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DEEP TRENCHES FOR RESERVOIRS

UNCERTAINTY IN EXCAVATION WORK OFTEN THE CAUSE OF TROUBLE AND EXPENSE—NOTES ON METHODS OF TIMBERING, WITH REFERENCE TO SEVERAL DEEP RESERVOIR TRENCHES.

By J. M. M. GREIG, A.M.I.C.E.; Assoc.M.Can.Soc.C.E.

EXCAVATIONS going down 80 and 100 feet over a considerable area or length of trench are not very common except in dock work or in dam foundations. The writer has been associated with a number of waterworks schemes in each of which the trench for the watertight stop wall went down over 80 feet. In one case the trench was nearly a mile in length and for the greater part of that distance the depth excavated exceeded 50 feet while the maximum depth was 112 feet. The trenches were all dug through alluvial deposit for the most part and finished either in clay or rock.

There is a peculiarity about reservoir trenches not common to other excavations, that is the difficulty of deciding, even from bores, what the probable extent of the trench will be, and it is often a condition of contract that three-quarters or even the whole trench must be taken down to approved watertight strata before filling commences. This stipulation is made to enable the engineer to follow out what he thinks is a good bed of rock or

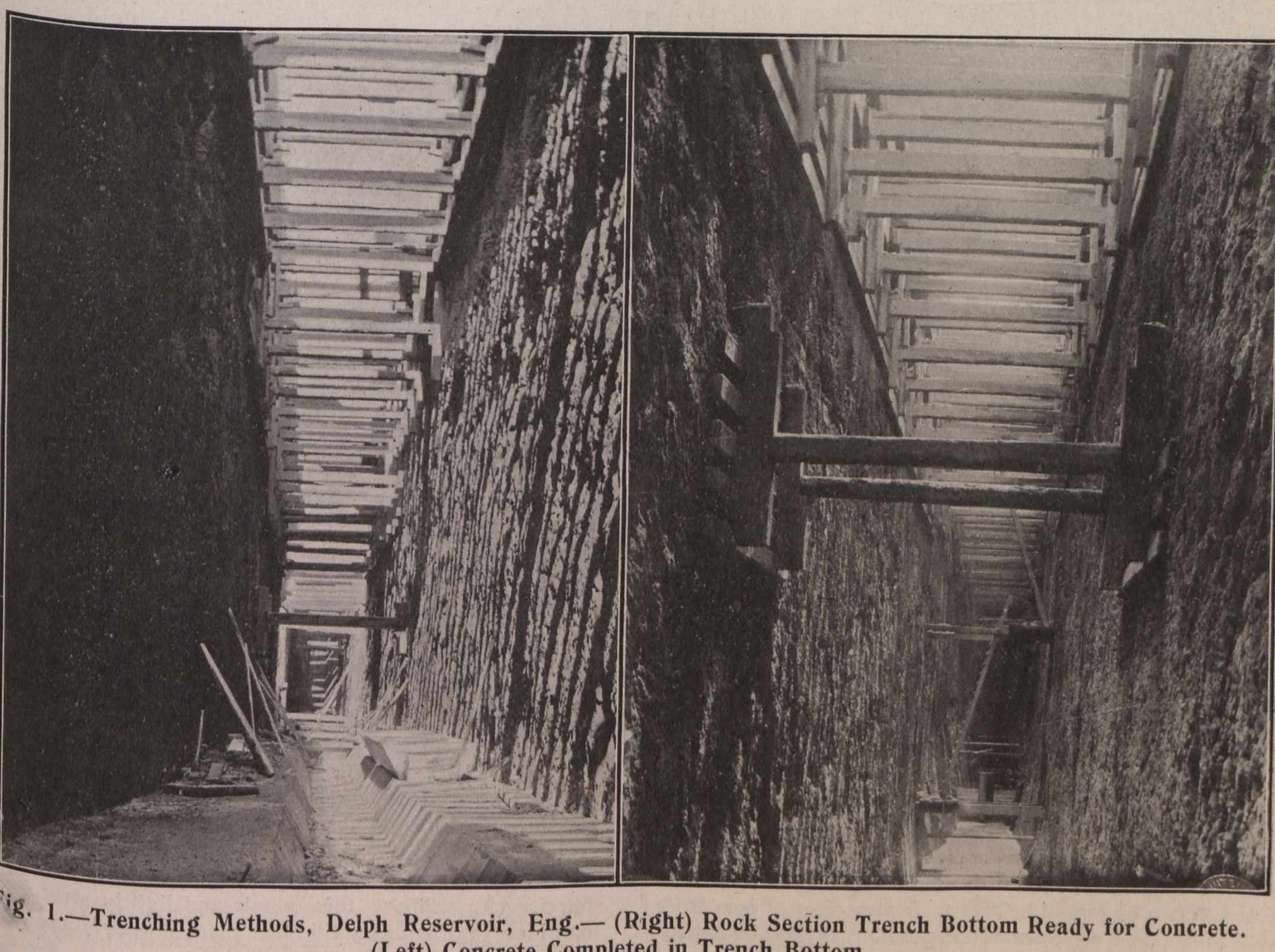


Fig. 1.—Trenching Methods, Delph Reservoir, Eng.— (Right) Rock Section Trench Bottom Ready for Concrete. (Left) Concrete Completed in Trench Bottom.

layer of clay and to prove its continuity before covering up a part of it.

There is one instance of a trench having been filled for a portion of its length with concrete when it was discovered in the open trench farther on that a pervious bed of rock ran in below the finished work. That this discovery was made when the work was so far advanced entailed a great additional expense, for it was necessary to put in a downward extension of the existing stop wall by a process of tunnelling. The total depth of this particular wall from the surface of the ground was over 200 feet.

A case like the above is apt to make engineers insist on seeing the bottom from end to end before commencing filling. Few engineers who have not had experience of this work realize what this means.

If there is a big deposit of loose material above the impervious ground it may mean having enough timber to fix a trench four or five thousand feet long by fifty feet in depth. The timber in this may be tied up for possibly two years and all this time the contractor has a certain amount of anxiety as to the safety of his men.

The timber has all to be placed in position and, as a rule, it has all to be taken out again. Timber which has been in position for more than a year is not easy to handle, especially if the struts have so embedded themselves in the walings that they have to be sawn through to get them free.

The description of a particular piece of work is usually more interesting than generalization on a number of instances. Hence the following particulars having reference to a reservoir trench in Britain, on which the author acted as contractor's engineer, are given. The amount of the contract was over a million dollars, so the work was extensive enough to bring out some interesting points.

Fig. 2 shows a typical cross-section of the embankment with its core wall of concrete and clay and gives the ruling dimensions of the trench and bank. It was expected that rock would be met with at 50 feet or less from the surface, and so it would be possible to go down with the narrow portion and fill it with concrete while the wider upper part could be formed of puddle clay. This forecast turned out to be fairly correct but a long stretch of trench had to be put down through running sand and mud and the pressure exerted by this ground on the timbers after two years put them badly out of shape and made it nearly impossible to withdraw them through a clay filling. It also made it very doubtful if a clay core would keep its thickness after the struts were taken out, so the general type was departed from for a long stretch of trench and concrete brought up to within 15 feet of the surface. (This point may not appear very clear to the reader at present, but it will be brought out in discussing the timbering.)

The clause of the specification relating to the timbering of the trench read as follows: "The trench shall be secured with timber of sufficient strength to prevent slipping or cracking of the ground, and be so arranged that, commencing at the bottom it can be withdrawn plank by plank as the puddle or concrete is filled in; the sheeting shall for this purpose be placed horizontally, and shall be not less than 3 inches in thickness, supported by walings and soldiers at least 4 inches and 6 inches respectively and struts having a sectional area of not less than 70 square inches."

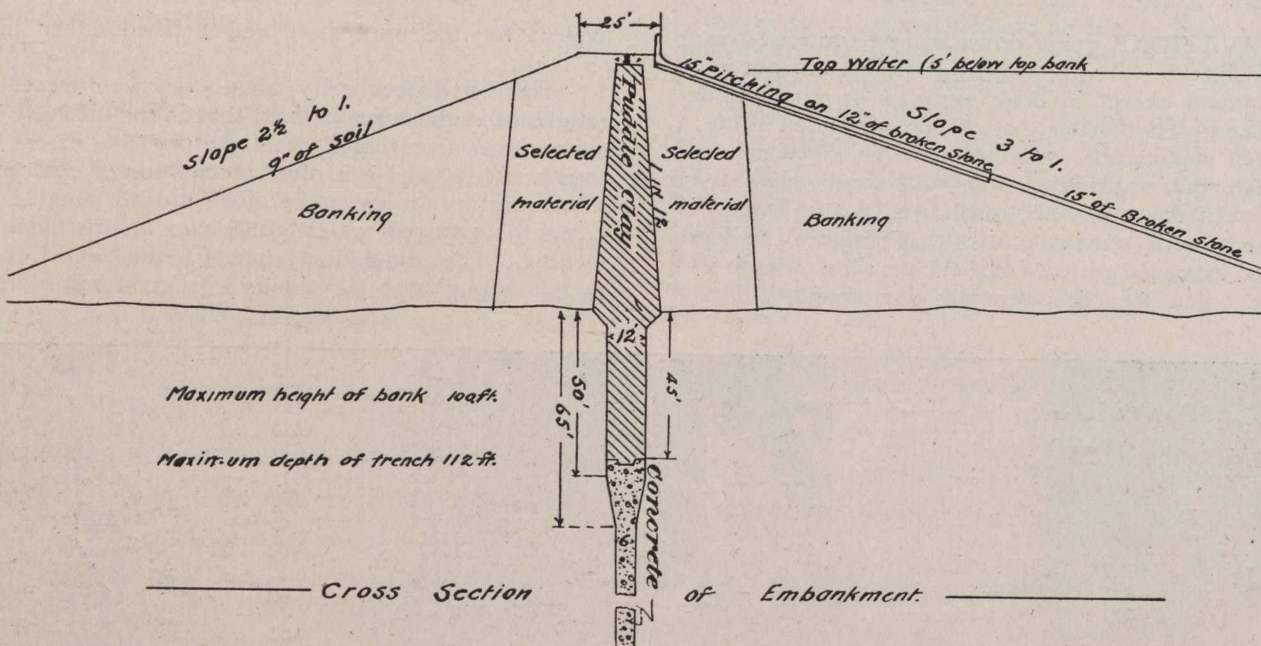


Fig. 2.—Cross-section of a Reservoir Embankment, Showing Core Wall of Concrete and Puddle Clay.

A commencement was made with the excavation of the trench, using the horizontal method of timbering, and this worked well in good ground as was to be expected, but whenever soft ground was reached trouble arose.

An example of horizontal timbering is shown in Fig. 3.

The vertical soldiers covered five planks as a rule, except for the first five or six feet, where longer soldiers were used to permit the placing of two struts against them. It was necessary to have two struts against the top soldiers as any disturbance of surface conditions might put soldiers singly supported out of the vertical, for they would pivot on the strut end.

Except in very firm ground the procedure adopted was to excavate for the depth of one plank at a time, temporarily support this plank and lightly strut it and continue in this way till five planks were standing on "temporaries," as the men called them.

Then the permanent soldiers and struts were put in place. These squared timbers were all of pitch pine and the sheeting of hemlock. There are two points about this system of timbering which are objectionable: (1) It has no strength in tension vertically; when finished it is simply a series of planks laid one on the top of the other and, except for the spikes in the puncheons, has no vertical cohesion. (2) It is necessary to expose an area of the side of the trench equal to each plank at least before placing the plank in position. One advantage it has over the vertical system is that it is not necessary to step in with each new set of runners or piles and so the side of a trench can be maintained vertical to any depth.

Whenever bad ground was opened up the contractors urged the engineer to permit the use of vertical runners zontal timbering was abandoned in favor of a second setting of vertical timbers though this reduced the width of the trench.

From one cause and another much of this trench stood open for about two years with the result that the ground settled very heavily against the timbers. In many cases the soldiers, though 6 inches thick and only 3 feet 9 inches long, were badly bent and a few were actually broken. At depths of 20 to 40 feet in running sand every horizontal plank was broken in places for many bays in succession and alternate bays had to be closed with new struts and soldiers in the centre while the bays left open for hoisting were dealt with as shown in Fig. 5.

As experience proved, the bays were too long for 3-inch planks in this ground. It is a point to be borne in

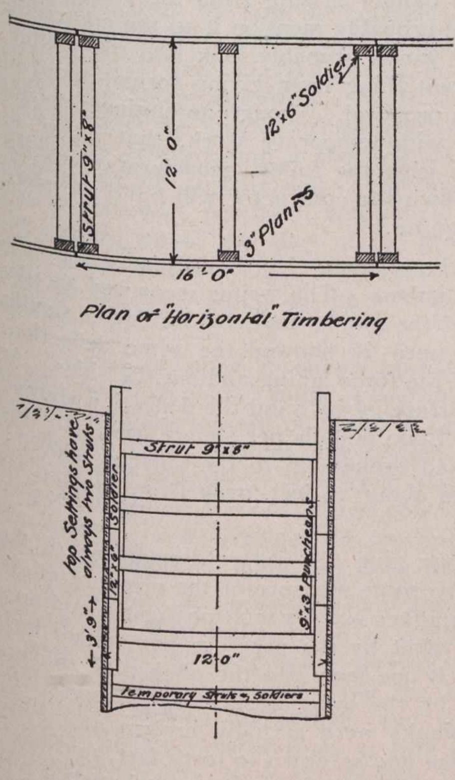


Fig. 3.

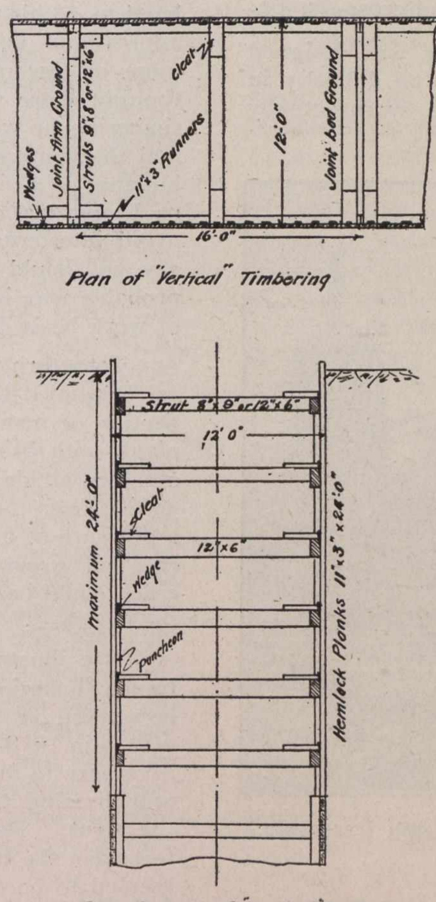


Fig. 4.

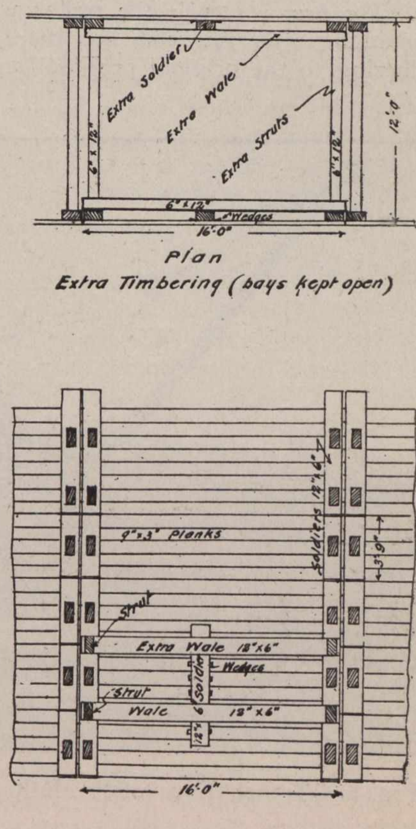


Fig. 5.

and finally the engineer consented to the use of vertical timbering for the first setting, as shown in Fig. 4. To take the greatest possible advantage of this permission to depart from the specification, very long runners were used, the planks being 11 in. x 3 in. x 24 feet long in some cases.

As the excavation was being hoisted by three-ton travelling cranes with 18-foot jibs, a difficulty arose in pitching these long planks on the side of the trench next to the crane; but this was easily overcome by starting short temporary runners in the dry sand of the top six feet and, after a certain amount of trench was out, replacing them, one at a time, with the long permanent planks.

The type illustrated in Fig. 4 was adopted for several thousand feet of trench though not all of the runners were 24 feet long, the majority being 17 feet long. The running sand was hard to deal with and in places the hori- mind with horizontal timbering that once the size of the bays is fixed it must be adhered to all the way down. The limit of a bay is the strength of a plank, while with vertical timbering, though the bays may be fixed, the spacing of the walings may be altered to suit circumstances.

There was no difficulty in excavating the trench where runners were used or was there much trouble experienced drawing them where the trench was filled with clay. In one section of the trench the ground settled all on one side with the result that some of the struts were nearly two feet out of level but no accident occurred owing to constant care in placing raking struts as the weight came on.

It was specified that all timber was to be removed from the trench as it was filled. Having attempted to remove some of the horizontal timbering in running sand, as the concrete was being placed, without much success, and realizing the great pressure there was against the sides, the engineer decided to leave in the sheeting in the worst parts and to fill parts of the trench (originally intended for clay filling) with concrete up to the bottom of the vertical runners. This meant bringing the concrete up to within about 17 feet of the surface instead of 45 feet, as shown on the typical section. Had all the circumstances been foreseen, it would have been much better to have formed the trench in this very bad ground with two or even three settings of vertical timbering, as the wall, even when thus reduced, would have been thick enough as formed in concrete.

Another design of trench is that in which a definite width is fixed at the probable bottom or at the rock line and slopes outward sufficient to permit the insets of vertical timbering are shown on the typical cross-section.

The first reservoir the writer was on was designed something after this plan and there was no difficulty in adhering to the original proposal as the work actually

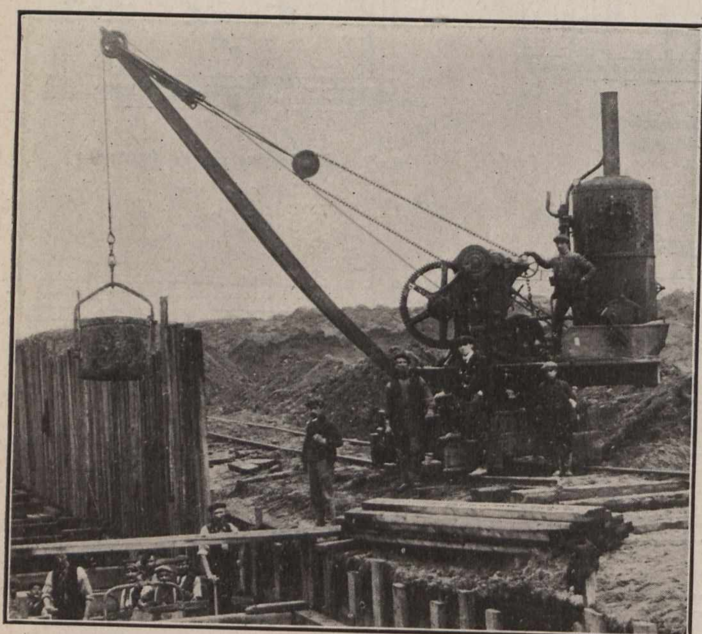


Fig. 6.—Trench Excavation Method, Delph Reservoir.

done by the contractor was about equal in quantity to that involved in the cross-section shown.

After experiencing the many makeshifts and uncertainties arising from the difficulties of adhering to the vertical sided trench in bad ground the writer is of the opinion that there is much to be said for a design which suits the use of vertical timbering. Why should not the design be such that it can be carried out in a safe manner and the payments be so made that the contractor has no inducement to do otherwise than follow the drawings? Of course, the engineer might take up the literal interpretation of his specification and say to the contractor, "Well, if you can't do it with vertical sides, take out the extra width necessary for your own system of timbering and fill in the extra width at your own expense"; but that is not a fair attitude, for the engineer by specifying a vertical sided trench has limited the contractor to a particular method of working and, if he (the engineer) has been mistaken in thinking this method possible then he has more or less misled the contractor and should help him out of the difficulty.

All these contracts were measured jobs and paid for at rates per cubic yard, etc. There was in every case a rate per cubic yard for all excavation from the surface of the ground to 10 feet in depth and another rate for excavation from 10 feet to 20 feet in depth, and so on.

Several large reservoir trenches have been done in Britain by administration, without the aid of a contractor, and there is a good deal to be said for this way of doing work where there is much uncertainty as regards probable depths to impervious strata.

One thing is clear: the engineer should never specify the form or size of timbering. It is even a mistake to say that the contractor shall submit drawings of his proposed methods of timbering for approval. The contractor takes the risk of accident and should, therefore, have a free hand to do his work in a way of his own choosing. Any approval of designs of temporary work carries with it more or less responsibility. Of course, if an engineer thought there was danger arising from the state of the timbering he would probably mention it to the contractor and the contractor would probably look into the matter, but that is a different thing from giving formal approval or disapproval of a proposal. Though an engineer should avoid interference with temporary work, that is not to say he should not give the fullest consideration to the probable way in which the contractor will build the piece of work he is designing.

To return to the amount of pressure exerted by the earth against the timbers. The writer measured the deflection of many of the planks and, by loading a similar plank with bricks until it showed the same deflection, obtained an idea of the force acting against the sides. At 30 feet from the surface in wet sand the deflection showed a pressure of over 1,000 pounds per square foot. In this case the ground had broken up to the surface where a crack could be seen about 20 feet away from the side of the trench.

The illustrations give the exact dimensions of the trench timbering, so some measure of the pressure might be worked out in another way by multiplying the end area of a 9-in. x 8-in. strut by the pressure per square inch necessary to force it one inch into the pitch pine soldiers and dividing this by the area of sheeting supported by the strut. The planks were actually broken at twenty feet from the surface and so down to forty feet, and there seemed to be little difference in appearance between one place and the other. The fibres of these timbers were sprung on the surface and showed as projecting splinters, but the planks were not so far gone that they fell out of their places because before that happened they had received new support. These planks were of hemlock and, of course, always dripping wet.

There is very little enlightening literature on the subject of earth pressures. If one could get the measure of the pressures in a number of cases by deflections of timber, etc., these results of experience would be very useful.

Fortunately, timber gives warning before it breaks, as a rule, and errors of judgment can be rectified by adding more supports if the dangers are noticed in time.

All trenches should be looked over every day by a practical timberman, especially if for any reason they have been standing open for some time.

It is astonishing how much silt will come through a knot-hole in a week, and once settlement has started it is hard to keep timbering right.

CONTROL AND PROTECTION OF ELECTRIC SYSTEMS.*

By Charles P. Steinmetz.

WHEN the first commercial electric circuit issued from a station the problem of control and of protection arose. It was a simple problem at first—an ammeter and voltmeter to measure current and voltage; a knife-blade switch to send the current into the desired path or withdraw it; the fuse to open the circuit in emergencies, and if the wires became crossed and the fuse and switch failed, the generator and engines stopped, and not much harm was done. With the extension of the circuits into the suburbs some lightning troubles were felt, which led to the introduction of lightning arresters.

Since those days, less than a generation ago, enormous changes have taken place, and the electric systems have increased in size, in voltage, and in extension. Where 100-h.p. machines were large once, now turbo-alternators of over 40,000 h.p. are in commercial operation. The steam engine has made room for the steam turbine, and the steam turbine does not stop when the wires are crossed and a short-circuit occurs; the momentum of the turbine disks, revolving at velocities of 300 to 400 miles per hour, can supply ample energy for the destruction of any part of the system. Attempts to open such circuits by the knife-blade switch of old would lead to the destruction of the switch, and probably its operator.

Instead of small machines operating separately on independent circuits, huge generators now feed in parallel into the system of busbars, on which is concentrated all the power of the station or the group of stations tied together. Numerous stations and systems of interconnected stations of 100,000 to a quarter-million horse-power and over are in operation, and the half-million horse-power mark has been reached.

Anywhere on the busbars of the station or in the feeders near the station there is available, destructively in case of an accident, as a short-circuit, not only the entire power of the station, but the far greater power which the station generators can give momentarily. Short-circuit currents of forty to fifty times normal full-load current may momentarily flow from some turbo-alternators, representing ten and more times full-load power. Such a station, or group of closely interconnected stations, of half a million horse-power full-load capacity, may momentarily send into a short-circuit at the busbars over five million horse-power. This is the power of Niagara, which is estimated variously at from 5,000,000 to 15,000,000 h.p. It is obvious that no switch or circuit-breaker can be built to safely relieve such power.

With half a million horse-power station capacity, a momentary overload capacity ten times as high, assuming that we could build a circuit-breaker to open this short-circuit power as quickly as in three to four cycles, or one-eighth second, would require dissipating in the circuit-breaker the energy of over 200,000,000 ft.-lb.—the destructive energy of 1,000 tons dropping from a height of 100 ft., that of a projectile weighing 2,000 lb. leaving the cannon at a velocity of 2,500 ft. per sec., or the destructive energy of two heavy railway trains, going at sixty miles per hour, and meeting head-on.

Equally great has been the increase of voltage. Where once 2,000 volts was high, in circuits of a few miles in length, now circuits of over two hundred miles are in operation at 100,000 to 150,000 volts. Current at such voltages jumps toward an object over a foot distant, and will maintain arcs of practically unlimited distance; that is, with 100,000 volts and almost unlimited power back of it, an arc can extend for several hundred feet. Thus no simple switch will open a circuit at such voltages under power.

Lightning protection also has become a far larger problem than in the small circuits of old. But far greater than the energy of any lightning stroke is the energy stored as magnetic field surrounding the conductors and as dielectric field radiating from the conductors of these big transmission systems, and, if this internal energy of the system is set surging, its effects are far more destructive than those of lightning. The effects may not be merely momentary, as those of lightning, but continual, as machine energy keeps replacing the stored internal energy, which causes the destructive surge. The foremost problem of control of electric systems thus is that of controlling enormous powers; the foremost problem of protection is that against self-destruction by its own power.

Current and voltage have grown beyond the values for which instruments can be built, and current transformers and voltmeter transformers are interposed between the circuit and the instruments measuring it. With the general introduction of parallel operation, power-factor indicators are required to insure the division of load without excessive waste currents; and frequency indicators and synchronizing devices to safely connect machines into the system.

With hundreds of feeders radiating from the generating station, the office of the load dispatcher has become essential, and the necessity of keeping exact records of all operations and of all accidents and incidents is of the greatest importance. Automatic recording devices thus have been developed, as the multi-recorder, to record within fractional seconds all important events —opening and closing of switches, starting and stopping of generators, surges, lightning disturbances, etc. Such automatic devices afford a valuable check on the operating staff, but more important still is their record in emergencies. Where a number of things happen almost at once and the attention of the operator is distracted from accurate observation by the necessity of action, the record thus could be made only afterwards from memory. It is just in such abnormal conditions where the most complete and accurate record is of greatest importance, to enable the engineers to determine with certainty what happened and why it happened, so as to take steps to guard against its recurrence.

Oil circuit-breakers have been developed which can safely and without disturbance close and open feeder circuits of over 10,000 h.p. and generator circuits of 40,000 h.p. In these the circuit is opened under oil so that at the instant of opening the current is extinguished at the end of a half-wave by the rapid expansion and chilling of the oil vapor produced by the opening arc; this at first is under high compression, due to the momentum of the oil, which has to be set in motion.

Power-Limiting Reactances. — The possibility of self-destruction by the power let loose under short-circuit

*From a paper presented at a joint meeting of the Philadelphia Section, A.I.E.E. and the Franklin Institute.

was solved by the development of the power-limiting reactances. In the generator leads, between generators and busbars, are inserted reactances capable of withstanding enormous overloads, but of a size sufficiently small not to interfere with the normal flow of power at full load or any overload that the generator may be called upon to carry. They are large enough, however, to materially limit the generator current and power on short-circuit. Usually the generator reactances limit the momentary short-circuit current to about ten to twelve times full-load current; that is, the momentary short-circuit power to about two and one-half times full-load power. This solved the problem for medium-sized stations.

However, even with generator reactances, with the increasing size of station, the power that may be let loose under short-circuit becomes large beyond control, and busbar reactances were next introduced. By such reactances in the busbars and in the tie feeders between the stations, the system is divided into sections of about 60,000 h.p. each. A short-circuit, then, can seriously involve one busbar section only.

With hundreds of feeders radiating from the busbars, the probability of a short-circuit in the feeders is far greater than in the busbars, and a material advantage, therefore, is given by feeder reactances.

By the development of generator reactances, busbar reactances, and feeder reactance the problem of the power control of large systems for protection against self-destruction by short-circuit has been solved and unlimited extension of systems without any increase of danger has been made possible; and experience has shown that after the introduction of such power-limiting reactances dead short-circuits have occurred at the busbars of very large systems without even interfering with the operation of most of the synchronous apparatus on the system.

Grounds and Short-Circuits between Phases.—The two main sources of trouble in lines and cables are grounds and short-circuits between phases. In transmission lines a ground on one phase is the most frequent trouble, and short-circuits are rare except in lines in which the design is faulty or reliability has been sacrificed to cheapness. A short-circuit is far more serious than a ground, as in the former the current is limited only by the generator capacity, while with a ground the current has no return unless the neutral is grounded, and then over the resistance of the neutral. In a well-designed transmission line a short-circuit usually occurs only as the result of two simultaneous grounds. A ground on one conductor, however, raises the voltage to ground of the other two phases, from the Y voltage to the delta voltage of the system, and thereby increases the strain on the insulation of the other two phases. It thus introduces the danger of a second ground, causing a short-circuit, or requires higher insulation.

This has led to two methods of operation of transmission systems. In the first, the neutral of the transformers is grounded, frequently through a resistance, where the resistance of the ground is not high enough to limit the current. Then a ground on one phase is a partial short-circuit to the neutral, causing a large current to flow, and thereby opening the circuit-breakers before the ground has developed into a short-circuit. However, this method, the grounded Y system, means a shut-down at every ground, every flashover of an insulator by lightning, etc. In the second method the neutral is not grounded, but the insulation of the circuit is good enough to safely stand the increased strain put on it by a ground on one phase, and by means of an arcing ground suppressor, etc., care is taken not to continue the arcing ground leading to high-frequency disturbances, but convert it into a metallic ground. In this case the "isolated delta" system can be maintained in service, even if one phase grounds, until arrangements are made to take care of the load or the fault is found and remedied. However, the cost of line construction is higher, because of the better insulation required. The relation between grounded Y and isolated delta is one of cheapness versus reliability and continuity of operation.

Protecting Underground Cables.—Different are the conditions in underground cable systems. In a cable the three conductors are so close together that a ground on one conductor quickly reaches the others and becomes a short-circuit. A grounded cable, therefore, cannot be kept in service, but has to be cut out promptly. In these systems it is customary to ground the neutral through a resistance sufficiently low, in case of a ground on one conductor of a cable, to allow enough current to flow to open the circuit-breaker and cut off the cable, but not sufficient to give a severe shock to the system. Or, where grounding of the neutral is considered undesirable, an arrangement of relays is made to give the same effect. With underground cables such cutting off of a disabled feeder does not interfere with the continuity of service, as a number of feeder cables are always used in multiple for every important substation.

However, the problem of cutting off a disabled feeder by the operation of the circuit-breaker, owing to the large current taken by the grounded feeder, is not so simple. Therefore, so-called "inverse time-limit" circuit-breakers are generally used; that is, circuit-breakers in which the time limit of their operation decreases with increasing overload. Such circuit-breakers would first cut off the cable carrying the greatest excess current—that is, the faulty cable—and then those of less excess current; but, as the excess current stops with the cutting off of the faulty cable at both ends, other cables should not be interfered with. However, the inverse time-limit circuit-breaker necessarily must be practically instantaneous under short-circuit, and, therefore, while the time limit discriminates between 100 per cent. or 200 per cent. or 300 per cent. overload, it cannot discriminate between short-circuits of different magnitude.

Thus devices become necessary for selecting a disabled feeder and cutting it out without cutting off its parallel feeders or the tie feeders to the substation served by the faulty feeder, regardless of what excess currents these may carry. This is a problem that has not yet been completely solved.

In general, in high-power systems of high standard of reliability the radial system of substation supply is used: that is, each substation is fed by a separate set of cables, and the substations are not interconnected into a network by a system of tie feeders. This radial system, however, is less economical in feeder copper than the interconnected network, since the radial system requires for each substation a feeder capacity equal to the maximum power demand of the individual substation, while in the network, by cross-feeding between the substations, the feeder capacity is reduced to that required by the average maximum demand of the substations. Because of the economic disadvantage of the radial system an effective selective feeder relay that could be relied upon to pick out the faulty feeder and no other would offer material advantages.

Such a selective device is afforded by the use of pilot cables. Each cable or feeder is duplicated by a smaller low-voltage, three-phase cable, which joins the secondaries of current transformers connected into the two ends of the main cable. If the main cable is undamaged, the same current comes out of it as flows into it, and the connections to the pilot cable are such that in this case the secondary currents would be in opposition; that is, neutralize each other. If, however, the main cable grounds, current flows into it from both sides, the secondary currents in the pilot cable then add, and the current flowing in the pilot cable operates the relay which opens the circuit-breaker. This arrangement is very perfect in operation, and is capable of cutting out the damaged cable without interfering with any other, but it has the disadvantage of doubling the number of cables required in the system. While the pilot cables are small and of low voltage, they occupy room in the underground ducts; hence, this method of control is little used in this country.

Another method is that of the split-conductor cable. Every cable conductor is made of two parts, of which the one surrounds the other concentrically, with some insulation between them. Normally, there is no potential difference between the inner and the outer half of the conductor, as they are connected with each other at the ends of the cable. If, however, a ground occurs on the cable, this ground can at first reach only the outer half of the conductor, and a potential difference and current appears between the inner and the outer half of the conductor and operates the circuit-breakers through a relay connected between the halves of the conductor at either end of the cable. This method also works very satisfactorily, but has the same economic disadvantage, though to a lesser degree than the method of pilot cables, in that the split-conductor cable is materially larger and more expensive.

The usual method of taking care of the problem, at least in most cases, is by the so-called reverse-power relay, also wrongly called "reverse-current relay." Such a reverse-power relay operates perfectly so long as there is any voltage for the reverse current to act upon. If, however, a short-circuit occurs at or close to the substation, the voltage vanishes, and with it the reverse-power relay loses its pull. To guard against this the installation of reactances is recommended between cables and substations to give a sufficient voltage drop to operate the relay. However, this is an additional complication.

The reverse-power relay is not adapted to guard the feeders between stations, as in these the current reverses in direction with the change of the distribution of load between the substations. Thus the reverse-power relay does not make the operation of interconnected networks of substations possible, but in the radial system of operation it is the only device which is generally available economically, and it is very satisfactory with the exception that it cannot operate where there is no voltage left.

Lightning Interference.—Interference by lightning, with high-potential transmission lines, has rather decreased with increasing line voltage. In 100,000-volt lines the insulators are tested for one minute at 200,000 to 250,000 volts, and stand momentarily for the very short time of lightning, over half a million volts. Thus it is rare that lightning flashes over or punctures the suspension insulators of our very high-voltage transmission systems. A flashover, with the grounded Y system, shuts down the circuit, often without any damage, while with the isolated delta system it may not even shut down the circuit, but is taken care of by the protective device against flashovers—the arcing ground suppressor in the station. Most lightning voltages incapable of destroying the line insulation run along the line until their energy is dissipated or they reach a station, and there they often do serious damage. The most important problem of lightning protection thus has become the rapid damping out of line disturbances caused by lightning, so as to make them harmless before they reach the station. The most effective method has been the overhead ground wire. By its screenings effect it lowers the voltage which lightning can induce in the line, but far more important is its powerful damping effect on the line disturbance—the travelling wave caused by lightning which runs toward the station.

In considering the protection of modern electrical systems it must be realized that the various sources and kinds of interference or danger require correspondingly different protective devices. It would be just as unreasonable to expect a standard type of "lightning arrester" to protect an electric system against all possible troubles as it would be to call for a single-standard "safety device" which would protect a railway train against all possible dangers, from a broken rail or a washout to a collision or a boiler explosion.

QUALIFICATIONS OF UTILITY COMMISSIONERS.

Experience in connection with public utilities should be made a necessary qualification for public service commissioners, according to a committee of engineers representing national and New England engineering societies, which has addressed a strong plea on the subject to the committee on public utilities at the Constitutional Convention of the State of New York.

Men familiar with the technical, financial, commercial and legal matters which come before a public service commission are best fitted to render valuable service to the public. The committee feels that there are to be found among those connected with public utility companies men with as broad conceptions of public rights and of the duties to be fulfilled to the public as can be found in other walks of life.

The engineers also urge on the committee on public utilities that the point of greatest importance in any plan for an organization of the public utility commissions of the State is the preservation of the principle of continuity, whereby the terms of office of the members of the commission expire at different times, so that only one member of the commission at a time goes out of office. Represented on the committee of engineers making these representations are the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Institute of Consulting Engineers, the New York Section of the American Institute of Mining Engineers, the Municipal Engineers of the City of New York, and the Brooklyn Engineers' Club.

The Denver (Colo.), municipal asphalt plant has been in operation nearly five years. During 1914 the output, which exceeded that of any previous year, was 99,717 yards, which were laid at an average cost of $0.723 per yard.

CHLORINE CONTROL APPARATUS FOR WATER AND SEWAGE PURIFICATION.

THE value of liquid chlorine in the destruction of germ life in water is a discovery of comparatively recent date. Yet current investigation and experience show it to be most efficient, and in many water supply systems it has superseded the use of chloride of lime and other methods dependent on the introduction of solids in admixture with the water. The application of liquid chlorine to the water to be purified is, however, ordinarily fraught with difficulties arising from the activity of the gas itself. Though very real, these difficulties are largely overcome in the design and construction of the control apparatus as now manufactured by various firms, and appliances are on the market at the present time adequate to meet the requirements of handling chlorine in the liquid or gaseous state for the purification of water and sewage.

The use of liquid chlorine is an evolution of the process of sterilization by chlorination. Various compounds

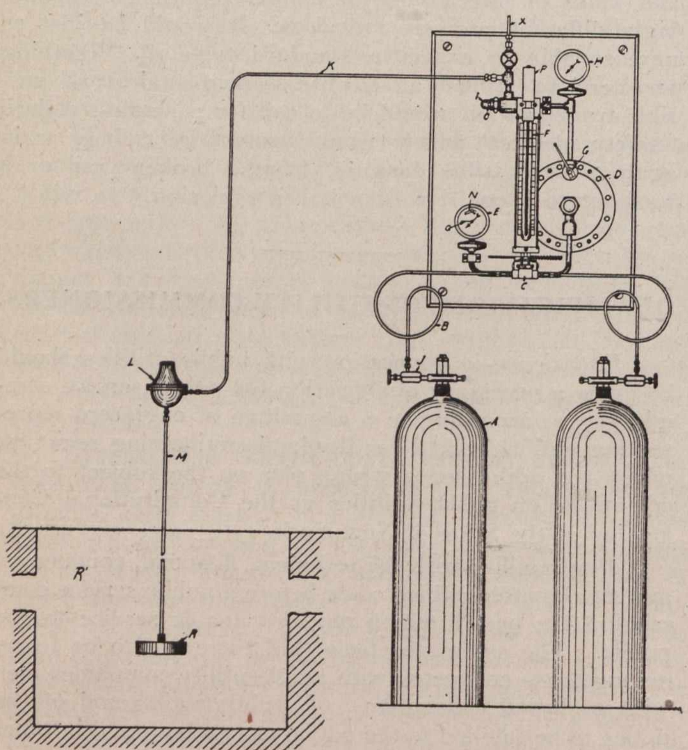


Fig. 1.—Manual Control Chlorinator, Direct Feed.

of chlorine—notably calcium hypochlorite or chloride of lime—have been largely used, applied in solution to the water or sewage to be treated. But this method involved so many difficulties and presented so many unsatisfactory features that liquid chlorine is now gradually supplanting these various compounds.

In 1896, James Hargreaves, of Liverpool, England, in a paper read before the Liverpool Polytechnic Society, discussed the disinfection of sewage by means of chlorine manufactured by the electrolysis of salt. One of the first investigations into the sterilization of water and sewage by chlorine and its compounds on this side of the Atlantic was carried on by Prof. Earle B. Phelps in 1906 and 1907, and the development of the process is largely due to the published data and reports of his work. The first recorded attempt, in North America, to sterilize water on a large scale by the process of chlorination was made at the Bubbly Creek water filtration plant at the Union Stock Yards, Chicago. Calcium hypochlorite was the compound used in this case, and the results accomplished justified the acceptance of the process as a highly important method of water purification.

Further research into the utilization of pure chlorine as a sterilizing agent was done by Dr. C. R. Darnall, Major of the Medical Corps, U.S.A., in 1910. Under Dr. Darnall's supervision an experimental apparatus for applying chlorine gas to water was constructed at Fort Myer, Va. A board of officers, appointed by the Secretary of War to investigate the operation of the apparatus, reported favorably and recommended the adoption of this method of water treatment.

Further experiments along this line were made in 1911 and 1912 by several independent investigators—notably C. F. Wallace, M. F. Tiernan, George Ornstein, Seth M. VanLoan, John A. Kienle, and D. D. Jackson.

Developments in the process and in the apparatus necessary for the application of liquid chlorine were rapidly made. At the present time, over two billion gallons of water are being sterilized daily by this method.

Liquid Chlorine vs. Chloride of Lime.—Liquid chlorine is a more efficient and economical sterilizing agent than chloride of lime. Some of its specific advantages may be briefly discussed. In the first place liquid chlorine is an absolutely pure chemical. It is usually placed on the market in small cylinders which require very little space for storing, while chloride of lime is bulky. The disagreeable odors and corrosive effects of chloride of lime are absent in the use of liquid chlorine, when controlled by efficient apparatus.

Chloride of lime deteriorates with time, whereas liquid chlorine retains its full efficiency indefinitely. This is one of the greatest advantages to be derived from the use of liquid chlorine, especially for small installations.

Under working conditions, due to necessary waste of bleach, one pound of liquid chlorine is equal in sterilizing value to eight pounds of chloride of lime. The sterilization is also more uniform. Water treated with liquid chlorine is less liable to taste or odor, due to the more accurate control possible. The liquid chlorine apparatus is more compact than the installation for chloride of lime.

The liquid chlorine process is applicable under any conditions and all pressures. It is adapted to remote control. The gas can be controlled by automatic feed. With it the freezing difficulties encountered in the use of chloride of lime are entirely obviated.

As between the two sterilizing agents, the costs of chemicals are about the same, but the costs of installation and operation are, it is stated, in favor of liquid chlorine.

Method and Apparatus.—Chlorine gas, compressed to liquid state in iron cylinders holding a hundred pounds, is controlled and measured by the apparatus and introduced into the water or sewage in the proper proportion to effect sterilization.

There are two general types of apparatus, one by which the chlorine gas is introduced directly into the water or sewage and the other by which the chlorine gas is first dissolved in a small quantity of water and the resulting chlorine solution piped to the point of application, the first type being called a dry feed and the second type a wet feed.

Each general type is furnished for either manual or automatic control—the automatic being a proportional feed apparatus, that is, it varies the flow of chlorine in proportion to varying flows of water or sewage.

Manual Control Types.—The accompanying diagrams and their descriptions, of these several types, have been furnished us by Messrs. Wallace and Tiernan Co., New York. Fig. 1 illustrates the apparatus, with a capacity of purifying 50,000,000 gallons per day, installed at Smith's Pond pumping station, Brooklyn, New York. It is of the manual control, direct feed type. Chlorine gas in the cylinder *A* controlled by valve *G* is measured on flow meter *F* through the orifice *O* and piped through tube, check valve and silver tube, to the point of application where it is dissolved and diffused by the chlorine diffusor *R*. Any number of chlorine cylinders of any size may be connected up at a time by means of a suitable header. The automatic three-way valve *C* is an essential part of the apparatus inasmuch as it ensures a constant supply of chlorine. If a cylinder on one side of the valve becomes used up at a time when there is no attendant present, the valve *C* automatically throws over, cutting in a new cylinder. The gauge *N* has electrical contacts for ringing a bell if desired to give warning of any failure in the flow of chlorine from the cylinders. Gauge *H* will instantly indicate any stoppage in the chlorine line to the water.

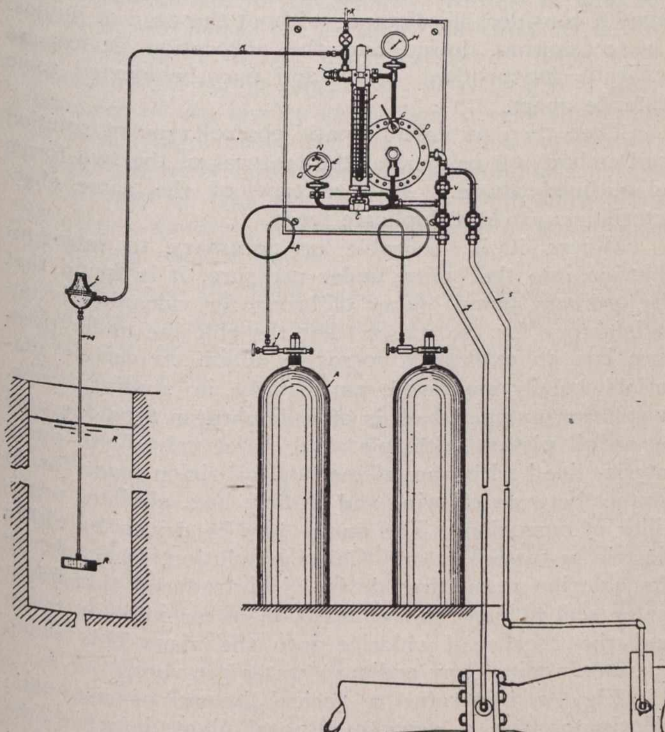


Fig. 2.—Automatic Control Chlorinator, Direct Feed.

The chlorine meter *F* is of the enclosed manometer type. One side is connected ahead of the orifice and the other side after the orifice. The drop in pressure across this orifice is indicated by a column of liquid in the manometer. The different positions of the liquid indicate different flows of chlorine. This calibration is done empirically for each apparatus and checked by actual chlorine flow when the apparatus is tested.

The tubing *K* may be of copper or ordinary galvanized iron pipe. Chlorine does not attack these metals when dry. The check valve *L* prevents any moisture from getting into this pipe. The dry gas may be piped most any distance without danger of freezing.

The diffusor *R* may be dropped into a pump well, gate chamber, open conduit, or stream. In sewage disinfection an inverted siphon arrangement may be used. Perfect solubility of the gas is obtained at a depth of four feet, and no gas will come to the surface. The diffusor *R* is a carborundum sponge of fine porosity. This becomes saturated with water because of the capillary action of the carborundum upon the water. The natural pressure of chlorine in the cylinder forces the chlorine in minute bubbles through the carborundum in which passage they become saturated with moisture. When they strike the water, they go immediately into solution, not only on account of their fineness but also because they are already saturated.

In another type a tank is inserted in the chlorine line to act as a trap to prevent flooding of the apparatus in case of a failure of the check valve at any time when the chlorine might be turned off. The tank is equipped with a gauge to indicate any stoppage in the chlorine line between the apparatus and the water. By this apparatus chlorine can be introduced directly into water mains against pressures up to 25 lbs.

Another type provides for the introduction of chlorine at different points, as in parallel conduits or mains. It involves a duplicate apparatus in which either unit may be run separately.

The automatic control type is designed to vary the flow of chlorine in proportion to varying flows of water. As indicated in Fig. 2, it operates in conjunction with a venturi throat.

The arrangement of the different parts of the apparatus and the method of securing solubility of the chlorine are the same as in the manually operated type and of essentially the same construction with the exception of the automatic regulating valve. In this valve *G* is a gas constriction of such design that the drop in pressure across it for any flow of chlorine follows the same law as the drop in pressure across the venturi for any flow of water. By keeping these drops or differences in pressure proportional to each other, a proportional flow of chlorine and water is obtained. In other words, the water is treated with the same proportion of chlorine, no matter what its flow at any instant.

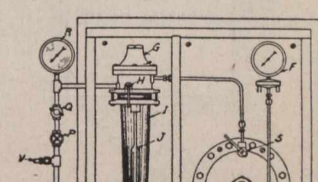


Fig. 3.—Manual Control Chlorinator, Solution Feed Type.

Suitable diaphragms, one set actuated by connections to the venturi tube and another set actuated by connections to the chlorine constriction are so connected to a valve in the chlorine line that any difference in flow of either the water or chlorine throws the diaphragms out of equilibrium, and there is allowed to pass a greater or less amount of chlorine until the diaphragms come into equilibrium. This valve will likewise take care of varying pressures of chlorine in the cylinders as well as varying flows of water. It also acts as a differential pressure reducing valve.

The automatic control does not depend upon the opening or closing of a valve a certain number of turns. Consequently any deposit in the valve seat or any corrosion in no way affects the accuracy of the control.

A variation of this type is used in conjunction with a weir or a submerged orifice. There is very little difference in design, as the law governing the discharge of a liquid with varying head through an orifice is practically the same as that for the flow through a venturi throat. In this particular type the thrust from a float is transmitted by a capillary tubing to actuate diaphragms suitably arranged to proportion the flow of chlorine according to varying heads.

Solution Feed Types.—The types mentioned above all provide for direct feed. The following apparatus provide solution feed. In the installation at the Bridgeton, N.J., filtration plant (Fig. 3) chlorine gas in cylinder *A*, controlled by valve *S*, is introduced through the check valve *G* and meter *J* into the chlorine absorption chamber *I* and water at the same time is introduced through the connection *V*. The resulting chlorine solution is piped

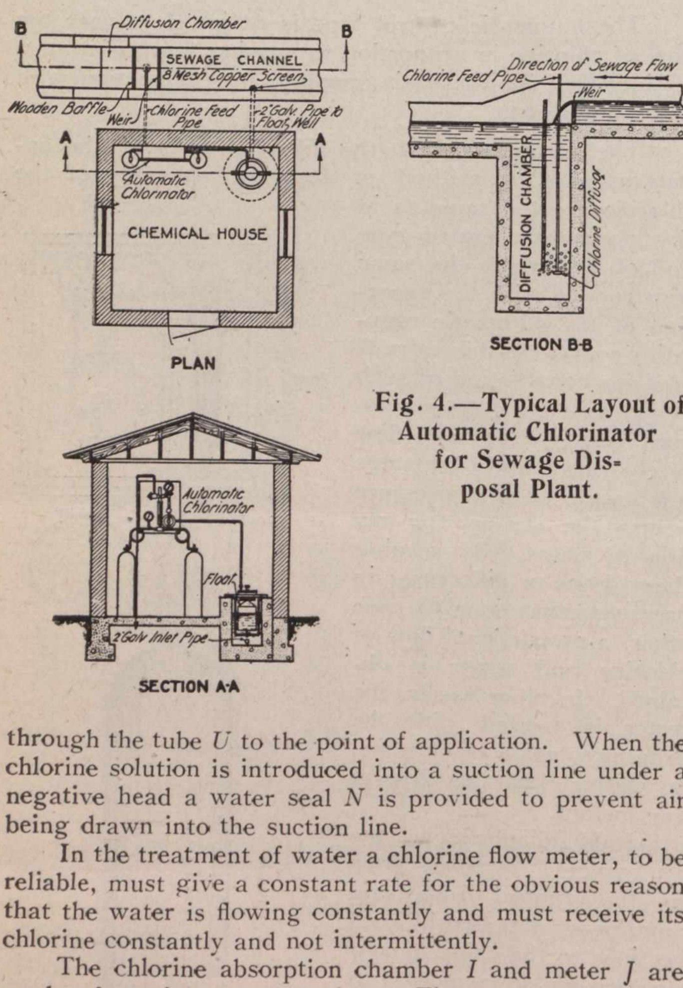


Fig. 4.—Typical Layout of Automatic Chlorinator for Sewage Disposal Plant.

through the tube *U* to the point of application. When the chlorine solution is introduced into a suction line under a negative head a water seal *N* is provided to prevent air being drawn into the suction line.

In the treatment of water a chlorine flow meter, to be reliable, must give a constant rate for the obvious reason that the water is flowing constantly and must receive its chlorine constantly and not intermittently.

The chlorine absorption chamber *I* and meter *J* are made of special annealed glass. They are consequently unattacked by the chlorine solution. Furthermore, the flow of chlorine can be seen no matter how small.

A flow of 1 pound of chlorine per 24 hours (which amount will treat 300,000 gallons of water) is a flow of 0.000694 lb. per minute, or 0.0000115 lb. per second. This quantity is too minute to be measured conveniently and accurately, except by a volumetric one.

A ready solubility of chlorine is secured by the action of a water jet which operates in the jar.

The apparatus in operation at Trenton, N.J., treating about 25,000,000 gallons of water daily, differs in that the chlorine gas, in place of being introduced into the water through a carborundum sponge is continuously dissolved in a small amount of water and the resulting solution piped to the point of application. Water under a pressure of about 15 lbs. or more and at the rate of 40 gallons to 1 lb. of chlorine, is introduced into a solution vessel simultaneously with the gas. The arrangement is such that no chlorine in a gaseous state can enter the water being treated. In this system the solution can be piped a considerable distance without the need of pumps. The measuring device and the absorption device are separate independent units and may be located some distance apart.

Then there is an automatic control type of solution feed embodying in general the features of the two forms as outlined above. Another type of the same characteristics provides duplicate feeds.

Where it is desirable or necessary to introduce chlorine into the mains under pressure, it is found that the ordinary pump, either of bronze or vulcanite, is unsatisfactory for the reason that the chlorine under pressure has an extremely corrosive action on certain materials usually employed, particularly in stuffing boxes. A solution pump, which is of a diaphragm type operated by an oil piston, with inlet and outlet valves and pump interior lined with pure silver, and provision made for no contact between chlorine and stuffing box, obviates possibility of corrosion. The pump may be driven by either electric or water motor. Chlorine solution, measured by the chlorine regulating device, is introduced through a water seal to prevent the intrusion of air into the pump and the escape of chlorine into the air. This pump operates against any ordinary water pressure.

Fig. 4 illustrates a typical layout of automatic chlorinator for a sewage disposal plant, in which the chlorine layout is essentially the same as that already described for direct feed. The chlorine diffusion chamber provides a ready diffusion of the gas and sewage. The latter flowing down the right-hand side of the invert meets and thoroughly diffuses the chlorine as introduced.

We are indebted to Messrs. Wallace and Tiernan Co., of New York, for this information regarding their apparatus.

SELF-PROPELLING CONCRETE MIXERS.

Messrs. Thos. Kelly and Son, who have a large section of the Shoal Lake concrete aqueduct to build for the Greater Winnipeg Water District, a length of nearly 18 miles, in fact, have put into service three self-propelling mixer outfits. Ordinary flat cars of 60,000 lb. capacity, standard gauge, have mounted upon them chain belt mixers complete with water tank (3,000 gal. capacity), boiler and steam pump. Concrete is shot direct from the mixer to the aqueduct forms through special "U" shaped No. 10 gauge steel spouts, each 18 ft. 9 in. long, made in two sections, rolled to 24 in. diameter with a depth of 8 in. They are reinforced on each side with angles, with holes punched every 6 in. for attaching supporting cables.

The water piping system is such that both mixer and boiler are fed from the 3,000-gal. tank.

The Lake Huron and Northern Railway, to run from Sault Ste. Marie, Ont., to a junction with the Transcontinental between Cochrane and Hearst, will be 300 miles long, with an estimated cost of $24,000,000. The National Engineering Company, of Cleveland, has been awarded the contract, as announced in a recent issue.

TIMBER BERTH SURVEYS IN MANITOBA, SASKATCHEWAN AND ALBERTA.

THE surveyor performing the original subdivision of a township must make a separate report upon the timber to be found within the township. In his report, he states whether, in his judgment, from the knowledge gained on the ground, it would be desirable to reserve the timber for the needs of settlers or whether it would be advisable to set apart the same as a timber berth or reserve for the conservation of water supply. Should the former be suggested, he is to give a general statement of the quality and extent of the timber over ten inches in diameter suitable for lumbering purposes. If reporting on several timbered townships, he must make a statement of their relative value, taking into account the extent, quality and facilities afforded by streams, etc., for getting out the timber.

Following the field notes, the surveyor must make an affidavit of integrity and good faith. The examination is not commenced nor is anything else done before the affidavit is made.

This obligation requires that the survey operations have been carried out under his personal supervision and direction in such a manner that he is certain of their correct execution. It involves the presence of the surveyor on the ground. He may assign to his assistants such parts of the work as he may see fit.

A survey of a timber berth has been made according to law and the instructions of the Surveyor-General, when the directions of the law and of the Surveyor-General have been carried out as far as practicable. Cases may occur where it is impossible or manifestly inexpedient to comply with some clause of the instructions. In such cases, the surveyor is expected to use his own discretion. On the other hand, a departure from the instructions is not justified when they can be carried out without causing any harm.

Timber berth surveys may be made either with a transit or compass. In case a compass is used, the magnetic declination must be determined for each separate berth or block, either by means of an astronomical observation or by comparison with the known bearing of some line of the Dominion Lands system of survey. All berths or blocks must, if possible, be tied to some survey previously accepted. Special instructions for these ties are given in each case.

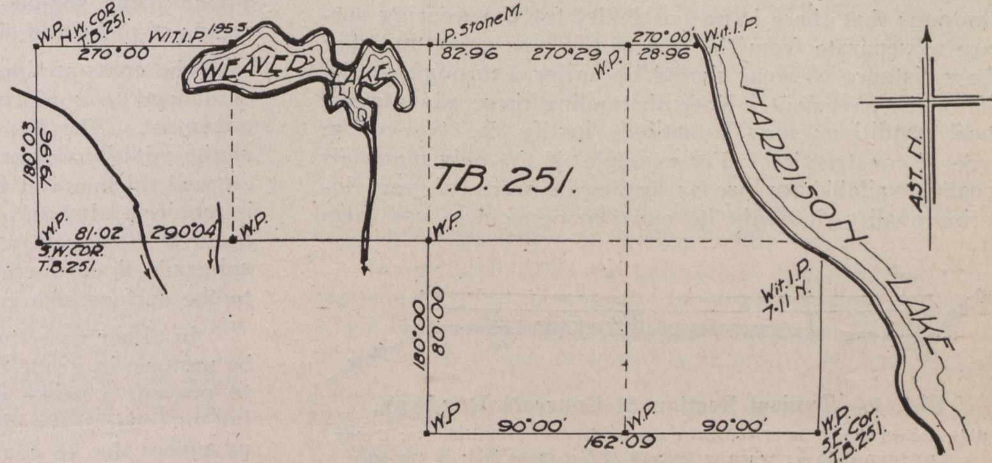
Boundary lines are to be cut out through bush and well blazed and the angles of the berths or blocks marked with wooden posts. Posts are also to be planted at every half mile (approximately) along land boundaries and at convenient points near the high-water mark on lines intersecting water boundaries.

A wooden post must be at least thirty-six inches long with one-half the length in the ground. It is to be squared twelve inches from the top and the faces must be at least three inches wide. The top is to be bevelled to turn off rain.

On the side facing the berth the post is to be marked with the number of the berth, or if a berth is divided into a number of blocks, with the number of the berth and the number of the block, as for example "T. B. 1914, B. 2." When a post is on a boundary common to two or more berths, it is marked on the side facing each berth with the number of that berth.

When a monument of the Dominion Lands system of survey is situated at an angle or anywhere along any boundary of a berth, such monument is sufficient to define the angle or boundary; no additional posts are erected in close proximity thereto or is the post marked to indicate that it defines the boundary of a timber berth. When section or other lines previously surveyed from the boundary or part of a boundary of a berth, such lines are not resurveyed further than may be necessary to establish proper ties between the two surveys.

The position of a post may be defined by ascertaining the astronomical bearing and distance therefrom of one or more adjacent trees likely to be permanent marks. A blaze is cut on the side of the tree facing the post, and the letters "B.T." and the distance from the post to the tree are to be marked on the blaze with a knife or a scribing iron. The bearing and distance from the post to the tree are recorded in the field notes.



Plan of a Typical Canadian Timber Berth.

The returns for the survey consist of plan and field notes, which should be forwarded to the Surveyor-General's office as soon as possible after the completion of the field work. As a general rule, the surveyor is not required to prepare plans, the final plans being prepared by the Department. When a plan is required the surveyor is specially instructed.

The field notes give the astronomical bearings and lengths of all boundaries, topographical information, positions and markings of posts and bearing trees, a report on the character and resources of the limit, and generally all information called for by the Manual of Survey.

In general, the survey and returns are made in accordance with the rules prescribed by the Manual of Survey, where these rules can be applied. The accompanying plan of a timber berth illustrates the rules and methods employed, as required by the Canadian laws.

Exports of copper from United States Atlantic ports for week ended July 29 were 4,023 tons, since July 1, 14,621 tons, a year ago 33,311.

PRESENT KNOWLEDGE OF BEST METHODS OF CONCRETE ROAD CONSTRUCTION.

PART II.
Construction Methods.

IN last week's issue of *The Canadian Engineer*, Part I. of this article dealt with the incomplete nature of the present state of knowledge concerning the best methods of constructing concrete pavements. In regard to materials used, and their proportioning, the opinions of roadway engineers were not at variance to any unlikely degree and the generally accepted conclusions pertaining to each were given. The following notes deal with the construction of such pavements.

There are two general types of concrete pavement, known as the one-course and the two-course. These designations are due to the fact that the former consists of one course of concrete, all of which is mixed in the same proportion and composed of the same kind of materials, while the latter consists of two courses of concrete, usually mixed in different proportions and containing different kinds of aggregate. Fig. 1 shows a typical cross-section for a concrete pavement, and this general form is suitable for either one-course or two-course work. The one-course pavement is somewhat simpler to construct than the two-course type. It possesses the advantages that there is no possibility for the wearing surface to separate from the rest of the pavement, and that the resistance to wear should be uniform throughout the life of the pavement. Notwithstanding these advantages, local conditions may sometimes justify the two-course type of construction. For example, if the only materials locally available for use as aggregate were of very inferior quality, it might be more economical to use them

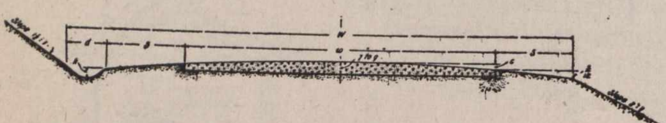


Fig. 1.—Typical Section of Concrete Roadway.
Side ditches should be of sufficient size to dispose of all drainage; C may vary from $\frac{w}{98}$ to $\frac{w}{72}$; when w exceeds 20 feet make joint in center and crown subgrade; k varies from 6 to 12 inches.

for aggregate in the lower course of a two-course pavement and import aggregate for the wearing course than to employ a one-course pavement and import all the aggregate. The two-course pavement also requires slightly less cement per square yard than the one-course type if different proportions are used in the top and bottom courses; but this factor alone would seldom, if ever, justify a preference for the former type, especially in view of the objections to this method of construction, already noted.

Besides the two general types of concrete pavement described above, there are several special patented types, but so far as is known these do not possess any particular advantages and will not be discussed in detail. The one-course pavement is believed to be better adapted to most ordinary conditions than any other type of concrete pavement and will be given principal consideration in the following discussion.

Grading and Preparing the Subgrade.—In forming a roadbed upon which a concrete pavement is to be constructed, the features which should receive primary consideration are (1) adequate drainage, (2) firmness, and (3) uniformity in grade and cross-section.

It is impracticable to prescribe definite methods for securing thorough drainage which would be applicable to every location. The local conditions which affect the accumulation and "run-off" of both surface and ground water vary considerably even in the same locality, and it is only by means of a careful study of these conditions that a satisfactory system of drainage can be devised. For example, if the material composing the roadbed consists of springy earth, either tile or French drains would probably be necessary. In another case extremely flat topography may make it necessary to elevate the grade, by means of an embankment, considerably above the level of the adjacent land. The nature of the soil, the character of the topography, and the amount and rate of rainfall must all be taken into consideration, if a system of drainage is to be properly planned.

The second requirement, firmness, can be secured only after the road has been properly drained. Soils which readily absorb moisture will not remain firm in wet weather and therefore should not be permitted to form a part of the roadbed, especially if they occur in the subgrade. This requirement also makes it necessary that the roadbed be thoroughly compacted. In forming embankments the material should be put down in layers not more than about 12 inches thick, and each layer should be thoroughly rolled. The subgrade in both excavation and embankment should be brought to its final shape by means of picks and shovels and rolling.

The cross-section of the subgrade may be either flat or shaped to conform with the finished surface of the pavement. The flat cross-section involves the use of a slight additional quantity of concrete, but gives an increased thickness at the centre, where maximum strength is required. It has been observed that longitudinal cracks occur less frequently in concrete pavements laid on a flat subgrade than where the subgrade is curved to conform to the surface of a crowned pavement.

In either case the subgrade, when completed, should be uniform in grade, cross-section, and firmness, not only to prevent a waste of concrete in filling up depressions but in order to facilitate the necessary movement of the pavement due to contraction and expansion and thus reduce its tendency to crack. The subgrade should be rolled and re-shaped until the specified shape is secured. The forms, which should be set before the final shaping, may be made to serve as a guide for this work.

Use of Sub-base.—Where old pavements which have been constructed on a sub-base are replaced by concrete pavements, it is frequently convenient to place the new pavements on the old sub-base. Furthermore, soil conditions are sometimes such as to make the use of a sub-base very desirable. This is especially true of soils which do not compact readily under the roller or which can not be effectively drained at a reasonable cost.

A satisfactory sub-base may be constructed of gravel, broken stone, telford, cinders, or any other similar material. The essential features in every case are firmness, smoothness, and uniformity in grade and cross-section. Telford is seldom employed as a sub-base for concrete pavements, except when old macadam roads having such sub-bases are being re-paved with concrete. When this is the case it would seem advisable to spread a layer of sand or other fine material over the sub-base before the concrete is placed. Otherwise the irregularities in the telford surface would prevent the pavement from contracting and expanding readily and would thus cause cracks to occur at frequent intervals.

When old macadam or gravel roads are to be surfaced with concrete it is advisable to scarify the entire surface to a depth of several inches before the subgrade is shaped to receive the concrete. If this is not done, it is almost impossible to prevent a lack of uniformity in the subgrade wherever it is necessary to grade or shape up any part of the old road.

It has been suggested, with an apparent show of reason, that a thin cushion of sand might be advantageously used under concrete pavements. The purpose of this construction is to facilitate the sliding of the pavement, due to expansion and contraction, and thus to increase the allowable distance between contraction joints. So far as is known there are no experimental data which bear on this subject.

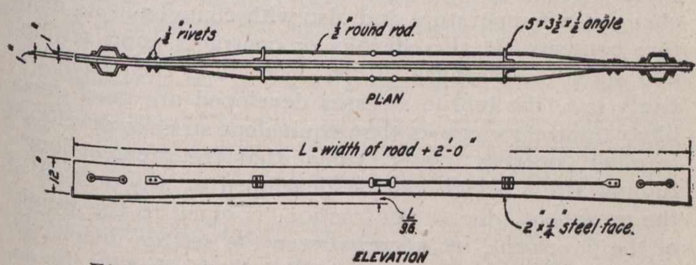


Fig. 2.—Typical Design of Strike Board.

Forms.—The form work required for concrete pavements is very simple and inexpensive. Ordinarily the forms may consist of 2½-inch boards having a width equal to the edge thickness of the pavement, though metal forms are in general more economical and are always to be preferred. The forms should be set before the subgrade is finished, in order to serve as a guide for the finish grading, and should be securely held in place by means of stakes driven on the shoulder side to such depth that they do not extend above the top of the forms. Care should be taken to see that the forms bear uniformly on the subgrade, as otherwise they are likely to sag while the concrete is being struck off and tamped, and thus produce an irregular surface. It is also well to have the ends of the different sections fastened together in such a manner that no relative displacement is possible.

The forms should always be set true to line and grade, and where curbs or gutters are to be provided they must be modified to suit the requirements for these features.

Mixing and Placing the Concrete.—When a considerable area of concrete pavement is to be laid it is usually economical to employ a mechanical mixer for mixing the concrete. Hand mixing is much more expensive than machine mixing, and hand-mixed concrete is rarely as uniform as machine-mixed concrete either in consistency or in the distribution of the component materials. Since lack of uniformity is believed to be one of the most potent causes for the formation of cracks, machine mixing is greatly to be preferred. There are several makes of machine mixers which have proved to be satisfactory for such work. The self-propelled batch type with a distributing device is probably the most economical to use where the amount of work to be done is sufficient to warrant the purchase of such a machine.

The distributing device may consist of a bucket and boom attachment or of a chute or a revolving tube which conveys the concrete from the drum of the mixer to its place in the road. The chute is objectionable, because if the concrete is mixed to such a consistency that it will readily flow down the chute it is too wet for best results; and, furthermore, there is a tendency for the mortar to separate from the coarse aggregate. This is especially true when the mixer is working down a steep grade. No matter what kind of distributing device is used, however, steep grades are liable to interfere with the proper working of the mixer, and if such grades occur on any particular piece of work that is to be undertaken this point should be investigated before the concrete mixer is purchased.

Even when the very best type of concrete mixer is employed it is necessary to exercise considerable care to see that the concrete is mixed thoroughly and to a uniform consistency. Tests have shown that increasing the time during which a batch of concrete remains in the revolving drum of a mixer, within reasonable limits, has very much the same effect as increasing the proportion of cement. It is also almost certain that varying amounts of water in successive batches will tend to cause cracks to develop in the pavement. It is impracticable to state definite rules for determining the number of turns of the mixer drum or the exact quantity of water which each batch should be given, because these features are considerably affected by the condition of the mixer and the materials. In general, it may be said that each batch should be mixed until there are no uncoated particles of sand or coarse aggregate remaining, and the amount of water should be such that the resulting concrete will be quaky or jellylike, but not sufficiently wet to flow readily while it is being handled. On steep grades somewhat less water should be used in mixing the concrete than when the grade is level. A comparatively wet concrete is easier to handle on level grades, but is liable to flow on steep grades after the pavement has been struck off and tamped, causing irregularities to develop in the surface.

Immediately after the concrete is mixed it should be deposited in the pavement. Otherwise the materials of which it is composed will begin to separate, and if it is permitted to stand an appreciable length of time before being placed the heavy materials will settle to the bottom of the containing vessel, so that when it is emptied a core will be formed in the centre of the space occupied by the batch. Concrete mixed in a stationary mixer and hauled to its place in the road is especially subject to this objection.

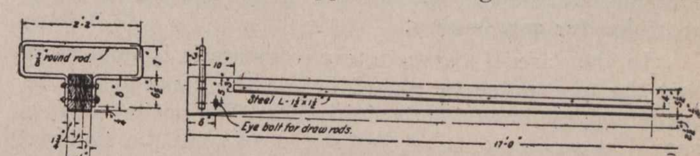


Fig. 3.—Wooden Strike Board.

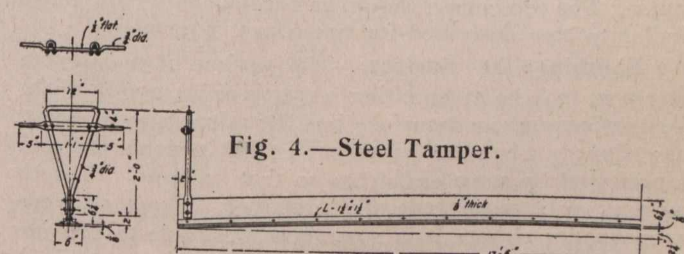


Fig. 4.—Steel Tamper.

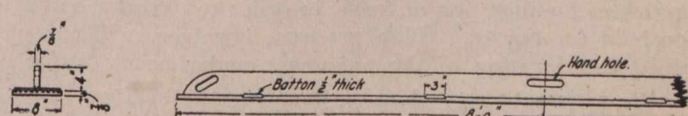


Fig. 5.—Long Wooden Float.

Before any concrete is placed the subgrade should be thoroughly sprinkled with water or a part of the water contained in the concrete will be absorbed by the subgrade, which may interfere with the process of setting.

For one-course work the concrete should be deposited between the forms in such quantity that when it is struck off and compacted it will present a uniform surface and have the depth required for the finished pavement. Each batch of concrete should be dumped as nearly in place as is practicable and should preferably be spread by means of mortar hoes. The men who do the spreading should avoid walking in the concrete, because each time the foot sinks into it the coarse aggregate is shoved down, and when the foot is withdrawn the space thus left tends to fill with mortar, which causes a lack of uniformity in the concrete.

After the concrete has been spread approximately to the required cross-section it should be struck off with a strike board having slightly more crown than the cross-section of the road. This allows for a slight amount of settlement when the concrete is compacted. The compacting should be done with a tamper shaped to conform with the cross-section of the road and operated by two men, one standing on each side of the pavement. Suitable designs for strike boards are Figs. 2 and 3. The heavier design (Fig. 3), on account of its durability, is especially adapted for use where a considerable amount of work is to be done. It is also in general somewhat more satisfactory than the light design on account of its greater rigidity. Fig. 4 shows a design for a tamper made of steel which has been used very satisfactorily for compacting concrete after it has been struck off, and which is very rigid and durable.

Sometimes the tamping and striking off are done with the same template, but this is not altogether satisfactory, because when this is done it is impracticable for the template to have a greater crown than is required for the finished pavement, and it is difficult to strike off the concrete with such a template and at the same time make provision for compacting.

In the case of two-course pavements it is important that the top course be placed before the concrete in the bottom course has taken its initial set. The bottom course should be well compacted and struck off, but the striking off need not be as carefully done as in the case of the top course. The top course should be constructed in a manner similar to that described for one-course pavements.

Finishing the Surface.—The surface of a concrete pavement may be given either a rough or a smooth finish. A slightly roughened surface has the advantage of being less slippery when the pavement is first constructed and is preferred by some engineers on that account. Smooth surfaces are more generally preferred, except on very steep grades, where it is sometimes desirable to provide grooves or other comparatively deep markings at right angles to the direction of traffic in order to afford a better foothold for horses. Such grooves, however, will cause rapid deterioration of the pavement under heavy traffic.

A satisfactory method of finishing the surface is to use a wooden float for smoothing out all template markings and evening up other slight irregularities. This method of finishing produces a surface sufficiently rough for all ordinary grades and possesses the advantage of being extremely simple. In using the float special care must be exercised to keep the pressure of the hand uniform, in order not to produce irregularities in the surface. Wherever a depression occurs it should be filled by adding concrete, and not by raking mortar into it with the float. The workmen who do the floating should be provided with one or more light bridges, which span the pavement and which can be easily moved as the work progresses. Various sizes of floats are used, and provided they are handled by skilled workmen the size is not important. The long float shown in Fig. 5 requires less skill on the part of the operators than short floats. A suitable design for a finishing bridge is shown in Fig. 6.

Joints.—It is customary to provide transverse joints at regular intervals in concrete pavements, to prevent irregular cracks from being produced; and if the width of the pavement exceeds 20 feet, longitudinal joints are also usually provided. Concrete contracts and expands with changes in temperature and also with changes in its moisture content. It also shrinks or contracts upon setting; and since the strength of the concrete is then comparatively low, the tensile stresses developed are much more likely to produce cracks than equivalent stresses developed in older concrete. It is evident that the greatest longitudinal stress which can be developed at any section of the pavement, due to contraction, is equal to the weight of the pavement, included between the section under consideration and the nearest free end, multiplied by the coefficient of friction between the pavement and the subgrade. Therefore, if contraction joints are spaced sufficiently close together to prevent this stress from exceeding the tensile strength of the concrete, no cracks should occur.

If no transverse joints are constructed in the pavement, the length of the sections between cracks, judging from such limited data as are at present available, will vary from 20 to 150 feet, and depends upon the kind of aggregate used, the relative richness of the concrete, the condition of the subgrade at the time the concrete is placed upon it, and the method employed in curing the concrete. It is common practice to space the transverse joints from 25 to 50 feet.

If there were no curves in the alignment, or summits in the grade of a road, it is doubtful if any provision for expansion would be necessary in constructing the joints, because the elasticity of the concrete should be sufficient to take care of the expansion caused by changes in temperature and moisture content. In nearly all cases, however, there are curves in alignment and changes in grade which might permit a displacement of the pavement before a very high compressive stress was developed. For this reason it is advisable that joints be constructed to provide for a slight amount of expansion as well as for contraction.

There are a number of different methods of constructing joints, but none of them appear to be entirely satisfactory from every standpoint. Probably the simplest type of joint is that made by introducing into the pavement a board about five-eighths inch thick and shaped to conform with the cross-section. This board is held in place by means of stakes until the concrete is placed against it on both sides. The stakes are then removed and the board is left in place with its upper edge even with the surface of the pavement and its lower edge resting upon the subgrade. The principal objections to this joint are that the board wears rather rapidly and does not protect the adjacent edges of the concrete.

A second method is to form a plane of weakness by placing a board so that its top edge is about 3 inches below the surface of the pavement. Then, when the contraction of the concrete has caused a crack to form immediately over the board, the crack is filled with bituminous material. This joint is said to have proved very satisfactory for dense concrete where the distance between joints is comparatively small, but it is subject to the objection that compressive stresses developed by expansion of the concrete are likely to be concentrated in the upper part of the pavement and to cause spalling at the joints.

Another method is to use a board, such as that first described, which is removed before the concrete has taken its final set. The opening thus left is later filled with bituminous material. The principal difficulty with this method is that when the board is withdrawn the adjacent edges of the concrete are usually disturbed and a rough joint is produced.

Probably the method most often used in constructing joints is to separate the successive sections of the pavement by means of specially prepared bituminous felt boards. These are usually held in place by means of properly shaped steel templates until the concrete is deposited against them, after which the templates are removed and the concrete flows around the boards. The thickness of this joint has varied in common practice from one thickness of two-ply tar paper up to about one-half inch. A thickness of one-quarter inch seems to give very satisfactory results when the joints are spaced about 30 feet apart. Joints of this kind are sometimes provided with metal armor, which is intended to keep the adjacent edges of the concrete from being spalled off. It is claimed that armored joints require less maintenance than other types, but they are more expensive to construct.

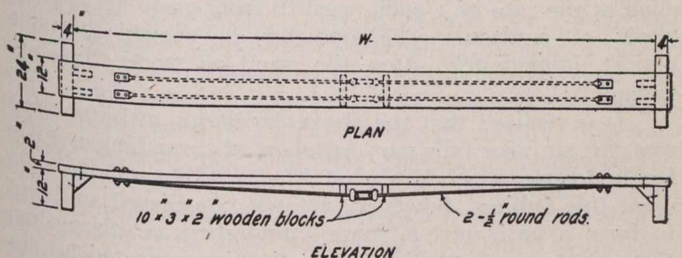


Fig. 6.—Typical Design of Finishing Board.

The joints are undoubtedly the weakest feature of the concrete pavement; and no matter what type of joint is used, they must be given frequent and careful attention to prevent rapid deterioration of the pavement adjacent to them.

In the past, contraction joints of all types have usually been placed at right angles to the line of the pavement. This method of construction has the disadvantage that two wheels of a vehicle strike the joint at the same time and thus produce the maximum amount of impact. By skewing the joint at an angle of about 15 degrees the wheels strike one at a time, and the total resultant impact is reduced by at least one-half. This is advantageous to both the traffic and the pavement, and since the difficulties involved in constructing skewed joints are not at all serious, there is no apparent objection to their use.

Protecting and Curing the Concrete.—The quality of the concrete depends to a great extent upon the conditions under which it sets or hardens. When early exposed to dry air, for example, water is evaporated out, thereby greatly accelerating the shrinkage of the concrete and delaying the process of setting. It is evident that these results form a very effective combination for producing cracks. The effect of freezing on concrete is still more harmful; not only are cracks produced, but the internal structure of the concrete is also damaged.

The precautions that must be taken in order to protect a newly constructed concrete pavement during the process of curing depend largely on the weather conditions. In drying weather small hair-like cracks will frequently begin to form almost as soon as the surface of the concrete is finished, and unless the concrete is quickly covered and protected from the air these cracks increase in size very rapidly. At other times, when the atmosphere is moist, the concrete may sometimes be permitted to stand for several hours before being covered, without any danger of cracks forming. Heavy canvas made into sections of convenient length and proper width should be used for covering the concrete surface. The canvas should be spread over the pavement as soon as this can be done without marring the surface. Under unfavorable atmospheric conditions it is sometimes better to spread the canvas immediately after the surface is finished, even at the risk of marring the surface slightly, than to run the risk of having cracks develop in the pavement. The canvas should be sprinkled until thoroughly wet immediately after it is spread and should be kept wet until removed and replaced with an earth covering. Under ordinary weather conditions about 24 hours will be required for the concrete to set sufficiently hard not to be damaged by men walking upon it while covering it with earth. The canvas should therefore usually remain on the pavement about one full day. Immediately after the canvas is removed the pavement should be covered with a layer of earth about 2 inches thick, which should remain on the pavement and be kept constantly wet for a period of about two weeks. During this period the roadway should be kept entirely closed to traffic. If the weather conditions are favorable the concrete ought to be sufficiently strong to withstand traffic at the end of two weeks. In cold or otherwise unfavorable weather the earth covering should preferably be thicker than 2 inches and left in place for a longer period of time. No concrete should be laid during freezing weather, but if danger of freezing develops after the concrete is laid and before it sets, the first cover of canvas should be supplemented in some way in order to prevent damage to the pavement. This may be done by spreading over it a layer of straw, or by using two thicknesses of the canvas, if this is practicable.

The protection of the concrete is an extremely important feature of concrete-pavement construction. It is impossible to secure satisfactory results unless some such precautions as those described above are taken to prevent the concrete from drying out too rapidly after it is placed, and to insure that it sets up under uniformly favorable conditions.

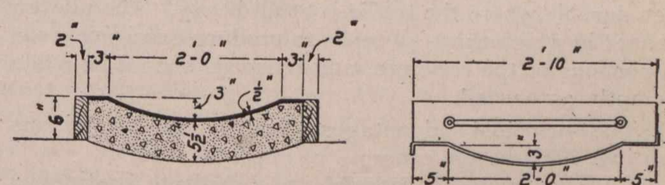


Fig. 7.—Typical Cross-section of Concrete Gutter and Design for a Template to be Used in Its Construction.

The Use of Reinforcing Steel.—Probably the most satisfactory method, in point of efficiency, yet devised for reducing the number of objectionable cracks in concrete pavements is that of employing steel reinforcement. The reinforcement usually consists of woven wire or some similar material, though there is no apparent reason why plain round or square rods might not be satisfactorily used. One-quarter-inch round rods embedded about 2 inches above the lower surface of the pavement and spaced about 12 inches centre to centre in both directions would seem sufficient to eliminate practically all objectionable cracking, provided proper joints were introduced at changes in the grade and at curves in the alignment. But any satisfactory system of reinforcement will probably add from 15 to 20 cents per square yard to the cost of the pavement, and this additional cost is no doubt responsible for the fact that concrete pavements are seldom reinforced. Furthermore, reinforced pavements are more difficult to repair than those made of plain concrete, which may be a very serious objection under some circumstances.

Gutters.—It is frequently desirable to provide concrete pavements with paved gutters in order to prevent the side ditches from eroding. Fig. 7 shows a typical design for a concrete gutter. This design has been frequently used and has usually proved to be satisfactory. A suitable strike board for forming this gutter is also shown in the figure.

It is impracticable to construct the pavement and the gutter at the same time, and on account of the convenience of using the pavement as a platform for material and for mixing concrete for the gutter the pavement is usually constructed first. When there is no space between the gutter and pavement the joints should always be continued through both. If this is not done, the joints in each are apt to be continued as cracks in the other.

Curbs.—Concrete pavements on country roads are not generally provided with curbs, because it is usually desirable to use the shoulders as part of the roadway. Under some circumstances, however, curbs may be employed to advantage. For example, in deep cuts it might be justifiable economy to omit the shoulders and side ditches and provide curbs along the edges of the pavement so that the sides of the pavement would serve as gutters. Likewise, on very deep fills curbs are sometimes used to protect slopes from erosion. When this is done it is necessary to provide catch basins at low points in the grade.

Bituminous Wearing Surface.—Since 1906 a number of experiments have been made in an effort to develop some satisfactory method of constructing a bituminous wearing surface on concrete pavements. Various kinds of bituminous materials have been used and several methods of applying them have been tried. Some of the surfaces are reported to have given moderately good service under light traffic, but in general they have not been durable where the traffic is at all heavy. The uneven manner in which they fail tends to produce excessive wear on portions of the concrete, and renewals should be made promptly as needed.

The principal advantages claimed for bituminous wearing surfaces on concrete pavements are:

(1) They make it possible to substitute continuous maintenance for periodic renewals of the pavement.

(2) They reduce the noise made by the impact of horses' hoofs and steel-tired wheels.

(3) They remove the principal objection to bituminous expansion and contraction joints.

(4) They overcome the somewhat objectionable glare of concrete pavements in strong light, though this objection may also be overcome with much less cost by sprinkling the pavement with crude water-gas tar.

The principal disadvantages may be inferred from what has already been said. It is also well to note that, where traffic conditions are such as to make a bituminous surface practicable on a concrete road, a bituminous-surfaced macadam road might also be practicable and would certainly be cheaper to construct, unless the difficulties involved in securing suitable stone for the macadam were very unusual.

In constructing bituminous surfaces on concrete it is essential to have the surface of the concrete entirely clean and free from laitance when the bitumen is spread. Generally about one-half gallon of bitumen to the square yard is put on in either one or two applications, by hand or by means of pressure distributors. It is sometimes swept with hand brooms in order to make it adhere better to the pavement. Hot applications have hitherto been almost exclusively used, though there is no apparent reason why materials which could be spread cold might not be employed with equally satisfactory results.

After the bitumen has been spread as described, it is covered with coarse sand, pea gravel, or stone chips, applied at the rate of 1 cubic yard to from 75 to 100 square yards of surface. The road may be opened to traffic almost immediately after the sand or stone chips are spread.

It is realized that the above discussion of bituminous wearing surfaces falls very far short of furnishing a guide for undertaking work of that kind. The available data upon this subject, however, are not considered sufficient to form a basis for a more comprehensive discussion. Not only have contradictory results been reported by different engineers concerning the same methods of construction, but the results now being obtained from carefully conducted experiments with different materials and different construction methods do not yet seem to warrant any definite statements as to what materials are best adapted for such work nor which construction method will give the best results, though they do indicate in a general way that tars are preferable to asphalts for this purpose.

We are indebted for the foregoing information to the U.S. Office of Public Roads, Department of Agriculture, Washington. It has been abstracted from the bulletin, prepared by Messrs. Moorefield and Voshell, on "Portland Cement Concrete for Country Roads.

EQUIPMENT FOR VICTORIAN RAILWAYS.

Tender forms, specifications, indents and drawings have been forwarded by Mr. D. H. Ross, Trade Commissioner at Melbourne, for equipment required by the Victorian Railways. These tender forms, etc., are open to the inspection of interested Canadian manufacturers at the Department of Trade and Commerce, Ottawa (refer File No. 1435). Particulars of the requirements, together with the date on which the tenders close at Melbourne, are briefly outlined thus:—

No. 28,350, September 29, 1 combined chain cutter and hollow chisel mortising and boring machine.

No. 29,004, September 29, 1 batch concrete mixer with petrol motor and accessories.

No. 29,080, September 29, 5,000 fuse blocks (as per drawing).

No. 29,080 September 29, 5,000 spare porcelain bases.

No. 29,080, September 29, 10,000 spare fuse clips.

No. 29,012, October 13, 5,800 imperial gallons lubricating oils.

No. 29,012, October 13, 3 tons lubricating grease for electrical equipment.

No. 29,113, October 6, 2 12-inch Gap lathes, tools and accessories.

No. 29,130, October 6, 20 "V" double-side tipping wagons.

The departure of the next mail is from Vancouver, September 1, due Melbourne, September 25.

The Spirit Lake-Grande Prairie branch of the Edmonton. Dunvegan and British Columbia Railway is now under construction, Mr. J. D. McArthur having sublet a contract for it to Mr. G. H. Webster, of Calgary.

Editorial

THE TORONTO HARBOR SITUATION.

Hon. Robt. Rogers, Minister of Public Works for the Dominion, turned his attention last week to the Toronto harbor work, and, it is to be hoped, put the quietus on the "scandal" and "mystery" talk which the daily press, in some small measure, succeeded in creating. Some Toronto newspapers, recognizing the reading value of the Winnipeg graft exposure, at a time when the general sameness of war news was not conducive to creating public interest in scare heads, imagined when a section of the Toronto harbor work closed down a month ago without public ceremony and with the head of the Department of Public Works presumably tied up in the Manitoba elections, that the event would make excellent "scandal" copy, and with a we-should-worry-as-to-whom-it-hits attitude started in accordingly to implicate many in the "$22,000,000 scandal" centering around the water front development.

Some piling, driven by several firms operating on sub-contracts for that portion of the waterfront development that is being executed by the Canadian Stewart Company for the Department of Public Works, Ottawa, did not fit tightly and allowed sand to get through in places. The Department, through the general contractors, stopped the work, removed its idle inspectors, and had a commission of engineers investigate the extent of the defective work. This, being under water, could not be effected in an hour or a day. The general contractors at once satisfied the Department that the defects would be removed, and, pending a knowledge of the amount of work not up to specifications, had the job remain at a standstill. The extent of defective piling has been ascertained, and operations are in full swing again this week.

Thus the "$22,000,000 scandal" petered out, but not without injury in the public mind to some very capable and exacting engineers. The Toronto Harbor Commission, the Department of Public Works, Canada, and the Canadian Stewart Company are fully aware of the vital importance of good engineering design and workmanship in the development of Toronto harbor and waterfront. They have set about to carry out the greatest piece of harbor improvement work in America. They are seeing to it that no sub-contractor slips out from under the specifications.

Will the newspapers that perpetrated the "scandal" stigma endeavor to remove all traces of it? They have found no mystery, no scandal, no faulty design, or no occasion for such gross misrepresentation. There had been some loose inspection, with apparent advantage taken of it by sub-contractors, unknown to the general contractors, who are at all times responsible to the Commission and to the Government for workmanship in accordance with specifications. There is no misunderstanding regarding the removal of any defective work (which is very liable to occur on a job of such proportions), or concerning reconstruction in accordance with the specifications without incurring any additional expenditure on the part of either the Government or the Commission.

WIND STRESSES DETERMINED BY THE SLOPE-DEFLECTION METHOD.

The desire to get a large rentable floor space on a small parcel of land has led to the general use of the steel-skeleton type of building, in which the live and dead loads are carried by a system of beams and girders to columns and are carried by the columns to the footings.

A mathematical analysis of the stresses in the steel frames of office buildings due to the wind load on the building has come to hand from the Engineering Experiment Station of the University of Illinois. The bulletin, prepared by Messrs. W. M. Wilson and G. A. Maney, is one of the most extensive studies of the subject which have appeared.

The steel frames of office buildings resist the horizontal shear due to wind by virtue of the stiffness of the columns and girders. The sum of the moments at the tops and the bottoms of all of the columns in a story is equal to the total shear on the story multiplied by the story height. The distribution of this moment depends not only upon the relative stiffness of the columns but also upon the relative stiffness of the girders which connect the columns. Further, the distribution of the moment in one story depends not only upon the size of the members in that story but also upon the size of the members in the adjacent stories.

General equations are derived which can be used to determine the wind stresses in both symmetrical and unsymmetrical bents from one to five spans wide and any number of stories high. These equations are used to determine the numerical values of the moments, shears, and direct stresses in a symmetrical three-span bent twenty stories high. The method of determining these stresses presented in the bulletin is called the "Slope-Deflection" method. It is mathematically exact except for the assumptions upon which it is based. In the discussion of the assumptions the fact is brought out that while the assumptions are not exactly true, the errors do not materially affect the results.

Four approximate methods are presented which are in use. The moments are determined in a number of bents having different proportions, by these approximate methods and by the slope-deflection method. This comparison shows that two of the approximate methods are so inaccurate that they should never be used. The other two approximate methods are quite accurate when applied to certain bents but when applied to other bents they may give results which are seriously in error. A new approximate method is presented which agrees with the slope-deflection method except where there are large changes in the size of the columns and girders.

A model of a bent cut from a sheet of celluloid was subjected to a known shear. The deflection of the columns and the changes in the slope of the elastic curve at the ends of the girder as measured, and as computed by the slope-deflection method agreed very closely.

The slope-deflection method can be used in the design of buildings but it has its greatest value as a standard for determining the accuracy of approximate methods.

THE PAVING OF STREETS.*

By H. J. Fixmer.

THE paving of streets and roads is being gradually regarded as a subject requiring expert knowledge, and not to be determined by an individual's prejudice, convenience and taxes. There are many general qualities which pavements must have to prove satisfactory. They should be designed to conform to the condition of use and provide for adequate service. General rules may be adopted and rational formulas followed, but their use must be based on reason and an observance of the peculiarities applying to the particular problem in hand. We should not adhere too closely to "standards" so-called, which, while designed to reduce work and perhaps promote efficiency, tend to eliminate freedom and thereby discourage experiment, discovery and progress.

There should be good and definite reason for every element entering into the rational design of pavements, as contrasted to the "rule of thumb" methods so commonly used. The engineer building pavements should be impressed with the fact that his work is of common use and continuously in evidence, and should therefore make every effort to secure the best results.

Reasons for Paving.—The reasons for paving the street must be explained to the general community, and must be borne in mind by the engineer when preparing his recommendations and designing the pavement. The reasons and the results to be secured therefrom are: (1) Decrease in cost of transportation (20 cents to 5 cents a ton-mile). (2) Increased fire protection (speed doubled and certainty of service). (3) Establishment of a permanent grade (necessary for comfort of travelling public and for permanent construction). (4) Improvement of the general appearance and beautification of the town. (5) Improvement in sanitation, health and drainage (eliminate dust, stagnant water, etc.). (6) Facilitation of social intercourse; by rendering pleasure driving and pedestrian traffic easy and agreeable. (7) The enhancement of property values (at least twice the cost of paving can be added to values). While these results are to be realized in city pavements, they should in great measure be sought after in the building of country roads.

Roadway Widths.—As a general policy, the length of road improved is more important than the width. This rule does not often apply to city streets. The determination of proper width of roadway is an extremely important element in design. A traffic census is often desirable, but unless it is truly comprehensive, more can be learned by direct and frequent observation of the street. A traffic census must give not only number of vehicles, but the different kinds of vehicles, kinds and sizes of tires, wheel loads, rates of speed, space required for storage and parking, and character of adjoining property.

It is customary to allow 8 ft. in width to each line of vehicle, reducing this width as shown in Table I. Where two car tracks are built, not over 10½ ft. c. to c., 20 ft. is allowed for the free movement of the cars. Table II. shows width and length of typical vehicles found in Chicago.

Unless the traffic exceeds or promises to exceed 5 to 10 vehicles a mile in either direction, 9 ft. width should prove ample on country roads. It is better policy to build a so-called "permanent" road 9 ft. wide (with 5-ft. earth shoulders on each side) than a poor road 18 ft. wide. In view of the fact that perhaps over 90 per cent. of the time

TABLE I.

Width of roadway in feet	Type of street usually applied to	No. of lines of vehicles provided for
9	Ave. or light traffic road	1+
16-18	Side res. st. or double roadway sts.	2
24	Residence streets	3
30	Res. sts. and business sts.	4
38-42	Business and car line sts.	5 (4 on car line)
48-52	Business and car line sts.	7 (6 on car line)
60	Business and car line streets and boulevards	8 (6 on car line)

TABLE II.

Kind of Vehicle.	Width—Hub to Hub. Feet.	Length—Back to Curb. Front Wheels at Rt. Angle. Feet
Delivery wagon	5.5 to 6.7	8.7
Single truck	5.8 to 6.0	11.4
Large truck	6.4 to 6.6	12.8-14.0
Newspaper truck ...	7.75	14.75
Touring car	5.5 to 5.8	10.0-16.0
Auto truck	6.7 to ?	12.0

the vehicle occupies the middle of the road, and even in practice on the wider road usually prefers to suffer the slight inconvenience of turning out occasionally in order to ride on the more comfortable or acceptable part of the road, it appears logical to give due weight to this factor of "practical use." If a 9-ft. permanent road is built, additions can always be made whenever the traffic warrants it, and would be indicated by a traffic census or by excess cost of maintenance of the earth shoulders. When consideration is given to the habits and needs of the users of the roads, the soundness of the policy that length of permanent road is more important and desirable than width is soon appreciated.

In city pavements, the use of the streets for "storage," or rather provision for vehicles to stand alongside or back up to the curb in front of abutting property, must be considered and is a vital factor in ascertaining the rational width of roadway. Take the case of a street having many warehouses, where large trucks back up to the curb to handle goods. After finding this condition prevails on both sides of the street and that allowance must be made for two lines of moving traffic between the "standing" trucks, we would determine the roadway to be not less than two times 8 ft. plus length of truck back in position. From Table II. this would give two times 8 plus 14, or 44 feet. In residence districts, where connecting streets are paved as a system, the roadway on all streets where the lots front are made 24 to 30 ft. wide and side frontage streets 18 to 24 ft. wide. The curb corners are built to a radius of 3, 6 or 8 ft.

Congested Roadways.—Perhaps the most serious condition in securing adequate roadways exist on streets having a double track car line. These are invariably business streets and require storage space for vehicles and automobiles. On such a street, providing for two lines each of street railway cars, moving vehicles and standing vehicles, we find a width of 2 (8+7+10), or 50 ft. is required. If the moving traffic is expected to use the car tracks, and the service on the street railway is infrequent, the width may be reduced to 2 (8+10), or 36 ft. A roadway width of 38 to 48 ft. in this case would be wasteful.

*From Thirteenth Annual Report, Illinois Society of Engineers and Surveyors.

A street car that makes good time attracts more people and gives more time to shop, while it distributes business uniformly along the street. For this reason, when a street becomes too congested it becomes necessary to widen the street in order to secure ample roadway or place the car line on an elevated structure or in a subway. It is an extremely important question to decide whether it is better to build a subway in a congested business street or use the money to widen the street and keep the car traffic on the street surface and easily accessible.

Layout of Surface of Pavement.—The contour of the pavement surface is important. For the purpose of drainage and maintenance the pavement is built with a convex or crowned surface. Table III. shows general or constant maximum and minimum crown for various types of pavements, as followed in Chicago. A formula for height of crown is C = WF, where C = crown, F = constant or crown ratio, and W = width of roadway.

TABLE III.

Pavement.	General or constant ft.	—Chicago— Max. ft.	Min. ft.
Earth	.025 to .030	....	....
Gravel	.022 to .025	....	....
Macadam	.020 to .025	.035	.020
Asphalt	.012	.025	.011
Asphaltic concrete.	.015	.025	.012
Brick	.012	.025	.010
Creosoted wood ..	.010	.024	.010
Granite	.015	.025	.010
Concrete	.010	.020	.010

As usually built, the surface is either an arc of a circle or a parabola. Experience has demonstrated that the parabola form is preferable for residence streets, and the "compromise" form for business or car-line streets, and particularly pavements having macadam base. Country roads can usually be built with a constant crown since they follow the contour of the natural surface and have sufficient longitudinal grade. If the grade is level, the drainage can be taken care of by sloping the grade of the side ditches. The two forms of crown noted above are proportioned as follows, C being the crown and the other figures the offsets below the horizontal line from curb to centre.

	Curb.	¼ width.	½ width.	¾ width.	Centre.
Parabola ...	C	.56C	.25C	.06C	0
Compromise.	C	.61C	.32C	.12C	0

With city streets, which are invariably curbed, if the longitudinal grade is not sufficient to carry off the water, drainage must be provided. This is done by building sufficient sewer inlets and establishing summits between them whose location depends upon the grade of street, slope required to drain, and the permissible depths below the curb of the summits and the inlets. The following formula is given for locating summits (in the gutter): $X = (I \div 2) - (D \div 2R)$. Here X = distance of summit from higher inlet; L = distance between inlets; R = grade of gutter (6 in. fall per 100 ft. = .005); D = difference of elevation at inlets (or usually, difference of elevation of curbs). On a concrete gutter the assumed value of R should not be less than .004. For any block pavement, including alleys, this value should be not less than .005.

The following formula is given for determining depth of summit and depth of inlet below curb (or grade) to satisfy values in formula No. 2. Here J = depth of inlet below curb (8 to 12 in.); K = depth of summit below curb (usually 3 in.). This formula is $J = K + RX + (DX \div L)$ or, $K = J - RX - (DX \div L)$. The minimum crown from Table III. is used at the summits, and the maximum crown is permitted at the inlets. This reduces the grade along the centre line of the pavement to about one-half the gutter grade, and gives a comfortable surface for travel.

Use of the Street.—In designing the contour of the surface of a city pavement, there are the often overlooked factors of comfort and safety of the users of the pavement; both pedestrian and vehicle traffic. About ten pedestrians cross a pavement to every vehicle travelling along that street. In practically all streets (of whatever character) while the ratio may not be 10 : 1, yet the number of pedestrians having occasion to use the pavement in crossing the street, greatly exceeds that of the vehicles using the street. It should be rational, therefore, to so pave the street as to afford pedestrians the maximum degree of comfort and safety, while not interfering with the right of safety and comfort of the vehicle users. In relation to this matter some interesting, if not exceptional methods have been developed and their success established.

In retail business and residence streets it is the general policy to eliminate the usual step at all street intersections and alley returns where pedestrians cross. This is done by paving the street or alley flush with the curb in line with the continuation of the usual 6 ft. sidewalk. To drain the intersection, the catchbasin inlet at the curb corner is set 4 to 6 in. below the top of the curb. From the line of the outer edge of the sidewalk the pavement slopes on a straight line to the nearest sewer inlet. In residence districts, where there are no sewers in the side frontage streets, and the catchbasins are already built in the customary manner (at the curb corners and in the middle of the standard 600 ft. block) it is often advisable to save expense by a method originated by the writer. This consists of building a raised header in the combined curb and gutter with its top 1 in. below the curb and recessed in the middle of its top for a slab 5 in. x 6 ft. which is an extension of the adjacent 6-ft. sidewalk. The header is 6 in. thick and is so built as to make the width of gutter between the curb and header wider at the end nearest the inlet. The gutter is built with an increased slope under the slab.

The purpose of this arrangement is to render the gutter, especially under the slab, self-cleaning. The header is connected to the surface of the gutter by a reverse curve for a distance of 6 ft. on each side of the extended sidewalk, or slab cover, making the header 18 ft. long. This construction has been in use for four years, and has proved satisfactory. It eliminates the step at the crossing, covers the usual dangerous opening where a false gutter is employed, affords a dry and clean crosswalk at all times, prevents breaking of curb through expansion of sidewalk, is self-cleaning, and has a slab cover which is not slippery and cannot be displaced. The writer secured a patent on the novel feature of this construction and has given the city of Chicago the right to use it free of any charge or royalty. At alley returns the pavement is brought flush with the top of the curbs for the full width of the sidewalk. At the end of the return or street line, the centre of the alley is dished at the rate of 1 in. per 5 ft. of width and this point connected on a straight line to the gutter line of the street proper, affording good drainage and keeping the crossing dry and clean.

The ideal solution for a business and two car line street is to bring the pavement flush with the walk of the business street at the returns for the cross streets, run the pavement surface at the gutter line to the curb corner at a depth of about 4 to 6 in. below the top of the curb; thence around the curb corner to the catchbasin inlet, located about 70 ft., more or less (depending on the grade) from the curb corner, at a depth of about 8 to 10 in. below the top of the curb. This eliminates any step for the main lines of pedestrian traffic along the business street, but does present a 6-in. step to those crossing the business or car line street. This tends to cause pedestrians to hesitate before crossing a busy street, and affords a smooth, full width of roadway for the vehicle traffic along the direction of the busy street.

Fundamentals of Construction.—The construction of roads can be divided into five principal parts, as shown in Table IV., which gives the comparative costs and life of the various components.

TABLE IV.

	Cost per cent.	Life in years.
1. System of drainage (sewers, inlets, ditches, culverts)	10-20	20-100
2. The earth subgrade	10-30	20-100
3. The foundation	20-40	10-50
4. The wearing surface	20-50	2-30
5. *Maintenance	5-50	

*Maintenance ought to be included as an element of cost, and, while chargeable almost entirely to the wearing surface, may operate to reduce the average cost of such wearing surface because of prolonging its life.

There are but two approved forms of foundation construction; namely, macadam (including telford) and concrete. The thickness and quality of the foundation must be based on the maximum loads to be supported, and the amount of pressure which the subgrade will bear, together with the inherent structural resistance of the material composing the foundation. If it is assumed that 30 per cent. of the total weight of a vehicle is transmitted by each rear wheel, and a 30-ton auto truck is to be provided for, then we can expect a pressure of nine tons across the area of contact of tire of approximately 9 x 6 in., or 54 sq. in.

In the case of macadam, the lines of pressure fall within lines making an angle of about 45° with the surface, due to the interlocking of the stones. The area distributing pressure on the subgrade varies directly as the square of the depth or thickness of the foundation plus part of the thickness of the wearing surface. Hence a thickness of 12 in. would support on a given subgrade about four times as much as a thickness of 6 in. Since a dry, well rolled subgrade will support more than a wet subgrade, the question of adequate drainage, as opposed to increased thickness of foundation, must be considered. Design can be based on rational principles, and, if not, then it should be based on direct investigation at the site in question.

In the case of a concrete base, the failure is more likely to be due to shear than to tensile failure under beam action. The strength of a concrete base varies directly as the square of its depth. Definite information is needed as to the strength of concrete under the daily stress of use. A coefficient could be determined by experiment, by laying, say, a 2-in. and a 4-in. base and subjecting them to various loads at known speeds. With such knowledge we could design more intelligently. Is a 6-in. concrete base of 1:3:6 mix on an undrained clay soil strong enough to resist the trucks; if so, with what factor of safety? If not, what is the economical thickness? It is commonly assumed that a 6-in. concrete base is equal to a 12-in. macadam base, but is this true?

Conclusion.—The engineer often has too little experience to decide as to the more desirable type of pavement, as well as to the elements of its construction. In this case he should be advised by competent specialists. Often, though able, he is not consulted, and the public, with its opinion crystallized by the happy assurances of the elusive promoter, adopts a kind of pavement not suitable to the conditions.

It is often necessary to vary the kinds and types of pavement to suit various conditions on the single job. Standards and uniformity, while easy to specify, must be modified to suit definite conditions. A specification, which is successful in one locality, may be a failure in another; due to climate, traffic, grades, poor subgrade, and inadequate experience and equipment of the inspector and contractor.

An engineer, in recommending an improvement, should give the reasons for the type of design adopted and for the kind of construction deemed best for the stated conditions. When the authorities welcome, or rather demand, this of us, then we can furnish, or secure, competent counsel which will in time be appreciated by the public. As the public reposes more confidence in the engineer, which the engineer in turn will merit by rational study, popularly explained, it will be possible to build pavements in a fair, intelligent and economic way. Then the present alleged safeguards usually present in the typical specification, such as contractors' guarantee, irresponsibility of the specifications to secure the desired product, uncertainty of quantities and ignored contingencies, will disappear. Where the contractor must shoulder all these omissions or commissions of the so-called "standard specification," let it be known that the public pays dearly for their relief of responsibility.

Since the engineer is the agent of the public he should be given the power to specify the best suitable construction and be afforded the support and means of securing it. The specification should be definite and if the contractor executes his work in strict accordance with the specifications he should be relieved of any responsibility or guarantee. Since the contractor is not consulted in the drawing up of the specification he cannot logically be held to account for their insufficiency. The engineer's position and duty is a peculiar one—he must protect the public by requiring good work, and must aid the contractor in securing it. To this end he should know definitely what he is doing, and how it should be done, although he has no right, under conditions where the contractor guarantees the work, to insist on his method being followed. The engineer's responsibility is vague under prevailing conditions, which places him continually in an awkward position, exposed to criticism from both parties—the unthinking public and the unsympathetic contractor.

Between 50 and 60 tons of tailings are being treated daily at the cyanide plant of the Porcupine (Ont.) Crown Mine. These tailings have an average gold value of $3.15 per ton, which gives a net return of $2. The company is enabled to go on with the treatment of 15,000 tons of these tailings. The cyanide plant is capable of treating 150 tons, but at present the output of new ore has been cut down to 75 tons each day. With the tailings this keeps the cyanide plant going at its full capacity.

ESTIMATING QUANTITIES FOR HIGHWAY BRIDGES.

THE Illinois Highway Department has prepared standard plans and quantities of material covering a number of standard designs for highway bridges. In a recent issue of the journal, "Illinois Highways," some very useful charts appear, prepared by Mr. G. F. Burch, assistant bridge engineer of the department, for use in the selection of the most satisfactory type and in estimating the quantities of materials from these standards. The accompanying diagrams, as investigation will show, give the weight of steel and the amount of concrete in steel truss spans from 50 to 160 ft. long, with a 4-in. concrete floor, in reinforced-concrete girder spans from 30 to 60 ft. long, and in reinforced-concrete slabs from 5 to 30 ft. long. The amount of concrete required in the bridge abutments of both plain and reinforced types is also shown. As stated, the curves relate to quantities alone.

The following data, from Mr. Burch's explanatory article, relate to the types of superstructures and to the abutments also in the case of plain concrete. The steel trusses are of the ordinary Pratt truss type, with parallel chords and riveted connections. The design provides for a 4-in. concrete floor, with a wearing surface assumed to weigh not less than 50 lb. per square foot. On account of the weight and rigidity of the concrete floor no allowance is made for impact. Floor systems are designed to carry a 15-ton traction engine in addition to the dead load. Trusses are designed to carry a uniform load of 100 lb. per square foot of road surface for spans from 50 to 150 ft. and a uniform load of 85 lb. for spans exceeding 150 ft. long. The usual American Railway Engineering Association unit stresses are used in the design. Pony trusses are used for spans of from 50 to 85 ft., and through trusses for spans of from 90 to 160 ft.

Fig. 1 gives the curves for the weight of structural steel, and the yardage of concrete in floors, for 16 and 18-ft. roadways. The break in the steel curves is at the point where the change is made from low to high trusses.

Reinforced-concrete through girders are used for spans of from 30 to 60 ft. This type of structure is designed to carry either a uniform load of 125 lb. per square foot, or an engine load of 24 tons. The design provides for a wearing surface weighing 50 lb. per square foot. As free expansion and contraction are allowed by the cast-iron rockers placed under each girder at one end of the spans the allowable unit stresses used are quite high. Designs are figured for a steel stress of 16,000 lb. per square inch and a compression stress in the concrete of approximately 1,000 lb. per square inch. A maximum unit shear of 120 lb. per square inch is allowed. Stirrups are provided for all shear in excess of 40 lb. per square inch. Fig. 2 shows curves giving the quantities of concrete and reinforcing steel for 16, 18 and 20-ft. roadways.

For spans less than 30 ft. the slab type of construction has been found to be somewhat cheaper than the girder type, due to the fact that the arrangement of the steel is much simpler and less steel is used per cubic yard of concrete. It has not been found practicable to make provision for free expansion of slabs. Accordingly, a stress of 12,000 lb. per square inch of reinforcing steel is allowed for dead-load and live-load stresses. The concrete stress is 800 lb. per square inch. Slabs are designed for the same live load as girders. Fig. 3 gives the quantities of concrete and steel in slabs having clear roadways of 16, 18, 20, and 24 ft., for spans of from 5 to 30 ft.

In preparing curves to show the quantities in abutments it was found that there were many variables which might be considered, but which if used would produce

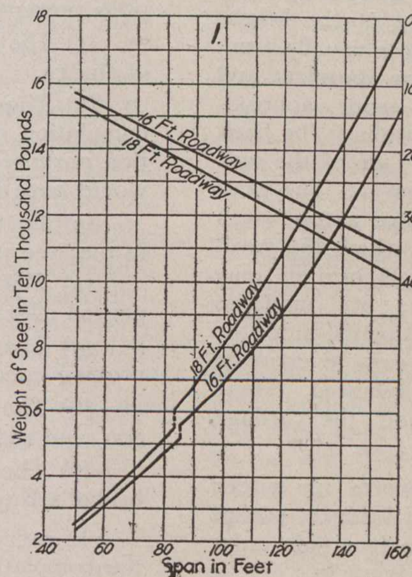


Fig. 1.—Steel Truss Superstructures.

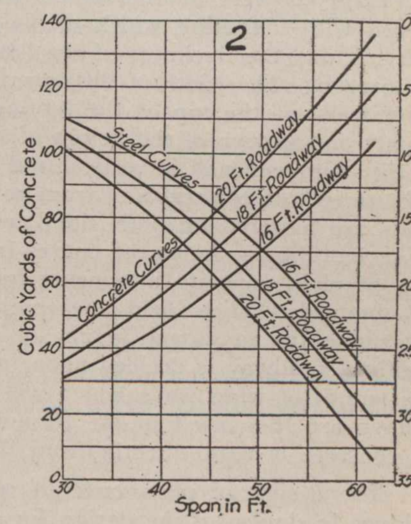


Fig. 2.—Reinforced Concrete Through Girder Superstructures.

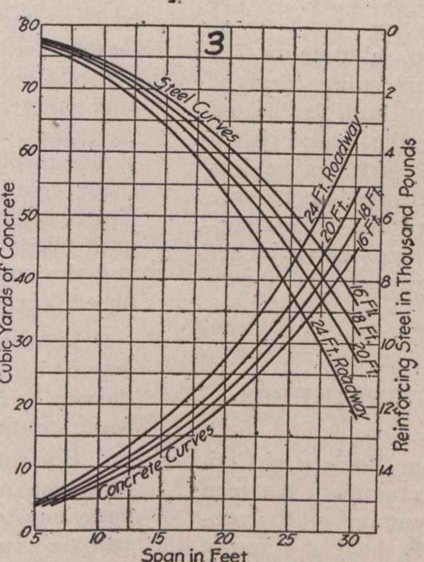


Fig. 3.—Reinforced-Concrete Slab Superstructures.

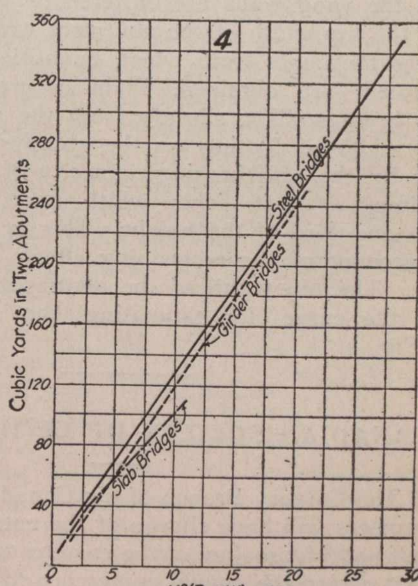


Fig. 4.—Plain Concrete Abutments for Three Types of Bridges.

such complex formulas as to make the curves of little use in the field. It was found that curves giving reliable results might be obtained by plotting the cubic yards of concrete in two abutments against a formula which represented a measure of the quantities desired. The variables in this formula are H, height of abutment from bottom of foundation to top of roadway; R, clear width of roadway on superstructure, and W, length of average wing wall. For plain concrete abutments the best results were obtained by using the term $H^2 (R + 2W)$.

Plain concrete abutments for steel bridges are designed with a footing width of one-third of the height over all, and the thickness of the footing is usually from 18 to 24 in. The width of the base of the abutment and wing walls at the top of the footing is made approximately one-quarter of the height of the walls. The back of the abutment wall is vertical and the face of the wall is battered to a top width of from 30 to 39 in. The wing walls are battered on both sides and have a top width of 12 in. Fig. 4 shows the curves from which the yardage of plain concrete abutments for steel bridges may be obtained. When field measurements are made to determine the necessary height of abutments, and the width of roadway is decided upon, it is easy to estimate the length of wing walls which will be required. These figures are then used in the formula and the yardage of concrete is read directly from the curve.

The design of plain concrete abutments for girder bridges is similar to the design for steel bridges, except that the wing walls are battered on the face side only, and the top width of the abutment wall is 18 in. Fig. 4 shows the curve from which quantities for this type of abutment are obtained. Plain concrete abutments for slab bridges differ slightly from the preceding design. The width of footing on the abutment wall is limited only by the safe bearing capacity of the soil, with a minimum of 3 ft. This width may sometimes be less than one-third of the height. This is deemed to be safe on account of the restraining effects of the superstructure. The top width of the abutment wall is 12 inches and the curve for estimating the yardage is shown in Fig. 4.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Calgary Branch of the Canadian Society of Civil Engineers will have charge of the entertainment between Banff and Moose Jaw of the eastern members on the proposed trip to the annual conference to be held in Victoria next month. The points of engineering interest to be visited include the Kananaskis Falls hydro-electric development of the Calgary Power Company, the Brooks aqueduct and the Bassano dam of the Canadian Pacific Railway irrigation system. These features in store for those who attend the conference will form a part of the return trip.

Through an arrangement with the Canadian and British Columbia governments the Pacific Great Eastern Railway Company has secured funds to continue construction work on its line between Vancouver, B.C., and Fort George. The line is now in operation out of North Vancouver towards Squamish, and from Squamish to Lillooet, 120 miles. Considerable work has been done between Lillooet and Fort George, and the company expects to have 100 miles additional completed during 1915.

TORONTO SEWAGE DISPOSAL PLANT.

The main sewage disposal plant of the city of Toronto is situated near Morley Avenue, on the eastern water front and about three miles from the central portion of the city. It has provoked many complaints during the past two years owing to the foul odors which at times beset the residents of that section. The city officials ordered an investigation recently, resulting in a preliminary report, prepared by Dr. Chas. J. Hastings, Medical Officer of Health, and Mr. R. C. Harris, Commissioner of Works. The following are the chief observations presented:—

(1) That the tanks were not designed for the storage of sludge.

(2) That if the original intention to discharge the accumulation of sludge into Ashbridge's Bay for reclamation purposes had been carried out, serious consequences would have followed.

(3) That odor was caused by the ebullition of gases in the area in which the sludge had been enclosed.

(4) That the covering of the sludge with lime has proved effective.

(5) That certain experiments for the purpose of improving conditions were made without result.

(6) That to install Imhoff tanks would cost $6,000,000, and without sprinkling filters $3,287,000.

(7) That the opening of a channel through to Ashbridge's Bay will improve conditions.

In regard to these findings it is to be noted that upon the completion of the plant it was deemed advisable to confine the sludge within a definite area, contiguous thereto, and for this purpose a portion of Ashbridge's Bay immediately to the south was enclosed. After considerable sludge had been deposited in this area the ebullition of gases caused odor. In order to minimize this about eighteen months ago the area was divided into comparatively small pockets, which virtually acted as separate digesting lagoons. Sludge was deposited in each of these until filled. In this way the sludge depth was increased, and the superficial area exposed to the atmosphere reduced, thereby retarding the rate of gas ebullition.

Immediately upon the discharge of fresh sludge, the deposit is covered with shavings and lime or bleach spread thereon. This method has proved quite effective and is being continued.

For some time past, according to the report, the officials have been experimenting along other lines, in an endeavor to find means of improving conditions. Electrolytic experiments proved of little value, as did the application of sludge on slate beds. The aeration treatment was tried, but did not answer.

"We have made extensive investigation with different filter media, to find which would permit the highest rate of application of effluent. In North Toronto, we have a brush filter operating at the rate of 5,500,000 Imperial gallons per acre per day, and giving excellent results. The usual rate over stone filters is about 2,000,000 Imperial gallons per acre per day. If this record is fortified by future experience it will materially decrease the cost of filter installation."

The report calls attention to the experiments that are being carried on in various cities in connection with the activated sludge process, which has been described in recent issues of *The Canadian Engineer*, and states that the results are being awaited with great interest.

COAST TO COAST

Montreal, Que.—The new macadam road between Levis and Jackman, which has been under construction during the past two seasons, has been completed.

Guelph, Ont.—It is expected that the interurban electric line between Toronto and Guelph will be completely ballasted before the close of the season. Operations are being rushed at the present time.

Moncton, N.B.—The Main Street subway has been practically completed by Messrs. Soper and McDougall, of Ottawa, the contractors. It is claimed to be one of the finest improvements undertaken in this city by the I.C.R.

Macleod, Alta.—Mr. C. V. Cummings, general manager of the Northern Construction Co., states that about 200 men and teams are now engaged in grading work on the Macleod extension of the Canadian Northern Railway.

North Bay, Ont.—Commissioner Lee is the authority for the statement that a big gold strike has been discovered at mileage 153 on the T. & N. O. The whole township of Pecud has been staked out, and the rush of prospectors has been large.

Winnipeg, Man.—Over five miles of the Shoal Lake aqueduct have been completed and work is under way at eleven different points on the line. The diversion dyke to prevent Falcon River water from approaching the intake at Indian Bay has been completed.

Saanich, B.C.—The contractors, The Warren Construction Co., have commenced the paving of the main Saanich Road. The progress on the waterworks system has been satisfactory, and, generally speaking, there is a considerable amount of municipal engineering activity.

South Porcupine, Ont.—Frederick-house Lake has been drained by the power companies, incidentally rendering available for farming purposes several thousand acres of excellent soil, and the land rush which developed when the job was completed bore strong resemblance to a mining stampede.

Quebec, Que.—The new road between Quebec and Montreal has been practically completed as far from this city as the Batiscan River. It will be finished to Maskinonge by fall. On the Montreal end the road is practically completed to Lanoraie, and will be finished to St. Barthelemi before the season closes.

Winnipeg, Man.—The construction of a large pulp mill on the Birch River, about 75 miles east of Winnipeg, is being contemplated. Controller John Midwinter, of Winnipeg, is the man reported to be behind the scheme. The construction of the Shoal Lake aqueduct has revealed a vast supply of suitable pulp-wood in this section of the province.

Victoria, B.C.—The large pulp and saw mills of the Ocean Falls, Limited, about 300 miles up the coast, have been taken over by a new company, the Pacific Mills, Limited., in which Portland and San Francisco firms are heavily interested. It is now proposed to erect a large paper mill. The new company is capitalized at $9,500,000. Mr. J. H. Lawson, Jr., of Vancouver, is president of the new concern.

Kingston, Ont.—The new garbage incinerator will be completed in two weeks and ready for operation. Canadian Allis-Chalmers, Limited, Toronto, supplied the equipment and Messrs. Cockburn and Lesslie erected the stack, which is 110 ft. in height. The amount of garbage which it will be required to consume amounts to 10 or 12 tons per day.

Vancouver, B.C.—The West Vancouver Marine Drive was officially opened on August 11th. It is a road nine miles long, extending from North Vancouver to Point Atkinson. It has a bitulithic surfacing on heavy concrete base for practically the greater part of its length, although, owing to shortage of funds, the last several miles consist at present of macadam. It has cost over $250,000.

Grand Forks, B.C.—Construction of a $65,000 bridge over the North Fork Canyon on the railway spur into Granby smelter was commenced recently by the Great Northern Railway Company. The new bridge will be 692 feet in length, with stone and concrete abutments. It replaces the old structure which has seen service for a dozen years. The Great Northern will make temporary use of the C.P.R. spur and bridge into the smelter until the new bridge is completed. For this purpose 2,000 feet of new track will be laid to link up both lines.

Vancouver, B.C.—Concrete work has been completed on the new government dock at the foot of Salisbury Drive (described in *The Canadian Engineer* for April 15th, 1915), and the wharf will be entirely finished in the course of a few days, nothing remaining but some filling in behind the side walls of the dock. Several dredges have this work under way at the present time. The dock will be in use next month. Messrs. Henry, McFee and McDonald, of Vancouver, are the general contractors for the Department of Public Works, Ottawa.

Quebec, Que.—The report for 1914 of the Quebec Harbor Commissioners has just been completed. The Commission, established in 1887, entered upon an active construction period in 1913. The harbor now provides over 5,000 ft. of length for ocean steamers of any size or class, with an average of 91 ft. of width. The freight sheds are well supplied with modern equipment. The new 1,000,000-bushel grain elevator with a grain transporter to facilitate dispatch in grain handling, is now in operation. During 1914 the revenue of the Commissioners amounted to $287,000.

Montreal, Que.—The Park Avenue subway will be completed and street cars will be running under the C.P.R. tracks at this point before the close of the year. Mr. J. E. Vanier is engineer in charge of operations for the city. Messrs. Laurin and Leitch are the contractors, and started work last November. The grading of Park Avenue on either side of the railway track for a total distance of 1,200 ft. has been finished. Concrete retaining walls are now being built, and considerable rock excavation completed. The heaviest work still to be done is the tunnelling under the railway and the construction of abutments. The subway was projected many years ago, and, after considerable administration, is being built at a cost to the city of $250,000.

Edmonton, Alta.—Foley Bros. expect to finish their grading contract on the Edmonton, Dunvegan and British Columbia Railway as far as Smoky River crossing early in October, and grading to Spirit River will be completed by November 1st. Piles are now being driven for a temporary bridge to carry the steel across Smoky River. Messrs. McPherson & Quigley are the contractors for this structure. The abutments for the permanent bridge will be completed this fall, and the bridge will be completed before the high water of next year. The erection of a temporary bridge will enable steel to be laid to Spirit River, beyond the Smoky, and will also give access to a very fine gravel pit on the west side of the river. Access to this pit is necessary to the railway, for ballasting purposes, as there is no other deposit of equally good gravel on the line. From the level of the upland on the west side of the Smoky the grade is eighty per cent. completed to Spirit River.

PERSONAL

A. A. TISDALE has been appointed superintendent of the Regina division of the Grand Trunk Pacific Railway.

J. RYAN has been appointed superintendent of the Edmonton sewage disposal plant, under the direction of Mr. A. J. Latornell, city engineer.

SIR CHARLES ROSS, president of the Ross Rifle Company, has been given the temporary rank of colonel in the Canadian militia, according to militia orders just issued.

ANGUS MORRISON, one of the assistant engineers on the construction of the Hudson Bay Railway, walked 689 miles to join his regiment before its departure for Shorncliffe, Eng.

FRANK STILWELL, C.E., has been appointed town engineer of Cornwall, Ont., during the absence of Capt. W. H. Magwood, who has been given command of D. Company, 77 Battalion.

Dr. J. W. S. McCULLOUGH, Chief Medical Health Officer of Ontario, has been given the temporary rank of major in the Canadian militia, and is in charge of sanitation at the Niagara military camp.

Lieut. A. N. WORTHINGTON, of the 13th Battalion, C.E.F., is back in Ontario on sick leave, having been wounded at Festubert. Lieut. Worthington, a graduate in civil engineering of the University of Toronto, was formerly in the employ of the Trussed Concrete Steel Company of Canada, Limited, at Walkerville, Ont.

GEORGE D. MACKIE, city engineer-commissioner of the city of Moose Jaw, has been elected an associate member of the Canadian Society of Civil Engineers.

C. E. AUSTIN, general manager of the Moose Jaw Mills, Limited, has been appointed general manager of the Dominion Government interior storage elevators between Fort William and Vancouver, with headquarters at Fort William.

J. H. LARMONTH has resigned as superintendent of the Edmonton street railway systems. He has held the position since April 1st, 1914, prior to which he was engaged in private practice as a consulting engineer in Toronto, and was formerly in charge of the construction and management of the Peterborough street railway. He was also general manager of the Electric Power Company for some time. On the occasion of his leaving the Edmonton position Mr. Larmonth was the recipient of an address eulogizing his able and conscientious administration of the street railway affairs during his tenure of office.

The 9th annual convention of the Illuminating Engineering Society will be held in Washington, D.C., September 20-23. There will be ten sessions with a lengthy list of papers.

OBITUARY.

The death is reported of Mr. John Barr, managing director of Messrs. Glenfield and Kennedy, hydraulic engineers, Kilmarnock, Scotland. The deceased was the father of the late James Barr of the Waterworks Department, Toronto, who, with his wife, was lost in the "Lusitania" disaster while on a trip to visit his father.

It is reported that Lieut. D. Hook, a young civil engineer of Vancouver, B.C., has been killed in action. He went to England on the outbreak of war and after a course of training obtained a commission in the Lancashire Fusiliers.

COMING MEETINGS.

PROVINCIAL ASSOCIATION OF FIRE CHIEFS.—Annual Convention to be held in Ottawa, Ont., August 24th to 27th, 1915. Secretary, Chief James Armstrong, Kingston, Ont.

NEW ENGLAND WATERWORKS ASSOCIATION.—Annual Convention to be held in New York City September 7th to 9th, 1915. Secretary, Willard Kent, 715 Tremont Temple, Boston, Mass.

AMERICAN ROAD BUILDERS' ASSOCIATION and AMERICAN HIGHWAY ASSOCIATION.—Pan American Road Congress to be held in Oakland, Cal., September 13th to 17th, 1915. Secretary, American Road Builders' Association, E. L. Powers, 150 Nassau Street, New York, N.Y. Executive Secretary, American Highway Association, I. S. Pennybacker, Colorado Building, Washington, D.C.

AMERICAN ELECTROCHEMICAL SOCIETY.—Twenty-eighth annual general meeting to be held in San Francisco, Cal., September 16th to 18th, 1915. J. M. Muir, 239 West 39th Street, New York City, Chairman of Transportation Committee.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Calvin W. Rice 29 West 39th Street, New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, F. L. Hutchinson, 29 West 39th Street, New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Annual convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Charles Warren Hunt, 220 West 57th Street, New York.

INTERNATIONAL ENGINEERING CONGRESS.—To be held in San Francisco, Cal., September 20th to 25th, 1915. Secretary, W. A. Catell, Foxcroft Building, San Francisco, Cal.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—Annual convention to be held in San Francisco, Cal., October 4th to 8th, 1915. Secretary, E. B. Burritt, 29 West 39th Street, New York.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Annual convention to be held in Dayton, O., October 11th and 12th, 1915. Secretary, Will P. Blair, B. of L. E. Building, Cleveland, O.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Annual convention to be held in Dayton, O., October 12th to 14th, 1915.. Secretary, Charles Carroll Brown, 702 Wulsin Building, Indianapolis, Ind.