided.

FAILURE OF DAM AT MINNEAPOLIS DUE TO PREVIOUS WEAKENING THROUGH ICE PRESSURE.

By James W. Rickey.*

A striking example of the effect of ice pressure, causing the failure of a masonry dam by sliding, was afforded in the case of the destruction of a portion of the main dam belonging to the Minneapolis Mill Co., which controls the falls of the Mississippi River at Minneapolis, Minn.

Fig. 1 shows a cross section of the mill pond, dam and river basin.

The sectional dimensions of the dam, which is 535 ft. long, are shown. It was built during the winter of 1893-4, of first-class ashlar masonry, with Kettle River sandstone facing and Trenton limestone backing, all very large stones, laid in Louisville cement mortar, 1 part cement to 2 of sand.

On the left of the dam, the river basin just above the main falls, is shown, while on the right is the mill pond.

It will be remembered that the winter just passed was one of unusual severity in this locality, both as regards the exceedingly low temperature, and the continued duration thereof; as a result, the ice formed in the river to an unprecedented thickness. To afford an idea of the intensity of the cold, it may here be remarked that when a diver made an examination of the dam in February, 1899, he found that ice had formed upon the upstream face from 10 to 12 ft. below the surface, and that at this depth it was from 10 to 12 ins. thick! The only way this ice could have

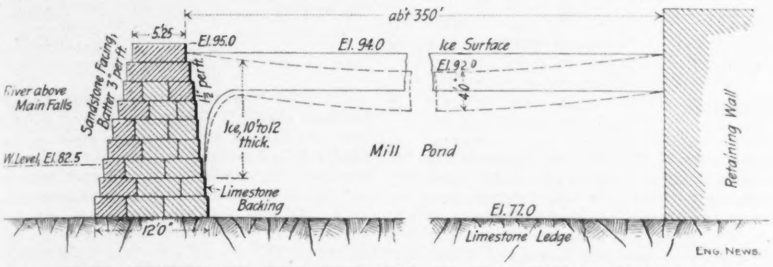


FIG. 1.—CROSS-SECTION OF DAM AND MILL POND OF THE MINNEAPOLIS MILL CO.

formed was by the cold penetrating the dam itself, since it could not freeze to this depth from surface exposure. The contour of this ice along the upstream face of the dam is shown in Fig. 1.

On Sundays, when there is no draft by the flour mills, the water rises in the mill pond to about El. 94.0; while it is drawn, at intervals, down to El. 92.0 during the remainder of the week. The surface of the ice in the former case is shown in Fig. 1, by the full line, and in the latter case by the broken line. The effect of this alternate rising and falling during the past five years has been to crack and raise the ice in the middle of the pond, and not to exert any dangerous pressure at the side against the dam. During the early part of February, 1899, the ice formed to a thickness of about 4 ft., during the time when the surface was drawn down to about El. 92.0; when it raised on Sunday to El. 94.0; it did not crack and rise, as usual, in the middle of the pond, but, expanding laterally, it moved the dam so that the coping, which was originally level, was 3 ins. low on the downstream side of the dam.

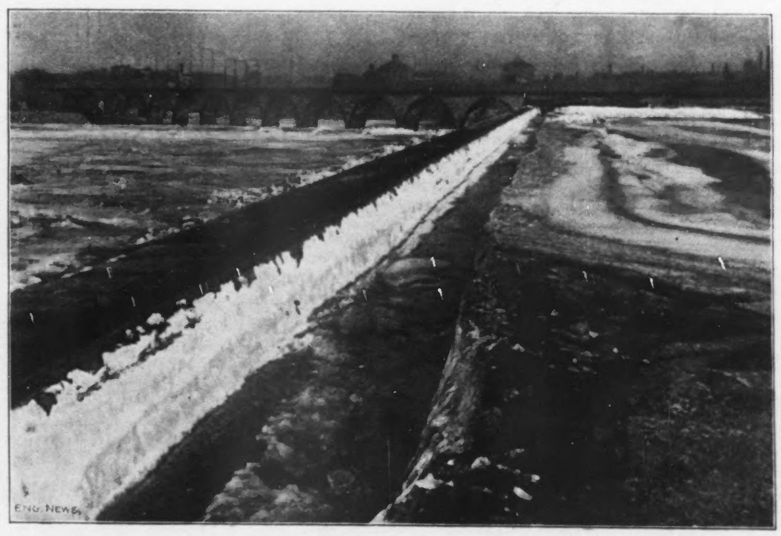


FIG. 2.—TRENCH CUT IN ICE ALONG FACE OF DAM.

Subsequent observations showed that the dam had not slid, but had revolved as an unbroken mass, about, or near, the toe; the top having moved downstream from 10 to 12 ins., the bottom remaining fixed. A trench was immediately cut in the ice along the upstream face of the dam for its entire length, and it was maintained during the remainder of the winter. This trench is shown in Fig. 2.

A series of observations showed that, as spring advanced, the dam was gradually settling back into its original position, and on April 24 it had returned more than half way. No percolation of water, entering through or under the dam, had at any time been visible.

Meantime, at intervals of about 25 ft., 4-in. holes were drilled vertically through the dam and extended 4 ft. into the solid ledge beneath. Into these holes, steel rods, 3 ins. in diameter, were inserted, and grouted in with Portland cement.

The dam had safely withstood 2 ft. of water running over its crest during the spring freshet in 1897, and as no leakage could be found, coming through or under it, since the movement in February, it was considered safe, pending improvements in the line of buttresses, as soon as the spring freshets had passed. April 29, the water rose to within 1 in. of the crest of the dam with no leakage or sign of failure. On Sunday, April 30, at 7.30 a. m., the water was running over the crest 2 ins. deep, when suddenly, without the slightest warning, a stretch of 170 ft. failed by sliding. The plan of this break is shown by Fig. 3, and a photographic reproduction in Fig. 4. There were two eyewitnesses to this sliding, and their testimony is corroborated by the fact that a section of the dam, marked "A," 30 ft. long, and weighing approximately 400 tons, revolved about the point "B," where the stone dam joined a concrete pier, as an entire and almost unbroken mass. The corner, "C," of this section, moved about 5 ft. from its original position.

It is thought that the extreme pressure of the ice opened up a joint in the dam, extending almost to the face, but not allowing water to flow through. The water entering this joint created an upward pressure which probably caused the failure at the 50-ft. spillway, which, while planked up, was 4 ft. lower than the crest of the dam. It will be impossible to examine the break closely until a coffer dam is built.

The estimated cost of repairs is $35,000, including the cost of the 900-ft. cofferdam, designed to retain an 18-ft. head of water. Until the cofferdam is completed the mills will only be able to run on half water power.

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NOTES FROM THE ENGINEERING SCHOOLS.

Cornell University.—An interesting pamphlet entitled "Summer Vacation Work in Railway and Locomotive Shops, as a Supplement to and Preparation for Courses in the School of Railway Mechanical Engineering," has been issued by the University. The pamphlet was written by Mr. H. Wade Hibbard, Principal of the school, and explains the advantages of this class of summer work. Arrangements have been made with certain locomotive builders and railway superintendents of motive power to take students of Sibley College into their shops during the long vacation, and pay them fair wages, everything considered. The pamphlet forms interesting reading, and can be obtained by addressing the college.

Another pamphlet entitled "Cornell and Ithaca Views" affords some idea of the beautiful scenery surrounding the University.

University of Minnesota.—The Engineering College now provides for a five years' course in the engineering departments. This course is one in which an engineering student may obtain more English and general culture studies, together with more science, than is now presented in any of the regular four-year engineering courses. At the end of four years the student taking this course obtains the degree B. S. in Engineering, and if he should complete the fifth year the full engineering degree, M. E., C. E. or E. E. will be granted.

This course does not in any way interfere with the present engineering courses, which will be administered as heretofore, leading to the full engineering degree at the end of the fourth year. The new plan simply allows a distribution of the work over a more extended period, thus offering opportunity for additional literary and scientific study.

Princeton University.—The civil engineers of the junior class will make a survey of the Manasquan River, near Point Pleasant, N. J. The survey party will leave on June 15, immediately after commencement. Prof. W. B. Harris has charge of the arrangements, and will direct the party.

University of Illinois.—The senior class in mechanical engineering made an inspection trip to Chicago on April 24, remaining until May 3. The time was spent in visiting various large plants in Chicago and vicinity, and tests were made of the machinery at the 12th St. Station of the Chicago Edison Co.

Columbia University.—Circulars have just been issued by the School of Architecture, giving the conditions for the fifth McKim Fellowship competition. It is the intention to award two single fellowships of $1,000 each, instead of one of $2,000. As usual the winners will be required to spend at least one year in travel and study in Europe. The subject for this year's competition, which began on April 1, was the design of a school and museum of architecture.

During the absence of Prof. Crocker, head of the Department of Electrical Engineering, who is traveling in Europe, Prof. W. A. Anthony is delivering the senior lectures on electric power, electrochemistry, and the management of electrical plants. The members of the senior class in electrical engineering, under the direction of Messrs. W. H. Freedman and G. F. Sever, visited the works of the General Electric Co., at Schenectady, N. Y., on Feb. 9 and 10. The following day the hydraulic-electric power plant at Mechanicsville, N. Y., was inspected.

Johns Hopkins University.—At the meeting of the Board of Trustees, held on May 1, authority was given for the reorganization of the Department of Physics. It is the intention of the directors of the laboratory to buy new apparatus, engage new instructors and invite distinguished lecturers from a distance.

THE PATTON AUTOMOBILE TRUCK, now being experimented with in Chicago, was invented by W. H. Patton, of that city. It is a combination of gas, or gasoline engine, electric generator, electric motors and storage battery, carried on each transportation unit, of whatever form. The truck now used is built for heavy work. It is 12 ft. long, 5½ ft. wide, and weighs, with machinery, but without load, about 3½ tons; it carries a load of two to three tons. The four wheels have iron tires 4½ ins. wide, wooden spokes and ball-bearings. It is said that solid rubber tires are to be substituted. Power is obtained from a 3-cylinder gasoline engine, made by the American Motor Co., and this is directly connected to an 8-kilowatt, 125-volt, six-pole Crocker-Wheeler dynamo. This set is installed lengthwise, well forward in the truck and under the driver's seat, projecting slightly above the floor of the wagon box. The dynamo is attached to one end of the engine-shaft, and a small flywheel is at the other end of the shaft. The engine and dynamo make 500 revolutions per minute; the cylinders are upright, and electric ignition is used, actuated by a current from the storage cells. Two 4-pole motors, claimed to be 7½ HP. each, are suspended partly on the rear axle and partly on the wagon-body; these two motors, one to each, drive the rear wheels through double-reduction gearing. The storage-battery, which consists of 55 Willard cells of 120-ampere-hours capacity each, is placed in a box under the wagon and behind the engine. The water tank for the gasoline engine is under the engine, and a small pump connected with the engine circulates and cools this water by passing it through the tank and a considerable length of brass piping running around the outside of the side boards. The gasoline tank holds 15 gallons, and is under the driver's seat. There is one hand brake for each motor-shaft, operated by the foot. The steering wheel is mounted on a shaft fitted with a pinion engaging in a rack controlling the front wheels. The controller is like that used on an electric car, and is arranged for speed of 3, 6 and 8 miles per hour, forward or back. The controller, dynamo and batteries are connected in multiple, so that the dynamo is driven with a nearly constant load; when the service is light the current goes into the storage batteries, and when the demand occurs the battery adds its power to the dynamo. No exact statement of test and actual operating cost are available; but it is said that the consumption of gasoline is about 1¼ gallons per hour. The effect of the concentrated load of the 5 or 6 tons on a narrow wheel base, as effecting street paving, is one of the serious questions yet to be answered.

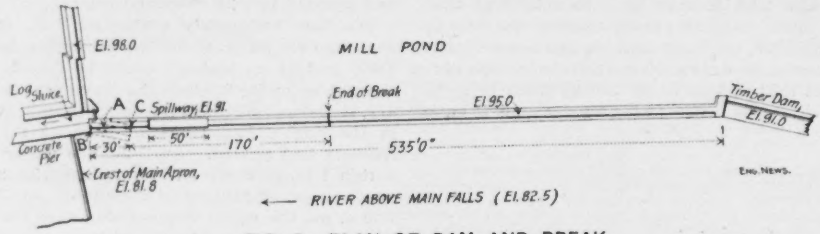

FIG. 3.—PLAN OF DAM AND BREAK.

THE ECONOMY OF MECHANICAL DRAFT in one instance is pointed out in a letter from the B. F. Sturtevant Co., of Boston, Mass., which describes the results said to have been obtained from its installation in the boiler plant of the United States Cotton Co., at Central Falls, R. I. The letter says:

The plant consists of three Babcock & Wilcox boilers, each of 335 rated HP., making a total of 1,005 rated HP. The engine is a cross-compound Harris-Corliss, developing an average of 1,543 I. HP. The remarkably low fuel cost of $5.80 per I. HP. per year in a plant without economizers is primarily due to the employment of a low-grade mixture, costing only $2.29 a ton, the burning of which has been rendered possible by the introduction of mechanical draft. The draft of the chimney, which has been previously employed lacked the intensity necessary to the free combustion of this fuel, and as a consequence it was formerly necessary to use Cumberland semi-bituminous coal. The installation of the fan, costing less than $600, brought about an annual saving of no less than $6,500 in the fuel bill. The fan is provided with a direct-attached engine, the speed of which is regulated by a device of the Chief Engineer, Mr. Thos. P. Burke, whereby a scarcely perceptible change of steam pressure immediately alters the speed of the fan, and consequently the intensity of the draft, and instantly brings the pressure back to normal. As a result the steam pressure remains almost absolutely constant. The following record covers a period of 52 weeks:

Number of hours run	2,908
Average I. HP.	1,543.84
Cost of mixed coal per ton	$2.29
Cost of coal per I. HP. per year	5.80

Coal.	Composition of mixture.	Burned, lbs.	Cost.
Buckwheat	78%	6,074,400	$7,316.89
Anthracite	15%	1,173,826	800.34
Cumberland	7%	565,906	836.00
Total	100%	7,814,132	$8,953.23

FELLING TIMBER DURING THE WANING MOON has been generally regarded as an old-world superstition, without a basis of fact. In a late paper on "Modern Gold-mining in the Darien," Republic of Colombia, S. A., presented to the American Institute of Mining Engineers, Mr. Ernest R. Woakes, of Panama, has some notes on this head. He says that the country is completely covered with forests; but not 50% of the trees are fit for lumber, and about 25% are not even good for firewood. Unless all timber is felled in the waning moon, says Mr. Woakes, it will commence to rot almost as soon as cut; due, probably, to the rapid fermentation and decomposition of the sap, which is supposed to be present in the wood in greatest quantity during the waxing moon. Mr. Woakes says that he expects engineers to laugh at the idea; but he warns the scoffers that experience is abundant in support of the theory; and lumbermen from the Western States who came there to get out timber for the stamp-mills, and refused to obey the native warning, found that nearly all their sawn timber rotted before the carpenters could use it.

THE FORESTS OF CANADA, says U. S. Consul-General Bittinger, of Montreal, cover a total area of 3,315,647 square miles, of which 1,248,798.59 miles may be classed as woodland, with 37.6% of wood. In this table of area of woodland 696,952 square miles are credited to the Northwest Territories and 285,554 square miles to British Columbia. Ontario and Quebec Provinces have 102,118 and 116,521 square miles, respectively. The quantity of pine is estimated as follows: Ontario, 19,404,000,000 ft. B. M.; Quebec 15,734,000,000 ft. B. M., and the other provinces 2,200,000,000 ft. B. M., or a total of 37,338,000,000 ft. B. M. The annual cut, at a low estimate, is about 1,000,000,000 ft. B. M. British Columbia is said to possess the largest compact timber resources in the world; the estimate of the Douglass pine, cedar, spruce, Alaska pine, etc., standing in the railway belt amounts to 25,000,000,000 ft. B. M., worth $25,000,000. In 1897 Canada exported to the United States and to Great Britain manufactured forest products to the value of $1,715,792, and the total manufactured and unmanufactured is put down at $33,046,329. In a table of forest areas in various countries, in acres, Canada is credited with 799,230,720 acres, Russia with 498,200,000, the United States with 450,000,000, India, 140,000,000 acres, and all other countries are under 50,000,000 acres.

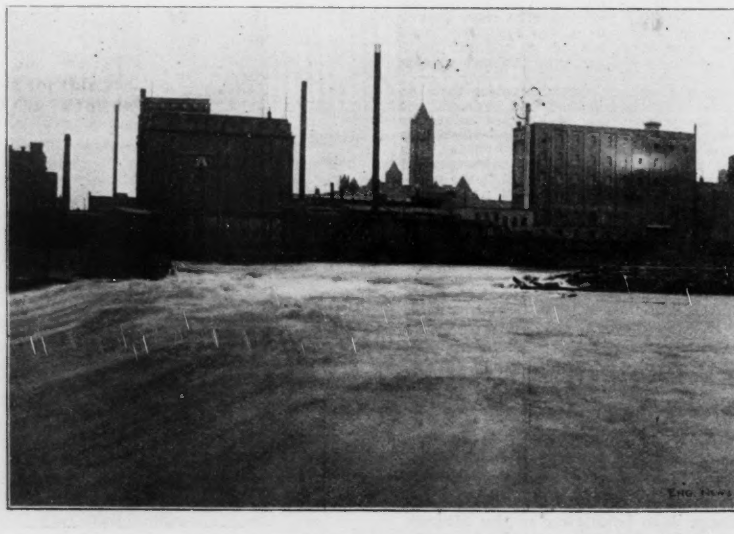

FIG. 4.—170-FT. BREAK IN DAM; ALSO 30-FT. LENGTH MARKED A, IN FIG. 3, AT LEFT OF OPENING.