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AND
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THE TWO NEW EAST RIVER BRIDGES at New York city have been favorably acted upon by both branches of the New York City Municipal Assembly. As we stated in our issue of Dec. 28, 1899, the agitation in favor of these bridges had reached the stage where there were two resolutions before the Assembly, each favoring the appropriation of $1,000,000 for beginning construction of one of the proposed structures. The resolution for the new suspension bridge to cross the river about a quarter of a mile above the present Brooklyn bridge was passed by both the Board of Aldermen and the City Council at their meetings on Dec. 30, 1899. The other resolution for the new cantilever bridge at Blackwell's Island passed the Board of Aldermen and the City Council approved its construction, but failed to pass the appropriation of $1,000,000 for beginning work. The prospects are, however, that this neglect will be remedied at the Council's next meeting and then all that will remain to ensure work being commenced on both bridges will be the Mayor's signature. As the Mayor has made it his personal business to push these bridge schemes through the Assembly there is no reasonable doubt but that he will sign both resolutions very soon. The merits of these bridge plans were discussed quite fully in our issue of Dec. 28, 1899.

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A BRIDGE ACROSS NEWTOWN CREEK in the Borough of Brooklyn, New York city, is provided for in a resolution passed by the New York City Council on Dec. 30, 1899. This resolution appropriates $200,000 for construction. A despatch from Washington states that Congressman May of Brooklyn will introduce a bill in Congress also providing for the construction of a bridge across this stream. Newtown Creek is an arm of the East River or Long Island Sound, which separates what was, before consolidation took effect, Long Island City from Brooklyn. It carries a very heavy commerce by water and the one crossing near its mouth also has an enormous street traffic. The swing bridge constituting this crossing has been in a very dilapidated condition for a number of years and propositions to replace it by a new and modern structure have been made frequently. In 1896 competitive designs were received from a large number of bridge engineers and bridge contractors for a new bridge at this crossing, but owing to various complications construction work was never begun. We published a full description of the various competitive designs in our issue of Nov. 5, 1896.

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THE CONSTRUCTION OF GRAIN ELEVATORS is regulated by a special section of the new building laws of the city of Montreal. The law requires that elevators shall be erected only on sites approved by the City Council. They may be constructed with bin walls, made entirely of wood, provided such walls are made solid and without cellular open spaces within them. The external bin walls shall have a covering of brick, slate, metal or other incombustible materials. If brick is used for casing, it shall not be less than 8 ins. thick, and securely fastened to the woodwork by iron anchors. If the weight of the bins is independently carried on a skeleton construction of wood, steel or iron, and does not rest upon the enclosing walls, the enclosing walls as high as the bottom of the bins shall be made of brick not less than 20 ins. thick, or stone not less than 30 ins. thick. The walls and roof of the cupola and the roof shall be covered with incombustible materials, also the roadways and the ground floor, together with the supporting timbers when detached. All the external openings in the cupola shall be covered with wire netting of No. 14 wire, with mesh not over ½ × ½-in. The engine and boiler used in connection with any such elevator shall be enclosed with solid brick walls, and the roof over the same shall be fireproof. Any opening between the engine room or boiler house and the elevator shall be fitted with fireproof doors. Any elevator lighted by gas shall have all the lights protected by a wire basket or cage. Every elevator shall have two 4-in. standpipes connected with the water mains, and carried up to the cupolas, the lower end of each pipe to be fitted with a valve, and the end in the cupola with a valve, and not less than 100 ft. of hose and branch pipe, attached to same. It is interesting to note also that the new laws specify that in all first-class buildings constructed on the skeleton principle "all supports, beams, girders, etc., shall be joined by riveted connections."

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NEW RAILWAY CONSTRUCTION IN 1899 aggregated about 4,500 miles according to the best available statistics. In their last issues the "Railroad Gazette" and the "Railway Age" both publish preliminary statements of new construction compiled from special reports made to them by the railway companies. The total construction given by the two papers is, respectively, 4,557 miles and 4,500 miles. This is the largest mileage constructed in any one year since 1890, when 5,670 miles were built. It is curious to notice that the State of Iowa which for a number of years has shown very little activity in railway building heads the list of 44 states and territories with 583 miles built by 15 companies. Arkansas comes next to Iowa with a new mileage of 270 miles. The section of country which has shown the greatest activity is that west of the Mississippi River, 20 states of this section contributing 2,591 miles out of the total 4,500 miles. More than 75 per cent. of the new lines has been built by or in the interest of existing lines. The longest continuous line built was the extension of the Choctaw, Oklahoma & Gulf Ry., in Indian Territory, 162.4 miles. No new railway was built in New Hampshire, Rhode Island, Delaware, Nevada and South Dakota.

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THE CHICAGO DRAINAGE CANAL was opened on Jan. 2, by turning into it the waters of the Chicago River. The admission of water was unaccompanied by any formal ceremony, and was, in fact, conducted with a certain degree of secrecy, to avoid any interference by the opponents to the work, who were supposed to be ready to enjoin the trustees from opening the canal.

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THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred Dec. 30, on the Southern Ry., near Spartanburg, S. C. The vestibule limited train from Washington ran into a freight train, and five people were killed and many injured.——A freight wreck near Bear Mouth, Mont., on the Northern Pacific R. R., on Dec. 25, resulted in the death of four men.

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AMERICAN SHIPS BUILT IN 1899, says the Bureau of Navigation, numbered 954, of 267,642 gross tons; in 1898 the figures were 955 ships, of 267,600 gross tons. Of this total, last year, 421 were steam vessels, of 160,132 gross tons, sail vessels numbered 533, of 107,510 gross tons. The increase is almost wholly on the Atlantic and Gulf coasts; on the Pacific coast only 114 vessels, of 20,087 tons were built, as compared with 240, of 61,923 tons, in 1898. The building of 75,313 tons of steel steam vessels on the seaboard is the largest on record for this class.

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THE NEW BATTLESHIP DESIGNS, agreed upon by the Naval Board of Construction, are to surpass in fighting qualities and speed the finest ships laid down by foreign nations. The "Georgia," "New Jersey" and "Pennsylvania," as they will be named, will each have an approximate displacement of 14,000 tons, and a speed of "at least 19 knots," with a bunker capacity of 2,000 tons of coal. There will be two fore and aft superimposed turrets, each carrying two 12-in. and two 8-in. new elongated guns adapted for the use of smokeless powder. The rest of the main battery will include twelve 6-in. quick-fire in broadside; with an alternate plan doing away with superimposed turrets and substituting four 12-in. and sixteen 6-in. quick-fire guns. It is said, however, that the superimposed turrets of the "Kearsarge" and "Kentucky" are no longer of doubtful success, and foreign governments propose to copy this unapproached concentration of fire and angle. Modern Krupp armor will be used, but its thickness and distribution are not fully determined upon. The total cost of each of these ships ready for sea is estimated at $7,000,000. They will have a sailing radius of 7,000 miles, or twice across the Atlantic.

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A MEGAPHONE WITH A SIREN WHISTLE is being experimented with by the United States Lighthouse Board at the Falkner's Island lighthouse station. This megaphone is 17 ft. long and 7 ft. in diameter at the mouth, and stands upon a circular platform 28 ft. in diameter, upon which it revolves. When the tube is due north of any vessel the ship will hear the north signal—a short, a long and a short blast. If it is due west of a ship the vessel will hear three short blasts, and so on, with a different combination of long and short blasts for each of the eight points of the compass. The signals are 15 seconds apart and the apparatus makes a complete revolution in 2 mins. All the sounds indicating the various directions are regularly classified, the western being longer than the eastern signals, and those indicating south being shorter than those for signaling north. Recent experiments in sea signaling, it is stated, have proved that it is possible to confine a sound even so powerful as that of a siren and to project it into space in a given direction with the same certainty and accuracy that the rays of a searchlight can be projected. On the other hand, sounds sent at an angle of 45° may be absolutely inaudible at all distances beyond a mile, and even at half a mile the closest attention may be required to hear them at all. Direct rays of sound properly focused, as they are in a powerful megaphone, can be heard at a distance of eight or ten miles.

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THE SIMPLON TUNNEL is progressing at the average rate of 16 ft. per day. This tunnel is 12.4 miles long and was commenced 14 months ago; it must be finished in 5½ years from the date of beginning, under a penalty of 5,000 francs per day for all delay. In 13 months about one-fifth of the tunnel has been drilled, or about 2½ miles. The recent strike among the workmen has been settled; but the necessity for continuous work is shown by the fact that the loss of a little over one minute per day for the 5½ years would mean a whole day at the end of that time, or a penalty of 5,000 francs.

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A TROLLEY CAR SYSTEM FOR LONDON has been determined upon for the County Council, and it will apply to Parliament for permission to expend about $15,000,000 on an underground electric system. Plans have not yet been completed, as to exact system to be used and location of lines.

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THE FIRST CHINESE ELECTRIC TRAMWAY, about 4 miles long, has been opened, connecting the Pekin railway station at Machiapu and the South Gate of the capital. Its installation is important as breaking through the official superstition which located the steam railway terminal 4 miles outside the walls of Pekin. It was believed by the Chinese that a nearer approach by these "foreign devilries" would incense the Feng-shin, or Spirits of water and air, and that the Emperor's gaze would be profaned by the smoke of the locomotive. The promoters of the tramway explained that electricity was open to neither of these grave charges, and they eventually succeeded in reaching the outer wall of the sacred city.

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THE MAIN ENTRANCE TO THE PARIS EXPOSITION is being constructed. It is made up of three great arches almost covering the sides of an equilateral triangle and presenting three openings each 65.6 ft. in clear width. The public enters at one of these, and the other two open upon a semicircular arrangement of 18 double stations for depositing tickets and registering those entering. The engineers estimate that the capacity of these stations is 10,000 visitors per hour. The entrance itself will be light in appearance, but very ornate, and is made of a steel framework covered with "staff" decoration.

DR. EDWARD H. WILLIAMS.

Dr. Edward H. Williams, of the firm of Burnham, Williams & Co., owners of the famous Baldwin Locomotive Works, of Philadelphia, died at Santa Barbara, Cal., on Dec. 21; his death resulted from heart trouble.

Edward Higginson Williams was born in Woodstock, Vt., on June 1, 1824. At the age of 14 years he spent a year with an uncle—Rev. George P. Williams, senior professor of the University of Michigan, at Pontiac, Mich., and he there found employment under Col. John M. Berrien, State Engineer, who was then locating the Michigan Central Railway, in company with Dr. Douglas Houghton.

The youth's desire was to become a civil engineer, but an attack of asthma compelled him to relinquish this plan and take up instead the study of medicine at the Vermont Medical College, of which his father, Dr. Norman Williams, was dean, and he was graduated from that institution in 1846. The following year he spent with his uncle, then at Ann Arbor, Mich., and he was again employed for a time in an engineering corps on the Michigan Central.

From 1847 to 1851 he practiced medicine at Proctorsville and at Northfield, Vt.; and it was while practicing at the former place that he became known to the medical profession by his successful treatment of a workman who had a 3-ft. tamping bar blown through his head—a case of recovery now famous in the annals of medicine. Having completely recovered from his asthma, Dr. Williams decided to return to the profession of his choice, and in 1851 he became an Assistant Engineer on the railway connecting Caughnawaga and Plattsburg; and on the death of the engineer in charge he assumed this position and satisfactorily completed the road.

Dr. Williams then went West, and in 1856 was Assistant Superintendent of the Michigan Southern & Northern Indiana R. R. at Adrian, Mich. He was then for two years a Division Superintendent of the same road at Laporte, Ind. From 1858 to 1859 he was Assistant Superintendent of the Milwaukee & Mississippi R. R., at Janesville, Wis., and in the five following years he was Assistant Superintendent of the Galena & Chicago Union R. R., the pioneer road west of Chicago. Upon the absorption of this road by the Chicago & Northern, he became a Division Superintendent, but he soon after accepted the position of Assistant General Superintendent of the Pennsylvania Railroad, and in 1865 he was made General Superintendent of the same line.

He held this position until Jan. 1, 1870, when he became a partner in the Baldwin Locomotive Works. In the interests of this firm, Dr. Williams made extensive journeys, especially in connection with the development of its foreign trade. He three times visited South America and Australia, went twice to China, Japan and India and a number of times to Europe. It was largely through his efforts that American locomotives were introduced into Russia, Mexico, Brazil, the Argentine Republic, Australia and Japan. In connection with the Centennial Exposition of 1876, he received the decoration of the North Star from Sweden, and was made a member of the Swedish Royal Academy. In 1879 he was the United States Commissioner to the Sydney Exposition.

Dr. Williams accumulated a large fortune, but was liberal with his means, especially in aiding educational institutions. In 1881 he built Williams Hall for the college at Carleton, Minn., as a memorial of a deceased son, and in 1891 he presented that institution with a 16-in. equatorial telescope. In 1884, he erected upon the site of his old home in Woodstock, the Norman Williams Public Library in memory of his father, and provided a liberal endowment for its maintenance. He also erected, as a memorial of his wife, a large building for the scientific department of the University of Vermont, and made other generous gifts to that institution.

In 1848, Dr. Williams married Cornelia Bailey, daughter of John A. and Sarah (Bailey) Pratt, of Woodstock. His wife died several years ago, but two children survive him—Prof. Edward H. Williams, Jr., of Lehigh University, and Mrs. William F. Dreer, of Philadelphia.

The "Public Ledger," of Philadelphia, in editorially noting the death of Dr. Williams, says that his prominent characteristic was to keep himself in the background, but to push his work so that it would be seen and known by all men. Comparatively few outside of his immediate circle of friends and business associates knew Dr. Williams: but everyone, here and abroad, knew the Baldwin Locomotive Works, and to extend this knowledge was his untiring work for thirty years. He was a man of great business ability, kind heart, and broad philanthropy, and the large measure of business success which he won came as a result of his own ability and industry.

Edward Higginson Williams.

HINTS UPON TRANSIT SURVEYS, AND THE AVOIDANCE AND CHECKING OF ERRORS.

By E. Sherman Gould, M. Am. Soc. C. E.*

The neat method given by Mr. Antonio Llano, in Engineering News of Nov. 23, for correcting distances in a balanced traverse, suggest to an old engineer that probably some hints regarding the prevention of errors in instrumental work may be acceptable to "the boy behind the transit." I may add that the methods I am about to recommend are the fruit of a long experience in extensive surveys made for the city of New York, and have proved eminently satisfactory when submitted to the test of actual practice.

It is exceedingly vexatious, after completing a survey which may have occupied several weeks or months, to find that the calculated traverse does not close, particularly if the discrepancy is so great as to point to the existence of at least one considerable error, rather than to the accumulation of unavoidable inaccuracies. These latter can be treated by a systematic balancing of the traverse, such as is spoken of in the article referred to, or as is generally and probably quite as satisfactorily done, by judicious "fudging." This cannot be done in the case of an evident error, and then much time is consumed in going carefully and painfully over transit books to see if the mistake is one of record or of calculation, and finally it may be necessary to rerun a number of the courses in order to locate the blunder.

All this is wholly unnecessary, and by taking a few simple precautions the transitman can satisfy himself at the close of each day's work that his notes, up to date, are absolutely accurate. Let it be understood that I am speaking now of an ordinary chain and transit line when the refinement practiced in laying out city lots is not required, but sufficient accuracy is necessary to condemn land for railroad, water-works or any similar undertaking. In other words, high-class country work, though not fine town or city work, where any error makes itself apparent at once.

The mistakes which may occur in such work, as we are now considering, are of several different kinds, and may be classed as follows:

Errors of manipulation;
Errors of observation;
Errors of record;
Errors of calculation.

To show how all can be avoided by means of a proper system and ordinary care, let us suppose that the transit is set up at a certain station, and that it is required to run on to the next one. It is immaterial whether the next station is a corner of a survey, or a point upon a railroad location, but in order to fix upon a definite case, we will suppose that it is a question of running the tangents of a proposed railroad line.

Probably a common mode of procedure in such cases is, or was, to take a back sight, call up the back flagman, get the general direction of line from the one in charge of the party, changing it a little if necessary, so as to bring the vernier on an even fraction of a degree, enter the angle in the transit book, calculate the course and enter that, and compare it with the magnetic bearing, as a check. When it becomes necessary to move up again, the plug and tack are set by the transitman, who then comes up with his instrument, and the same process is repeated at the next station.

While this procedure may answer for rough work, such as a preliminary line, it unites about every source of error which it is necessary to avoid in finer work. The method, which is by all means to be recommended, is as follows:

The transit being set up, centered and leveled, let the transitman get the direction for the next station and clamp his instrument on it, paying no regard to back sight nor angles. He then lines in the stakes until the head chainman indicates by signal (such as moving his hand up and down upon the flag pole) that a plug is to be driven. The transitman acknowledges the signal, lines in the plug, but does not set the tack, and immediately prepares to measure and record his angle. We will premise that the six columns of the left-hand page of his note-book are headed consecutively, beginning at the left—Station, Distance, Left, Right, Calculated Course, Magnetic Course, using abbreviations for these words, and that entries are made beginning at the bottom of the page, and running up.

His first care is to see that the instrument is correctly centered over the tack, and is leveled. He then clamps the vernier he intends to use on zero, examining the opposite vernier as a check, takes his back sight, turns over the telescope and unclamps the vernier. By this time the new plug will have been driven, and the head chainman is plumbing his pole on the tack, which he has driven in the center of the plug. The telescope is now directed upon the flag pole, and the transitman notes mentally whether he has turned it to the left or right. He quickly and accurately bisects the pole, and signals the head chainman that he has got his sight. He then reads his vernier, always using the magnifying glass, and enters the angle in the proper column, left or right, as the case may be. He notes also the direction in which he reads the vernier; if from left to right, it means "angle left;" if from right to left, "angle right." This verifies his mental note already made. He now passes around to the other vernier, and reads that also, entering that reading over on the right-hand page, as he has no space left on the other one. If, as is usually the case, his horizontal limb is graduated from 0° to 180°, both ways, the sum of these readings will equal 180°. He enters also his magnetic bearing in its proper column. Next, he brings his vernier back to 0°, clamps it, reverses his telescope and looks for his back sight. If he bisects the flag pole, or at least strikes it somewhere, so that an almost imperceptible touch of the tangent screw suffices to make the vertical cross hair coincide with the flag, everything is all right, and he can call up his back flagman and move on, after giving a parting glance at the plumb bob and levels. An additional check would be to take the magnetic bearing of the back sight, as well as of the forward one, and this is recommendable, though it may be generally dispensed with.

The objects of these different steps are as follows: The tack is driven and the angle measured

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*Yonkers, N. Y.

rather than setting it at a given angle, because it is far quicker and more accurate to measure an angle, than to move the flag from side to side till it coincides with the line of sight. The office work may in some cases be slightly increased by the odd minutes which will ensue, but this is a very small matter, and it is always better to use methods ensuring greater accuracy and ease in the field, even at the expense of a little extra work in the office, because the importance of securing correct data transcends all other considerations.

Both verniers are read, and their sum taken, because this gives the absolute certainty that no error has been made in reading the angle. It is done also when setting on 0°, to guard against the not uncommon blunder of setting on 10° by mistake. This precaution of always reading both verniers should never be omitted. It is, perhaps, the most important of all which I have suggested.

The magnetic course is taken as a rough check on the calculated course. It can be made a pretty close one if, as suggested, the magnetic bearing of the back sight be taken also, because the deflection angle can then be calculated at any station from magnetic bearings, regardless of local attraction.

After recording all the observations the vernier is brought back to zero and the telescope reversed and looked through, to see if it bears upon the back flag, in order to complete the cycle of observations and ensure that no disturbance of the instrument has occurred. This precaution, too, should never be omitted.

By operating as above, the transitman at the end of the day's work, has the certainty that there is no mistake in his field work, because he has not depended entirely upon his care and vigilance to avoid mistakes, but has adopted a system of checks which must inevitably detect them on the spot, if made. He will find that this relieves his mind from a great strain.

We now come to checks on calculation, having satisfactorily covered the ground so far. In making a survey or running a line for any purpose the magnetic bearing of the first course is taken, and from this the bearing of each subsequent course is calculated, by applying the successive deflection angles turned off with the transit. These constitute what are called the "calculated courses." These courses should be calculated every evening, after the day's field work is finished, and unless done very carefully errors are almost sure to occur. The check on these calculations is to add up all the left angles and all the right angles, which can be easily done by keeping them in separate columns, and taking their difference, the balance being carried forward, page after page. At the end of any day's work, the calculated courses are checked by applying this balance to the first course of the survey, when the calculated course thus obtained should agree with that calculated by using each angle separately. This is an absolute and most valuable check. It may be here remarked that the reason why the column of left angles comes first in the note-book, is because in that way it occupies its correct relative position in regard to the transitman, as he looks along the line from the instrument.

After calculating and checking the courses as above, the distances between each station should be figured, by subtracting the number of each station from the next one ahead. As a check on the distances, they, too, should be added up on each page, and the amount carried forward to the next. At any station the sum of the distances should then agree with the number of that station.

When all this is done, the transitman can at any moment turn in his book to the draftsman, with the absolute certainty that, as far as he is concerned, there is no mistake in it, and this result has been secured by the exercise of a very trifling amount of extra work. Indeed, it is very probable that the work has gone on faster, because by the simple and efficacious system of checks suggested, all pottering over the angles, reading each one, two or three times over so as to be sure that no mistake has been made, etc., etc., is avoided, and the work goes on quietly, quickly and with a serene mind.

If, now, in plotting the work, supposing it to form a closed polygon, the traverse does not balance, it is clear that an error has been made, unless, indeed, the discrepancy is so small as to indicate a mere accumulation of small and unavoidable inaccuracies. This error must be due either to a mistake in calculating the traverse, or to an error in the chaining.

To detect it, the traverse must be first examined. We assume that the courses and distances have been called back, so that there is no error in copying, also that the taking out of sines and cosines and multiplications have been checked, so that there is no error there. We also assume that before the columns were footed up, care was taken to see that all entries were made in the proper columns. In this connection it may be stated that it will be found conducive to accuracy to head the columns of Latitudes "N" and "S," and those of Departures "E" and "W," rather than + and —. It is then very easy to see if any mistake has been made in putting the latitudes and departures in the wrong column. To see if they have not been interchanged, that is, latitude placed in the departure column, or vice versa, observe if the bearing of each course has more or less than 45° of departure. If it has more, the departure is greater than the latitude; if less, the latitude is the greater. Thus, suppose the bearing to be N. 36° 24' E., and the distance 463 ft. The sine and cosine of this angle are, respectively, 0.59342 and 0.80489. Multiplying both by the distance, gives 274.753 and 372.664. A glance shows that the latter must be the latitude, and the former the departure.

If all this is correct, then without a shadow of doubt, the error, if a considerable one, is in the chaining. If numbered stakes have been driven every hundred feet, and leveled over, as in the case of a railroad line, there will be no mistake in the full stations, because the leveling party would detect and report it. The chief source of error is in the plusses, and these errors are commonly made, if at all, by reading the chain backward, for instance, taking 64 ft. for 36. The distances used in the traverse must be then carefully examined to see if such a change, or any change, in fact, in one or more distances would reduce the error to the limits of normal inaccuracy. By diligent scrutiny such an error is sure to be detected by an expert eye, and then a couple of trustworthy chainmen are sent out to verify the suspected measurement, not informing them, of course, of what the error is suspected to be. In almost all cases a resurvey can be avoided by an intelligent guess at the point where the mistake was probably made. Undoubtedly a great deal of unnecessary work is frequently gone through with in such cases merely for lack of a little reflection.

All actual blunders or "busts" being thus eliminated, there will still remain some discrepancies between the Northings and the Southings and Eastings and Westings, unless by pure chance they should happen to balance. Mr. Llano has very justly called attention to the fact that it does not suffice to merely correct the sines and cosines of the courses; their distances should also be made to agree with the corrections. In other words, when the base and altitude of the right-angled triangle is changed, the hypotenuse should be correspondingly altered. If necessary, the bearings also must be slightly varied so that when all is done the description of the survey shall be that of a closed polygon. Mr. Llano gives a method which appears to be a new and excellent one for correcting the distances proportionately, but in practice I do not think this necessary or even advisable, especially in the case of a large survey comprising, perhaps, a hundred or more stations. It seems to me that this would involve a great many decimals. The practice of the old land surveyors when given a survey to locate from a description, was to first work out a traverse for it, which, as a matter of course, never closed, and then retain all the courses and distances intact, till the last one was reached. A closing course and distance was then calculated, and the area of the survey determined accordingly. This I believe is the legal way of treating a survey which does not close, unless some metes and bounds are cited which conflict. It is, however, awkward when the last course is a course of an adjoining tract, particularly if of earlier date.

I believe the best way to balance such a survey as we have been considering, that is, one in which there can be found no absolute mistake, and only a slight discrepancy remains to be eliminated, is to go very carefully over the traverse and see to what changes of distance it will respond most sensitively. For instance, supposing that in a large survey of several hundred acres the North latitudes exceeded the South by a few feet, and the East departures were less than the West, by a somewhat smaller discrepancy. In the first place we would look to see if this difference was about in the right proportion. That is to say, if the total latitudes were greater than the total departures, then the difference between the Northings and Southings should be greater than that between the Eastings and Westings, and the fact of their being so would give us additional confidence that the errors were simply due to ordinary small inaccuracies, although this evidence would not be conclusive either way. We would then see what courses, if any, ran nearly North and South. It is clear that by lengthening and shortening these by a small amount, we would make a great impression on the total latitudes. And the same in reference to the departures. On the other hand, the change of a single minute in the bearing of a long course running nearly North and South will make a great change in the departure. In a word, by an intelligent study of the traverse all minor discrepancies can be eliminated with a very small number of changes when placed where they do the most good, and this method will prove the most satisfactory in practice.

All that has been said so far respecting the instrumental work, refers to the avoidance or detection of actual blunders. Accuracy is another matter. One of the chief requisites for accuracy on the part of the transitman, is rapidity of execution. After bisecting your backsight—and you can take your time about this—get your foresight coolly and serenely, but as rapidly as you can, and clamp on it. You must remember that your instrument is never for an instant immobile, but is in constant, though very slight motion. As little time as possible should therefore intervene between the two sights. Indeed, there will be a general gain in accuracy as well as in time, by a rapid but perfectly steady manipulation throughout all the steps of setting up, centering, leveling and sighting. A slow operator, or at least a pottering one, is sure to be inaccurate, or at best cruelly slow.

In office work use tables as much as possible, constructing them, if necessary, for special use. For instance, to turn square feet into acres, always have at hand a little card with the products of 4356 (omitting the final cipher) by the digits from 2 to 9. This will expedite divisions, and avoid errors. The same observation holds good regarding cubic yards, using a similar table with successive products of 27. In other words, perform as many arithmetical calculations as possible once for all, and make sure they are right. Then tabulate results for future use.

REINFORCEMENT OF THE WALLS OF THE KANSAS CITY SETTLING BASINS AND THE USE OF A COAGULANT TO AID CLARIFICATION.

By W. Kiersted, M. Am. Soc. C. E.[*]

(With two-page plate.)

The original water-works of Kansas City, Mo., were constructed by the National Water-Works Co., in 1873-5, taking water from the Kaw or Kansas River. In 1888 the present water supply works were completed. They are located upon the banks of the Missouri River, near the old town of Quindaro, Kan., about six miles from the original pumping station, and serve to supply Kansas City with settled Missouri River water. The Quindaro supply station, together with the original water-works and extensions thereto, passed into possession of Kansas City by purchase in 1895.

Reinforcements to the Partition Walls of the Settling Basins.

After the purchase the city had ample opportunity for proving the rumors of insecure construction of portions of the plant, which prevailed

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[*] Chief Engineer Water-Works, Kansas City, Mo.

to a greater or less extent during the negotiation to purchase. The almost complete overthrow by water pressure of the partition wall between Basins 1 and 4 very soon after the basins were put in operation, and the failure of a portion of the west embankment of Basin 4 and the north embankment of Basin 2, constituted substantial grounds for such rumors, so far, at least, as they related to the Quindaro supply works. Besides the repairs which followed the breaks just described, a general reinforcement of all the partition walls of the settling basins was known to have been made at considerable expense by the National Water-Works Co.

Fig. 1 on the two-page engraving is the general plan of the Quindaro settling basins as originally designed, excepting the buttresses, which were added later. A brief description of these basins, with illustrations designed chiefly to show their operation, was given in Engineering News of Dec. 3, 1887. Each partition wall contained two conduits, one above the other, each 3 ft. wide and 6 ft. high, roofed with 3-in. matched plank spiked to 4 × 4-in. stringers, and with masonry above in each case, as shown by Fig. 1.

The upper conduit received water either directly from the river pumps through the inlet tower, or from influent ports connecting with one of the settling basins and discharged it through a large downpour into the lower conduit, whence it passed into the adjoining basin through a series of ports near the bottom of the wall. A typical section of the partition walls as originally designed is shown in Fig 2.*

All the partition walls yielded more or less under a head of water of 15 ft. or more. As a reinforcement of these insecure walls, the National Water-Works Co. constructed a series of heavy pile and timber braces, bolted at the upper end to double 8 × 8-in. range timbers about 12 ft. above the bottom of the basin, inclined downward, and bolted at the lower ends to deeply driven piles at points about 3 ft. above the bottom of the basin and 12 ft. from the base of the wall. A similar set of braces was framed horizontally from the same pile to a second set of range timbers parallel to the first, but about 3 ft. above the floor of the basin. These timber braces and pile supports were in pairs, on opposite sides of the walls, and connected by 3-in. bolts extending through the wall from pile to pile and from pair to pair of inclined braces. Around each pile was placed a cone of concrete. The photograph (reproduced as Fig. 9 in the text) shows the general arrangement of these wooden braces. The entire thrust of the yielding walls was transferred through the timber braces to the piles with considerable leverage, and as a result the bending piles permitted the entire structure to yield as a unit under an unbalanced water pressure. The company subsequently built as an additional reinforcement the buttresses marked "A" upon the plan, Fig. 1. These buttresses were constructed of rubble masonry, in pairs, on either side of each partition wall, upon the concrete floor of the basin, which is 6 ins. thick, and without any bond into the masonry of the walls. The several buttresses upon one side of a partition wall were built while the opposite side was under a pressure due to a head of 15 ft. or more of water. Upon reversing the conditions the wall sprang away from the buttresses and beyond the normal position in the opposite direction. In this position of the wall, the several buttresses upon the opposite side were built. As a natural consequence the wall in its normal position had no contact with the buttresses on either side by approximately one-half the range of yielding, which in most instances varied from 1 to 2 ins.

The greater part of the reinforcements made by the company were carried out during 1888 and the first half of 1889.

The writer, as chief engineer to the water department, was requested in the fall of 1897, directly after assuming the duties of the office, to examine the condition of the settling basins and to devise a plan for strengthening the insecure partition walls and to improve upon the method of clarifying the water. At that time the water department was engaged in filling with concrete the lower conduit of the partition wall between Basins 2 and 3, leaving only a vertical brick duct, Fig. 3, of semicircular cross-section at each of the effluent ports at the base of the walls. The communication between the upper conduit and each of these ducts was made by bedding in the masonry between the conduits a piece of 20-in. pipe. The top of the pipe was dressed to receive a disc valve. This valve, as shown by Fig. 3, consists of a cast-iron disc with babbitt seat and a vertical spindle. It was designed by Mr. John F. Sickles, Chief Engineer of the Quindaro pumping station.

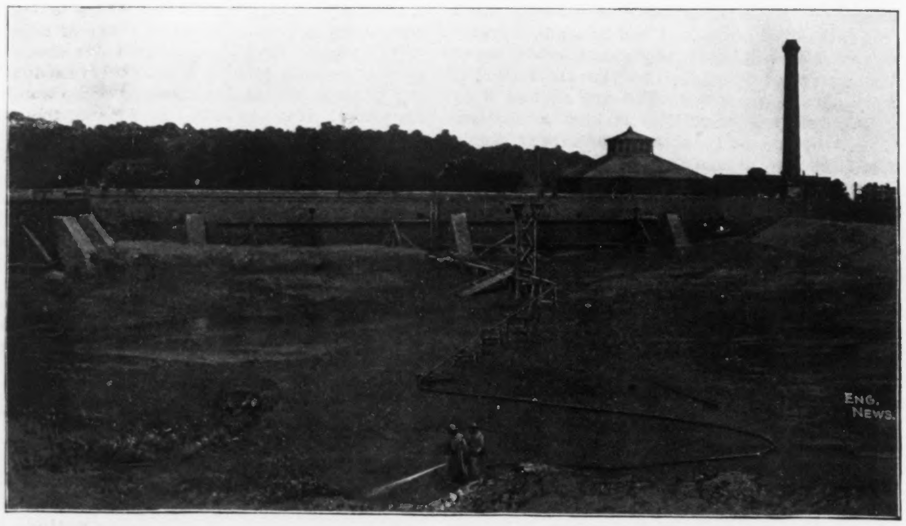

FIG. 9.—CLEANING ONE OF THE SEDIMENTATION BASINS OF THE WATER-WORKS OF KANSAS CITY, MO.

(Timber Work and Buttresses Show Early Attempts to Reinforce Division Walls.)

Two of the diagrams employed in the study of reinforcements are embodied in Fig. 2. One shows the pressure curve computed for the partition wall as originally designed, when under a pressure upon one side of a full head of water; the other represents a design of a stable section of wall under a full head of water upon one side. This stable section was finally employed as a basis for computing the size and distribution of the buttresses needed to properly reinforce the partition walls. The buttress reinforcement is shown in plan by Fig. 1, and in elevation by Fig. 4. All buttresses except those marked "A" are the design of the writer.

Fig. 5 shows the buttresses of the partition wall between Basins 3 and 4. The buttresses are bound in pairs by three I-beams extending through the wall. The I-beams of each pair of buttresses are connected by tie rods and anchored to the foundation by four anchor rods, thus insuring the united action of all buttresses to resist the overturning effect of an unbalanced water pressure. The filling of the lower conduit with concrete was coincident with the construction of the buttresses. All ironwork is carefully bedded in a concrete composed of crushed flint, gravel and Portland cement. A recess 4 ft. wide and 7½ ft. high was cut into the masonry from 12 to 18 ins. deep as a buttress insert. The details of the ironwork are so designed as to use as much as possible of the iron removed from the wooden braces.

The buttresses of the wall between Basins 1 and 4 (Fig. 6) are fewer, larger and of somewhat different design. They are constructed in pairs and spaced in such a manner as to utilize the 3-in. bolts which pass through the partition wall and which were connected with the timber braces previously described. The wide spacing of the buttresses is warranted in view of the heavy and well-bonded character of the masonry with which this wall was reconstructed after the failure before alluded to—a work which also dispensed with the lower conduit of the original construction. The diagonal braces consist simply of railroad iron, wedged between the 3-in. rods, with straps passing over the rods. Because of the great expense attached to cutting out the heavy masonry of this wall an insert but 3 ft. in height at the top of the buttress was made.

The reinforcement of the curved wall between Bains 1 and 3 was built as a continuous wall, as shown by Fig. 7, because of the shattered condition of the original wall, particularly about the lower conduit, and because of the fact that the suction pipe to the low service pumps, which deliver water to the storage reservoir at the city pumping station, connects directly with the lower conduit of this wall. This reinforcement consists of an outer shell of stone masonry, which formed a mold for the concrete filling. It is bonded into the partition wall by eight inserts 3 ft. wide by 7 ft. high, and 12 to 18 ins. deep; also between inserts by 10-in. I-beams bedded 2½ ft. into the old wall and projecting 2½ ft. into the new portion. Anchor rods loop over the I-beams and extend to an anchorage near the foundation. Fig. 7 shows the general design of this reinforcing wall.

The partition walls between Basins 2 and 3 and Basins 1 and 2 are reinforced in a manner similar to that of the wall between Basins 3 and 4. The distribution of the buttresses is shown on Fig. 4 and a section of the two large buttresses of the wall between Basins 1 and 2 is shown by Fig. 8.

All buttresses were constructed of Portland cement concrete in proportions varying from 1 to 2 to 1 to 3 of cement and sand, and from 5 to 6 parts of broken limestone. The concrete was deposited in the molds in a condition that showed no surplus water and was thoroughly rammed. All surfaces of contact of both the masonry and the wooden molds received a heavy coat of cement plaster immediately in advance of each layer of concrete. The molds were removed from 24 to 48 hours after filling, and left the buttresses with a smooth and finished surface that required little or no after work.

A mold consisted of two 8 × 8-in. upright wall timbers, secured by bolts leaded into the wall; of two 8 × 8-in. batter posts, and of sides and front of 3-in. yellow pine plank. The posts were secured by rods extending from post to post.

Little difficulty was experienced in cutting the inserts for the buttresses into the masonry of the original walls, for they contained scarcely a stone but what one or two men could handle, and much of the cement used at that time has proved to be of inferior quality.

The upper 3 ft. of the wall between Basins 2 and 3 was removed because of the disintegrated condition of the masonry. A masonry arch was sub

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*This brief description of the course of the water through the basins may be supplemented by the following extracts, mostly verbatim, from an article by Mr. G. W. Pearsons, then chief engineer of the works, in our issue of Dec. 3, 1887:

Water enters the center basin through a spreading inlet near the bottom at the center of the circular end; this prevents the formation of currents, and when the water has risen above the inlet it appears to be at rest. Passing slowly to the east end of the basin it flows in a thin sheet over a weir 100 ft. wide, and through openings in the wall to the upper conduit; from this it descends to the lower conduit and enters the north basin at the bottom (and so on through the other basins).

The depth of water in the various basins ranges from 20 to 30 ft., except that the east end of the small central basin is shallower. The capacity of the four basins is 60,000,000 gallons.—Ed.

stituted for the plank roof over the upper conduit. The wall was rebuilt to the original level by face walls of vitrified paving brick, 17 and 21 ins. thick, tied together every 10 ft. by 13-in. cross walls. The pockets between the face and the tie walls were filled with Portland cement concrete, as shown by Figs. 2 and 3. The tops of the other partition walls were repaired to a less extent in a similar manner.

The walls between Basins 1 and 4, 3 and 4 and 1 and 3 were reinforced, and the tops of the several partition walls repaired, during the Fall of 1898. The buttresses of the walls between Basins 2 and 3 and 1 and 2 were completed in October and November, 1899, respectively.

The examination by the writer also resulted in a recommendation to substitute for general use an overflow circulation of water from basin to basin for the original downflow method. Accordingly, during the repairs to the top of the walls, in the Fall of 1898, weirs were made therein in accordance with designs of the writer. The floor of the weirs is of paving brick, laid on edge in Portland cement mortar with a fall of about 2 ins. across the wall, a distance of about 7 ft., as shown by Figs. 5 and 6. Figs. 1 and 4 show the location and elevation of the weirs.

Coagulation as a Supplement to Sedimentation.

The process of merely skimming the more clarified surface water by means of weirs does not prevent the passing of a sufficient portion of the fine and light sediment from basin to basin to impart to the water a decided turbidity. In order to remove this remnant of sediment from the water the board of public works authorized, in the spring of 1899, and at the request of the writer, the installation of a coagulant plant. This plant consists of two wooden tanks, 12 ft. high and 12 ft. in diameter, in which the coagulant is dissolved in water to any degree of strength that may be desired in order to suit the varying condition of the river water. In connection with the wooden tank is a smaller iron tank, which may be used to introduce a small portion of milk of lime should the river water at any time contain an insufficient alkalinity to insure the proper decomposition of the coagulant. The system of pipes connecting the tanks is such that one or all may be used for coagulating purposes. The coagulant solution may be delivered directly into the river water as it passes through the pumps into the settling basins, or into the partially settled water in transit over the weirs, through a pipe laid upon the top of the partition walls from weir to weir, or into the low pressure force main delivering water into the 17,000,000-gallon storage reservoir at the city delivery station. Thus the river water may be allowed natural sedimentation in one or more basins before the introduction of the coagulant. During the greater portion of the year, at least, natural sedimentation previous to coagulation is necessary, for the heavy sediment which rapidly settles out of the water carries with it the coagulant when introduced directly into the river water and leaves the light and fine sediment uncoagulated. But when natural sedimentation is allowed in at least one basin and the coagulant is introduced in a series of jets as the water passes over a weir, the process of coagulation and clarification proceeds with surprising and marked rapidity. At the present time the coagulant is pumped from the tanks through a 1¼-in. iron pipe and delivered into the water passing over the weirs, through ¼-in. pet cocks, spaced 4 ft. apart. At times the introduction of the coagulant at one weir suffices to clarify the water; at other seasons a second treatment becomes necessary. With the Quindaro basin in normal working condition the work of clarification can be completed without depending upon the storage basin at the city delivery station for any material part of the work.

In a late special report I recommended to the Superintendent that Basin No. 1 should be made a clear water basin instead of a basin to receive the raw river water. Changes to accomplish this end were made accordingly, and were practically completed on Nov. 9. The river water henceforth will be delivered by the new delivery pipe running diagonally across Basin No. 1 into the lower conduit at the East end of the wall between Basins 1 and 2; thence the water passes out of ports at the bottom of the East wall of No. 2 basin.

Since April 23, 1899, sulphate of alumina has been systematically used in the clarification of the Missouri River water at the Quindaro supply station. Frequent analyses have been made since the above date with a view of determining the amount of sediment contained in the river water, the alkalinity of the water and the maximum amount of the sulphate of alumina the river water is capable of decomposing. The sediment analyses were made by filtering through filter paper one liter of water. The alkalinity was determined by volumetric analysis, using methyl orange and lacmoid as indicators. The alum-decomposing capacity of the river water was determined by titrating the water with a 1% alum solution, using lacmoid as an indicator. In addition to these analyses occasional tests were made of the clarified water, taken from the basin, for undecomposed alum.

In these tests both the logwood decoction, prepared by Mrs. Richards, of Boston, and lacmoid, as suggested by Mr. Fuller in his Louisville report, were used as indicators. Lacmoid invariably gave an alkaline reaction, but in a few instances the logwood gave an alum reaction. The evidence that this alum reaction was due to the presence of suspended hydrate of alumina, and not to undecomposed sulphate of alumina, was made conclusive by testing a portion of the same sample of water, carefully filtered, with a 1% alum solution in the presence of lacmoid, which developed the fact that the water would decompose much more of the sulphate than was originally introduced for the purpose of clarification. Certainly the water which still possessed the alkalinity to decompose a large amount of the sulphate of alumina could contain no undecomposed alum of the original introduction.

During the last four days of April, 1899, the sediment carried by the Missouri River varied from 2,786 to 5,350 parts per 1,000,000. The alkalinity of the river was 115 to 128 parts per 1,000,000. During May the sediment ranged from 2,530 to 5,279 parts, and the alkalinity from 110 to 126 parts. Throughout June, July and August, the sediment ranged from 2,340 to 5,756 parts, and the alkalinity from 105 to 128 parts. In October, 1899, the alkalinity was about 160 parts per 1,000,000.

The greatest amount of sediment in the river water was found in samples taken during a rapid rise of the river. The season of lowest alkalinity observed was in the latter part of May, when the river was suddenly affected by the floods of local tributaries, though doubtless the early spring floods will yet be shown to be productive of the least alkalinity.

Since June, 1899, when the present method of clarifying the water as above described was introduced, Kansas City has been supplied with a clearer and more acceptable water than at any time in the history of the water-works. Although sulphate of alumina has been freely used as the emergency arose, still at no time has any undecomposed alum reached the clear water basin. Although a remnant of the hydrate of alumina in a finely divided state occasionally reaches the water delivered to the city, still it has not yet been detected in objectionable amounts. In fact it is doubtful whether even filtration as ordinarily practiced completely eliminates the hydrate from water.

The cost of the coagulating plant will scarcely exceed $1,500. The cost of sulphate of alumina varies, but it will average about $1.50 per 100 lbs.

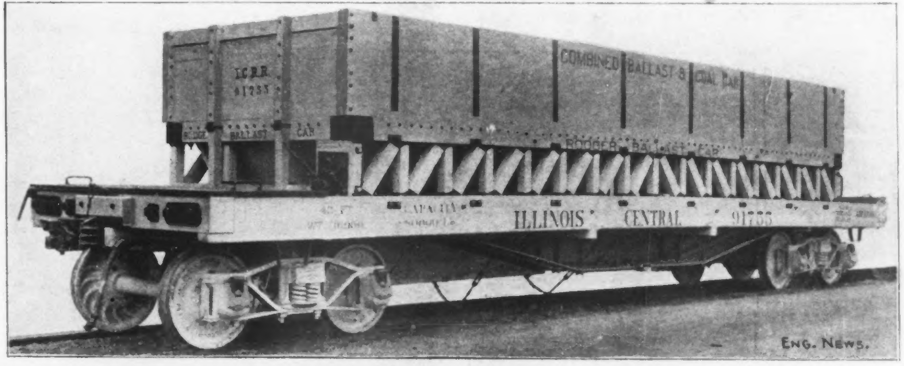
From analysis made of the sediment contained in the river water during May, June, July, August, it is estimated that the river carries about 11½ cu. yds. of sediment per 1,000,000 gallons. The average consumption of water during this period was about 11,000,000 gallons per day.

The sediment received from the water is washed from the basins by hose streams, into a sewer discharging into the river. At the present time the cost of this washing per million gallons cannot be given because of the fact that much excavated earth accumulating during the repairing of the basins, and old mud which had accumulated in the interior conduits of the various walls for the past several years, has been disposed of by washing into the sewer. The expense of these washings cannot now be satisfactorily separated from those due to the normal operations of the basins.

* * *

COMBINATION BALLAST AND COAL CARS; ILLINOIS CENTRAL R. R.

The Illinois Central R. R. has adopted the policy of getting more work out of its ballast cars by adapting them for use in coal traffic. The cars are of the Rodger pattern (Eng. News, Feb. 17, 1898), with longitudinal hoppers, and have low sides, owing to the great weight of the ballast contents. They are used during the summer for ballasting, filling and general improvement work. As this work cannot be carried on in the winter, the cars are then converted into coal cars by fixing removable sides and ends, so that they may thus be kept constantly in service, instead of being stored on sidetracks during the winter months. The accompanying cut represents one of a number of these cars recently built by the Rodger Ballast Car Co., Fisher Building, Chicago, Ill. The car is shown with the extension sides fitted, but when used for ballasting, the heavy timber lettered "Rodger Ballast Car" forms the top of the car.



COMBINATION BALLAST AND COAL CAR; ILLINOIS CENTRAL R. R.
Rodger Ballast Car Co., Builders.

The car is 40 ft. long and 9 ft. 6 ins. wide, over the sills, while the hopper is 30 ft. 6 ins. long on top and 24 ft. 6 ins. at the bottom, the sides sloping up to the full width of the car at the top. Its depth is 5 ft. The doors are operated by the ratchet lever on the front of the car, above the sills. There are two side sills 6 × 14 ins., and two intermediate sills 8 × 10 ins., with end sills 9 × 11 ins. Across the ends of the hopper are two cross timbers, into which the intermediate sills are framed, and between which and the end sills are two short center sills, with four tie rods passing through the sills and cross timbers. This framing is stiffened by six 1⅝-in. truss rods with upset 1⅞-in. ends, and is tied laterally by the needle beams and four ⅞-in. transverse tie rods. The top plate of the hopper is 6 × 8 ins., supported by posts 4 × 4 ins. and diagonal braces 4 × 5 ins., all set in malleable iron pockets or angle blocks. A transverse bulkhead divides the hopper into two compartments, and the top is braced transversely by a cross timber in each compartment, with a ⅞-in. tie rod on each side of these timbers and of the bulkhead. The flooring is of pine planks, 1¾ × 6 ins. ship-lapped. The removable sides and ends have planks bolted to steel deck beams, which are fitted to inside stake pockets and secured by U-bolts. This arranagement of inside stakes increases the capacity of the body, and is employed in some coal cars. It was designed by Mr. E. S. Hart, General Manager of the Rodger Ballast Car Co., and was described in our issue of Feb. 3, 1898. The sides and ends can be stacked for storage during the summer, and when winter comes they are simply set in place, the U-bolts screwed up, and the vertical and horizontal tie rods at each end put in place and screwed up.

The cars are mounted on diamond frame trucks having the "Common Sense" cast-steel bolster, supported by spiral springs seated on a saddle over the bottom member of each frame. The cars are equipped with M. C. B. couplers, and Westinghouse brakes, with inside hung brakeshoes and metal brakebeams. The weight empty is 36,900 lbs., and the nominal carrying capacity is 80,000 lbs., and it is said they will carry a full load of 40 gross tons of coal. The cubic capacity, without the extension sides, is 22 cu. yds. level full, or nearly 30 cu. yds. with the contents heaped up.

A NEW METHOD FOR COMPOUNDING ALTERNATORS.

The problem of compounding a direct-current generator is comparatively easy of solution. The whole or a certain fraction of the current output of the machine can be used to aid in maintaining or increasing the strength of the fields to compensate for the increased armature reaction, magnetic leakage and ohmic drop attending increased load.

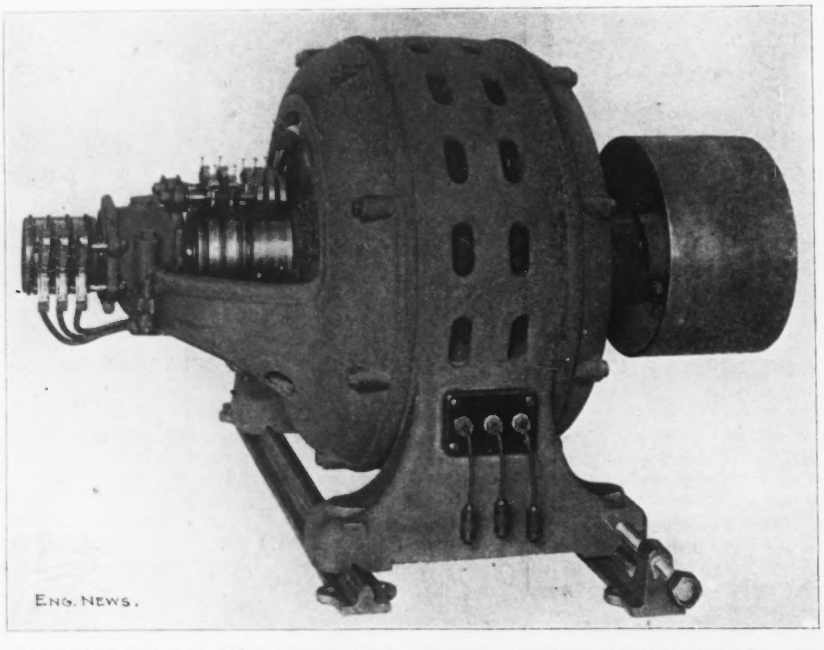


FIG. 1.—COMPENSATED REVOLVING FIELD ALTERNATOR, BUILT BY THE GENERAL ELECTRIC CO., SCHENECTADY, N. Y.

In an alternating current generator the voltage falls with increase of load from nearly the same causes, namely, armature reaction, leakage and impedance, which latter is the geometrical sum of reactance and resistance. The drop of voltage is usually larger in an alternator than in a direct-current machine, but it may be remedied by substantially the same method. The total current delivered by the machine may be passed through windings on the field poles, where it will serve to keep up, or increase, the field strength. Or a current proportional to and derived from the main current by means of a series transformer may be used for the same purpose. In either case, the current must be rectified before passing around the field.

One of the causes named above of the fall of potential at the terminals of an alternator was the armature reaction. This should be considered further, as its action is somewhat different from the armature reaction in a direct-current machine. The latter depends only on the strength of the current in the armature, and the position of the brushes. In an alternator, however, it is affected by the nature of the external load. If the external circuit contains self-induction, the current lags in phase behind the E. M. F. impressed upon the circuit by the alternator. That is, the current passes through the maximum and zero values a little later than the E. M. F.

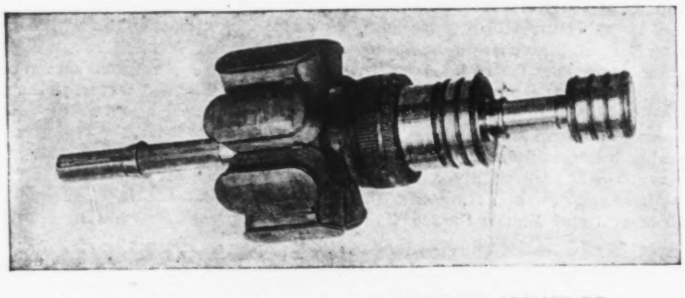


FIG. 2.—REVOLVING FIELD AND EXCITER ARMATURE.

The effect of this lagging current is to further increase the deleterious effects of the armature reaction, and it can not be remedied by the compounding described above, as that varies only with the magnitude of the current. If the current is exactly in phase with the E. M. F., the effect of the armature reaction is mainly to distort but not decrease the field. When an armature coil is approaching a pole the current is flowing in such a direction as to decrease the magnetization; when it is opposite the pole the current has ceased and the effect is nil; and as it leaves the pole the current is in such a direction as to increase the magnetization. If the current is lagging, it will be seen, the harmful effect is increased and the beneficial effect diminished. As noted above, the ordinary compounding will not remedy this.

A machine recently put on the market, however, embodies a neat and ingenious solution of this problem of lagging currents. The complete machine is shown in Fig. 1. The armature of the exciter is mounted on the same shaft with the revolving field of the generator. This structure is shown in Fig. 2. The field of the exciter has the same number of poles as the revolving field of the generator. Then, since the rotating structures are on the same shaft, the currents in the armature of the exciter will bear a definite relation in time to the currents in the armature of the alternator. The latter armature has a distributed winder which is tapped off at three points, giving three-phase currents.

In the following explanation reference will be made to the diagram of circuits shown in Fig. 3.

The armature winding is also tapped off at three points, where it is connected with slip rings on the shaft. If three-phase currents are supplied to these rings a rotating field will be produced. Now let the armature be rotated in a direction opposite to the direction of motion of this field and with the same speed, and the field would stand still in space. Brushes applied at the proper points on the commutator of this armature would receive direct current at a voltage depending on the magnitude of the three-phase currents supplied to the rings. The device would act as a rotary converter.

Ignoring for the instant the slip rings and the two-phase currents, we may provide the armature with a fixed externally-excited field. The voltage at the brushes will then depend on the strength of this field. If now we allow both fields to be produced at once, we may place the external field in such a position that the two fields will coincide and will be added. The voltage at the brushes will now be variable, being composed of a nearly constant amount due to the external field and a part varying with the strength of the three-phase currents supplied to the slip-rings. If the current for the excitation of the field of the alternator is drawn from these brushes, the excitation will vary with the voltage at the brushes.

The current supplied to the slip-rings may be the main current of the alternator, or a current proportional to and derived from it by series transformers. The latter method is for some reasons preferable, and is used in the present instance.

In what precedes we have supposed that the alternating currents supplied to the exciter armature bore a definite time relation to the speed of rotation of the latter. But suppose now that, on account of self-induction in the external circuit, these currents fall back in phase. The field produced by them will be carried forward that much by the revolution of the armature, since, as was explained before, the motion of the field in the armature is opposite in direction to the motion of the latter.

If the internal field exactly coincided with the external field originally, this action would result in weakening the resultant field and reducing the voltage at the brushes. The external field, however, could be so placed that this action would throw the two fields more nearly into coincidence, and the voltage would be raised. This would cause an increase in current in the alternator field windings, which would counteract the demagnetizing effect of the lagging currents in the armature. It will be seen, then, that this device may be used to compensate for lagging currents.

Such a device may be so designed as to regulate with great nicety. Perfect regulation may be obtained without the "stiff" field, and its accompanying large air gap, hitherto thought necessary. Consequently, leakage can be reduced and the weight of the machine for a given output diminished, and the efficiency may be increased, as less energy will be needed in excitation.

Such a device should be particularly valuable in small machines, where hand-regulation is not feasible. The most common cause of lagging currents is the polyphase induction motor. If the bad effects of the latter may be met as above, another possibility is offered. The non-inductive load, as incandescent lamps, may all be connected on one phase, which secures greater simplicity in wiring, and the induction motor will act as a sort of regulator, taking energy from the unloaded phases and transferring it to the loaded phase.

The machine illustrated in Fig. 1 embodies the features we have been describing. The general construction is evident. The shaft carries, besides the revolving field of the alternator and the armature of the exciter, the commutator of the latter, two rings carrying the exciting current to the revolving field, and the three slip-rings, by means of which the three-phase currents are introduced into the exciter armature. The field of the exciter is attached to the inside of the front cover plate of the alternator. For the initial adjustment a rheostat is inserted in the field circuit of the exciter. Together with the series transformers mentioned above, this may be placed in any convenient place.

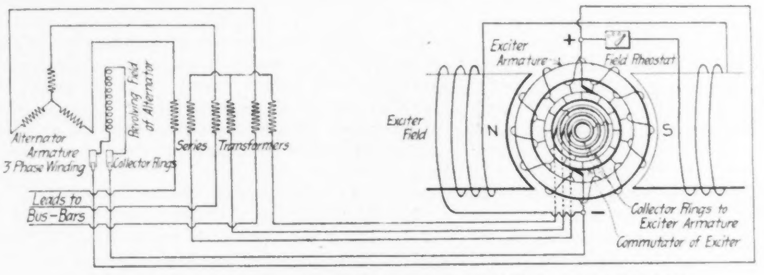


FIG. 3.—DIAGRAM OF CIRCUITS OF ALTERNATOR AND EXCITER.

The manufacturers of the machine illustrated are the General Electric Co., of Schenectady, N. Y., who have kindly furnished us information concerning it, together with the illustrations shown in Figs. 1 and 2.

THE ACTION OF WATER ON LEAD, TIN AND ZINC SERVICE PIPES.

A large number of cases of lead poisoning having occurred in Massachusetts recently, the Board of Health of that State carried on investigations in 1897 and 1898 to determine the effect of different classes of water upon lead service pipes. Incidentally, the effect of different waters on the zinc and tin coatings of galvanized and tin-lined service pipes, respectively, was also studied. A review of these investigations, by Mr. H. W. Clark, Chemist of the Board, occupies over 40 pages of the report of the Board for 1898.

It was learned at the outset that 71 of 136 cities and towns from which information was secured used either lead or lead-lined service pipes. Seven used nothing but lead, namely, Ashburnham, Everett, Fall River, Lexington, Milford, South Hadley and Warren; two, Easton and Millbury, used only lead-lined pipe. Stoughton used either lead or lead-lined pipe exclusively; 14 others used either lead or lead-lined pipe for over 50% of the services; the remaining 47 towns used from 1 to 50% of pipe in which lead was in contact with the water, but generally these towns had few lead services, although probably all of them have lead pipes beyond the services in many of the houses.

Some idea of the extent of the investigation may be obtained from the statement that during the two years some 800 samples of water, from 63 towns and cities, were examined by the Board. Certain places, 30 in number, were selected for detailed study, partly on account "of the large amount of lead pipe in use, and partly because of real or supposed lead poisoning in these towns." The greatest amount of lead found in any one sample is given for each of these places, ranging from 8.5460 parts per 100,000 at West Brookfield, and 2.0440 at Lowell, to 0.0023 at Cohassett. West Brookfield and Lowell* showed maxima much above any other cities, and the figure for Lowell is far above the average for the series there, which was 0.1899 for services in ordinary use, and 0.1933 for water which had stood in a pipe for a number of hours.

The figures from the several towns are grouped in a variety of ways in the report to show the maximum, minimum, and average amounts of lead, and also the relations between lead and color, total solids; free ammonia, oxygen consumed, chlorine, nitrates and hardness, the groupings being arranged from greatest to least in order of the particular thing shown in each table, and by both ground and surface waters. The full list of 30 cities is not carried through all these tables, only those being included in each case the results for which are most significant.

The ground waters of 16 towns showed an average of from 0.1899 parts of lead per 100,000 for Lowell to 0.0055 for Methuen, when in ordinary use, and from 0.1933 to 0.0142 for samples from the same places, after standing in the pipes. Fourteen surface waters showed a range of from 0.0788 for Chicopec (Abbe system) to 0.0031 for Ipswich, when in ordinary use, and from 0.3921 to 0.0099 after standing.

The groupings by sanitary analyses, the report states,

> do not show very clearly the reasons why some waters attack lead and others do not. They apparently indicate, however, that the surface waters having the greatest amount of solids and chlorine and the greatest degree of hardness take the least lead from the pipes; while, with the ground waters, those with the greatest solids and hardness take generally the least amount of lead.

To throw more light on the subject "experiments were made to study the effect upon lead of water to which known amounts of the substances found in natural waters were added in different proportions." The conclusions drawn from these experiments were as follows:

> A review of results of all the experiments indicates strongly that the two active agents in the waters, causing them to take lead into solution, were oxygen and carbonic acid. The purer the water (for instance, distilled water), the more active these agents were upon lead when in this water. . . . The addition of substances which increased the fixed solids tended to decrease the action of water upon lead very greatly.

These conclusions are being verified by determinations of the dissolved oxygen and carbonic acid in the water supplies which were being examined for lead. This part of the work was started late in the summer of 1898 and was still in progress when the report was written. Highly colored water, both the experiments and the observations of natural waters show, "would attack lead if sufficient time and air were allowed for the change of this carbonaceous coloring matter to carbonic acid in the presence of oxygen." The New Bedford supply is an example of this, where lead is shown in samples drawn after standing some hours in lead pipes.

Lowell, Milford, Kingston and Fairhaven, all with ground water supplies, have had or are having many cases of lead poisoning. Their waters, after standing for several hours in lead pipes, show an average of about 0.2 parts of lead per 100,000. Inquiry fails to show a prevalence of lead poisoning outside of these four towns, although there have been occasional cases on other ground water supplies. Thus far no cases have been found by the Board in towns and cities having surface supplies,

> although many of these waters attack lead, the amounts found in some samples not being inconsiderable, and the lead, taken in this manner into the systems of many inhabitants of these cities and towns, may cause mild or unrecognized cases of lead poisoning.

Another series of experiments made during the course of this investigation was a study of the action of water upon service pipes of different material, placed at Fairhaven, Kingston, New Bedford, West Brookfield and Lowell. The pipes were ⅝-in. in diameter, 45 ft. long, and generally lead, iron, galvanized iron and block tin services were tested. Ordinarily, water was kept flowing through each pipe at the rate of at least 100 gallons a day. Samples were collected from two to seven times, at different places, through the year, after the water had been allowed to stand in the pipes from one to 24 hours. All the results are given in parts per 100,000.

At Fairhaven, samples from the iron pipe, after standing one hour, showed from 0.07 to 0.89 parts of iron, and samples standing over night from 0.22 to 1.272 parts. Galvanized iron pipe gave the following amounts of zinc: One hour, 0.2591 to 1.6485; over night, 1.1236 to 1.7971. Lead pipe showed lead as follows: One hour, 0.1051 to 0.2803; over night, 0.1986 to 0.73. Block tin: One hour, 0.0086 to 0.0457; over night, 0.0229 to 0.1029.

At Lowell the plain iron pipe was omitted. The greatest action was shown by the water from the Cook wells, which at the time contained 3.9 parts of free carbonic acid, against 2.0 in the water from the boulevard wells. The results given are for the Cook wells and for two sets of analyses, only: Galvanized iron pipe, zinc in parts per 100,000: One hour, 0.8736 and 1.55; twelve hours, 1.1418 and 1.99. Lead: One hour, 0.0511 and 0.3504; twelve hours, 0.4672 and 0.6424. Tin: One hour, 0.0140 and 0.0180; twelve hours, 0.023 and 0.0382.

The figures for West Brookfield are not reported. We will omit those for Kingston, but give those for New Bedford, as showing the results obtained with a surface water, the Fairhaven and Lowell supplies being ground waters. Iron, from iron pipe, at New Bedford: One hour, 0.055 to 0.3; 12 to 20 hours, 0.18 to 0.59; 24 hours (one sample only), 1.664. Zinc, from galvanized iron: One hour, 0.0057 to 1.4539; 12 to 14 hours, 0.0143 to 0.9942; 20 hours, 3.0315; 24 hours, 0.7797. Lead: One hour, 0.0876 to 0.2803; 12 hours, 0.4088; 13 hours, 0.4672; 14 hours, 0.4672; 15 hours, 0.2628; 21 hours, 0.7008; 24 hours, 0.8877. Tin: One hour, 0.000 to 0.0743; 12 hours, 0.1286; 13 hours, 0.1486; 14 hours, 0.0429 and 0.0657; 21 hours, 0.0292; 24 hours, 0.0629.

No comments on these results are made in the report, perhaps because it was deemed best to await further results. In general, it appears that the water took up more metal from the pipes soon after they were put in use than later on, but the reverse was sometimes true. It is also evident that the amount of metal shown by the samples increases with the period of contact, but not with so much regularity as might be expected.

The description of the results obtained from this investigation is followed by an account of the "Methods Employed for the Determination of Lead, Tin, Zinc and Copper in Drinking Waters."

For the benefit of those who wish to know something regarding the amount of lead that is dangerous to the human system we quote the following from the general report of the Board (p. xxxii.);

> While the quantity of lead dissolved may be small, and a single dose might not seriously harm the user of the water, the continued use of water containing lead is harmful, because lead is a cumulative poison. The exact amount of lead which may be taken into the system without producing harm is not definitely known and may vary with different people, but it is known that the continuous use of water containing quantities of lead as small as 0.05 parts per 100,000 or about 1-33 grain per gallon, has caused serious injury to health.

Comment on the studies reviewed in the foregoing will be found in our editorial columns.

* * *

A 16-IN. SUBMERGED GAS MAIN has just been laid beneath the Seekonk River, at Providence, R. I., to replace an 8-in. pipe located on a draw bridge and supplying East Providence. The new pipe is 25 ft. beneath mean low water, and is supported every 12 ft. in its length by two piles driven to hard pan and capped by timber, both the piles and caps being about 10 ins. sq. and the piles of each pair being about 4 ft., c. to c., at their tops. The caps are strapped to the piles and the gas main is strapped to the caps. According to a detailed account of this work in the Providence "Journal," Falcon flexible joints were used for every third joint. The submerged main was tested under an air pressure of 60 lbs. per sq. in. and found to be practically tight. The engineers for the work were John W. Ellis & Co., of Woonsocket, R. I., and Mr. J. G. Falcon, of Chicago, was the contractor.

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*West Brookfield is supplied with water from springs, which flows by gravity through small lead mains to cisterns in the cellars, from which it is pumped. The lead here given was in suspension. The Lowell sample was from 300 ft. of lead and lead-lined pipe.

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The construction of a bridge across the East River, barely a quarter of a mile from the present Brooklyn Bridge, has been approved by the New York Municipal Assembly, which has also authorized bonds to be issued and sold to the amount of $1,000,000 to provide the money for beginning work. As the matter now stands, therefore, there apparently remains nothing more to be done to embark the city finally upon this project except its formal approval by the Mayor, and this is almost certain to be given, since the bridge was first proposed by him and has been pushed from the beginning chiefly by his personal efforts. In our opinion, no more foolish plan for securing additional transit facilities across the East River could be undertaken by the city, and it would be difficult to conceive a more wasteful application of the money drawn from city taxpayers. At the very lowest estimate the bridge will cost $20,000,000 to construct. It is located so close to the present Brooklyn Bridge, that it must draw its traffic from practically the same territory. As we pointed out in our issue of Oct. 26, 1899, this location will necessitate the purchase by the city at a round figure, of the franchise rights for a bridge at this location which are now held by private parties, who received them as a free gift from the city. Against these obvious objections to the new bridge, its advocates have presented, so far as we can find, but one argument: That the new structure is needed to relieve the overcrowding of the present bridge. To show the weakness of this argument, we only need to point out the fact that much of this overcrowding is certain to be removed when the New East River Bridge, now under construction, is opened for traffic, and that still further relief can be obtained by building at a third of the cost of the bridge the two tunnels to the Long Island R. R. station and to South Brooklyn, which were described in our last issue.

Suppose it be admitted, however, for the sake of argument, that there is a demand for additional traffic accommodations over the present Brooklyn Bridge route. Then it needs only the application of ordinary common sense to see that this can be equally well and far more cheaply secured by increasing the capacity of the present bridge. As an engineering proposition there is nothing new or impracticable about this suggestion. Within the last two years the 1,056-ft. suspension span of the Covington & Cincinnati Suspension Bridge has been reconstructed so as to double its capacity by adding two more cables to carry the additional load. A similar reconstruction of the Brooklyn Bridge is equally practicable, and according to the estimates of competent engineers, it would not cost more than $3,000,000 at an outside figure. This solution of the problem raised by the present overcrowding of traffic on the Brooklyn Bridge should commend itself to every sane and honest citizen as far preferable to duplicating the present structure by a new bridge built practically alongside of it. We have no hesitation in saying that it is the solution that would be adopted by a railway company having the interest of its stockholders at heart, if it were confronted with the same conditions and the same problem. If the city administration were influenced by no other motives than to secure a needed addition to the transit facilities across the East River with the least expenditure, it is safe to say that it is the solution which it would also adopt.

◆

Figures have recently been given to us by two of the leading locomotive works of the United States showing the average weight of the locomotives turned out by them during the past year and during 1891. They show an increase in the weight of the average locomotive of about 50%. That is to say, the average locomotive turned out last year weighed about 1½ times as much as the average locomotive turned out eight or nine years ago. Probably these figures somewhat exaggerate the progress made in that time toward heavier locomotives for standard freight and passenger service. The increased use of electric motors has nearly stopped the construction of small locomotives for suburban and other railways which was more or less of a feature at the beginning of the decade, and which served to reduce the average weight of the machines built. Yet making all allowance for this, it is plain that a great increase has taken place in the size of both passenger and freight locomotives. One firm which built 300 locomotives last year reports their average weight (locomotive and tender in working order) as 270,412 lbs. How great this increase is over the practice of a dozen years ago may be realized by reference to Wellington's "Economic Theory of Railway Location," published in 1887. In that book was given (p. 410) a table of the four most powerful locomotives in the world. They were two mastodon locomotives (a Lehigh Valley with 155,000 lbs. total weight of both engine and tender and a Southern Pacific weighing 186,000 lbs.) and two decapods "El Gubernador" of the Southern Pacific, weighing 239,650 lbs., and a Baldwin engine with a pony truck in front, weighing 224,000 lbs. Of El Gubernador, Mr. Wellington said: "This locomotive develops the enormous tractive power of 32,039 lbs., or just 39 lbs. more than one-fourth the weight on the drivers." This was, indeed, enormous at that day, and yet in less than a dozen years from the time that was written, locomotives were built with a tractive power of over 53,000 lbs.

We shall not now attempt to discuss the causes which have led to this increase in locomotive dimensions, further than to remark that they may be summed up as an increase in the weights and speed of both passenger and freight trains, both of which have come about through the demand for greater economy in the movement of a traffic that has grown and multiplied year by year.

◆

Newspaper discussion of Isthmian canal matters has been revived by the incorporation of the Panama Canal Co. of America and by the renewed agitation in Congress for immediate action upon the Nicaragua enterprise. Mr. Wm. Nelson Cromwell, of 45 Wall St., the attorney and promotor of the Panama company, is reported to have stated that among the financiers interested in the new company are: J. Edward Simmons of the Fourth National Bank; Kuhn, Loeb & Co., E. C. Converse, President of the National Tube Company; Warner Van Norden, President of the Bank of North America; August Belmont, J. &. W. Seligman, George R. Sheldon, Levi P. Morton, Chas. R. Flint, Capt. J. R. De Lamar and Vernon H. Brown.

It is also stated that the new corporation proposes to go ahead and complete the canal at Panama with private capital and will issue $100,000,000 in bonds and increase its capital stock to $120,000,000 to complete the work.

Mr. Edward R. Cragin, who secured what is commonly known as the Eyre-Cragin concession, from the Nicaraguan Government a year ago on behalf of a New York syndicate headed by Hon. Wm. R. Grace, is quoted as expressing doubt as to the genuineness of the Panama company's claims and as to its ability to raise funds for its work. He also declares that his own company is willing to go ahead and construct a canal with its own means.

In Washington, the representatives of the old Maritime Canal Co., of Nicaragua, have been making a great effort to enlist official influence to aid them in securing from Nicaragua a renewal of their lapsed concession, and have declared that their successors, the Eyre-Cragin syndicate have no franchise from Costa Rica, and so are powerless to proceed.

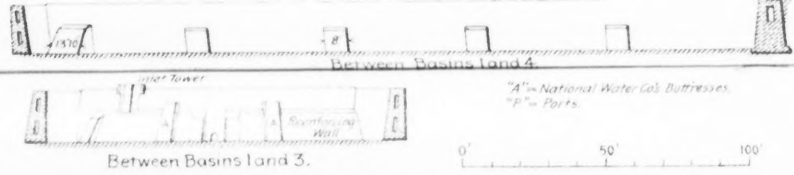
Finally, we have in Congress a small but indefatigable group of men who are trying to push through some measure at the present session of Congress authorizing the building of the Nicaragua Canal by the Government, without regard to the claims of the rival syndicates. A bill looking to that end has already been introduced by Mr. Hepburn.

We may be wrong, but in our opinion the boomers of all these various schemes will succeed only in checkmating each other. In the present state of the money market, private capital is exceedingly unlikely to be subscribed in sufficient amount to build a canal at either Panama or Nicaragua; and the promoters of each scheme are too shrewd to undertake the risky experiment of placing their bonds on the open market.

On the other hand, Congress, which, last year appropriated a million dollars and set an expert commission at work to find and report the facts respecting Isthmian canal routes, is not at all likely to ignore its own action. The impatient few who clamor for immediate action can hardly overcome the conservative common-sense of the majority who will favor postponement at least until the present commission can complete its investigations and present its conclusions. As the present session of Congress is the long session, it may be that the Commission will reach conclusions sufficient to base action upon before the adjournment of Congress. To pass any bill at the present time, or even waste time in its consideration would be decidedly unwise.

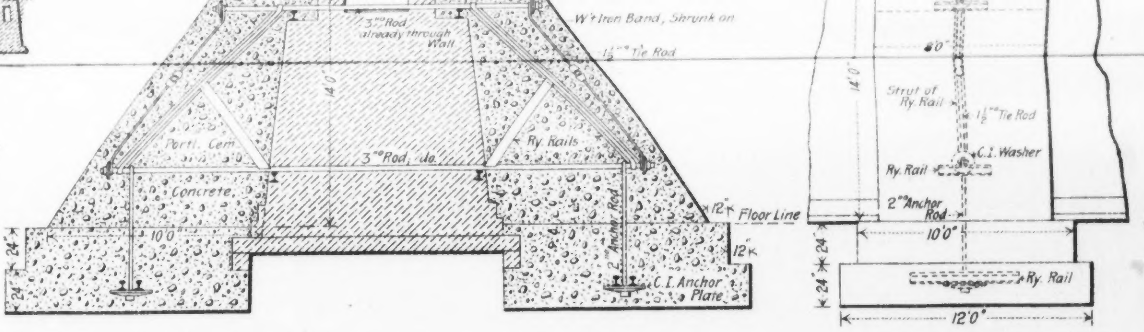
◆

One of the unsettled points in water-works practice is the best material for service pipes, or the connections between street mains and houses. A glance at the returns on this subject in "The Manual of American Water-Works" for 1897, shows a great diversity of practice, without any readily apparent scientific explanation for it. Probably lead and galvanized iron are the materials in most common use. Many object to lead because of the danger, real or feared, of lead poisoning. Discussions of this phase of the subject at the water-works conventions almost always bring out words of alarm from some, which are frequently pooh-poohed by others. Not long ago a prominent member of one of the water-works associations challenged anyone to bring forward proof of lead poisoning from an ordinary service pipe—not one of the long lines of lead pipe conveying water from springs to a house or small group of houses. The challenge was not accepted. It seems now, however, that evidence of sufficient weight to go far towards convincing the most sceptical is at last available. We refer to the studies of the subject made by the Massachusetts State Board of Health, set forth in its last annual report and abstracted elsewhere in this issue. The studies, accompanied by recent prevalence of lead



Between Basins 1 and 3.

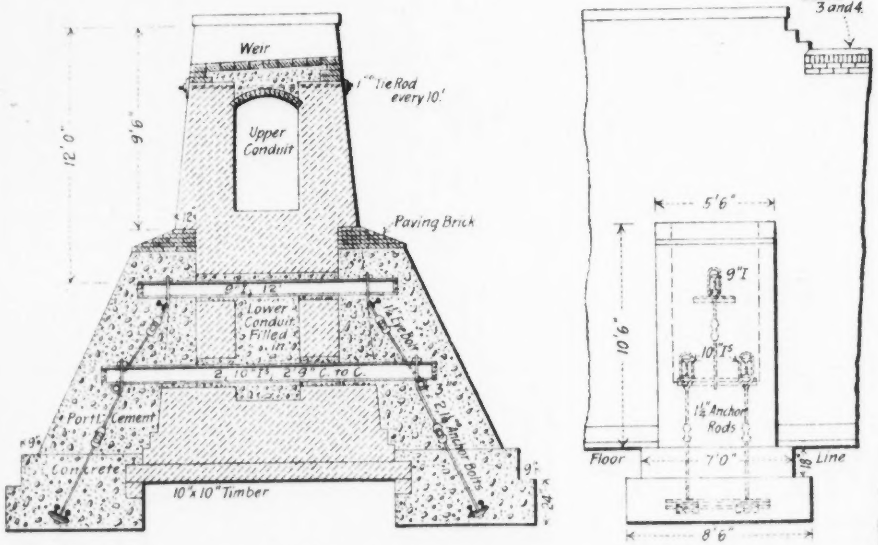
FIG. 4. ELEVATIONS OF DIVISION WALLS, SHOWING LOCATION OF BUTTRESSES.



Cross Section.

Side Elevation.

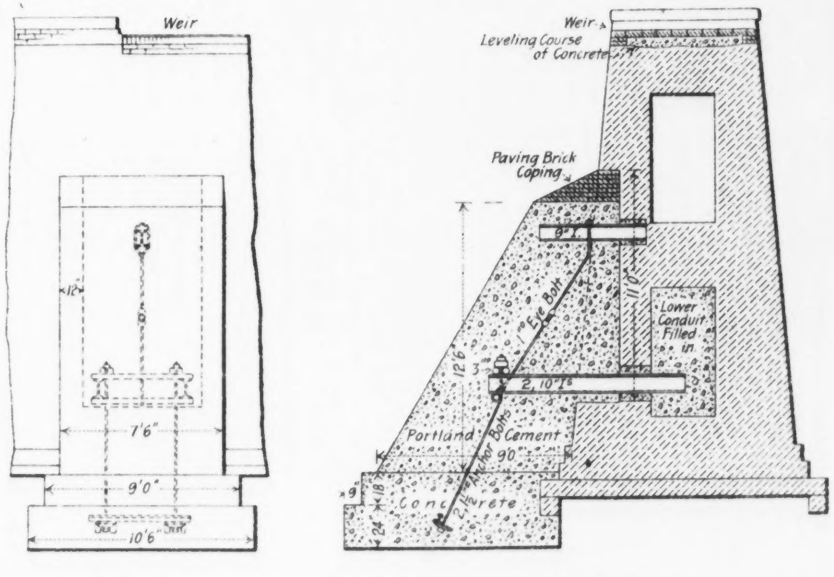
FIG. 6. LARGE BUTTRESSES BETWEEN BASINS 1 AND 4.



Cross Section.

Elevation.

FIG. 5. BUTTRESSES TO WALL BETWEEN BASINS 3 AND 4.



Side Elevation.

Cross Section.

FIG. 8. SINGLE BUTTRESSES FOR WALL BETWEEN BASINS 1 AND 2.

{ Original Section of Walls Shown thus ▨

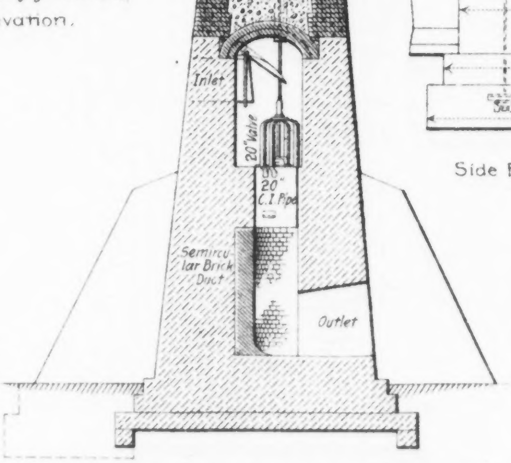


FIG. 3. METHOD OF FILLING LOWER CONDUIT IN DIVISION WALL

REINFORCEMENT OF THE DIVISION WALLS OF THE QUINDARO SETTLING BASINS OF THE WATER-WORKS OF KANSAS CITY, MO.

W. Kiersted, M. Am. Soc. C. E., Chief Engineer.

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

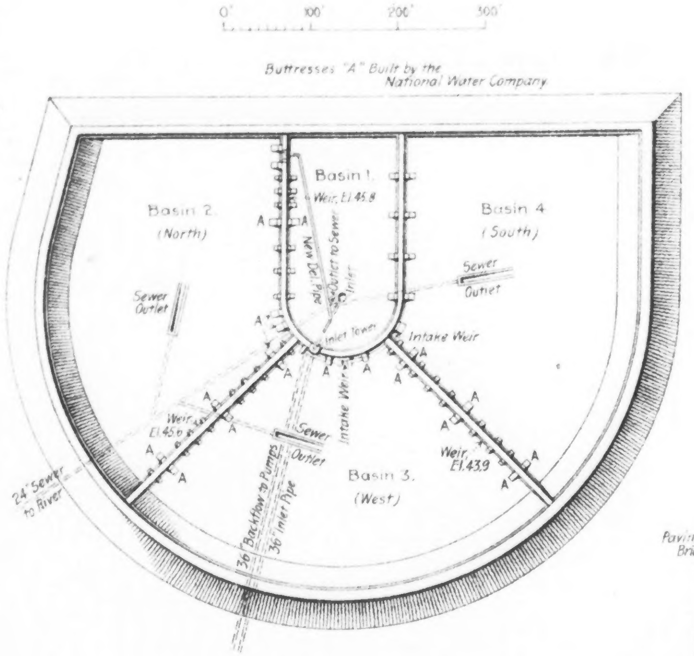
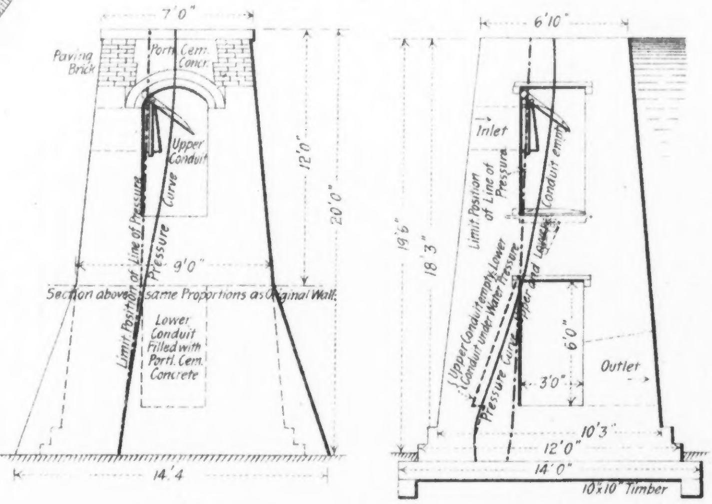


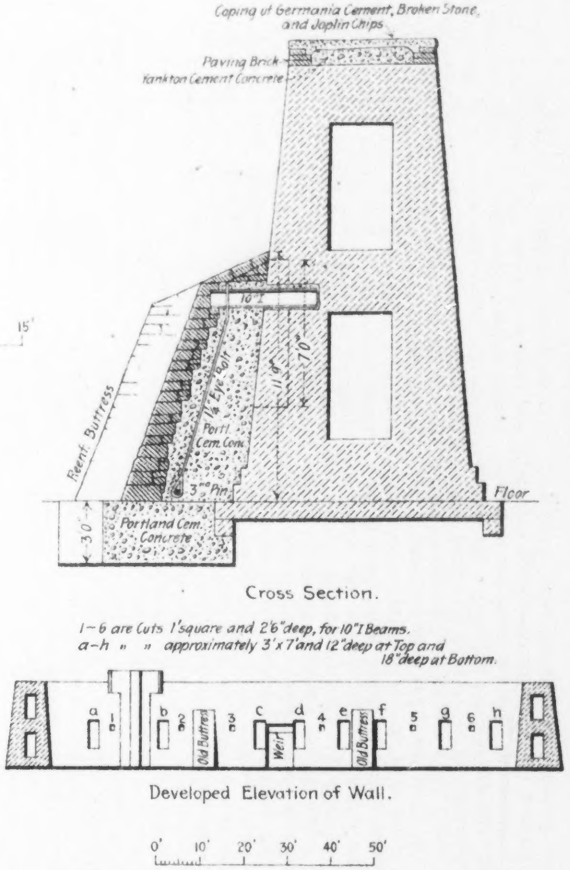
FIG 1. PLAN OF SETTLING BASINS, SHOWING POSITION OF REINFORCING BUTTRESSES AND WALL.



Stable Wall.

Original Wall.

FIG. 2. SECTIONS OF ORIGINAL AND OF STABLE WALL, WITH PRESSURE CURVES.

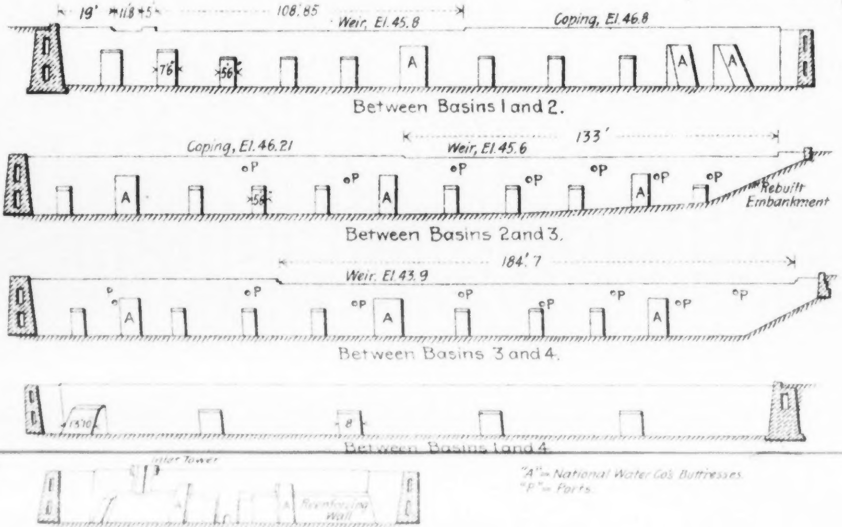


Cross Section.

1–6 are Cuts 1' square and 2'6" deep, for 10" I Beams.
a–h " " approximately 3' x 7' and 12" deep at Top and 18" deep at Bottom.

Developed Elevation of Wall.

FIG. 7. REINFORCEMENT OF WALL BETWEEN BASINS 1 AND 3.

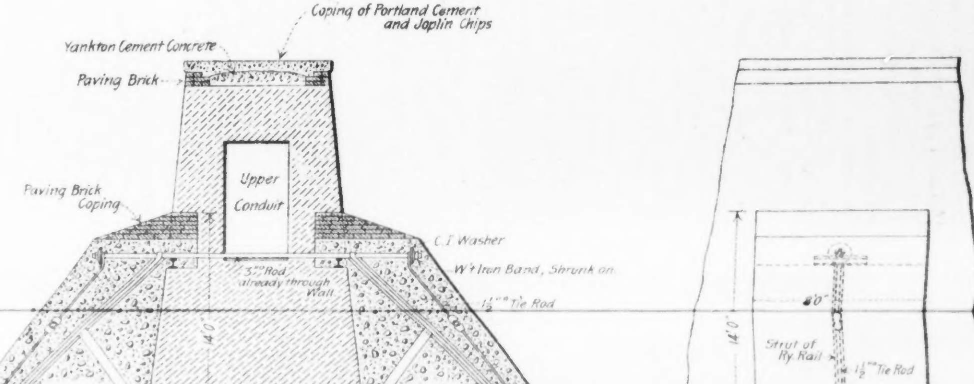


Between Basins 1 and 2.

Between Basins 2 and 3.

Between Basins 3 and 4.

Between Basins 1 and 4.



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poisoning at Lowell, Kingston, Fairhaven and Milford, Mass., and occasional cases elsewhere in Massachusetts, seem to show conclusively that waters high in free carbonic acid and oxygen, will take up lead in dangerous quantities if allowed to remain in contact with it, as in service pipes of that material. Where the water is hard, contains much organic matter or fixed solids, the action seems to be materially lessened. The observations and experiments recorded in the report plainly show the desirability of a full knowledge of the action, or probable action, of a given water supply on different metals before choosing the material for service pipes, and also for distributing water within the house. They also confirm the advice frequently laid down in books intended to guide householders and housekeepers, to the effect that after a service pipe has been out of use for even a few hours, whatever its material, it is advisable to let the water from it run to waste for a short time before using it.

We would suggest that much interest, and possibly considerable value, would have been added to the reports of the amounts of lead found in various waters if the age of the service pipes from which they were drawn had been stated. Perhaps this would have been impracticable.

In its general report (p. xxxii.), the Board points out that "private wells, even more than public water supplies, are subject to the same danger when lead pipe is sued for the conveyance of drinking water." It is a significant fact, and forms another example of the failure of communities to heed the warnings of those whose advice they should respect and follow, that the danger of using lead pipes to convey the ground waters of Lowell was pointed out as far back as 1842, by a special committee, appointed at the instance of the leading physicians of Lowell, to study this very subject. The report of the Massachusetts State Board of Health says:

> So far as we know, this public document of the city of Lowell is the earliest, as it is one of the best, statements of the peculiar danger from the unnecessary use of lead pipe.

As a public water supply was not introduced in Lowell until more than 30 years after this report was made, and as a large part of the supply was taken from the Merrimack River for some years prior to the recent introduction of the new driven well supply, perhaps the people of Lowell cannot be greatly blamed for having forgotten this old report of 1842.

CONTROLLING THE LEVELS OF THE GREAT LAKES.

To establish and control by artificial means the water levels of Lakes Erie, Huron and Michigan, covering 60,000 square miles, with their connecting waterways, would be, without doubt, the most stupendous physical effort ever produced by man's agency. As we state elsewhere in this issue, however, it is seriously proposed to accomplish this task, detail plans have been prepared for carrying it out, and a bill has been introduced in Congress which provides that it shall be undertaken by the United States Government. A fact which makes this bill of particular interest to engineers is that its passage is advocated by the Government Board of Engineers on Deep Waterways, which has made a special report to the Secretary of War, in which it sets forth the facts and arguments which have influenced its action. These are summarized briefly elsewhere in this issue, and in our issue of Nov. 23, 1899, and we believe that a careful study of them will demonstrate that the proposed regulation can be carried out by methods entirely within the precedents of modern engineering, and at a cost which will be moderate in comparison with the benefits to be secured. At the very least estimate the evidence which the Board presents must be regarded as a noteworthy endeavor to solve an engineering problem of vast commercial importance, and for that reason, if for no other, it deserves the careful consideration of engineers.

The proposition to control the water levels of the Great Lakes by artificial means is not new. Many of our readers will recall that in one form or another it has for a number of years attracted the attention of engineers familiar with the hydraulics of these great fresh water seas. The first definite plan for carrying it out was, we believe, outlined by Mr. George Y. Wisner, M. Am. Soc. C. E., in a paper read at the Toronto meeting of the International Deep Waterways Association, in the Fall of 1894. Mr. Wisner's plan was substantially the plan which is now advocated by the Board of Engineers on Deep Waterways. In 1895 Mr. L. E. Cooley suggested damming the Niagara River, or preferably the St. Mary's River, at the outlet of Lake Superior, as a means of remedying any lowering of the lake levels by the opening of the Chicago Drainage Canal. In our issue of Oct. 3, 1895, we discussed Mr. Cooley's arguments at some length, and expressed the belief that some plan of lake regulation presented not only an admirable solution of the problem under consideration, but would wipe out the present variation of the lake levels due to natural causes, and would hold them permanently at a point which would add substantially to the navigable depth of every harbor and channel on the lakes.

The significance to the Great Lakes' shipping interests of this last result, if it can be obtained, is evident upon a moment's consideration of the factors controlling lake navigation. The size of the vessels plying on these waters is directly regulated by the depths of their harbors and of the waterways connecting the several lakes. For a number of years work has been in progress by the United States on the deepening the lake channels to 21 ft. So far this improvement has not been extended to the lake harbors, except in isolated instances, and until this is done lake transportation interests can gain little benefit from the deepened channels. Obviously any increase in the height of the water levels which can be brought about by regulation reduces by that much the amount of future deepening required to be done. The depth gained in this manner, moreover, benefits the harbors and the connecting waterways equally. In some respects this appears to us to be one of the strongest arguments in favor of regulation.

To obtain a rough idea of what this one item of saving in excavation may amount to, let us make a short calculation. According to the figures given in another column by the Board of Engineers on Deep Waterways, the plan of regulation proposed will raise the level of Lake Erie about 3 ft. higher than the usual stage of water during the low water period in the latter part of the season of navigation. The aggregate cost of improving Lake Erie harbors has averaged up to the present time in round numbers $1,000,000 for each foot of permanent depth secured. It is evident, therefore, that to obtain the same results by excavation as it is claimed will be afforded by the plan of regulation which is proposed, would cost fully $3,000,000. The entire cost of the regulating works is estimated by the Board at $800,000 in round figures. Making all due allowances for errors in these estimates, the saving shown is remarkable enough to justify the most thoughtful consideration of any feasible plan for raising the levels of Lake Erie. It will become plain, as we proceed, furthermore, that this is only one of the possible opportunities for a similar saving.

It is pointed out in the report of the Deep Waterways Board that the further deepening of the Detroit River shoals seems imperatively necessary in the immediate future. At present there is less than 18 ft. depth over them at low water, if the information presented is trustworthy. It is maintained by the Board that not only a deepening of this channel, but a substantial increase in its width is demanded by commerce, and figures are presented to show that the 2 ft. increased height of this stream, which will result if Lake Erie is raised 3 ft., will save more than enough excavation to pay for the construction of regulating works. In this connection the report of the Board brings out a fact which is in some respects, we think, the most interesting natural phenomenon which its investigations have developed. Briefly stated, these examinations show that at the outlet of Lake Huron, the St. Clair River has been deepened by erosion in recent years over 18 ft. This has increased the cross-section of the river at this point over 20 per cent., and has resulted in lowering the surface of Lakes Huron and Michigan about one foot since 1886. Raising the levels of these lakes will restore this decrease. On the other hand, if the work of deepening and enlarging the Detroit River is continued, in the absence of works to retain the level of Lake Erie, there will be a still further lowering of Huron and Michigan.

These facts, brought out by the Board's report, evidently deserve careful attention in settling upon the best method of securing an improved channel between Lakes Huron and Erie. It is, however, from another direction that we believe the greatest benefits of raising the lake levels as compared with dredging lake harbors and channels are to be looked for. It is manifest upon the merest mention that one of the chief requisites of economical transportation on the Great Lakes is to have a constant depth during the entire season of navigation, so that vessels will be able to carry full cargoes at all times. Lake vessels are now generally constructed to utilize the maximum depth of the navigable channels. Under natural conditions these depths are subject to periodical fluctuations. Besides the local variations of level due to temporary natural causes of short duration, such as wind effects, there is the larger annual fluctuation due to the seasonal low water. This means that vessels designed for maximum depths must sail light during a greater or less portion of each season. Furthermore, as low water occurs in the Fall, the decrease in carrying capacity takes place just when the rush of business closing the year's navigation makes full cargoes of the greatest importance. It is plain that deepening the lake channels cannot alter the annual decrease in depth to which they are subjected by the natural fluctuations in lake levels, and that the control of these fluctuations is the only thing which will remedy the condition.

From what has been said the advantages to be secured by regulating the lake levels at a constant stage are sufficiently apparent, we think, to explain the interest which engineers have taken in the proposition. Evidently the next question to be decided is the feasibility of accomplishing the proposed regulation. This is the phase of the question which is discussed particularly in the report of the Board of Engineers on Deep Waterways. A very little thought makes it plain that this question involves problems which extend far beyond the mere structural task of building a dam which will control the outflow of the lake waters beyond a certain volume. These arise chiefly from the fact that any restraint set upon the normal conditions of flow in any of the lake waterways is certain to affect somewhat the regimen of at least the immediate waters which supply them, and which they feed. The hydraulic conditions of the various streams will, of course, determine how far-reaching this effect will be for any given amount of restriction. If it reaches the point where vested rights are disturbed, the benefits gained in one way may easily be overbalanced by the damage which will result in other ways. We hardly need to point out to engineers that interference with riparian rights is a thing to be avoided wherever possible; and in a case like the one under consideration, where the water lines which it is proposed to alter are partly within a foreign country, such interference is especially risky. These brief remarks are ample, we think, to show the wide range of the problems involved in any scheme for controlling the water levels of the Great Lakes and which have consequently had to be considered by the engineers of the Deep Waterways Board.

To summarize briefly the reasoning of the Board's engineers, it will be observed that they assume at the outset that the fact that the evaporation from Lakes Huron and Michigan is at times largely in excess of the supply, establishes the impossibility of regulating those lakes directly. Since also the greatest discharge from Lake Superior occurs at the time when the two lower lakes are being lowered most rapidly by evaporation and outflow, it is reasoned that it would be a distinct injury instead of a benefit to alter the natural conditions by damming the St. Mary's River. The conclusion follows then that the only available location for regulating works is in the Niagara River. Observations made by the Board show that the outflow of Lake Erie is practically equal to the maximum supply. If, therefore, regulating works are located at the foot of Lake Erie which, when the supply commences to decrease, will correspondingly diminish the outflow, the level will be maintained constant, and this is in substance what the Board proposes.

The abstract of the Board's report, published in another column, and the article in our previous issue of Nov. 23, 1899, explain the essential structural features of the proposed regulating works, and they need not be described further here. It will be seen that what it is really proposed to do is to maintain the level of Lake Erie 3 ft. above the normal stage of water during the latter part of the navigation season, which is the season of low water. In effect the plan is to maintain constant mean high water in this lake, but with the provision that any other stage of water may be substituted should conditions make it desirable. The result of this will be, according to the Board's figures, to increase the corresponding low water depth in Lake St. Clair 2 ft., and that in Lake Huron and Lake Michigan 1 ft. Lake Superior is, of course, beyond the range of effect. As is pointed out above, however, the waters of this lake reach their high stage in September, so that it produces the maximum discharge into Lake Huron just at the time when that lake is being lowered most rapidly by evaporation and outflow.

It will be observed that since it is proposed to raise only the low water levels of the three lakes affected by the dam, there will be no extension of their existing water lines beyond the horizon they attain during each year's high water. Riparian rights, therefore, will not be injured on these lakes, but will actually be benefited. The outflow of Lake Erie, which feeds Lake Ontario and the St. Lawrence River, will, of course, undergo some modification, due to the controlling works. From all appearances, however, there will result from this no measurable alteration in the levels of those waters. According to the figures which are presented by the Board's engineers, there will be no change in the total annual discharge of the Niagara River, but its character will be altered to the extent that there will take place during the first half of the year an increase in the discharge amounting to 5 per cent. of the total annual discharge, and a decrease of a similar amount during the last half of the year.

It is a curious fact, worth noting at this point, that the measurements of the Niagara River, made by the Board's engineers and confirmed by the last year's measurements of the United States engineers, show the discharge at the mean stage of Lake Erie to be about 220,000 cu. ft. per second at the present time. The measurements made in 1890-91 by the United States engineers showed the discharge to be 230,000 cu. ft. per second, and those made in 1867-9 gave it at 265,000 cu. ft. per second. These figures indicate quite conclusively that there has been a gradual decrease in the volume of discharge of the river since 1867, and that it is apparently still continuing. Recent observations also bring out the fact that the discharge of the St. Mary's, St. Clair and St. Lawrence rivers exhibit about the same relative reduction from the volume shown by the determinations of 1867-9. It would be an interesting speculation to determine just what causes have been instrumental in bringing about these changes, and it is to be hoped that in its final report the engineers of the Deep Waterways Board will endeavor to throw some light upon the matter.

Before concluding this review of the Board's data pertaining to lake regulation, the attention of hydraulic engineers should be directed to the short table of coefficients of discharge over submerged weirs, which is given in the abstract of its report published in another column. These figures appear to indicate a smaller effect due to submergence by backwater than might have been anticipated. It will be interesting to engineers to know that the observations made for the Board at Cornell University to determine the coefficients for the Francis formula for depths up to 5 ft. on crests will be fully discussed in the final report of the Board.

To return to the main subject, it seems to us that to regulate the level of Lake Erie in the manner proposed by the Deep Waterways Board, presents one of the most promising solutions of the problem of securing improved lake navigation which has ever been brought forward. Wider, straighter and deeper channels for harbors and through the lake waterways are urgently demanded by the increasing shipping interest. No plan which has been presented for securing these improvements offers so great a benefit for so small an expenditure as regulation. The control of the levels of the Great Lakes is an international matter, and of course will require international consideration and agreement to accomplish, but there appears to be no good reason why this phase of the question should not be arranged satisfactorily, if it is properly undertaken. So far as at present appears, Canada has everything to gain and nothing to lose by the proposed work, and even though she may not contribute toward its cost, no reason appears why she should not give to it her hearty consent and approval.

LETTERS TO THE EDITOR.

The Success of Engineers in Railway Service.

Sir: I read with interest the letter of "One Who Has Been An Engineer," published in your last issue. I think the subject admits of considerable discussion, and any effort that will secure the engineer the proper recognition that he deserves should be encouraged.

In looking over the list of high operating officers of the railroads of the United States, I venture the assertion that there are very few indeed taken from the engineering profession, while on the other hand we find the names of men without number who have risen from the ranks of stenographers, clerks, brakemen, firemen, enginemen, conductors, station agents, telegraphers, section foremen, etc., etc. Of course there have been a few notable exceptions, but I can only recall the names of Geo. B. Roberts, late President of the Pennsylvania R. R., and Albert Fink, at one time prominently connected with the Louisville & Nashville R. R.

I do not pretend to give reasons why the positions in the operating department are so sparingly filled with men from the engineering ranks, except that their education and training does not fit them for such work.

Civil Engineer.

Chicago, Dec. 29, 1899.

(We think our correspondent is "dead wrong." A large number of the Presidents, Vice-Presidents, Managers and Superintendents on American railways will be found to have at some period in their career been engaged in engineering work on railway construction. We recall at random the names of A. J. Cassatt, Theodore Voorhees, John F. Wallace, Samuel Spencer, R. S. Hayes, John M. Egan, A. A. Robinson and Robert H. Sayre. It is true that an engineering education does not fit a man for an executive position in the railway operating department. On the other hand, such an education is a good foundation on which to build an experience in the railway service which may or may not lead to the highest positions, according to the abilities that a man develops in handling men of high and low degree.—Ed.)

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Stresses in Circular Plates.

Sir: There seems to be a lack of definite knowledge on the subject of the strength of circular plates, at least I have not been able to find a formula derived in a rational manner. Lanza, in his "Applied Mechanics," gives two formulæ for the strength of flat plates uniformly loaded, one merely supported at the edges and the other fixed. They are as follows:

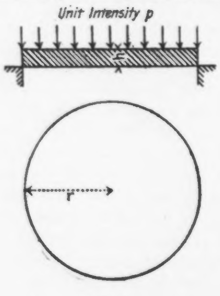

Fig. 1.

$$\text{Supported, } h = r\sqrt{\frac{5p}{6f}}, \text{ or } f = \frac{5pr^2}{6h^2},$$

$$\text{Fixed, } h = r\sqrt{\frac{2}{3}\,\frac{p}{f}}.$$

Where

h = thickness of plate;
r = radius,
p = load per square inch.

Now, I think I can show that the first of these is wrong, and the inference is that the other is as far off. To prove that the first is wrong, we have simply to cut a vertical section diametrically through the plate, and take the moment of the forces acting on one-half of the plate; then consider what there is in the way of section-modulus of the section cut to resist the bending moment on the plate. The reaction will be half of the load, or $\frac{\pi r^2 p}{2}$, and, since this acts on the semicircular arc supporting half of the plate, its resultant will act through the center of gravity of the semicircular arc, which is $\frac{2r}{\pi}$ from the center of the circle. The moment of the load on half of the plate will be half of the load multiplied by the distance to the center of gravity of the semicircle, which is $\frac{4r}{3\pi}$ from the center. The difference between these moments will be the bending moment acting on the section. The section is $2r$ in width and h in depth. Its modulus is then $\frac{rh^2}{3}$. Now, supposing the extreme fiber stress were uniform all along the diameter; this fiber stress would be found as follows:

Equating moments,

$$f \times \frac{rh^2}{3} = \frac{\pi r^2 p}{2}\left[\frac{2r}{\pi} - \frac{4r}{3\pi}\right]; \text{ or } f = \frac{r^2 p}{h^2}.$$

We know that the fiber stress is greater at the center of the plate than near the edges; therefore the maximum fiber stress would be greater than the above, which is the average. But, by the formula above quoted (given by Lanza and Grashof), the maximum extreme fiber stress is less than this average. This would be impossible.

The method by which Grashof's formula is deduced seems to be at fault. It is only partially rational, and makes assumptions about conjugate stresses as though they did not enter as determining factors in the result. In the following investigations I propose to show that what might be called conjugate stresses, or the stresses at right angles to those to be found, are primary stresses and aid in overcoming the bending on the plate. The formulæ derived and the method, if not new, are, at least, the result of independent investigation. I have been unable to find any completely rational formulæ on the subject; but these do not seem to contain any element of uncertainty that does not enter into the common theory of flexure of beams, used by engineers every day.

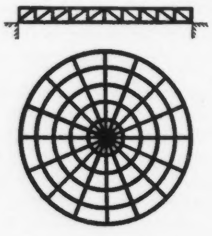

Fig. 2.

Conceive a flat plate made up of concentric rings at the top and bottom surface of the plate, and these rings joined by radial pieces at short intervals, and also by diagonal pieces from an upper ring to the next larger lower ring, in raidial planes, as in Fig. 2. We can readily see that, if such a plate were in the center or with a uniform load and supported around the edge, the rings could all be cut and the plate would still be sustained by the radial pieces, the diagonal pieces taking the shear; or the radial pieces could all be cut and the load be sustained by the rings, the diagonals still taking the shear. If, however, both the rings and the radial pieces are conceived to remain, both will act under a load and both will be prime factors in supporting the same. This is just what takes place in a flat plate supporting a load. There are radial stresses compressing the loaded side and putting tension in the unloaded side, and there are circular stresses having the same effect. This can be proven in two ways: First, there is extension in both directions, which must, of necessity, be accompanied by stress. Then, if there were only radial stresses, the extreme fiber stress could be shown, by the theory of simple flexure to be infinite at the center of a uniformly loaded plate.

The principal part of the problem is to determine the effect on a homogeneous circular plate of uniform thickness, of a uniform normal pressure or pull on its periphery; and also the effect, on a plate bounded by two concentric circles, of a uniform pressure or pull normal to the inner circle—in the planes of the plates. The solution of this is found in Rankine's Applied Mechanics, under the subject of thick, hollow cylinders under internal and external pressures. By taking his formula (6) on page 293 we find that, for the case of a circular plate having a circle cut out of its center, if we make the external pressure zero the hoop tension on the inner circle will be $\frac{R^2 + r^2}{R^2 - r^2}$ times the intensity of the internal pressure. It seems like an axiom that the result of applying a uniform pressure on the periphery of a flat circular plate will be to compress the plate, both radially and in an annular direction, to a unit intensity equal to the pressure applied. We know that this will be the mean pressure on any diameter, and if we assume it to be the radial pressure at any given point we find by the formula above cited that the hoop tension, or compression, will be the same. Further, if we assume the same unit pressure on an inner circle of diameter zero we obtain the same result.

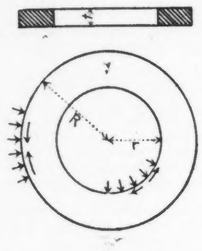

Fig. 3.

Having established these relations, the next thing to note is that the increment to the extreme fiber stress on a plate at any given section of radius r is in exactly the position of an external pressure on a circular plate, as regards its effect on the part of the plate inside of the circle of radius r; and is in the position of an internal pull on a plate bounded by two concentric circles, as regards its effect on the part of the plate outside the circle r. Then, since the compression or tension in an annular direction, due to these two effects, must be equal at r and, in fact, the same for the entire circle r, including the critical point, which is the center, the part of this increment which affects the inside circle will be found as follows:

Let

f = the unit "pressure" due to this increment,

f' = the part of this pressure affecting the inner part of plate, and

f'' = the part affecting the outer part of plate.

The annular unit compresion at $r = f'$, or

$$f'' \frac{R^2 + r^2}{R^2 - r^2},$$

but

$$f = f' + f'', \text{ and } f'' = f - f';$$

then

$$f' = (f - f')\frac{R^2 + r^2}{R^2 - r^2}, \text{ and } f' = f\frac{R^2 + r^2}{2R^2}.$$

The problem then resolves itself into one of finding the increment to the fiber stress in successive circular rings dr in width and taking the integral of the parts of these increments that affect the inner part of the plate. This will give the extreme fiber stress at the center of the plate.

First, for a uniform load of unit intensity p, the radius of plate being R and the thickness t.

Consider an elementary ring of the load of radius r' and dr' in width. The amount of the load will be $2\pi p\,r'\,dr'$. This will be the shear in any circular section of radius r (greater than r'). The increment to the extreme fiber stress at r would then be found by multiplying this shear by dr to get the bending moment, and equating to f times the section modulus. The section in this case is a rectangle $2\pi r$ in width and t in depth.

Hence

$$2\pi p\,r'\,dr'\,dr = \frac{2\pi r f t^2}{6},$$

$$\therefore f = \frac{6p\,r'\,dr'\,dr}{r t^2}.$$

But the part of this which is effective in producing stress at the center of the plate is

$$f \times \frac{R^2 + r^2}{2R^2},$$

which is also the unit intensity of stress at the center of the plate. The total effect of this element of the load, in extreme fiber stress at the center of plate, is found by integrating the following expression:

$$\frac{6p\,r'\,dr'}{t^2}\int_{r'}^{R}\left[\frac{R^2 + r^2}{2R^2}\right]\frac{dr}{r}. \qquad (1)$$

Integrating we have:

$$F' = \frac{6p\,r'\,dr'}{t^2}\left[\frac{1}{2}\log\frac{R}{r'} + \frac{R^2 - r'^2}{4R^2}\right]. \qquad (2)$$

where F' = extreme fiber stress at the center of the plate from a circular element of the load.

Now, to get the total fiber stress at the center from the total load we need only to consider r' a variable and integrate between the limits R and zero:

$$F = \int_0^R \frac{6p\,r\,dr}{t^2}\left[\frac{1}{2}\log\frac{R}{r} + \frac{R^2 - r^2}{4R^2}\right],$$

$$F = \frac{9}{8}\,\frac{p R^2}{t^2}, \qquad (3)$$

where F = total maximum fiber stress at the center.

Next, consider the effect of a load P disposed in a line describing a circle on the plate with radius r having the same center as the plate. To find the extreme fiber stress for this loading we have but to substitute for $2\pi r' p\,dr'$ in equation (2) the value P

$$F'' = \frac{6p\,r'\,dr'\,P}{2t^2\,\pi r' p\,dr'}\left[\frac{1}{2}\log\frac{R}{r'} + \frac{R^2 - r^2}{4R^2}\right],$$

$$F'' = \frac{3P}{\pi t^2}\left[\frac{1}{2}\log\frac{R}{r} + \frac{R^2 - r^2}{4R^2}\right], \qquad (4)$$

where F'' = maximum extreme fiber stress from circular load.

Professor Merriman, in his "Mechanics of Materials," derives a formula which would make the inner hoop tension on our plate bounded by two concentric circles $\frac{R}{R - r}$ times the internal unit pressure applied. Using this instead of the value found by Rankine's formula we obtain for the part of the increment affecting the inner part of the plate

$$f' = f\frac{R}{2R - r}.$$

Then, using the same nomenclature as above,

$$F' = \frac{6p\,r'\,dr'}{t^2}\int_{r'}^{R}\frac{R\,dr}{(2R - r)\,r},$$

$$F' = \frac{3p\,r'\,dr'}{t^2}\left[\log\frac{R}{r} - \log\frac{R}{2R - r'}\right],$$

$$F' = \frac{3p\,r'\,dr'}{t^2}\left[\log(2R - r') - \log r'\right]. \qquad (5)$$

Making r' a variable we have

$$F = \frac{3p}{t^2}\int_0^R \log(2R - r)\cdot r\,dr - \log r\cdot r\,dr.$$

Integrating and reducing we have—

$$F = \frac{3pR^2}{t^2}(2\log 2 - 1). \qquad (6)$$

This reduces to

$$F = \frac{1.1589\,p R^2}{t^2}$$

where the value by Rankine's formula is

$$\frac{1.125\,p R^2}{t^2}.$$

For the circular load replacing $2\pi r' p\,dr'$ in (5) by P we have:

$$F'' = \frac{3P}{2\pi t^2}\left[\log\frac{2R - r'}{r'}\right]. \qquad (7)$$

To compare formulas (4) and (7)—if we take, for example, $r' = \frac{R}{2}$, we obtain by (4) $F'' = \frac{1.602\,P}{\pi t^2}$ and by (7) $F'' = \frac{1.647\,P}{\pi t^2}$. The expressions for extreme fiber stress, therefore, deduced from Rankine's and Merriman's formulæ, agree very closely with each other.

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., Nov. 2, 1899.

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LAKE COMMERCE THROUGH THE CANALS AT SAULT STE. MARIE, MICHIGAN AND ONTARIO, IN 1898 AND 1899.

Freight through the Sault Canals was 19% greater in 1899 than in 1898, and reached a total of 25,255,810 tons. This included, over 15,000,000 tons of iron ore east bound, nearly 4,000,000 tons of coal west bound, and over 4,000,000 tons of flour and grain east bound. Of the total freight, 20,619,534 tons went east and 4,636,276 tons went went. The Canadian canal carried 3,003,671 tons and the United States canal, 22,252,139 tons. The United States canal was opened May 2 and closed December 18, 1899, making a season of 231 days. The Canadian canal was opened April 26 and closed December 20, 1899, making a season of 239 days. A complete statement of the traffic for 1898 and 1899 is given in the following table:

	Seasons			
Items.	1898.	1898.	Inc.	Dec.
No. of vessels: Steamers..	12,461	14,378	15%	..
Sailing	4,449	4,776	7%	..
Unregistered	851	1,101	29%	..
Total No. passages..	17,761	20,255	14%	..
Tonnage:				
Registered, net tons...	18,622,754	21,958,347	18%	..
Freight, net tons.	21,234,664	25,255,810	19%	..
No. of passengers.........	43,426	49,082	13%	..
Coal: Hard, net tons.....	540,843	841,281	56%	..
Soft, net tons	3,235,607	3,099,606	..	4%
Flour, bbls.	7,778,043	7,114,147	..	9%
Wheat, busn.	62,339,996	58,397,335	..	6%
Grain (other than wheat..	26,078,384	30,000,935	15%	..
Iron:				
Manfd and pig, nt. tons	250,170	214,585	..	14%
Ore, net tons	11,706,960	15,328,240	31%	..
Salt, bbls.	301,560	316,336	5%	..
Copper, net tons	124,226	120,090	..	3%
Lumber, M. ft., B. M.....	895,485	1,038,057	16%	..
Silver ore, net tons	....	487	..	..
Building stone, net tons...	4,670	39,063	736%	..
Unclassified freight, nt. tons	623,146	587,484	..	6%

◆

THE AVERAGE WEIGHT OF LOCOMOTIVES built by the Brooks Locomotive Works at Dunkirk, N. Y., in the year 1891 was 184,629 lbs. The average weight of the locomotives built by the same works in 1899 was 270,412 lbs., an average increase of 85,783 lbs. per locomotive. These figures represent in both cases the total weight of engine and tender in working order. For the engine alone the increase was from 112,633 lbs. in 1891 to 165,768 lbs. in 1899, or an average gain in the engine alone of over 53,000 lbs. These figures are based on an output of 226 locomotives completed in 1891 and 300 completed in 1899, and are interesting evidence of the tendency toward heavier locomotives and longer trains which has been so marked a feature of American railway practice during the past decade.

◆

AMERICAN EXPORTS TO RUSSIA, says the U. S. Bureau of Statistics, have increased from $2,477,414 in 1893, to $10,029,783 in 1899. A large part of this business is the export of American agricultural implements. Steam pumps, machine tools and bicycles also enter largely into the exports.

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REPORT OF THE DEEP WATERWAYS BOARD ON THE REGULATION OF THE GREAT LAKES.

The Board of Engineers on Deep Waterways, appointed by an act of Congress which was passed on June 4, 1897, has made a preliminary report, presenting its conclusions on the problem of regulating the level of Lake Erie. This report has been made previous to the complete report of the Board at the request of the Secretary of War, in order that the conclusions of the Board respecting lake regulation might be available in discussing the bill introduced into the present session of Congress, by Representative John B. Corliss, of Michigan (Eng. News, Dec. 21, 1899), and empowering the construction of a dam or regulating works in the Niagara River. The conclusions of the Board are briefly summarized in the report. They are based upon an exhaustive investigation of the question made by the engineers of the board, and summarized in a special paper by Mr. Geo. Y. Wisner, M. Am. Soc. C. E., who is one of its members. The conclusions of the Board as they are given in the preliminary report, are in abstract as follows:

> To maintain the level of a lake at or near some fixed stage, the discharge must be controlled so that it will always be approximately equal to the difference between the supply of water to the lake and the evaporation from its surface. In the case of Lake Erie this can only be accomplished by establishing regulating works in or near the discharging waterway. These works must be so arranged that they will not only maintain the level of the lake at or near a fixed stage adopted, but also so that they will produce no injurious effects upon the lakes and waterways from which a part of the supply is derived or upon those which receive the discharge.
>
> The Board is of the opinion that the best location for works for regulating the level of Lake Erie is at the foot of the lake, just below Buffalo harbor. The location in the Niagara River, below Tonawanda, has been advocated, but the Board finds upon investigation that regulation by works at this point would be less effective and much more expensive than at the adopted location.
>
> The works projected by the Board are designed to distribute the discharge of the lake so as to reduce its variation of level to a small amount. This result cannot be attained by the use of submerged fixed weirs only, and a series of sluices is added to secure, in combination with fixed weirs, the control desired. The weirs will be constructed of concrete blocks, and will have an aggregate length of 2,900 ft. The sluices, 13 in number, of the Stoney type, will each have an opening of 80 ft., making an aggregate of 1,040 ft. The piers separating the sluice openings will be of substantial, first-class masonry. These sluices can be operated under rules easily formulated and, in the opinion of the Board, amply provide for conditions more unfavorable than any recorded.
>
> A canal with a lock is provided on the American side around the end of the dam, and the rapids at the head of the river, affording a much safer navigable channel than the present one through the rapids.

The paper by Mr. Wisner discusses first the feasibility and effect of regulating artificially the level of Lake Erie, taking up the questions of storage, alteration in the levels of the connecting waterways, etc., in great detail. Summarized briefly, this portion of the paper shows that:

> Complete regulation of any lake level requires that the sum of the evaporation from the surface and the outflow shall at all times be approximately equal to the total

supply, and, since the evaporation from lakes Michigan and Huron is of itself, at times, largely in excess of the supply, a complete control of the level of those lakes is an impossibility. The reservoir capacity of the upper lakes is, however, sufficient to allow of considerable decrease of the extreme fluctuations of lakes Michigan and Huron, without injurious effects on the waterways.

The low water level of lakes Michigan and Huron has been lowered about 1 ft. during the past 13 years by the natural and artificial deepening of the channels of the St. Clair and Detroit rivers, and, since the indirect effect on Lake Huron will be about one-third of the amount that the low water stage of Lako Erie is raised, the regulation of the latter lake at a plane 3 ft. above ordinary low water will restore the limit of low water on lakes Michigan and Huron to what it was previous to 1886, and diminish the fluctuations of those lakes about 1 ft.

The regulation of Lake Erie will not materially change the total annual discharge through the Niagara River, and will only modify the distribution of flow about 5% of the average discharge, and therefore cannot materially effect the level of Lake Ontario and the St. Lawrence River.

Some of the reasons upon which these conclusions are based were given in our issue of Nov. 23, 1899, in a paper by Mr. Wisner.

In the second part of his paper presented with the Board's report, Mr. Wisner enters briefly into the engineering features of the proposed regulating works. This part of the paper, somewhat abstracted, is as follows:

The two different plans which have been generally advocated for controlling the levels of the lakes are to construct a dam with regulating sluices across the Niagara River below Tonawanda, N. Y., or to construct a submerged weir in connection with a set of regulating sluices at the foot of the lake just below Buffalo Harbor.

A preliminary study of the problem and estimate of cost of regulating works based on the surveys and examinations which have been made developed the fact that the first of these plans would require an expensive dam with lock and waste weirs in the Niagara River on each side of Grand Island, the excavation of over 5,000,000 cu. yds. of material in the head of the river, the purchase of at least $3,000,000 worth of property, which would be ruined by the works, and high water along the river front, and the construction of several miles of dikes to maintain safely the impounded water above the level of adjacent country. The distance from Lake Erie to the site where a dam would have to be constructed is twelve miles, on which the high water slope of the river is about 8.5 ft. With the river improved by regulating works and enlarged cross section of channel through the gorge, this high-water slope would be reduced to about 2.5 ft., and the low-water slope to 1.5 ft., making the fluctuation of the lake due to change of slope in river for different volumes of discharge, approximately 1.0 ft., which would be increased 0.5 ft. by change in velocity head at foot of lake, or a total probable fluctuation of 1.5 ft. when the discharge of the river is controlled by regulating works for maintaining the river at a fixed stage at a point twelve miles below outlet of lake.

The total cost of the project, including damages and the necessary drainage channel for taking care of Tonawanda Creek and the water from the adjacent country, would be over $12,000,000, which, with the fact that the lake would still have considerable fluctuation, practically eliminates all chances of the plan receiving favorable consideration.

If a deep waterway should ever be constructed from Lake Erie to Lake Ontario, via the Tonawanda-Olcott route, the improvement of the river by regulating works below Tonawanda would diminish the cost of the canal about $6,000,000, which would still leave a balance of $6,000,000 chargeable to the project.

Regulation of the lake levels by means of controlling works in the foot of Lake Erie will require either a submerged weir of such length that the change of discharge over the crest of the weir due to a few inches variation of stage of lake will be equivalent to a variation of outfloow through the gorge at the head of the river due to 3 ft. change in depth of river; or a short submerged weir in connection with a set of regulating sluices so designed that, with the sluice gates all closed, the low water flow for the regulated stage of the lake will be discharged over the fixed submerged weir, and, with the sluice gates all open, the additional volume of outflow necessary to maintain the lake at nearly the same level will pass through the sluices at times when the lake is receiving its maximum supply.

The surveys and examinations indicate that a combination of a fixed weir and regulating sluices is better adapted for an economical and complete control of the lake level than by means of a fixed weir, and the plans and estimates submitted are for such a product. (The estimated cost of regulating works of this character is given by the Board as $796,923.—Ed.)

The observations which were made for the Board at the Hydraulic Laboratory of Cornell University to determine the coefficients for the Francis weir formula ($Q = CLH^{3}/_{2}$) for the design of the weir proposed for the regulating works give the following values for C when h = depth on weir = 6.6 ft.:

Submergence from backwater.	C in the formula $Q = C\,L\,H^{3}/_{2}$
0.0 h = 0.00-ft.	3.70
0.1 b = 0.65 "	3.67
0.2 h = 1.30 "	3.64
0.3 h = 1.95 "	3.60
0.4 h = 2.60 "	3.54
0.5 h = 3.25 "	3.47
0.6 h = 3.90 "	3.36
0.7 h = 4.55 "	3.17
0.8 h = 5.20 "	2.88
0.9 h = 5.85 "	2.30

The minimum stage of Lake Erie since 1865 occurred in November, 1895, when the surface was 570.5 ft. above tide water, and the discharge at the outlet 178,000 cu. ft. per second, which compared with that for March, 1876, indicates a maximum variation of outflow of 121,000 cu. ft. per second.

With the exception of 1876, the average supply during storage period has not exceeded 271,000 cu. ft. per second, corresponding to the discharge through Niagara River when the lake is at a stage of 574.3 ft. above tide water, from which it is evident that when the lake is at its highest stage the outflow is practically equal to the maximum supply, and, if such maximum inflow should continue constant for any length of time, a practical state of regulation would exist. To establish regulation at any lower stage than 574.3 ft. above tide water will require that the gorge at the head of Niagara River be enlarged sufficiently to allow a discharge equal to the maximum supply at that stage.

In order, therefore, to maintain the lake at a fixed stage, it will be necessary to construct a fixed weir over which a discharge of about 178,000 cu. ft. per second can be maintained at times when the water below the dam is 4 ft. lower than the regulated surface of the lake (with stage of 570.5 below dam the discharge through gorge will be 178,000 cu. ft. per second), and a set of sluices through which, in connection with the flow over the fixed weir, 271,000 cu. ft. per second will be discharged when the sluice gates are all open.

For the purpose of obtaining this control of the outflow, it is proposed to construct a fixed weir 2,900 ft. long with 6.6 ft. depth of water on the crest, and 13 sluices, having 80 ft. clear opening each, and an aggregate cross section of 23,800 sq. ft.

For a low water discharge of the river, the submergence below the weir will be 0.4 h., making the value $C = 3.54$. Assuming the length of the proposed fixed weir to be 2,900 ft., the discharge will be $Q = 3.54 \times 2{,}900 \times (6.6)^{3}/_{2} = 175{,}000$ cu. ft. per second, and, since a complete control of the lake level for minimum outflow requires that it should never be less than the capacity of the weir, it would appear that the proposed dimensions of weir are reasonably correct.

It has been shown that the mean velocity for maximum discharge through the regulating works will be 6.4 ft. per second, which will require a theoretical velocity head of 0.64 ft. to generate the current, and 0.43 ft. to overcome friction and maintain flow, making a total fall of 1.07 ft. from the lake to the site of regulating works, instead of 0.72 ft. required under the present conditions.

Omitting the loss of head requisite to maintain flow above the works, the submergence from backwater will be approximately 0.9 h., making a coefficient for the weir $C = 2.30$ and the discharge $Q = 2.30 \times 2{,}900 \times (6.6)^{3}/_{2} = 113{,}400$ cu. ft. per second.

The mean velocity of flow through the sluices will be 6.7 ft. per second, which multiplied by the total area of sluice cross section gives a discharge of 159,500 cu. ft. per second, and a total discharge past the regulating works of 272,900 cu. ft. per second; an amount 1,900 cu. ft. per second in excess of the average supply during the storage period for any year since 1865, except that for 1876.

A year of maximum supply similar to that of 1876 can only occur after one or more years of excessive rainfall over the entire lake basin, and, when such conditions are known to exist, the level of the lake can be allowed to fall sufficiently after the close of navigation each year to provide storage for any excess of supply that may be expected.

If for any reason it should be deemed advisable to regulate the level of the lake at a lower stage than 574.5 it can be readily accomplished by enlarging the restricted cross section of the river at the gorge for a distance of about 3,000 ft.

The present low water cross section of the river through the gorge is only 22,000 sq. ft. area, and if enlarged 10% the outflow for all stages of the water surface below the regulating works would be increased sufficiently to allow full control of the levels at a stage of 573.5 ft. above tide water, which has been exceeded by the high-water level of the lake on eleven different years since 1870, and could not in any way be construed as likely to be of damage to vested rights.

Such an enlargement would necessitate the excavation of about 218,600 cu. yds. of earth, and 164,500 cu. yds. of rock, and would cost about $384,000.

The proposed elevation for regulated stage of 574.5 ft. above tide water is about 0.5 ft. less than the extreme high-water stage of the lake, and is considered a safe limit for construction.

Proposed Location of Works.—Starting at a point on the breakwater of Black Rock Harbor, about 2,000 ft. below the entrance at Buffalo Creek, a rock reef with an average depth of 6.6 ft. of water at proposed regulated stage is utilized for a distance of 1,300 ft. to the bank of the channel of the outlet, at which place the line of the works makes a deflection of 35° and extends to the Canadian shore, a distance of 2,810 ft., of which 1,600 ft. is to be a fixed weir, 1,040-ft. sluice openings, and 170-ft. sluice gate piers, as shown by the accompanying map.

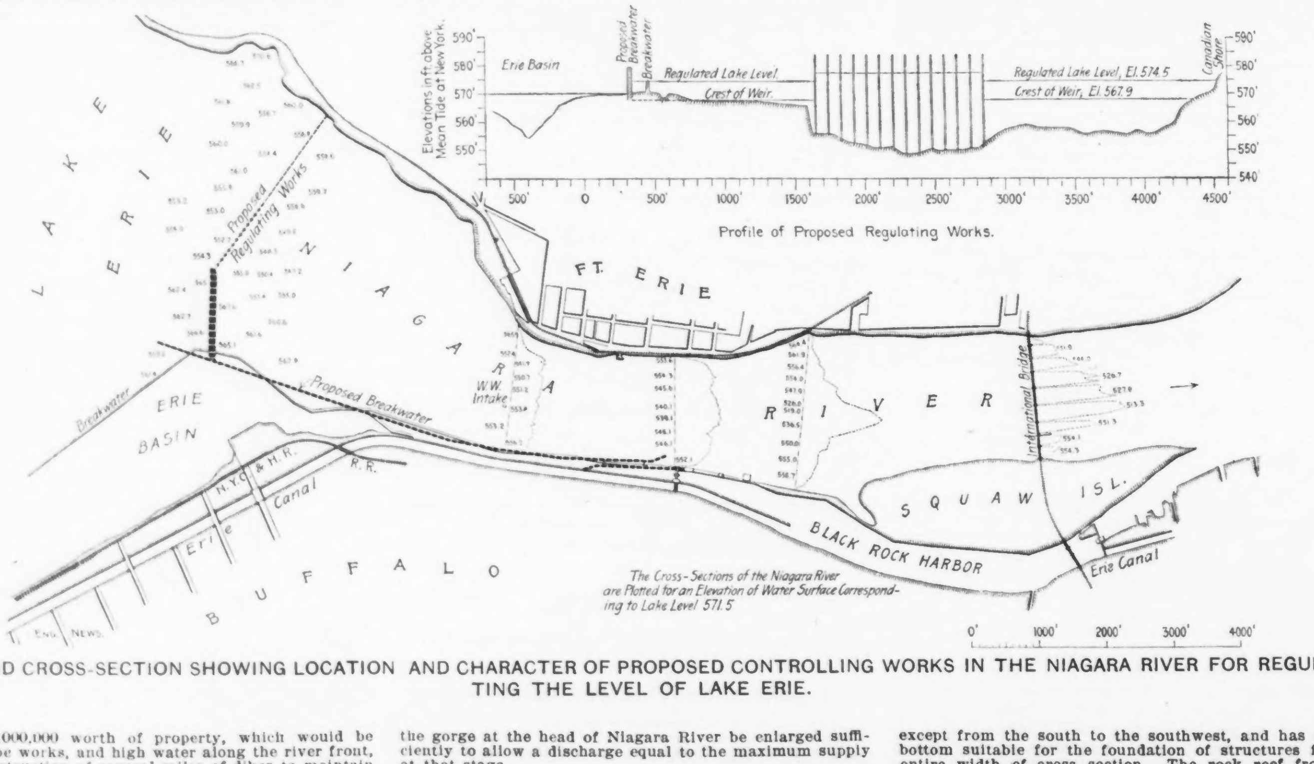
The site is protected from winds from all directions, except from the south to the southwest, and has a rock bottom suitable for the foundation of structures for the entire width of cross section. The rock reef from the Black Rock Harbor breakwater to the west end of the system of proposed sluice gates has approximately the elevation required for a fixed weir, and will need but a small amount of excavatoin (given in estimate) to make it suitable for 1,200 ft. of the proposed submerged portion of regulating works.

Design of Structures.—The fixed weir and the piers for regulating sluices have been designed with reference to securing a maximum volume of discharge for any given difference of level between that of the regulated lake and the water surface below the structure, and consist of 2,900 ft. of fixed weir, together with 13 sluices, 80 ft. wide and from 20 ft. to 24 ft. deep. The sluice gates and counterweights for the proposed works are of the "Stoney type," with a slight modification.

The operation of the gates will require two men for each sluice, and the entire system could probably be opened in about 45 mins. The piers for sluice gates can be constructed in one season, and the superstructure, gates and fixed weir during the second season after commencement of work.

The installation of regulating works will necessitate the construction of a lock for passing vessels from Lake Erie to ports on the Niagara River. Such a lock will however, be a necessity with any project which provides for the same depth of channel for Tonawanda as for Lake Erie harbors, and very likely will be required with whatever plan of improvement that may be adopted for Lake Erie harbors and waterways.

The heavy current in the head of Niagara River makes navigation of the river difficult and dangerous, but, below the gorge, the river is broad and deep, with a current of only about two miles per hour. A canal for passing vessels around the rapids will avoid excessive currents for all stages of the river and secure safe navigation between the lake and ports on the Niagara River.



MAP AND CROSS-SECTION SHOWING LOCATION AND CHARACTER OF PROPOSED CONTROLLING WORKS IN THE NIAGARA RIVER FOR REGULATING THE LEVEL OF LAKE ERIE.

THE TRANSMISSION OF ELECTRIC ENERGY a distance of 46.5 miles is being carried out near Limoges, France, to utilize a large water power in the Correze. This distance, between the point of generation of the energy and its utilization, exceeds anything heretofore attempted in Europe, excepting only that between Lauften and Francfort, of 106 miles, tried in 1891. In the United States, however, electrical energy has been conveyed 80 miles, and other plants are in progress intended to convey energy to still greater distances. The plant being established at Allazac, Correze, will have in total 4,000 HP. It will include eight turbines of 500 to 600 HP. each, operating under a head of 141 ft. Of this total 1,000 HP. will be transmitted to Limoges and the rest to different towns on the line. For the Limoges portion a tension of 20,000 volts has been adopted, reduced to 3,000 volts at a transforming station located 6½ miles from the town. The work is being done by the "Societe des Forces Motrices de la Vezere."

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A FIRE TEST OF GLASS CASEMENTS was made on July 5, 1899, by the British Fire Prevention Committee. Upon a dwarf wall three teak rebated casements were fixed reaching from the top of the wall to the ceiling of the testing chamber. The joints where the casements butted against one another were covered with 2-in. × ½-in. teak fillets. Teak fillets were also fixed where the casements butted against the walls and the ceiling. The casements were glazed with three different kinds of glass, namely, that at one end with 32-oz. sheet glass, that at the other end with "lead glazing" in 4-in. squares, and that in the middle with plate glass ¼-in. thick. The plan was to apply the heat to one side for 30 mins. at a temperature rising gradually to 1,200°. Within 6 mins. flames burst through the 32-oz. sheet glass casement and half of the sheet had fallen. The other half fell within 12½ mins. Within 7 mins. the lead glazing had collapsed. Within 12 mins. flames burst through the ¼-in. plate casements and within 14 mins. the whole sheet had fallen.

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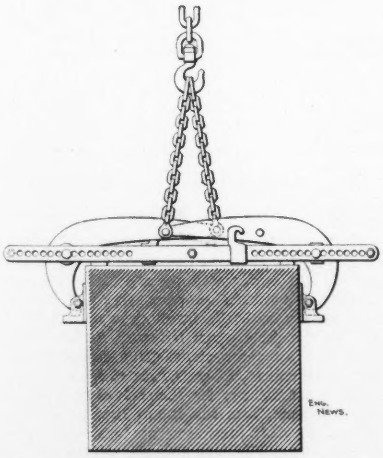
STONE TONGS FOR LIFTING CUT-STONE.

A new device for setting cut-stone has been invented by a Mr. Perdriel, and is described in "Le Genie Civil," from which the following illustration is taken. It is simple, and is claimed to be entirely safe. It is made of two bent levers, sliding horizontally by means of guides, between two bars pierced with holes, so as to adjust the distance between the shoes approximately to the width of the stone to be set by means of two pins inserted in the holes in the bars.

The shoes are hung by a pin joint to the ends of the levers, and as the axis of the supporting pin is above the center of gravity, their faces are always vertical. The faces of the shoes are smooth, but the pressure exerted by them upon the sides of the stone is claimed to be sufficient to prevent slipping. The other ends of the levers are joined by chains to the usual lifting apparatus.



A French Device for Lifting Cut Stone.

To loosen the grip of the device upon the stone, when the latter is in place, the chain is slacked and two sliding hooks are then moved along the bars until they catch over two pins in the upper part of the bent levers. The pins in the bars can then be pulled out and the levers turned on the new fulcrum, releasing the shoes. The device weighs from 1,650 lbs. upwards, according to the size of stone to be lifted.

STREET RAILWAY FRANCHISES IN AMERICAN CITIES.

In our issue of Nov. 30 we gave particulars of the franchises under which street railways are operated in a large number of foreign cities, from information compiled by Mr. Edwin F. Mack, Cashier of the Royal Trust Co. Bank, of Chicago. Acting on a suggestion from us, Mr. Mack compiled similar informaion in regard to leading cities in the United States, and turned it over for first publication to the Chicago "Record." We give below the particulars referred to as printed in the above paper, somewhat rearranged. The principal facts are given in tabular form. In this table, the "life of franchise" indicates the terms for which the franchise was originally granted, except where otherwise stated. In the column regarding paving, etc., the absence of a specific statement does not indicate that the companies are free from these requirements, as they are almost universally demanded, although full particulars were not given in the information from which this table was prepared. In the last column, the term "general transfers" means that transfers are given over the entire street railway system, while "on company's lines" means that they are given only over the lines of the company receiving the fare. Children under five years of age are usually carried free, and it is presumed that all companies pay the rental tax on actual property.

Atlanta, Ga.—The city receives rental for use of bridges crossed by car lines. The crowding evil needs regulating. A dispute exists as to the length of time which existing franchises have to run. Tickets are sold on slight reduction. Municipal ownership is being discussed.

Boston, Mass.—In addition to the usual property tax, the companies pay ⅞ of 1% of their gross earnings to the state, which is divided and paid to the several municipalities through which the lines run, according to the trackage in each. If the company pays dividends exceeding 6% it pays to the state an amount equal to such excess, which is divided the same as above. Consolidated in one company.

Buffalo, N. Y.—The following percentages are paid: Buffalo Ry. Co., when combined earnings not more than $1,500,000, 2%; to $2,000,000, 2½%; over $2,000,000, 3%. Buffalo Traction Co., on $2,000,000, or less, 2½%; over $2,000,000, 3%.

Cincinnati, O.—Cable is used on some streets.

Cleveland, O.—Car-license fee is $10 a car. "Various paving requirements" are said to exist. Eleven tickets sold for 50 cts.

Detroit, Mich.—On some lines six tickets for 25 cts. are sold. Workingmen's tickets, good during certain hours, are sold eight for 25 cts. Municipal ownership is much in favor.

Denver, Colo.—Has 150 miles of track, generally trolley. The people are talking about municipal ownership. A ride of 14 miles is possible on one fare. The excellent pavements of Denver have made bicycle riding almost universal and greatly impaired street car profits. Franchises on electric lines are for 20 years. Cable lines have been given franchises without specified limit of time. One company now owns all the lines. Children ride for half fare.

Indianapolis, Ind.—Twenty-five tickets are sold for $1. The street-car franchises have recently been extended under a well-prepared law having many new features.

Kansas City, Mo.—Cars are operated by trolley, cable, compressed air and horses. Franchises by a recent action of the city council were extended to June 1, 1925. The companies pay the usual taxes and besides $30 per car per year, and some of the lines pay 2% of their gross income.

Louisville, Ky.—School children ride for half fare.

New Orleans, La.—Fare 10 cts. from midnight to 5 a. m. Franchises are sold to the highest bidder. Cars are sometimes much crowded. The amount realized from sale of franchises varies according to the amount of business likely to be done on the lines.

New York, N. Y.—Since the adoption of the new charter in 1897 franchises are limited to 25 years. Cable, trolley and compressed air are used.

Omaha, Neb.—School children ride for reduced fares.

Philadelphia, Pa.—The overhead trolley system of traction is in vogue. The city does not own any of the lines of street railways, and such ownership is not contempleted. The rate of fare is 5 cts. for a continuous ride on a given line from one terminus to another. Tickets are not sold, except books containing coupons for 100 rides, which are sold at $5 each, there being no rebate. Where certain lines of railways have diverging lines in other directions, transfers are given to passengers without extra cost, to carry them from one terminus to another of the same line. Exchange tickets on cross lines are sold at the rate of 8 cts. There are no regulations relative to the crowding of cars.

The franchises are granted by the state legislature under charters which are perpetual. Prior to a company receiving a charter and laying its rails upon the streets in the city of Philadelphia, it is obliged to file bonds and enter into an agreement to be bound by all ordinances that are now passed or may be passed by councils regulating passenger railway companies. In addition to paying municipal tax upon their properties, they pay a certain percentage on their earnings, which is generally 6% per annum on all dividends declared over 6% per annum on the capital stock.

They pay annually into the city treasury $50 for each car run or intended to be run during the year, and an additional $50 for each car crossing city bridges. Where, however, a company desires to run extra cars on holidays or special occasions they are permitted to take out special license cards at the rate of 25 cts. a day for each day, the said card remains in the possession of the company.

The companies are also obliged to maintain in good order and repair, from curb to curb, the street pavement on all streets occupied by their tracks, and to repave with improved pavement, when directed so to do, all streets occupied by their tracks, from curb to curb. Cars are required to stop before crossing streets to avoid accidents and on the farther side of the street for passengers.

Pittsburg, Pa.—Cars run wholly within the city pay a license of $60 each per year. Those that run partly in the suburbs and partly in the city pay $30. Transfers are given on the consolidated lines. Two companies own the lines

St. Louis, Mo.—Cable and trolley systems are in use. Children under 12 years, half fare. Franchises have various terms, running as long as 45 years. Some lines pay compensation running as high as 3½%. Other lines are paying fixed sums, with increase as time passes. Lately all but two lines have been consolidated into one system.

San Francisco, Cal.—The cars are in good condition. The cables are requisite for the steep grades on many streets. Franchises are sold to the highest bidder. In addition to the purchase price, the city receives 2% of the annual gross income.

Seattle, Wash.—A proposition is pending to consolidate and give general transfers. The companies now pay 1% of gross receipts. After Jan. 1, 1900, will pay 2%. Cable

Street Railway Franchises in American Cities.

Cities.	Life of franchise.	Car fees and percentage	Paving, street cleaning, etc.	General transfers.
Atlanta, Ga.	30 to 50 years.	Nothing.	Bet. rails and 2 ft. outside each rail.	Partial.
Boston, Mass.	Unlimited.	(See remarks.)	....	Not given.
Buffalo, N. Y.	99 years.	(See remarks.)	....	Universally.
Chattanooga, Tenn.	......	Nothing.	Pave between the rails.	Given.
Chicago, Ill.	20 years.	$50 per car.	Between rails and tracks and outside.	On Co.'s lines.
Cincinnati, O.	50 "	$139,000.	....	Given.
Cleveland, O.	25 "	(See remarks.)	(See remarks.)	On Co.'s lines.
Denver, Colo.	20 "	Not stated.	....	Given.
Detroit, Mich.	Ex. in 12 years	P. ct. grs. rcts.	....	Given.
Houston, Tex.	35 years.	Nothing.	Bet. tracks & rails and 6 ins. outside.	Not given.
Indianapolis, Ind.	34 "	$50,000.	Bet. rails & tracks, & 18 ins. outside.	Given.
Kansas City, Mo.	Expire 1925.	$30 pr car & %	....	Given.
Louisville, Ky.	99 years.	Nothing.	....	Given.
Milwaukee, Wis.	Expire 1924.	Nothing.	....	Given.
Minneapolis, Minn.	Indefinite.	Nothing.	....	Given.
New Orleans, La.	Varying.	(See remarks.)	....	On two lines.
New York, N. Y.	Perpetual.	$347,878.	....	On Co.'s lines.
Omaha, Neb.	30 years.	Nothing.	Bet. tracks & rails, and 1 ft. outside.	General.
Philadelphia, Pa.	Perpetual.	(See remarks.)	Pave the entire street.	On Co.'s lines.
Pittsburg, Pa.	Perpetual.	(See remarks.)	Bet. tracks & rails, and 1 ft. outside.	Given.
Portland, Me.	No limit.	Nothing.	....	Given.
Portland, Ore.	30 years.	$25—$50 a car.	None.	Not given.
Salt Lake City, Utah	50 "	$25 per car.	Bet. tracks where streets are paved.	Given.
San Francisco, Cal.	25 and 50 yrs.	2% grs. an. rcts*	....	On Co.'s lines.
St. Louis, Mo.	......	....	Bet. tracks, rails and 1 ft. outside.	Given.
St. Joseph, Mo.	50 years.	Nothing.	Bet. tracks and 18 ins. outside.	Given.
St. Paul, Minn.	50 "	Nothing.	....	Given.
Seattle, Wash.	25 to 50 years.	Percentage.	....	Not given.
Topeka, Kan.	20 years.	Nothing.	....	Given.
Washington, D. C.	Sub. to Congrs.	4% grs. earngs.	Bet. rails & tracks, and 2 ft. outside.	On Co.'s lines.

*See remarks.

and trolley systems are employed. On some lines tickets are sold six for 25 cts.

Washington, D. C.—There are practically but two companies in the District of Columbia, and these own competing lines in a large measure paralleling one another at a distance of a few blocks apart, so that it is possible for a passenger to reach the desired destination on the lines of one company and for the payment of a single fare. The cars are provided with push-buttons at each seat, with which the passenger may announce his desire to alight. The cars are not crowded and are clean. Employees are attentive. An excellent underground trolley system is used. Franchises are subject to termination by act of Congress at any time. On some lines tickets are sold six for 25 cts.

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COMPARATIVE COST OF RAILWAY TRACK IN 1898 AND 1899.

The accompanying table is taken from a small pamphlet, issued by Mr. Francis How, 11 William St., New York city. It shows the approximate cost of a mile of railway track in December, 1898, and December, 1899. For rails and fastenings actual market prices have been taken; and figures representing average conditions have been assumed for ties and ballast. Rails are taken at $20 per ton in 1898 and $35 per ton in 1899. Spikes were $1.50 per 100 lb. keg in 1898, and $3 in 1899. Comparative prices on other items are:

	1898.	1899.
Angle plates, per 100 lbs.	$1.20	$2.75
Bolts and nuts, per 100 lbs.	1.70	4.00
Braces, per M	20.00	30.00
Washers, per M.	8.00	10.00
Ties, each	.50	.75

For 56-lb. rails, 28-lb. splices are used, and this is increased to 40 lbs. for 70-lb. rails and 45 lbs. for 90-lb. rails. For the light rails 2,640 ties per mile are assumed and 3,000 per mile for the heavier rails.

Approximate Cost of Railroad Track per Mile in December, 1898, and December, 1899, Exclusive of Grading, Culverts, Bridges, Etc.

Weight of rail.	56 lbs.		70 lbs.		90 lbs.	
	1898.	1899.	1898.	1899.	1898.	1899.
Rails	$1,760.00	$3,080.00	$2,200.00	$3,850.00	$2,828.00	$4,950.00
Spikes, 5½ ins. × 9-16-in.	90.00	180.00	99.00	198.00	99.00	198.00
Angle plates	118.27	271.04	168.96	387.20	190.08	435.60
Bolts, nuts, washers and braces	55.50	98.00	77.40	141.00	82.40	146.00
Ties	1,320.00	1,980.00	1,500.00	2,250.00	1,500.00	2,250.00
Track laying, including construction train	500.00	575.00	600.00	690.00	600.00	690.00
Ballast	300.00	360.00	900.00	1,050.00	1,500.00	1,800.00
Total	$4,143.77	$6,544.04	$5,545.36	$8,566.20	$6,799.48	$10,469.60

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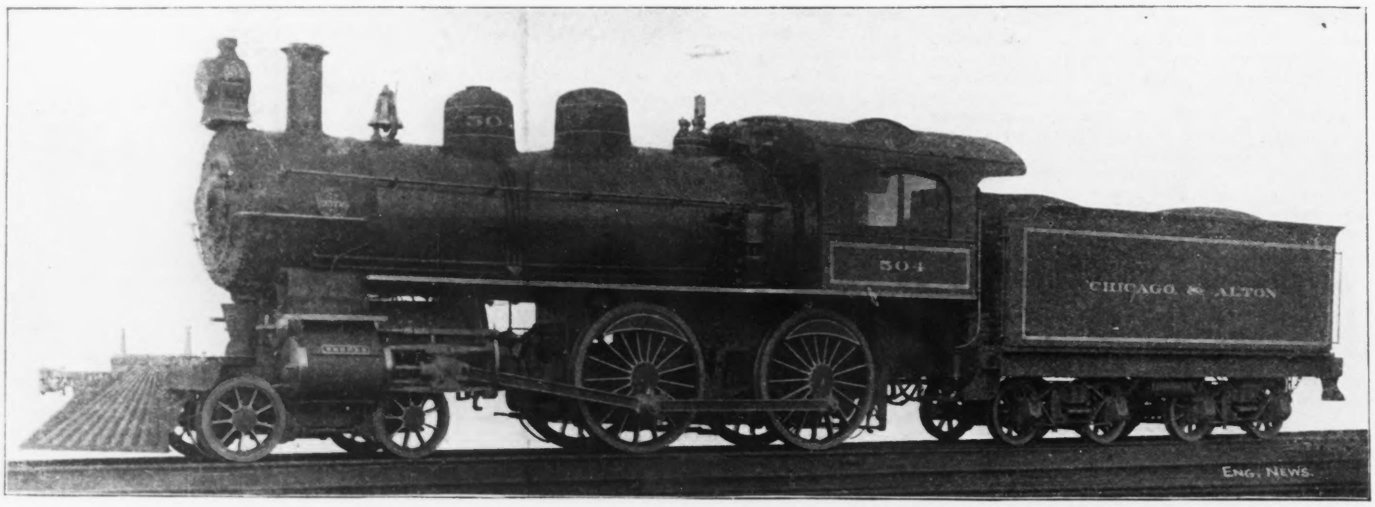
FAST PASSENGER LOCOMOTIVES; CHICAGO & ALTON R. R.

The Chicago & Alton R. R. has recently added to its equipment twelve passenger engines of the eight-wheel type, designed for hauling the "Alton Limited" express between Chicago and St. Louis (Eng. News, No. 23, 1899), and for other fast and heavy trains. These engines were built by the Brooks Locomotive Works, of Dunkirk, N. Y., and we are indebted to the builders for photographs, drawings and other information. The boiler has 2,179 sq. ft. of heating surface and 31.8 sq. ft. of grate area, so that a liberal supply of steam should be assured, the pressure being 210 lbs. The cylinders are 19 × 26 ins., and the steam is distributed by 10-in. piston valves having a travel of 6¼ ins. The firebox is above the frames and is provided with a brick arch. Its plates are only ⅜-in. thick, with the exception of the tube sheet, which is ⅝-in. thick. The weight on the driving wheels is 90,500 lbs., or a load of 22,625 lbs. per wheel.

The engine is equipped with the Pyle electric headlight and with electric incandescent lamps along the running board and under the boiler, for the convenience of the engineman in oiling and inspecting the engine. The marker or signal lamps are also lighted by incandescent lamps. Current for lighting is furnished by a dynamo and steam turbine mounted on top of the boiler, just in front of the cab. The Westinghouse high-speed brake is used, with reservoirs of 50,000 cu. ins. capacity, and a 9½-in. pump. The American equalized brake is fitted to the driving wheels and truck wheels, with brakeshoes of the Sargent make. A peculiar looking equalizing lever, 5 ft. 3½ ins. long, is used between the driving wheel springs.



FAST EXPRESS LOCOMOTIVE; CHICAGO & ALTON R. R.
Built by the Brooks Locomotive Works, Dunkirk, N. Y.

The tender is exceptionally large, carrying no less than 12 tons of coal. It has a frame of 13-in. steel channels, and is mounted on a pair of diamond-frame trucks with triple elliptic springs, the trucks being for a nominal capacity of 100,000 lbs. The tanks is of ¼-in. steel plates, with a sloping top, and is 22 ft. 0½ in. long, 9 ft. 8 ins. wide, and 5 ft. 3 ins. high, exclusive of the collar. The length of the tender, over its bumper beams is 23 ft. 8½ ins.

The principal dimensions of these engines are given below in our standard form:

Dimensions of Fast Passenger Locomotives; Chicago & Alton R. R.

Running Gear:	
Driving wheels (4)	6 ft. 1 in.
Truck wheels (4)	3 ft.
Tender wheels	3 "
Driving wheel centers	Cast steel.
Journals, driving axles	9 × 12 ins.
Wheelbase: Driving	8 ft. 9 "
Total engine	24 " 10 "
Engine and tender	53 " 2½"
Length over engine and tender	64 " 3⅜"
Wheels having blind tires	None.
Weight in Working Order:	
On driving whls, 90,500 lbs.; on truck whls.	48,500 lbs.
Engine, total	139,000 "
Tender, loaded	120,000 "
Cylinders: Number	Two.
Diameter and stroke	19 × 26 ins.
Crosshead.......Alligator; Guides	Two-bar.
Connecting rod, length between centers	8 ft. 9 ins.
Side rods	Solid ends
Valve Gear: Type	Stephenson link.
Ports, steam	2 × 21½ ins.
Ports, exhaust, minimum area	50 sq. ins.
Bridges, width	3¼ ins.
Slide valves, style..Piston; Maximum travel	6¼ "
" inside lap	1⅛ "
" outside lap	None.
" lead, Variable; in full gear	None.
Boiler: Type	Wagon-top.
Barrel, diameter inside smallest ring	5 ft. 6⅛ ins.
Dome, diameter	2 " 6 "
Thickness, barrel plates	11-16, ¾, ⅝, 9-16-in.
Thickness, smokebox tube plate	¾-in.
Horizontal seams	Sextuple riveted.
Circumferential seams	Double riveted.
Height from rail to center line	8 ft. 11½ ins.
Length of smokebox, from tube plate	5 ft.
Form of spark arresting device	Wire netting; mesh, 2½ × 2½ ins.
Injectors	Hancock.
Working steam pressure	210 lbs.
Firebox: Type	Radial stayed; above frames.
Length inside..9 ft. 6 ins.; width inside	3 ft. 5 ins.
Depth at front..6 " 7 " ; depth at back	5 " 5 "
Thickness, side and back plates	⅜-in.
Thickness, crown plates..⅜-in.; tube plates	⅝-in.
Crown stays........Radial; Grate	Rocking.
Is fire-brick arch used?	Yes.
Water spaces (width at top)	Front, 4 ins.; back, 4½ ins.; sides, 5 ins.
Mud ring, width	Front, 4 ins.; back, 3½ ins.; sides, 4 "
Tubes: Charcoal iron; Number	306
Thickness...No. 12 B.W.G; pitch	2⅞ ins.
Diameter, outside	3 ins.
Length over tube plates	12 ft. 7⅜ "
Heating Surface and Grate Area:	
Heating surface, tubes (interior area)	2,002.0 sq. ft.
" " firebox	177.0 "
" " total	2,179.0 "
Grate area	31.8 "
Miscellaneous:	
Exhaust nozzle, single, permanent, diameter	4⅞, 5 and 5⅛ ins.
Exhaust nozzle, distance above center line of boiler	1 in.
Smokestack, minimum diameter	13 ins.
" maximum diameter	14⅞ "
" height above smokebox	3 ft. 3 "
" height above rail	15 " 1 "
Capacity of tender tank	6,000 galls.
Capacity of coal space	12 tons.

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THE COST OF ARC LIGHTING.*

By H. H. Wait, M. Am. Inst. E. E.**

In Prof. Robb's paper on the Hartford system† of arc lighting, a comparison was made between a modern alternating current system and an old direct current system. It is obviously unfair to compare an antiquated direct current system with the latest type of alternating apparatus. In the table given herewith an attempt has been made to compare the systems given on an equitable basis.

Prof. Robb makes the statement that the changes in the Hartford plant will pay for themselves in about two years. It would appear from the tables that in some cases the more modern continuous current systems might replace older ones and pay for the changes in less than two years. This question is so dependent on local conditions, however, that it is impossible to make any general statements.

Nomenclature.

The following letters have been used with the corresponding signification: A. C., alternating current; D. C., direct current; D. D., direct driven; C. C., constant current; C. P., constant potential; c. p., candle power.

The vital question in comparing alternating and direct current systems is the relative amount of power consumed for the same amount of light. There is a great

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*Slightly condensed from a paper presented before the American Institute of Electrical Engineers.

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†Printed in Engineering News, Oct. 5, 1899.

diversity of opinion on this subject and good authority can be found for all sorts of factors.

In the table the different types of lamps have been given the following ratings for the sake of comparison:

D. C. open arc	450 watts at arc	2,000 c. p.
D. C. enclosed arc	450 " " "	1,500 "
A. C. enclosed "	450 " " "	1,150 "
A. C. enclosed "	400 " " "	950 "
D. C. open arc	300 " " "	1,200 "
D. C. enclosed "	300 " " "	900 "

It is unfortunate that the 2,000 and 1,200-c. p. ratings of 450 and 300 watts, respectively, adopted by most plants, do not refer to the watts at the arc, but seem to include some small loss in the mechanism. It has been thought advisable for the sake of definite comparison to give these ratings to open arcs, the watts being taken at the arc itself and corrections being made for the relative efficiency of the mechanism for different types of lamp. To arrive at an equitable figure for comparing the enclosed A. C. and D. C. lamps with the open arcs, resort has been made to an average of the information at hand on this subject. In comparing direct current open and enclosed arcs 75% has been used as the efficiency of the enclosed arc as compared with the open arc.

If the mean hemispherical candle powers had been taken, the ratio would have been more advantageous to the open arc, but the distribution is so much more even with the enclosed arc that the lighting is generally more serviceable, and consequently the mean spherical values were thought to give a reasonably fair basis of comparison.

For commercial lighting in stores, the superior distribution and steadiness of an enclosed arc undoubtedly give it so many advantages that for these cases it should be rated on a par with the open arc. For street lighting, however, the volume and intensity of the light are more important than the quality, and as the tables refer more especially to systems serviceable for street lighting, the above ratio was taken.

There is very little reliable information at hand for comparing A. C. and D. C. enclosed lamps. From such authorities as were available it was concluded that an excess of consumption of current amounting to 50% might fairly be assumed for A. C. lamps over D. C. lamps. Thus, if 1,200 c. p. is a fair nominal value for a 300-watt open arc, the enclosed D. C. might be called 900. A 300-watt A. C. enclosed would be approximately 600, and a 400-watt increased in the ratio of the watts would give 800. The candle power would undoubtedly increase more than in the ratio of the watts, and 950 has been taken as a mean value in working up from the 1,200 c. p. open, and down from the 2,000 c. p. open D. C. The resulting costs have been divided by all the nominal candle powers so that the cost can be compared readily at any reasonable rating.

It is only recently that much attention has been paid to the distribution of light at different distances along the street. The alternating current lamp, with its maximum illumination near the horizontal plane, has advantages in this respect. To get the full benefit of this feature of the lamp, it is necessary to suspend the lamp somewhat lower than has been customary with continuous current lamps. This brings out a feature which is worthy of consideration, namely, the effect of the direct rays on the eyes of the pedestrian or observer. For example, assuming that the illumination of objects from two lamps was equal when the observer was looking in the opposite direction from the lamp; suppose that one of the lamps was placed quite high and the other nearly in his line of vision when looking towards the lamp; it is quite evident that whereas the illumination of objects is equal, the perceptive power of the pedestrian is decidedly impaired by the glare of the low hung lamp and he is not only less able to perceive his surroundings but would also be considerably annoyed if the lowering of the lamp was carried to extremes.

It is also in order to call attention to the fact that if it is allowable to use reflectors to save the upper hemisphere of light in the alternating lamp, the direct current lamp should have the privilege of using reflectors or other devices to reflect some of the maximum rays so as to throw them in a horizontal plane, if that is the direction in which illumination is desired. Some of the globes in present use have considerable of this effect.

Another factor in this comparison is that of color, the alternating lamps generally having a larger amount of violet rays. Under certain circumstances this would be an objection, and it should also be noted in this connection that photographic studies of the relative illuminating powers of arc lamps are liable to be very greatly in error on account of the superior actinic value of the violet rays.

The table is made out assuming that the arc lighting part of the plant to be running at very nearly full load whenever it does run. This will, of coures, not apply to commercial lighting circuits, and considerable corrections will have to be made for such conditions.

In cases where there is already a greater generator capacity installed than is actually needed, it is, of course, possible to leave out a considerable portion of the investment assumed. This would apply to any of the motor-driven continuous current systems as well as the A. C. systems.

In rare cases, the peak of the commercial lighting and power load would not overlap the arc lighting load, and under such circumstances, some of the transformer systems, either direct or alternating current would have a great advantage.

Explanation of Table.

The table is on what might be considered a minimum basis, that is, there is no allowance made for reserve in buildings or real estate, nor is there any allowance for reserve in the generating plant beyond the fact that the engine and dynamo units have been so subdivided as to avoid a great percentage of shut-down in case of accident. The cost of line has been reduced, and in fact all other items in the different plans have been reduced to what might be considered a minimum for a first-class plant.

No data showing ordinary low-tension constant potential A. C. arc system, have been put in, as the economy is poor when compared with the series systems.

Real estate has been taken at 50 cts. per sq. ft. as representing a fair average value. Buildings have been taken at $1.50 per sq. ft., the range in this respect being nearly as great as for real estate.

Boilers, foundations, stacks, pumps, condensors, piping and other accessories have been lumped together at $25 per I. HP. We have figured on plants where this item runs as low as $9 and as high as $40 per I. HP. of engine. This item has been increased to $27 per I. HP. in the engine-driven D. C. arc plants to allow for extra accessories on account of subdividing the units. The engine and boiler items are, of course, inter-dependent, as, when engines are cheap, the tendency is for an increased cost of the boiler plant. The attempt has been made to get an average current market value for all classes of boilers and engines.

Engines and foundations have been figured at $20 per I. HP. This figure will run as low as $10 per I. HP. and as high as $50 per I. HP. for high-class triple expansion verticals. The rate has been increased to $22 per I. HP. on some of the engine-driven plants, to allow for greater subdivision, etc.

A. C. generators and foundations have been taken at $25 per K-W. as a fair value of what would be put in a modern plant. These figures vary from $12 to $35 per K-W. D. C. arc generators vary in price from less than $30 to $45 per K-W. The belted arc machines have been taken at $35 per K-W. and the higher speed motor-driven machines at $33 per K-W. Large direct-driven machines would average about $45.

A. C. constant current transformers have been taken at $15 per lamp for both 400 and 450 watt lamps, as there is considerable variation in the accessories to these transformers. A. C. inductive regulators have been taken at $9 per lamp. This can be made a very variable item on account of the amount of regulation to be provided for as well as other reasons. The figure is intended to cover a regulator to control the entire circuit.

The line has been figured at $51.10 per lamp for the 300-watt enclosed D. C. lamp. This figure was based on the use of hard-drawn copper wire with weather-proof covering and the ordinary pole and suspension construction such as would be used in small towns or the outlying districts of cities. The size of wire for the other systems has been increased as nearly as possible in the ratio of the current, the other conditions remaining the same. It will be noted that an increase in the cost of this line construction will add a fixed amount to the investment and operating expenses, and will not affect the absolute differences between the systems. The percentage difference will vary, however.

The line and pole work such as is used in large cities will run from $100 to $150 per lamp, while underground cables and conduits will run from $200 to $300 per lamp.

Operating Expenses.

Coal and water have been figured at 0.42 ct. per I. HP. hour. This figure was obtained by averaging the average values given by Foster and Moses in their papers before the Institute, the values given in the "Street Railway Journal" and from a number of arc lighting plants on which we had figures. The values vary from 0.28 ct. per I. HP. to 0.76 ct. and 0.42 ct. per I. HP. hour corresponds with 0.7 ct. per K-W. hour with 80% combined efficiency for engine and dynamo.

Wages have been figured at 0.15 ct. per I. HP. hour in the boiler room; the same in an alternating-current dynamo and engine room, and at 0.22 ct. in the arc dynamo room. The superintendence and office expenses have been figured at $2 per year per lamp in all cases, as this will not vary materially with the kind of plant used.

Interest, taxes and insurance are figured at 7%; depreciation at 6%; this depreciation factor might more strictly be called replacement, as it is intended to include not only real depreciation, but also a factor for replacing machinery caused by competition with improvements. A sum at compound interest at 6% would equal the original in 11½ years, so that this would seem to be large enough.

Extra depreciation on arc dynamos and arc lamps has been placed at 4%. This makes a total of 10% for the replacement factor on these portions of the plant. This would cover complete replacements in a little over seven years. The general repairs, renewals and supplies have been taken at .07 ct. per I. HP. hour. Extra repairs on arc dynamos have been taken at .015 ct. per I. HP. hour. It might be remarked that in several modern arc plans, of which the figures are at hand, this value is considerably less. Extra repairs on A. C. constant surrent transformers has been placed at .007 ct.

The figures for trimming arc lamps have been taken from the data of the plants at hand. In all cases we have figures a little more or less than half the values used. In some cases the cost for trimming runs up nearly double the values taken. For example, we have figures varying from $1 to $6.25 per lamp per year for direct-current enclosed lamps of 400 to 450 watts. The difference comes mainly in the time spent in cleaning the inner globes and in the price of labor as well as the number of lamps taken care of by a man. The figures on enclosed

COST OF ARC LIGHTING BY DIFFERENT SYSTEMS (IN DOLLARS PER YEAR OF 3,800 HOURS).

Items.	Hartford			D. C. arc.							
							Belted				
	400 watt enclosed.	450 watt enclosed.	Alt. C. Ind. Reg., 400 watt enclosed.	Driven by A. C. motors, 300 watt enclosed.	Belted, 300 watt enclosed.	Driven by D. C. motors, 300 watt enclosed.	450 watt enclosed.	450 watt open arc.	Direct connected, 450 watt open D. C.	Alt. C. Ind. Reg., 450 watt enclosed.	D. C. arc driven by A. C. motors, 450 watt enclosed.
Total cost per lamp	146.50	155.24	139.80	131.42	117.90	129.45	147.37	142.60	142.00	91.14	100.40
Total cost per nominal c. p.	.154	.1349	.147	.146	.131	.144	.0982	.0713	.071	.0795	.0669
I. HP. per lamp	.744	.822	.708	.630	.552	.642	.830	.832	.810	.804	.948
I. HP. per nominal c. p.	.000785	.000715	.000744	.000700	.000614	.000714	.000554	.000415	.000405	.000698	.000631
Operating expenses: 1. Coal and water	11.85	13.10	11.30	10.05	8.80	10.20	13.25	13.30	12.90	12.80	15.10
2. Wages	8.50	9.35	8.07	8.85	7.78	9.00	11.68	11.70	11.40	9.15	13.30
3. Superintendent's office, etc.	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
4. Interest, taxes and insurance—7%; depreciation—6%, = 13%*	19.00	20.20	18.15	17.10	15.30	16.80	19.10	18.50	18.50	11.90	13.20
5. Extra depreciation of arc dynamo	...	...	...	.42	.49	.42	.68	.73	.83	...	.63
6. Extra depreciation of arc lamps	.80	.80	.76	.72	.72	.72	.72	.60	.72	.76	.72
7. Repairs, renewals and supplies	1.86	2.26	1.77	1.57	1.38	1.60	2.07	2.08	2.02	2.03	2.36
8. Extra repairs arc dynamo	...	...	...	.32	.28	.32	.42	.42	.41	...	.47
9. Extra repairs, const'n current transf.	.15	.18	...	...	...	...	...	...	...	...	...
								Daily.	Alt. days.		
10. Trimming	5.20	5.86	5.20	2.60	2.60	2.60	3.15	11.00	6.50	3.15	3.15
11. Carbons	1.90	2.30	1.90	1.40	1.40	1.40	1.70	7.50	6.80	2.50	1.70
12. Globes	1.60	1.80	1.60	1.00	1.00	1.00	1.30	.70	.50	1.80	1.30
Total operating expenses	52.86	57.85	50.75	46.03	41.75	46.06	56.07	68.53	62.58	45.69	53.93
Operating expenses at 2,000 c. p.	.0264	.0289	.0289	.0235	.02087	.0231	.0280	.0342	.0313	.0230	.0260
" " rated at 1,500 c. p.	.0353	.0385	.0338	.0306	.0278	.0307	.0375	.0457	.0417	.0306	.0359
" " " 1,200 "	.0441	.0482	.0423	.0375	.0348	.0386	.0467	.0572	.0521	.0382	.0448
" " " 1,150 "	.0460	.0503	.0442	.0402	.0363	.0401	.0490	.0595	.0544	.0399	.0468
" " " 950 "	.0557	.0608	.0535	.0484	.0440	.0484	.0591	.0720	.0656	.0484	.0568
" " " 900 "	.0588	.0644	.0563	.0512	.0464	.0513	.0624	.0760	.0695	.0559	.0599

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*Detailed items making up the first cost for each system were given in Mr. Wait's paper, but are omitted here. The total investment per lamp for each system can be found from line 4 of the table which shows 13% of the total investment as stated.

lamps are such as would allow the globes to be kept fairly clean, and the cost of trimming alternating enclosed lamps has been increased by a small factor on account of the practice which obtains in some stations of cleaning the globes of these lamps oftener than the direct-current lamps under the same conditions.

The alternating lamps consume their carbons faster than direct-current lamps partly on account of the increased wattage and partly on account of the almost universal practice of using one cored carbon. The use of the cored carbon also materially increases the blackening of the globe. The cost for globes was taken in the same way as the trimming cost.

A LARGE STEEL PENSTOCK UNDER HEAVY PRESSURE AT CADYVILLE, N. Y.

A steel penstock from 14 to 6 ft. in diameter, ½-mile in length, supplying water under a head of 157 ft. to six 1,000-HP. turbines, was visited early in October of this year by a member of the editorial staff of this journal.

The power thus developed is used in one of the spruce pulp mills of the International Paper Co., at Cadyville, N. Y., a small village on the Chateaugay Railroad, which is located some 10 miles from Plattsburgh, N. Y. The company had three pulp mills at this point up to last July, when one of them was burned.

There are steel penstocks and concrete dams at each of the existing mills. The dam at the lower mill, supplying water to the large penstock, is 30 ft. high, more or less, and has two circular sluices extending through its bottom, at the old channel, a waste from the penstock gates to the channel and a logway. The steel flume starts at the dam with a diameter of 14 ft., and with but little fall, at first. After a few hundred feet the head increases more rapidly, and the size diminishes accordingly. When the penstock reaches the off-take for the first turbine it is 8 ft. in diameter, and its extreme lower end has a diameter of 6 ft. The joints are double-riveted, longitudinally, and single-riveted, circumferentially. Alternate lengths vary in diameter by double the thickness of the pipe. The thickness of the plates is said to be ¼ to ⅝ in. For the greater part of its length, including all the upper and largest end, the pipe is entirely above ground, supported on masonry cradles perhaps 10 ft. c. to c. The cradles, in section, are about 30 ins. wide by 40 ins. high, above ground, with an inverted arch-shaped resting place for the pipe, with a versed sine of 18 ins. They are of stone masonry, laid in cement. At the upper end of the line some of the cradles were cracked down through the center, and others were cracked from the extreme end of the inverted arch, through to the lower corner, these cracks being on the side nearest to the stream. The pipe generally hugged this side of the cradle, leaving 1 or 2 ins. of clear space between the shell and the masonry, on the other side, in some cases. Further down the line the pipe is partially embedded in the earth.

The pipe was coated with asphalt. The external coating seemed to be evenly applied, but apparently rather thin, there being rusty spots along the top, which is used as a foot path between the mill and the dam.

The expansion joints, of which there are quite a number, were formed, as stated, by omitting the circumferential rivets here and there. What extra lap, if any, was given at these points could not be learned. At the upper end, where the head is comparatively small, these joints seemed to be all right, but lower down some of them were leaking badly, although calked with wooden plugs, one in particular spurting a sheet of water 15 to 20 ft. from the joint. A thick sheet of rubber had been placed over the upper half of one of the joints and clamped with a steel band, but there was still a bad leak at this joint. A workman stated that two or three of these joints had been riveted up. Shavings were being piled up along the pipe, to prevent the formation of ice in the penstock during the winter.

The six 1,000-HP. turbines were made by the Stilwell-Bierce & Smith-Vaile Co., of Dayton, O. No. 1 is in the roof of the grinding-house, direct-connected to a shaft 365 ft. long, driving all the machinery in the mill, except the grinders. The other five turbines are below and drive four grinders each, or 20 in all. Each turbine is provided with a hydraulic gate valve, also supplied by the Stilwell-Bierce & Smith-Vaile Co. A second set of wheels has been put in, although the mill has been running only two years or so. The first set had valves opened and closed by hand, which could not be closed tightly against such a heavy pressure, and were operated with danger.

The spruce blocks, or pulp wood, are forced against the grinding stone by a hydraulic pressure of 80 lbs. per sq. in., working against a plunger, which accounts, in part, for the large amount of power required. The pressure is transmitted at will from side to side of the stones by a controlling device patented by Mr. Andrew Tromblee, of Crown Point, N. Y. The 20 grinders, screens, etc., are all in one room, about 100 × 350 ft. in size.

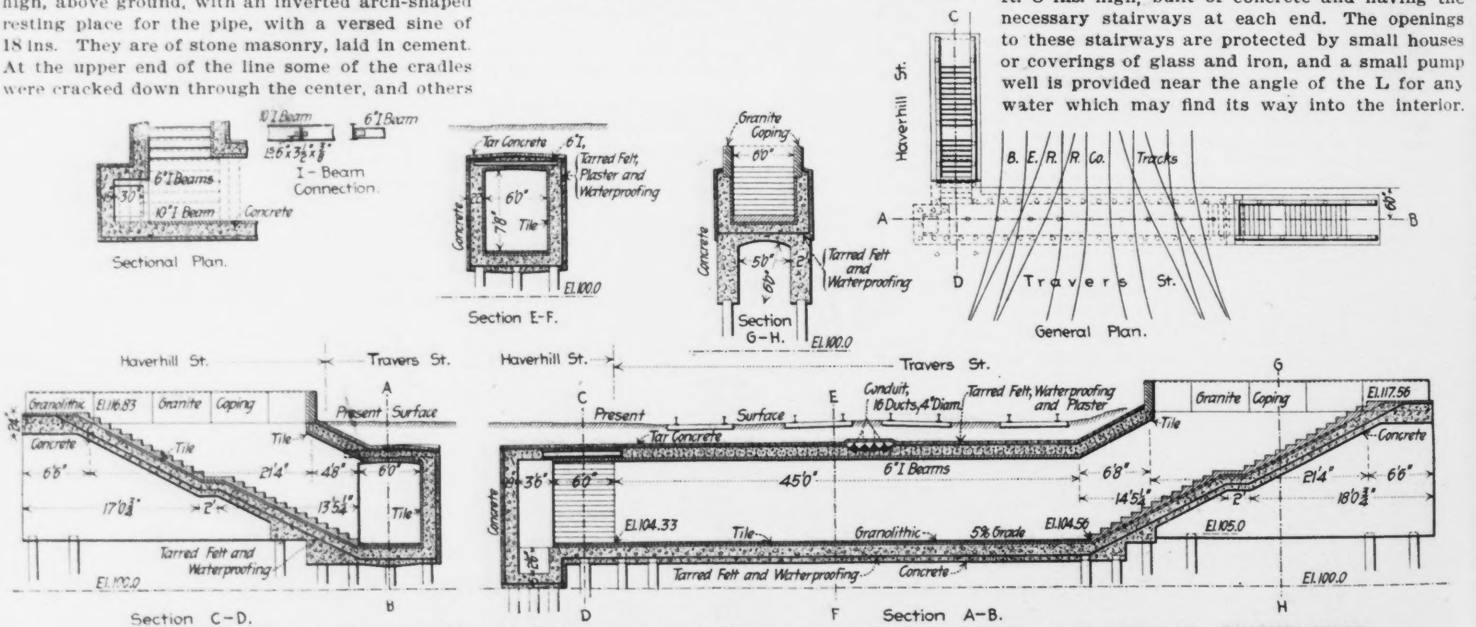
Mr. Warren Curtis, Jr., is engineer of this division of the International Paper Co., with headquarters at 30 Broad St., New York city. Mr. E. J Dickinson is manager of the mills at Cadyville, and Mr. F. A. Chapman is foreman of the lower mill. We are indebted to these gentlemen for information given for use in the preparation of this article.

In justice to the International Paper Co. it should be stated that the mills and power plant at Cadyville were built before they were acquired by it, so the company is not responsible for the original engineering work done there. Last summer the company completed a pulp mill and power plant at Milton, Vt., Mr. Curtis informs us, which has a 11-ft. steel penstock, 600 ft. long, outside the mill, laid above ground, on masonry cradles and without expansion joints. It affords a maximum head of 95 ft. and was built by Struthers, Wells & Co., of Warren, Pa. The turbines, of which there are three 1,000-HP., and one 500-HP., were from the Trump Manufacturing Co., of Springfield, O.

A SUBWAY FOR PEDESTRIANS UNDER ELECTRIC CAR TRACKS AT TRAVERS ST., BOSTON, MASS.

The diversion of pedestrian and street railway traffic to different levels at congested crossings is a matter to which very little attention has been given in American cities. When street cars were hauled by horses there was very little need for such precautions to avoid accidents; but with the advent of electric propulsion, greater speeds and heavier and larger cars, the conditions have been greatly changed. Many street crossings in the central part of large cities are now points of constant danger to pedestrians. It is only a matter of time when some means of separating the two classes of travel will be found necessary, not only for the safety of the people who go about their daily business on foot, but to lessen the obstruction to car movement. For this reason the accompanying drawings of the subway for pedestrians which is now being built under Travers St., near the entrance to the Boston subway, are of particular interest. This subway is being built by the Boston Transit Commission, Mr. Howard A. Carson, M. Am. Soc. C. E., Chief Engineer.

The law empowering the construction of the Boston subway and elevated railways provided that the Transit Commission should discontinue as much of the short block of Travers St., between Haverhill and Canal Sts., as might be necessary to provide a gradual incline from the subway to the elevated structure on Causeway St. The street was accordingly closed, but, as it furnished a convenient short cut, the people continued to use the street and pass over the surface tracks despite all the efforts of the railway company to prevent it. To solve the difficulty, the subway shown in the illustrations was designed. As will be seen from the drawings, the subway is L-shaped in plan, and consists of a rectangular passage 6 ft. wide by 7 ft. 8 ins. high, built of concrete and having the necessary stairways at each end. The openings to these stairways are protected by small houses or coverings of glass and iron, and a small pump well is provided near the angle of the L for any water which may find its way into the interior.



DETAILS OF SUBWAY FOR PEDESTRIANS BEING BUILT UNDER THE TROLLEY CAR TRACKS ON TRAVERS ST., BOSTON, MASS.
Boston Transit Commission, Howard A. Carson, M. Am. Soc. C. E., Chief Engineer.

The entire inside of the subway is lined with enameled white tiles. The various other features of the construction are so fully shown by the drawings that they do not need description. As will be seen, the whole subway is of simple and substantial construction. The contract price for the work, excluding the stone coping, stairway steps, tile lining and internal finish, which come under a separate contract not yet awarded, is $3,000, and the contractors are Grow & Ross, of Boston, Mass.