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WATER FILTRATION FOR INDUSTRIAL PURPOSES.

In a paper read before the state meeting of the Franklin Institute, January 18, 1911, by Mr. Churchill Hungerford, the attention of the members was directed to the importance of a standard water for industrial purposes.

Disregarding the hardness of the water, the reduction of which is not properly a function of filtration, there are a number of apparently harmless forms of pollution that are very troublesome in many instances. A case was mentioned where a party engaged in the manufacture of gorgeously printed lap robes, made use of large wooden blocks impregnated with certain colors imported from England. These colors are all mordanted with alum, and finally washed. Trouble developing in the washing bath, led the manufacturer to investigate the source of his water supply. The examination showed that the major part of it was derived from a shallow lake about seven miles back in the country. The elevation of the water in this lake had been raised four or five feet a number of years ago and overflows a peat-bog over a square mile in extent. During winter it is customary to close the outlet of this lake and allow it to fill up. About the latter part of May, when the water in the stream begins to get low the gates are opened and the highly colored water from the lake takes the place of the comparatively clear flow. When this colored water reaches the mill and the alum saturated lap robes are washed in it, the coloring matter derived from the peat is precipitated by the alum upon the fibre, and the more color there is to the water the greater the discoloration of the goods.

Another instance mentioned was in a city of some 60,000 inhabitants supplied from a fairly large stream. The water from this stream possesses considerable color and is filtered by means of a mechanical filter plant. This mechanical filter plant is very well operated indeed, shows a very high bacterial efficiency and is ideal in every particular save one, and that is that for some reason or other a small amount of hydrate of alumina, formed during the chemical treatment of the water with alum, finds its way through the filters. This has no hygienic significance whatever and the inhabitants of the town are enthusiastic over the many virtues of their filter plant insofar as the potability and appearance of the water is concerned. However, there are a number of large silk dye-works in this town and this trace of hydrate of alumina present in the water prohibits its use in silk dyeing. Most of the dye houses are located along the banks of the same stream from which the city supply is drawn but at a point below town. The stream at this point is not only badly contaminated with sewage but the discharge from the silk dye houses themselves enters into it making the general color of the water blue-black. Nevertheless, the silk dyers have solved the problem of water supply by filtering this badly contaminated water with a filter which will not permit hydrate of alumina to pass through it. The filtered water is, of course, crystal clear and entirely free from dye.

Originally filtration for industrial purposes meant the removal of clay, silt, and vegetable stains from the water. The problem at that time was a simple one as it merely meant that enough alum or sulphate of alumina or similar coagulant was employed as a preliminary treatment, after which the water could be passed through the filters and would be suitable for industrial purposes.

The filters of to-day have to remove industrial wastes, consisting very largely of dyestuffs, waste liquors from paper and pulp mills, chemical wastes from wire-drawing plants, gas-house liquors, tannery wastes, etc. Some streams contain only one or two different varieties of contamination while others contain several.

In some instances the ingredients existing in streams may be precipitated by discharged material entering the stream from another source. For instance, the waste dye from a woolen house mingling with the waste soap from the fulling and finishing department, coming in contact with lime dissolved in the water would by this agency be precipitated and dropped to the river bed. If sulphate of iron were being emptied into the stream at another point, it would combine with the coloring matter and form a heavy precipitate, so that it would be possible that much of the solid matter would form a coating of mud on the stream bed, and thus lessen the load on the filters.

The object of filtration is to remove all these substances which attempt to gain entrance into the storage vats of the manufacturer.

The next consideration is to precipitate as cheaply as possible the remaining deleterious substances. The most economical and effective substance for doing the major part of this work is sulphate of alumina. The writer realizes that there will be considerable protest made in favor of sulphate of iron and lime. Nevertheless so far as his own experience goes, and, in fact, the experience of some others, sulphate of alumina is cheaper, safer, more satisfactory and far easier to apply than sulphate of iron and lime.

Having applied the sulphate of alumina with a due regard for the alkalinity of the water as evinced by the chemical analysis, the treated water is allowed to flow slowly through a settling tank. The period of time occupied in sedimentation varies greatly with different waters. In some cases one and one-half hours may be sufficient. In others three hours. Occasionally twelve hours are required. Generally speaking, however, three hours sedimentation with aluminum sulphate for a coagulant is sufficient.

We occasionally find, however, upon operating a plant that complete decoloration of the water is not effected and that there is a very offensive odor. If large masses of sediment rise from the depths, come to the surface, spread out and disappear, and one point in the sedimentation basin shows a fairly good degree of sedimentation while further along where sedimentation ought to be further advanced we find the water far more turbid than when first introduced into the basin. The sewage in the water is simply fermenting and this fermentation is not only interfering with sedimentation by reason of the gases evolved but is producing resolution of the impurities entrapped by the hydrate of alumina.

It is necessary to stop the fermentation of precipitated matter. Copper sulphate (bluestone) applied at a strength of two or three parts per million will, in certain cases, cause this trouble to cease. There are, however, many cases where copper sulphate cannot be used in sufficient quantities or where it is not useful at all. Where the percentage of sewage is very high, it will be found that there is much undecomposed and unprecipitated organic matter in the water, and to get really satisfactory results it must be consumed in some manner. Calcium hypochlorite recommends itself but must be judiciously used, as a very faint excess would produce disastrous results in dyeing.

At Passaic, N.J., using Passaic River water, which runs about one million bacteria per cubic centimetre, or equal to ordinary sewage, it was found that with two parts per million of calcium hypochlorite and five hours' sedimentation the bacteria ranged from twenty-seven to one hundred per cubic centimetre, and that so long as the hypochlorite was used there was no tendency whatever of the sludge at the bottom of the basin to ferment.

In most plants the amount of calcium hypochlorite employed ranges from one to three parts per million. Where fermentation is interfering with sedimentation it must be applied as the water enters the sedimentation basin but if sedimentation is reasonably good an economy can be effected by applying the calcium hypochloric after sedimentation is completed. By following this procedure much of the oxidized matter that would be precipitated by the alum has settled to the bottom and the principal oxidizing activity of the hypochlorite is directed against the dissolved matter and the bacteria.

Another action of the calcium hypochlorite is to decolorize the dyes that may have resisted action of the aluminum sulphate. This action, however, is not especially important as the strength required to produce this result is usually greater than is safe to use.

Needless to say, the treated water must show no trace whatever of free calcium hypochlorite and the only logical way of attaining this result is to keep the quantity of chemical applied at such a point that its energy will be entirely expended upon the organic matter. An accurate chemical feed is of the utmost importance when using the calcium hypochlorite.

With certain waters it is found that although a suitable degree of precipitation is obtained by the use of the aluminum sulphate the precipitate is of a flocculent, buoyant nature and will not settle. In fact it has a tendency to come to the surface of the water. On examination it will be found that the buoyant tendency of the precipitate is due to small bubbles of carbonic acid gas given off in the reaction between the sulphate of alumina and the earthy carbonates. If the water is soft this tendency is corrected by adding either shortly before the application of the aluminum sulphate, or shortly after, a small quantity of calcium hydrate.

The quantity of water required in the various industries is very great in comparison to the requirements of municipalities. For instance, a supply of two million gallons per day would furnish a town of 20,000 inhabitants, a small paper mill of say twenty tons daily output, a very small bleachery, or a small silk dye-works. The largest silk dye-works in this country consumes 23,000,000 gallons of water per day and a contract has just been let for a bleachery in the New England States requiring a filter plant having a capacity of 36,000,000 gallons per day. This is approximately the amount of water used by the city of Philadelphia west of the Schuylkill. These figures seem stupendous to the person who has not studied industrial requirements.

A pound of muslin, or similar cotton fabric requires in the bleaching process about twenty-seven gallons of water. A pound of paper requires about fifty gallons of water, and a pound of silk not less than one thousand gallons of water. Moreover, many of these processes in which water occupies such an important part include very delicate chemical reactions in which strong acids and alkalis play their part.

There are two kinds of filters, pressure and gravity. Really they are identical in operation, the only difference being in their application. The pressure filter is the same device as the gravity filter, excepting that it is placed in an enclosed steel tank and operates under whatever pressure the service main may carry, delivering its water filtered and still under pressure with a loss of head ranging from two to ten pounds, depending upon the make of filter.

The gravity filter on the other hand relies upon the weight of water on it to drive the water through the bed and the water is discharged at the bottom under no pressure.

Taking the detailed parts of a gravity filter plant for an example, we find that they consist of a chemical feed, a settling basin with the necessary baffles, the filter proper and the machinery for washing the filter. As the consumption of every industry varies more or less from moment to moment there are fluctuations in the rate of flow of the raw water coming to the settling basin. The chemical feed must be an apparatus that will regulate whatever chemicals are being applied to meet this fluctuation. For instance, if the feed is set to apply two grains of sulphate of alumina and one-eighth of a grain of calcium hypochlorite per gallon of water it must do that and exactly that, whether the plant is running at full speed, one-quarter speed or a twenty-five per cent. overload. It is a small but vital part of the entire plant and might be compared in its way to the governor of a steam-engine. Of course, chemicals are applied in the form of solutions of a definite strength.

The water after receiving its dose of chemicals flows through the settling tank in a continuous process, in at one end and out at the other. To stop the tendency of the water to flow directly across the basin from inlet to outlet leaving a large eddy on either side, baffles are placed so as to compel the entire body of water to take a circuitous course through the basin. Much of the solid substance in the water has already been coagulated by the action of one set of impurities upon another, and the applied chemicals have produced further precipitation and have, moreover, gathered together the finer particles and suspended matter into comparatively large masses so that all settle with considerable rapidity toward the bottom of the basin, where they remain until such time as it is convenient to remove them.

The three essential parts of a filter are the case, the filter bed proper and the strainer system, which consists of a series of pipes leading to all parts of the bed terminating at their outer end in strainers or sand valves, devices which have slots or perforations of too small size to permit the sand to pass through, but sufficient in number to allow a definite quantity of water to leave the sand bed.

Calcium hypochlorite, chloride of lime or bleaching powder, as it is variously known, on being mingled with the organic matter is decomposed into calcium chloride, and ozone is liberated in sufficient quantities to produce the necessary oxidization. Calcium chloride, being an inert salt and existing in such minute quantities has no significance from any industrial standpoint whatever. We thus see elimination of the applied chemicals or their metamorphosis into harmless and insignificant substances.

In addition to economy in the use of chemicals the other costs of operation, such as attendance, power, etc., must be reduced to a minimum. One hour per day for each million gallons of water treated is sufficient to cover the attendance of a well designed industrial plant. The sedimentation basins are so arranged that the sludge drains into a channel passing down the middle connecting with a blow-off valve. Opening this valve at intervals of one to six months and permitting the entire chamber to drain takes care of most of the sludge.

The filters must be so designed that they can be washed very rapidly and very thoroughly. This is done by simply reversing the current in the case of the pressure filter and forcing the water up through it at a high rate of speed.

For every ten parts per million of alkalinity that the water contains one grain of sulphate of alumina per gallon can be used with safety, because this quantity of alkali will combine with the alum to convert it into an insoluble substance, hydrate of alumina, which is readily removed by the filters, and sulphate of lime. In other words, the carbonate of lime existing in the water renders the alum insoluble and converts it into a form in which the filter can hold it.

From the foregoing it will be seen that chemical treatment in many industrial problems is as important as the apparatus employed, and if the problem is met by the use of a well designed plant employing the proper chemicals, there is no reason why the most polluted rivers and streams cannot be used for all industrial purposes.

THE FORESTRY COMMISSION OF BRITISH COLUMBIA.*

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Let me direct your attention westward—to the forest province where half the merchantable timber of Canada now stands. Let me describe to you the work of the Forestry Commission of British Columbia, and the circumstances that gave rise to its appointment.

In the early days on the Pacific coast of the Dominion the forest had little value. It was the farmer's enemy; it hindered the prospector on his hunt for gold; and the few thousand people whose settlements were scattered among the multitude of trees were hampered at every turn by the monstrous growth of wood. The commercial activity of the country was oppressed by it; the forest "encumbered the land." It is true that small sawmills had begun their work, but the local need for lumber was easily satisfied, the export trade was in its infancy, and insignificant cuttings along the waterfront—on the very fringe of the ceaseless forest—supplied the logger with all the timber he could sell.

It was inevitable therefore that the legislature of this small isolated population should have put no value upon the standing timber that it owned, and that the timber should have been given away to every purchaser of land—thrown into the bargain along with the deer and the berry bushes and the scenery. In fact even upon these attractive terms it was by no means easy to dispose of timber-land, for capital was scarce in those early days, and in any case it was not often available for a stumpage investment that by the look of things, might possibly require half a century to mature. Then came the great upheaval caused by the completion of the Canadian Pacific Railway—by the linking up of the Pacific coast country to the rest of Canada. Population flowed in, trade improved, and the choicest patches of the most accessible timber of British Columbia began to have a slight market value. Prompted by this, the legislature in 1888 made the first attempt to grapple with the problem of selling forest property. It placed a price of fifty cents upon every thousand feet of lumber cut—a price that has remained unaltered ever since.

*Paper delivered to Canadian Forestry Convention.

Capital, as I have said before, was very scarce out west, and the struggling sawmill owner needed all that he possessed for the active development of his business. He could not easily afford to sink money in the purchase of timber lands. Hence that same legislature of 1888 organized the system of leasing Crown timber; a system that gave the lumberman all the stumpage that he needed without obliging him to pay cash for it. Moreover by granting these leases at the cheap rental of ten cents per acre to bona fide operators only the establishment of new sawmills in the province was given direct encouragement. For seventeen years this leasing system continued to exist as the standard method of disposing of the provincial forests, but long before its abolition a most important change had been made in the idea behind it, which had been originally, as I have said, the encouragement of immediate sawmilling operations in the province by grants of cheap Crown stumpage. In reality the first step towards the construction of the modern forest policy of the provincial government had been made. That step was simply the granting of leases at higher rates to non-operators, the throwing open of timberlands to the investor.

And now let me summarize the situation as it existed in 1905, the year in which the leasing of timber was brought to an end, the year that saw the adoption of a new and truly remarkable policy by the province of British Columbia. By that year, about one and a half million acres of the Crown timberlands had passed by sale or by railway grant into private ownership and out of government control; another million acres had been transferred to lessees. Probably thirty billion feet of standing timber had been alienated. Neither of the two forms of tenure secured to the people of the province any satisfactory share in the future value of the stumpage they parted with, for any future increase in the value of these two and a half million acres would benefit the private lessee or purchaser and not the government. As it was very evident that the value of British Columbia timber would rise greatly in the years to come, it was most desirable that some better method than lease or sale should be discovered for disposing of the Crown forests.

To quote the words of our Report "the legislative problem was solved in a most ingenious manner." In this year 1905, the government threw open the timberlands of the whole province. It invited private individuals to join it in a partnership in each and every square mile of the Crown forests. There was no sale, no auction, even no lease. The incoming partners were asked to sink no capital. The investor was merely asked to register a formal application to become a partner with the government in the timber on such-and-such a square mile of the province and the partnership was his. Stated in these attractive terms, the procedure sounds like some wild story of a commercial fairyland, where timberlands and wealth are given for the asking; but the truth is that a number of sound and useful "strings" were attached to these British Columbian gifts—and that, in fact, the gift idea was entirely absent from the mind of the provincial government. The government freely admitted investors to partnership in Crown timber, it is true, but it did so on its own terms absolutely, and it frankly admitted that only the future rise in stumpage and lumber values would enable it to say what these terms should be.

In fact, the partnership arrangement could have been stated thus; "Here," might have said the government, "are immense forests that will be put to no use for many years to come. They produce no revenue; they are in constant danger of destruction by fire; and it is beyond our power, financially, to give them any efficient protection. Moreover, the province needs revenue now, in its growing time and youth. Therefore, we will place these forests in private management but under our supreme control, and we shall frame regulations from time to time, in order to make sure that the timber is properly looked after. The revenue needed by the province and that needed for the conservation of the forest we shall obtain by requiring investors to pay for their privileges—so much a year for their partnership rights and so much as royalty on any timber they may cut. As the 'market' or prospective' or 'speculative'—call it what you will—value of stumpage rises we will take our fair share of the 'unearned increment' by requiring a larger annual payment to be made to us. As the profits of lumbering operations increase we will take our fair share of these by requiring a larger royalty. To begin with, we shall require the same royalty that we have been obtaining for the last seventeen years, namely, fifty cents a thousand feet, and we shall require an annual payment of about 1 3/5 cents per thousand."

This, then, was the logic of the policy of 1905, and the result is a matter of common knowledge. Upon these extremely moderate and equitable terms nine million acres of timber land were taken up by investors within three years. Now it is evident that no ordinary situation had been created. Nine million acres of some of the choicest timber in the world represents a property of enormous magnitude, and the transfer of this from the government to a partnership, in which a very large number of private individuals were placed in active management, gave rise inevitably to a host of most complex problems. For example, think for a moment of the difficulty of adjusting the claims of the government, the operator and the investor upon any point where they should happen to conflict. The government, in fact, had practically gone into the timber business on a vast scale and it was faced by the triple duty of securing to the people of the province fair treatment for their forests and fair prices for the timber sold; of giving equitable treatment to the investor in Crown stumpage; and of building up by wise assistance the active operations of the lumbering industry. Since 1905 this duty had become (as Stevenson has said of honesty in modern life) "as difficult as any art."

In these remarkable circumstances the government felt that the most careful and deliberate study of the situation was imperative. It placed a reserve upon all the remaining timberlands of the Crown (that are variously estimated at one-quarter or one-third of the timber areas under provincial control, in the neighborhood, let us say, of four million acres) and it proceeded to appoint a Royal Commission of enquiry, composed of Mr. Fulton who then held the portfolio of Crown lands, Mr. A. S. Goodeve and myself.

Part 2—From the beginning, our work as Commissioners fell naturally into two divisions—study of forest conditions in the province; study of forest conditions elsewhere—and we endeavored by contrasting impressions we obtained from these two sources to arrive at a sound judgment concerning the improvements we should recommend in the forest policy and administration of British Columbia. We found at once that in practical matters of forestry there was much for the province to learn. The older parts of Canada and many of the states of the United States had passed through the crude and early stage of forest exploitation at which we ourselves had just arrived; ideas and methods new to us had been well tried and proven by other governments. Ontario, Quebec, the United States Forest Service, the voluntary fire associations of the western states —each of these could show us how to do something that we ought to do.

I should be afraid to venture an opinion concerning the number of books, pamphlets and reports on forest subjects that we received and digested. There was valuable material here and there. But on the whole we read the voluminous literature of the beginnings of forestry upon the continent of America with a feeling akin to disappointment. We were depressed by the smallness of the work that had been accomplished and by the greatness of what ought to have been done; by the absence of experiment and investigation; and by the meagre amount of information concerning forest resources. There seemed to be so much academic discussion, so much good sentiment about conservation—and so little practical support given to aggressive work, so little expenditure of hard cash. It was like the Scotchman's breakfast in the fishing story—a bottle and a half of the best alcohol with a halfpenny bun. We grew accustomed to state boards of forestry that were all-title-and-annual-report, and no treasury.

The upshot of the matter was that we became convinced that conservation in British Columbia ought to be very different and a very business-like affair. That is what conservation means, at bottom—the application of ordinary business principles to natural resources. It must be action and not mere talk; immediate action and expenditure of large sums of money. Hence our recommendation to the government that—"Large appropriations must be made, a well-manned specialized forest service brought into being, thoroughly equipped."

Our province occupies a position that, looking at the history and the sad experience of forest countries, can be described as unique. Fire has ravaged certain districts; man has wasted freely; but British Columbia is in the extraordinary position of being able to undertake the conservation of the public forests before and not after fire and waste have squandered the bulk of them. We came to the broad conclusion that upon two conditions natural re-afforestation would take place in British Columbia.

"Firstly," we said, "both the young growth and the old must be protected from fire; secondly, there must be exercised a firm control over the methods under which the present forest crop is being removed. In short, effective re-afforestation depends largely upon effective discouragement of waste." "And," we continued, "by protection from fire we do not mean the mere temporary employment here and there of men to fight conflagrations that have been allowed to spread. We have in mind the active prevention of fire by the systematic work of a well-knit organization such as that described in our Report. This work would include, as a matter of urgency, the task of evolving for each locality a sound method of dealing with the reckless style of lumbering that leaves in every cut-over area a fire-trap of debris. That the young timber upon which our whole future as a lumber-producing country depends should be left, at the pleasure of any thoughtless workman, to grow up under the imminent menace of fire is so absurd commercially that an attempt at regulation is imperative."

A vexed question—this one of the disposal of debris; but one for experiment and not for discussion. The expenditure of a little public money on experiments will soon decide whether or no it will be commercially feasible in British Columbia as it has been in other forest regions to put an end to the liberty of careless workmen "to leave debris in any manner that may suit their own convenience, without the least regard for the safety of the cut-over area of the adjoining forests."

As for logging regulations we felt that the time was opportune for the restriction of waste. The levying of royalty upon all waste should prove an effectual remedy.

Taking a comprehensive view of the whole subject, we felt that this great timber business of the government of British Columbia should be placed upon the soundest financial footing. Hence our recommendation that its capital should be kept intact—that it should not be dissipated by treating it as current revenue. Royalties, we felt, were true forest capital, and we urged most strongly that they should be returned to the source from which they were produced in the form of protection for the growing crop. "No special circumstances," we continued, "that would justify departure from ordinary business principles have yet been proved to exist. General natural re-afforestation, though probable, is not an established fact in the province, and our uncertainty regarding it will not be removed until a thorough investigation has been made by the forest service. Until definite information has been obtained, we consider it essential that no surplus of royalty-capital should pass into general revenue." We recommended the establishment of a forest sinking-fund.

The rest of our conclusions, gentlemen, you will find in our official report. In many a practical matter of forest protection, as I have already said, our young province has much to learn from older communities, though it is learning fast. But in the matter of forest policy we have no doubts and no humility. We challenge the governments of the continent to produce a method of administering a tremendous forest estate that in breadth of statesmanship is comparable with the policy conceived and elaborated by the Honorable Richard McBride and his government. To have put a stop to alienation of the public forests and yet, without alienation, to have raised the annual forest revenue to two and a half million dollars is an extraordinary achievement. Further than this, so well thought out has been this provincial policy, that without the least danger to the public interest the provincial government was able, only last year, to give increased stability to the lumbering industry by granting a perpetual title to those who had made investments in the nine million acres of licensed timberlands. It was possible, at one and the same stroke, to make this concession to the lumbermen and to advance the public interest by it, for the direct effect of security of tenure was to enlist the hearty co-operation of investors in the conservation of the timber they owned jointly with the government.

The provincial policy is based upon these masterly principles:—1st, no alienation of the people's forests; 2nd, absolute reservation of a fair share of the "unearned increment" on Crown timber; 3rd, partnership between the government and the lumbermen in the profits of the lumbering industry; 4th, the judicious holding in reserve of forest areas that can be thrown into the market should any stumpage-holding monopoly threaten the province.

Let me ask you whether you think well of a government that in three short years has changed its annual expenditure in the war against forest fires from sixteen thousand to one hundred and eighty-five thousand dollars? Is there not a touch of the magnificent in this swift recognition of a duty. And now, gentlemen, let me enlist your interest in the progress of conservation in the part of Canada from which I come. The protection and the wise control of the cutting of the two hundred and forty billion feet of timber in British Columbia forests is of vital importance to the entire west—for this timber builds the prairie farms. Nay, further, the conservation of half the merchantable timber of Canada is a matter that affects all of you. Canada will not become the great wheat-producing country that we hope to see her, the growth of a farming population of millions in the vast region of the timberless prairie will be hampered and discouraged unless lumber is obtainable freely and cheaply for the building of the homes. Over-cutting in the United States will at no distant date exhaust that source of cheap supply; the east of Canada will need its lumber for itself. The proximity of coal was the vital factor that built up the iron industry—that back-bone of Great Britain's commercial supremacy. The proximity of timber—British Columbia's timber—will be the vital factor that will enable the granary of Canada to produce its wheat. The cheap lumber that will build the farms will be the British Columbian. This makes our provincial forest policy one of the national questions of Canada.

CLEARANCE OF BRIDGES OVER RAILROADS.

The following is abstracted from a paper by Robert H. Whitman of the Public Service Commission, New York, which appeared in Engineering and Contracting.

In city grade separation improvements it is seldom that a clearance in excess of 18 ft. has been allowed for street bridges over railroad tracks. This clearance is not sufficient to permit trainmen to stand on top of freight cars without being struck. In the past there have been many accidents caused by trainmen being struck by overhead structures. During the year ending June 30, 1909, 52 railway employes were killed and 809 injured by overhead obstructions. The necessity for trainmen passing over the top of cars is, of course, not as great as it was before the general introduction of the air brakes. It is considered that an 18 ft. clearance is sufficient to permit a trainman to sit on top of even the highest freight cars without being struck, and in terminals of large cities where added clearance means greatly increased construction cost, it is contended that an 18 ft. clearance is adequate. In Canada a clearance of 22½ ft. is required except with the approval of the Board of Railroad Commissioners for Canada, and thus far that Board has not approved of a smaller clearance. In 1910, a bill was introduced in the United States Congress proposing to fix the standard clearance for railroads throughout the United States at 20 ft. above top of rail.

W. H. Breithaupt, in a paper read before the Canadian Society of Civil Engineers, March 18, 1910, considers the subject of clearance as follows:—

"The highest fixed projection on an ordinary railway train is the locomotive smoke stack, and passenger cars project higher than the great bulk of freight cars; but some, comparatively extremely few, special freight cars are higher than either passenger cars or locomotive stacks. The extreme clearance requirement is for height, top of rail to running board, of highest car, height of brakeman added thereto, and a further allowance for contingencies, among which may be height of load of light material on an open car exceeding maximum box car height.

There are, at the present time, on the railways of standard gauge in the United States, Canada and Mexico, about 2,377,282 freight cars of all kinds. They classify as to height rail to running board as follows:—

	Pct.
Under 12 ft. including flat, gondola and tank cars	63.1
12 ft. to 13 ft.	23.4
13 ft. to 13 ft. 6 ins., inclusive	11.9
13 ft. 6 ins. to 14 ft. inclusive	0.65
Over 14 ft.	0.95

It is submitted that with conditions as they are and more so with regard to the future, 20 ft. (13½ ft. for car and 6½ ft. for man), is a reasonable vertical clearance. It has been shown that 13½ ft. covers the height to running board of all but a very small percentage of freight cars now in use, and that cars higher that 14 ft. to running board, i. e., higher than 14 ft. 6 ins. "over all" or to top of brake rod, can only to a limited extent traverse beyond their home railways. That higher cars will be economical or practicable is as little probable as that the gauge of railways will be widened or their entire structure changed. For a vertical clearance requirement greater than 21 ft. (14 ft. plus 7 ft), there can, in any event, be no conceivable rational need.

In Canada the Railway Act provides that every bridge over a railroad shall have a clearance of at least 7 ft. between the top of the highest freight car used on the railway and the lowest beams of the bridge, and that except with the approval of the Canadian Board of Railroad Commissioners, the clearance between the rail level and the overhead bridge shall not be less than 22½ ft. It is understood that in this case the rail level is taken to mean the base of the rail instead of the top of the rail as is more customary. In passing on proposed grade separation in Toronto, the railroads asked for a clearance of only about 19 ft. in place of the standard 22½ ft. The Commission in its decision dated Dec. 30, 1908, denies the request for a smaller clearance than 22½ ft., arguing that it woul prove a serious menace to employes required to work on top of freight cars.

It was said the rule requiring men to go on the tops of freight cars in the Toronto yards could be abolished; different rules for different terminals would only lead to confusion. The Board's accident inspectors are being continually called upon to investigate accidents caused by lack of headroom under bridges, and lack of lateral space along the sides of engines and trains. Our officials have been steadily endeavoring to eliminate these sources of danger, and it is entirely out of the question that we should sanction the erection of overhead bridges from York street east, of a character different from that which the law calls for. There are now too many of these structures in various parts of the country, and instead of sanctioning more, it is the plain duty of the Board to endeavor to get rid of those that now exist.

In New York State the Public Service Commission for the Second District has insisted on a minimum clearance of 21 ft. An exception was made in case of electric zone of of the N.Y.C. & H.R.R.R. near New York City. After issuing an order with the consent of the company that brakemen should not ride on the tops of cars within this zone the Commission permitted clearances of 16 to 16½ ft.

TABLE OF MINIMUM CLEARANCE OF BRIDGES OVER RAILROADS IN GRADE SEPARATION WORK.

Canada, 22½ ft., except with approval of Board of Railroad Commissioners.

Toronto, 22½ ft., Waterfront viaduct under order Railroad Commission, June 9, 1909.

Connecticut, 18 ft., Except with approval of the Railroad Commissioners, Connecticut Statutes S. 2018.

District of Columbia: Washington, 17 ft.

Massachusetts, 18 ft. Except with approval of State Railroad Commission

Brockton, Mass., 18 ft.

East Boston, Mass., 16 ft. In two cases 15½ ft., B. & A. R.R. Decree of 1904.

Newton, Mass., 16 ft.

Worcester, Mass., 18 ft.

New York State: 21 ft. 16 ft. to 16½ ft., within electric zone of N.Y.C.&H.R.R.R. near New York City.

Buffalo, N.Y., 16 to 18 ft. In a few cases 15 ft. N.Y.C. R.R. Belt Line 21 ft.

EARTH PRESSURES.*

CHARLES K. MOHLER, M.W.S.E.

A study of the sliding prism theory of Vauban after the graphics of Rebhann and of the analytical theory of Rankine, showing lack of agreement, and break-downs in the theories when worked out for results; also formulae and results from a new method.

There is no department in the whole field of engineering which can be charged up with so great a proportion of failures or partial failures as that relating to the design and construction of abutments and retaining walls. Until very recently there has been almost no progress made in designing structures of that class that will stand up without showing signs of weakness or failure.

While we are greatly in need of more reliable and exact data relating to earth pressure than we now possess, there is one erroneous dogma, which we should lose no time in

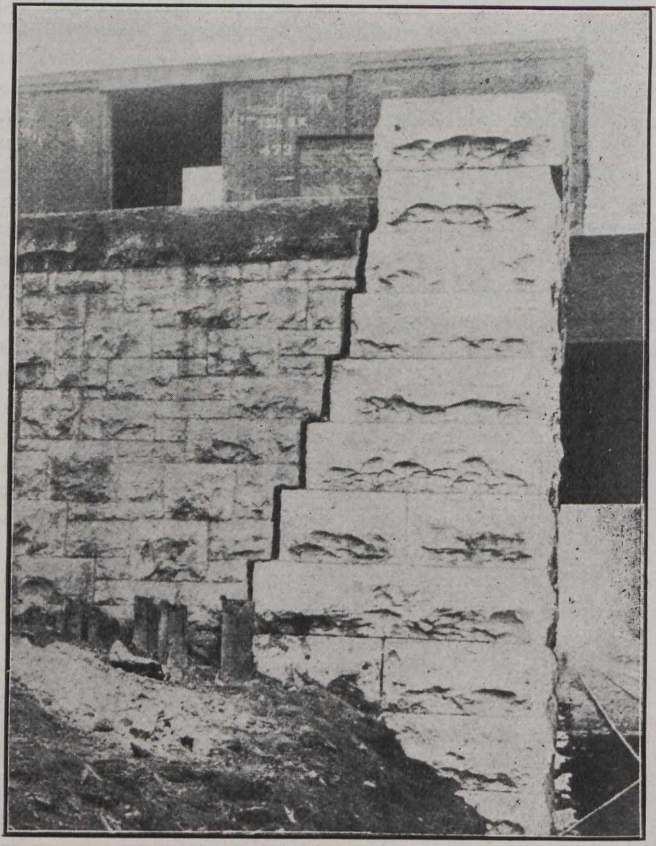


Fig. 1.—Characteristic Settlement Crack, Due to Excess Toe Pressure.

getting away from absolutely. That is the old text-book statement that "If the wall is designed so that the resultant of the forces acting on the base, cuts the base inside the middle third the wall is safe against overturning." Under some conditions nothing could be much farther from the truth. Unless we are to be satisfied with a tipped and cracked wall, it is a safe rule for only one condition; that is where there is a rigid and unyielding foundation such as solid rock. Unfortunately rock foundations are the exception rather than the rule for ordinary walls.

With a compressible or yielding foundation you cannot expect anything but a cracked or failing wall when the foundation reaction at the toe of the wall is greatly in excess of that at the heel, which the middle-third theory allows and usually gives. Piling is often used to correct the evil and

*Presented April 6, 1910, before Western Society of Engineers.

take care of the excessive toe pressure, but even that method, while adding greatly to the expense, often fails to prevent settlement and cracks. The only safe rule is to so design the wall that the resultant will pass through the centre of the base, or perhaps a little better, just back of the centre.

The misconception of the middle-third theory and its application has alone been responsible for most of the failures and partial failures of retaining walls and abutments.

Fig. 1 shows clearly a typical case of a wall having tipped forward on account of excess toe pressure, and consequent settlement.

The Earth Pressure Affecting the Foundation Reaction.

In the treatment of wall design we are at once confronted with the question, what is the amount and direction of the earth pressure against the wall, and how does it affect the direction of the resultant foundation reaction, and the determination of the point at which it cuts the base.

It has long been recognized that the data and formulae relating to earth pressure are not as complete and reliabe as we should have for correct designing, but for most conditions they are unquestionably better than guessing or working in the dark. Many of the formulae and resulting computations are very long and complicated, and it is almost a hopeless task to work out results for use and comparison.

Preparation of Tables, From Old Theories.

In order to get data in shape for convenient use and comparison, based on such theories and formulae as were available, the author computed tables* of constants C (so-called) for a large number of varying conditions governed by angles of repose or natural slope, back of wall batters, angles of surcharge, etc.

First, from the Analytical Theory of Rankine, of 1856.

Second, from the Sliding Prism Theory of Vauban, 1687, Coulomb, etc., after the graphics of Rebhann, of 1871.

After the tables were completed it was found, on comparison, that there was only one set of assumptions in which the two methods gave the same values. Namely, with vertical back of wall, and fill level back of wall.

To mention only one case of disagreement at this point; for the angle of repose or natural slope of 45°, surcharge of 45°, and with the back of wall batter away from the fill at an angle of 33° 42′ with the vertical, Rankine's formula gives the value of the Constant C as 144 lb., while Rebhann gives only 84 lb. Then again, neither theory gives self-consistent results throughout. Some of the points of divergence between the two theories, as well as the break-downs in the theories themselves, are clearly shown in the accompanying Figs. 2, 3, 4, 5 and 6.

Before discussing the figures it may be well to state the conventional abbreviations which are used. As Greek letters have been almost universally used in the treatment of earth pressure, a few of those in most common use have been retained, as follows:

ϕ = the angle of repose or natural slope of the earth or fill, measured from the horizontal.

ϕ' = the angle of friction between the earth and the back of the wall.

ϵ = the angle of surcharge of fill back of wall with the horizontal.

α = the angle which the batter of the back of wall makes with the vertical; positive when the back batter slopes up away from the fill and negative when it slopes up toward the fill.

δ = the angle which the direction of the resultant earth pressure makes with the horizontal.

γ = the weight in pounds per cu. ft. of the earth fill or backing.

h = the height in feet of fill or backing retained.

P = the horizontal component of the earth pressure.

W_e = the weight of earth carried on the wall foundation and is the vertical component of the earth pressure, being derived from the earth wedge over the back of wall batter.

E = the total earth pressure acting against the back of the wall.

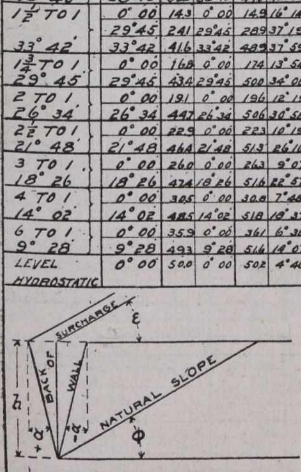
C = the constant (so-called) of the tables, and has the

EARTH PRESSURE CONSTANTS (C) AND ANGLE (δ) OF RESULTANT WITH THE HORIZONTAL FOR DIFFERENT ANGLES OF REPOSE φ, INCLINATIONS OF SURFACE ε, AND BACK OF WALL BATTER α. ANALYTICAL THEORY. RANKIN'S METHOD. AFTER HOWE.

BATTER AND ANGLE OF INCLINATION α OF BACK OF WALL TO THE VERTICAL. VALUES OF EARTH PRESSURE CONSTANT C AND ANGLE OF RESULTANT WITH THE HORIZONTAL δ.

Earth slopes and angles of repose φ	Surface slope back of wall ε	Vertical 0° 00 C	δ	1" in 12" (1 in 12) 4° 46 C	δ	2" in 12" (1 in 6) 9° 28 C	δ	3" in 12" (1 in 4) 14° 02 C	δ	4" in 12" (1 in 3) 18° 26 C	δ	5" in 12" (1 in 2.4) 22° 37 C	δ	6" in 12" (1 in 2) 26° 34 C	δ	8" in 12" (1 in 1.5) 33° 42 C	δ	12" in 12" (1 in 1) 45° 00 C	δ
1 TO 1 (45° 00)	0° 00	8.6	0° 00	9.5	25° 55	12.0	44° 11	15.2	55° 33	18.7	62° 46	22.5	67° 37	26.4	71° 04	34.4	75° 34	50.7	79° 17
	29° 45	11.6	29° 45	15.3	44° 04	20.0	53° 03	25.4	58° 57	31.4	63° 03	37.8	66° 01	44.8	68° 16	60.1	71° 26		
	45° 00	35.4	45° 00	44.8	49° 05	55.4	52° 08	67.2	54° 28	80.1	56° 10	94.1	57° 09	109.3	59° 02	144.1	60° 57		
1¼ TO 1 (38° 40)	0° 00	11.6	0° 00	12.3	19° 51	14.2	35° 50	17.0	47° 15	20.3	55° 17	23.8	61° 00	27.5	65° 13	35.3	70° 54		
	29° 45	17.0	29° 45	21.2	40° 03	26.2	47° 22	31.9	52° 40	38.1	56° 38	44.9	59° 19	52.2	62° 04	68.3	65° 36		
	38° 40	39.0	38° 40	47.0	42° 50	56.5	46° 14	66.6	48° 47	77.6	50° 56	89.2	52° 42	102.3	54° 11	130.0	56° 33		
1½ TO 1 (33° 42)	0° 00	14.3	0° 00	14.9	16° 14	16.4	30° 13	19.0	41° 07	22.0	49° 20	25.3	55° 30	28.8	60° 12	36.3	66° 46		
	29° 45	24.1	29° 45	28.9	37° 19	34.3	43° 06	40.5	47° 36	47.3	51° 09	54.6	54° 02	62.4	56° 21	79.6	59° 52		
	33° 42	41.6	33° 42	48.9	37° 59	57.0	41° 28	65.8	44° 17	75.4	46° 41	85.6	48° 41	96.5	50° 18	120.4	53° 08		
1¾ TO 1 (29° 45)	0° 00	16.8	0° 00	17.4	13° 54	18.8	26° 20	21.0	36° 32	23.7	44° 42	26.8	51° 02	30.1	56° 02	37.4	63° 12		
	29° 45	43.4	29° 45	50.0	34° 06	57.2	37° 43	65.0	40° 45	73.4	43° 19	82.4	45° 31	92.1	47° 24	113.0	50° 25		
2 TO 1 (26° 34)	0° 00	19.1	0° 00	19.6	12° 19	20.8	23° 36	22.8	33° 12	25.4	41° 07	28.3	47° 29	31.5	52° 38	38.4	60° 12		
	26° 34	44.7	26° 34	50.6	30° 58	57.1	34° 42	64.1	37° 52	71.7	40° 36	79.8	42° 57	88.4	45° 00	107.1	48° 22		
2½ TO 1 (21° 48)	0° 00	22.9	0° 00	22.3	10° 19	24.4	19° 59	26.1	28° 36	28.3	36° 01	31.0	42° 16	33.9	47° 29	40.6	55° 30		
	21° 48	46.4	21° 48	51.3	26° 16	56.6	30° 07	62.6	33° 34	68.8	36° 32	75.7	39° 09	82.8	41° 27	98.6	45° 18		
3 TO 1 (18° 26)	0° 00	26.0	0° 00	26.3	9° 07	27.3	17° 47	28.8	25° 41	30.9	32° 41	33.3	38° 44	36.1	43° 54	42.3	52° 05		
	18° 26	47.4	18° 26	51.6	22° 57	56.3	26° 58	61.3	30° 26	66.8	33° 41	72.6	36° 29	78.8	38° 59	92.2	43° 13		
4 TO 1 (14° 02)	0° 00	30.5	0° 00	30.8	7° 48	31.6	15° 58	32.9	22° 18	34.7	28° 40	36.9	34° 21	39.4	39° 22	45.2	47° 34		
	14° 02	48.5	14° 02	51.8	18° 37											84.4	40° 40		
6 TO 1 (9° 28)	0° 00	35.9	0° 00	36.1	6° 38	36.8	13° 05	38.0	19° 12	39.6	24° 55	41.5	29° 34	43.7	34° 52	48.0	42° 54		
	9° 28	49.3	9° 28	51.6	14° 07							64.0	29° 33	68.1	32° 50	76.9	38° 20	96.7	46° 15
LEVEL HYDROSTATIC	0° 00	50.0	0° 00	50.2	4° 46	50.7	9° 28	51.5	14° 02	52.7	18° 26	54.2	22° 37	55.9	26° 34	60.1	33° 42	70.7	45° 00

1" in 12" (1 in 12) −4° 46 C	δ	2" in 12" (1 in 6) −9° 28 C	δ	3" in 12" (1 in 4) −14° 02 C	δ	4" in 12" (1 in 3) −18° 26 C	δ	5" in 12" (1 in 2.4) −22° 37 C	δ	Surface slope back of wall ε	Earth slopes and angles of repose φ
9.5	−25° 55	12.0	−44° 11	15.8	−55° 32	18.7	−62° 46	22.5	−67° 37	0° 00	1 TO 1 (45° 00)
9.2	7° 43	8.7	−19° 07	9.8	−41° 22	11.7	−55° 57	13.8	−65° 06	29° 45	
27.1	39° 17	20.2	31° 04	14.8	18° 27	11.1	0° 06	9.3	−23° 11	45° 00	
12.3	−19° 51	14.2	−35° 50	17.0	−47° 15	20.3	−55° 17	23.8	−61° 00	0° 00	1¼ TO 1 (38° 40)
13.9	15° 24	12.1	2° 57	11.7	−22° 30	12.4	−39° 21	13.9	−51° 56	29° 45	
31.7	33° 10	25.4	25° 51	20.3	16° 03	16.4	3° 08	13.9	−12° 51	38° 40	
14.9	−16° 14	16.4	−30° 13	19.0	−41° 07	22.0	−49° 20	25.3	−56° 30	0° 00	1½ TO 1 (33° 42)
20.2	19° 54	17.3	7° 26	15.5	−7° 12	14.8	−22° 29	15.1	−36° 24	29° 45	
35.1	28° 20	29.4	18° 32	24.7	13° 09	21.0	2° 44	18.3	9° 27	33° 42	
										0° 00	1¾ TO 1 (29° 45)
37.5	24° 29	32.5	18° 07	28.2	10° 28	24.7	1° 27	22.1	−8° 45	29° 45	
										0° 00	2 TO 1 (26° 34)
39.4	21° 22	34.8	15° 15	30.9	8° 08	27.0	0° 00	25.4	−8° 58	26° 34	
23.3	−18° 19	24.4	−19° 59	26.1	−28° 36	28.3	−36° 01	31.0	−42° 16	0° 00	2½ TO 1 (21° 48)
42.0	18° 02	38.2	10° 54	35.0	4° 27	32.4	−2° 38	30.4	−10° 12	21° 48	
										0° 00	3 TO 1 (18° 26)
43.7	13° 23	40.5	7° 49	37.8	1° 44	35.7	−4° 46	34.1	−11° 33	18° 26	
										0° 00	4 TO 1 (14° 02)
								38.8	−14° 00	14° 02	
36.1	−6° 38	36.8	−13° 05	38.0	−19° 12	39.6	−24° 56	41.5	−29° 35	0° 00	6 TO 1 (9° 28)
47.5	4° 36							42.9	−16° 21	9° 28	
50.2	−4° 46	50.7	−9° 28	51.5	−14° 02	52.7	−18° 26	54.2	−22° 37	0° 00	LEVEL HYDROSTATIC



ASSUMED WEIGHT OF FILL OR BACKING γ = 100 LBS. PER CUBIC FOOT. h = HEIGHT OF WALL IN FEET.
TO OBTAIN THE EARTH PRESSURE E MULTIPLY THE CONSTANT C BY THE SQUARE OF THE HEIGHT h. $E = Ch^2$.

NOTE:-
THE VAUES FOR HYDROSTATIC PRESSURE SHOULD BE CORRECT IN EACH CASE.
WITH α NEGATIVE FEW IF ANY OF THE RESULTS ARE RELIABLE OR CONSISTENT WHEN φ IS GREATER THAN ZERO. (PORTION TO RIGHT OF HEAVY LINE)
WITH α POSITIVE AND ε EQUAL ZERO THE VALUES OF C ARE PROBABLY TOO SMALL, WHILE WITH ε = φ THE VALUES FOR C AND ALSO δ ARE TOO LARGE TO BE THOROUGHLY CONSISTENT.

Table No. 1.—Constants C from Analytical Theory of Rankine. (Courtesy of Engineering News).

*Tables published in Engineering News, Vol. 62, No. 22, Nov. 25, 1909, page 588.

same value as E when h = unity and $\gamma = 100$. E for any value of h equals h^2C. (C is termed a constant for the reason that when once computed for any set of conditions the corresponding value of E is derived for any height h by squaring h and multiplying into C.)

In Figs. 2 and 3 the angle of repose ϕ is platted as abscissa and the constant C in pounds as ordinates. The back of wall batter angle α is constant for a given curve or group of curves. In Figs. 4, 5 and 6 the back of wall batter angle is platted as abscissa. Positive values of α are given on the right of zero, and negative on the left. C is platted as ordinates as before. All values of C and E are for a portion of earth or wall one foot or unity in length.

Characteristics of Curves for Back of Wall Batter Constant.

By referring to the figures the following will be noted:

In Fig. 2 the curve for back of wall batter $\alpha = 0$, and surcharge $\epsilon = 0$, Rankine and Rebhann both give values for C that agree. For $\alpha = 0$, and $\epsilon = \phi$ (angle of repose) Rankine gives increasingly higher values for C than Rebhann, as the angle ϕ increases from zero or hydrostatic pressure.

In Fig. 3 curves are shown for $\alpha = -4^\circ 46'$, $\epsilon = 0$ and $\epsilon = \phi$. Also for $\alpha = -22^\circ 37'$, $\epsilon = 0$ and $\epsilon = \phi$. The apparent disagreement between the two theories is not so great, with one exception, as in the previous cases shown, and there appears to be no complete break-downs except in Rankine $\alpha = -22^\circ 37'$ and $\epsilon = 0$. The exceptional disagreement is also for $\alpha = -22^\circ 37'$ $\epsilon = 0$. For example, for $\phi = 45^\circ$ Rankine gives the value of C equal 22.5 lb., while Rebhann gives only 3.1 lb. The result from Rankine is over seven times as great as that obtained from Rebhann. As shown later, however, Rankine's theory breaks down for all negative back of wall batter angles, α.

Characteristics of Curves for Angle of Repose ϕ Constant.

In Figs. 4, 5 and 6, as previously stated, the back of wall batter angles, α, are platted as abscissa, with ϕ and ϵ constants for a given curve, and C as ordinates. Fig. 4 shows curves for $\phi = 45^\circ$ and $\epsilon = 0^\circ$ and 45°. For comparison, the curve for $\phi = 0^\circ$ or hydrostatic pressure is platted in the dotted line.

For $\phi = 45^\circ$ and $\epsilon = 0$, Rankine and Rebhann give the same result when $\alpha = 0$. With $\alpha = 45^\circ$, Rankine

EARTH PRESSURE CONSTANTS (C) AND ANGLES OF RESULTANT (δ) WITH HORIZONTAL; FOR DIFFERENT ANGLES OF SLOPE (Φ), INCLINATIONS OF SURFACE (ε), AND BACK OF WALL BATTERS (α). SLIDING PRISM THEORY. COULOMB AND REBHANN. FROM PRELINI.

BATTERS AND ANGLES OF INCLINATION OF BACK OF WALL WITH THE VERTICAL, α. — VALUES OF EARTH PRESSURE CONSTANTS (C) AND ANGLES OF RESULTANT WITH THE HORIZONTAL (δ).

Earth slopes and angles of repose (Φ)	Surface slope back of wall (ε)	Vertical 0° 00 C	δ	1 in 12 (1 in 12) 4° 46 C	δ	2 in 12 (1 in 6) 9° 28 C	δ	3 in 12 (1 in 4) 14° 02 C	δ	4 in 12 (1 in 3) 18° 26 C	δ	5 in 12 (1 in 2.4) 22° 37 C	δ	6 in 12 (1 in 2) 26° 34 C	δ	8 in 12 (1 in 1.5) 33° 42 C	δ	1 in 12 (1 in 12) −4° 46 C	δ	2 in 12 (1 in 6) −9° 28 C	δ	3 in 12 (1 in 4) −14° 02 C	δ	4 in 12 (1 in 3) −18° 26 C	δ	5 in 12 (1 in 2.4) −22° 37 C	δ	12 in 12 (1 in 1) 45° 00 C	δ	Surface slope back of wall (ε)	Earth slopes and angles of repose (Φ)
1 to 1	0° 00	8.7		10.0		11.7		13.3		15.3		17.3		19.7		24.3		7.3		6.1		5.0		3.8		3.1		35.4		0° 00	1 to 1
	29° 45	14.7		17.6		20.9		25.1		29.3		33.9		39.9		53.0		12.4		9.9		7.9		6.1		4.7				29° 45	
45° 00	45° 00	25.1		29.3		34.6		40.6		46.8		54.5		63.0		83.7		20.7		17.2		14.3		11.3		8.9				45° 00	45° 00
1¼ to 1	0° 00	11.5		13.1		14.8		16.6		18.7		20.6		23.1		28.0		10.0		8.6		7.4		6.3		5.0				0° 00	1¼ to 1
	29° 45	29.5		33.2		37.3		42.0		47.3		53.1		60.0		75.8		26.2		23.3		20.5		17.8		15.6				29° 45	
38° 40	38° 40	30.4		34.8		39.5		44.8		51.1		58.3		66.5		84.8		26.1		22.9		19.8		17.0		14.3				38° 40	38° 40
1½ to 1	0° 00	14.2		15.9		17.7		19.5		21.6		23.8		26.0		30.5		12.8		11.3		10.2		8.9		7.8				0° 00	1½ to 1
	29° 45	29.6		33.2		37.3		42.0		47.3		53.1		60.0		75.8		26.2		23.3		20.6		17.8		15.4				29° 45	
	33° 42	34.5		38.2		42.9		48.4		54.4		61.2		68.7		86.5		30.3		26.9		24.2		21.5		19.4				33° 42	
33° 42	45° 00	65.6		69.6		75.5		81.6		89.3		98.7		109.6		135.6		62.7		61.1		62.2		64.2		79.3				45° 00	33° 42
1¾ to 1	0° 00	16.8		18.5		20.6		22.5		24.6		26.7		29.2		34.8		15.5		14.2		12.8		11.5		10.4				0° 00	1¾ to 1
	29° 45	37.2		41.3		45.7		50.5		56.1		62.4		69.8		85.7		33.9		30.9		28.1		25.6		23.2				29° 45	
29° 45	45° 00																													45° 00	29° 45
2 to 1	0° 00	19.1		21.1		22.8		24.6		26.7		29.1		31.3		36.3		17.7		16.3		15.1		13.7		12.3				0° 00	2 to 1
	26° 34	39.3		43.0		46.8		51.4		56.7		62.8		69.2		84.9		36.0		33.1		30.8		28.5		26.3				26° 34	
26° 34	45° 00																													45° 00	26° 34
2½ to 1	0° 00	22.9		24.6		26.4		28.1		30.1		32.5		34.7		40.1		21.1		20.3		19.2		17.6		16.6				0° 00	2½ to 1
	21° 48	42.9		46.2		49.4		53.6		58.4		63.2		68.9		82.9		40.2		37.8		35.7		33.9		32.2				21° 48	
21° 48	45° 00																													45° 00	21° 48
3 to 1	0° 00	25.9		27.4		29.1		31.0		32.5		35.1		37.5		42.2		24.6		23.1		22.2		21.0		19.9				0° 00	3 to 1
	18° 26	44.9		47.6		50.8		54.4		58.7		63.5		68.9		81.3		42.3		40.4		38.9		37.3		36.1		113.3		18° 26	
18° 26	45° 00																													45° 00	18° 26
4 to 1	0° 00	30.5		31.9		33.2		35.3		36.8		39.1		41.8		45.9		29.4		28.3		27.2		26.3		25.6				0° 00	4 to 1
	14° 02	47.0		48.9		51.3		54.2		57.5		61.4		65.7		76.6		44.6		43.1		41.9		41.1		40.6				14° 02	
	29° 45																													29° 45	
14° 02	45° 00																													45° 00	14° 02
6 to 1	0° 00	35.9		37.0		38.3		39.9		41.6		43.0		46.1		50.5		34.9		34.3		33.9		33.6		33.1		61.7		0° 00	6 to 1
	9° 28	48.4		50.1		51.6		54.1		56.8		58.8		63.8		72.3		47.1		46.1		45.6		45.2		45.1		93.7		9° 28	
9° 28	33° 42	188.2		178.0		169.6		169.8		172.5		177.2		188.0		288.6		208.5		244.8						676.7		276.0		45° 00	9° 28
Level (Hydrostatic)	0° 00	50.0	0° 00	50.2	4° 46	50.7	9° 28	51.5	14° 02	52.7	18° 26	54.2	22° 37	55.9	26° 34	60.1	33° 42	50.2	−4° 46	50.7	−9° 28	51.5	−14° 02	52.7	−18° 26	54.2	−22° 37	70.7	45° 00	0° 00	Level (Hydrostatic)

ASSUMED WEIGHT OF FILL OR BACKING γ = 100 LBS. PER CU. FT. TO OBTAIN THE EARTH PRESSURE E MULTIPLY THE CONSTANT C BY THE SQUARE OF THE HEIGHT h IN FEET. $E = Ch^2$ = EARTH PRESSURE IN POUNDS.

Table No. 2.—Constants C from Sliding Prism Theory, Rebhann's Graphics. (Courtesy of Engineering News.)

For the positive back of wall batter $\alpha = 33^\circ 42'$ and angle of surcharge $\epsilon = \phi$, Rankine gives what would appear to be excessively high values for C. Rebhann gives a relatively rapid increase from $\phi = 0$ (hydrostatic pressure) up to a slope 3 to 1 ($\phi = 18^\circ 26'$), and but moderate increase up to 1¼ to 1 ($\phi = 38^\circ 40'$). At a slope of 1¼ to 1 there is a break-down and the values of C rapidly decrease. That is from the graphical determination in which friction against the back of the wall is not considered. On the other hand, when friction against the back of the wall is considered and taken at $\phi' = \phi$, the same graphics, see curve "Rebhann $\alpha = 33^\circ 42'$, $\epsilon = \phi$ (directrix angle $= \phi + \phi' = 2\phi$)" gives values for C that are high beyond any reason. For this particular case we get what may be termed a double breakdown in the sliding prism theory, while as above stated Rankine gives very high values.

gives a much higher value than Rebhann. For negative values of α, Rankine gives rapidly increasing values of C, while they should manifestly be decreasing. Rebhann gives decreasing values with the curve convex downward. Of course a negative back of wall batter angle 45° is outside of any probability, and the values were only calculated to show the character of the curves in reaching that limit. With the angle of repose $\phi = 45^\circ$, and a negative back of wall batter of $\alpha = -45^\circ$, C must reduce to zero. For $\phi = 45^\circ$ and $\epsilon = 45^\circ$, Rankine gives excessively high values for α positive. For α negative they run down to a fairly consistent termination. Rebhann gives much lower values with ϵ positive, while for α negative the results coincide with those from Rankine from $-14^\circ 02'$ to $-22^\circ 37'$. After passing $-22^\circ 37'$ they again diverge, Rankine giving the greater values until the limit of -45° is reached.

As the reduction in pressure should be most rapid as the negative back batter, —α, approaches coincidence with the angle of repose (equal to the complement of ϕ) or limit, we should expect the curve for these values of C to be convex upward instead of downward as obtained from Rebhann.

Fig. 5 shows curves platted from values of C for $\phi = 33° 42'$, and $\epsilon = O°$, $33° 42'$ and $45°$. While the natural slope and surcharge of 1½ to 1 (angle = 33° 42′) are the most commonly met with, Rankine and Rebhann show poor agreement. For $\phi = 33° 42'$ and $\epsilon = \phi$, Rankine gives ex-

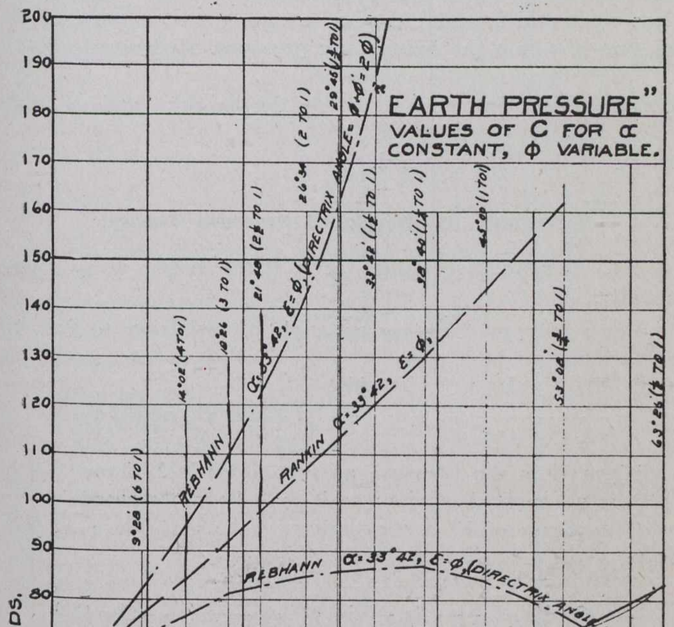


Fig. 2.—Platted Values for $\alpha = O$, $\epsilon = O$ and ϕ. Also $\alpha = 33° 42'$, $\epsilon = \phi$.

cessively high values. For $\phi = 33° 42'$ and $\epsilon = 45°$, Rebhann gives excessively high values, and when the negative value of $\alpha = 9° 28'$ is reached, a complete break-down occurs, as C begins to increase instead of continuing to decrease. With $\phi = 33° 42'$ and $\epsilon = O°$, Rankine gives the usual break-down for negative values of α.

In Fig. 6 is shown the curves obtained by platting the values of C for $\phi = 9° 28'$ (slope 6 to 1), and $\epsilon = O$, $9° 28'$ and $33° 42'$ respectively. The curve for hydrostatic pressure ($\phi = O°$) is platted here for comparison. For $\phi = 9° 28'$ and $\epsilon = O$, Rankine and Rebhann agree fairly well for positive values of α, both coinciding at $\alpha = O°$ and $45°$. Rebhann gives the larger intermediate values. For negative values of α Rankine gives values which increase with the negative increase while they should decrease. Rebhann gives a decrease in the values of C until $\alpha = —22° 37'$ is reached; then a slight increase is given up to $\alpha = —33° 42'$; after which they decrease, reaching zero when the value of —α = the complement of the angle of repose ϕ. With $\phi = 9° 28'$ and $\epsilon = 9° 28'$ the two theories give values for C that agree fairly well for α positive. For α negative, Rankine shows a decrease until $\alpha = —26° 34'$ is reached, after which an increase takes place. Rebhann gives a decrease for negative α until $—18° 26'$ is reached, and they remain almost constant up to $—38° 40'$. The values of C then increase until $—57°$ is reached, when they rapidly decrease, reaching zero at $\alpha = —80° 32'$ = complement of ϕ. These improbable negative values are given only to show the behavior of these formulae in reaching the limit.

Angle of Surcharge ϵ Greater Than Angle of Repose ϕ.

The most notable deficiency in one theory and the utter break-down of the other, is where the angle of surcharge ϵ is greater than the angle of repose ϕ. Rankine's formula gives no results whatever for those conditions, while Rebhann's graphics breaks down completely. Rebhann's break-down is most strikingly shown in Fig. 6, where the values of C for $\phi = 9° 28'$ and $\epsilon = 33° 42'$ are platted. Also in almost as marked degree in Fig. 5 for $\phi = 33° 42'$ and $\epsilon = 45°$. In both cases the values are excessively high. For $\phi = 9° 28'$ and $\epsilon = 33° 42'$ the lowest value of C is given when $\alpha = +9° 28'$ and equal 169.6 lb. Instead of continuing to decrease to $\alpha = O$ and throughout the increased

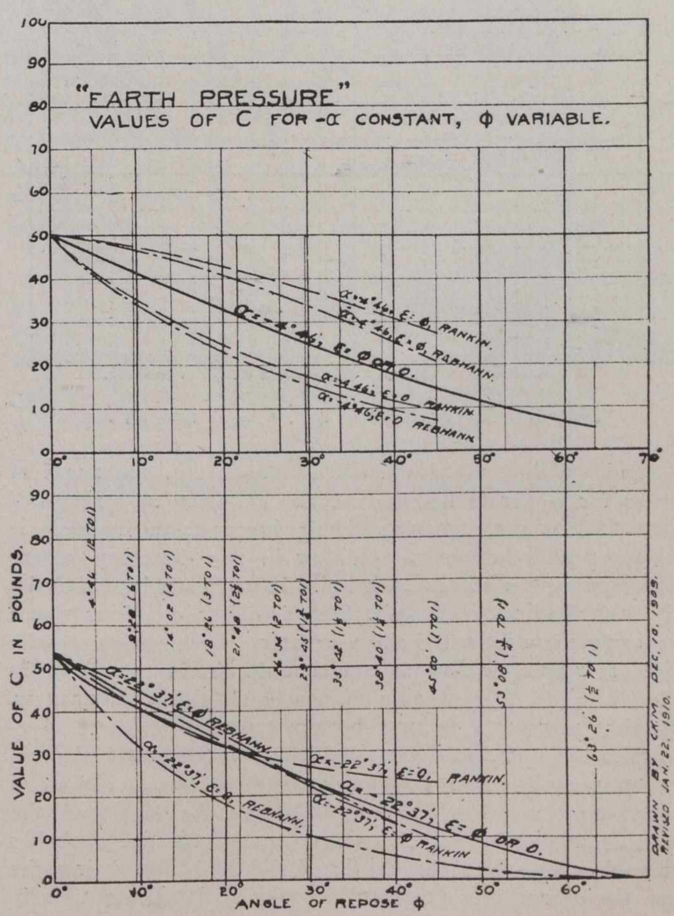


Fig. 3.—Curves for $\alpha = —4° 46'$, $\epsilon = O$ and ϕ, and $\alpha = —22° 37'$, $\epsilon = O$ and ϕ.

negative values of α, a very rapid increase takes place reaching the enormous amount of 677 lb. for $\alpha = —22° 37'$; while hydrostatic pressure only amounts to 54.2 lb. The sketch of Rebhann's graphics from which the above values were derived is shown in Fig. 9.

The failures of Rankine and Rebhann under conditions of angle of surcharge ϵ greater than the angle of repose ϕ are very important for the following reasons:

1st. It is not uncommon to have a bed of sand, gravel, or stiff clay overlying a stratum or bed of very soft material which is penetrated by the excavation. With good, firm material above and below such a stratum, the pressure developed by the flow of the soft material caused, by the superimposed load and high surcharge (over the vertical projection of the back of wall batter) should be considered as giving the amount to be taken care of.

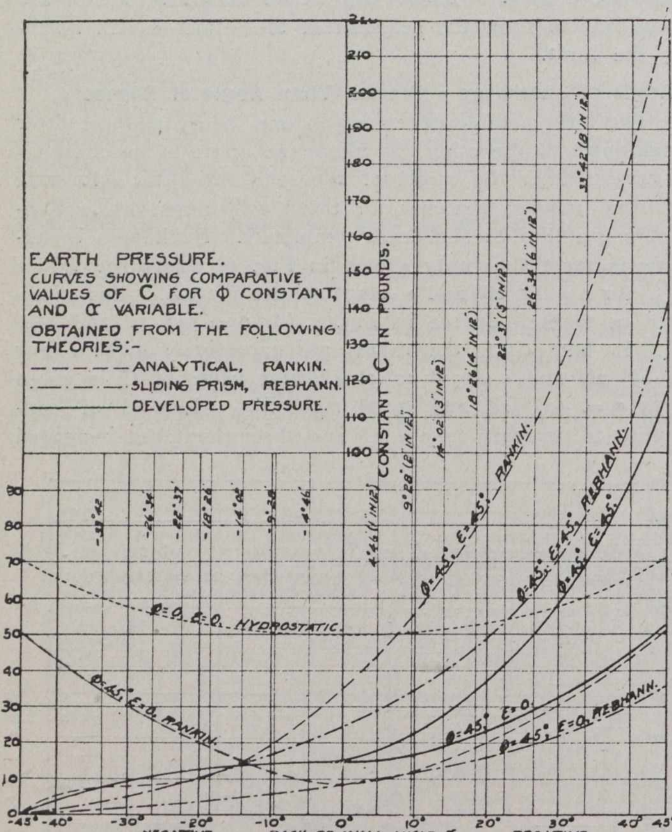


Fig. 4.—Curves for $\phi = 45^\circ$, $\epsilon = 0$ and 45°.

2nd. With a material such as plastic clay the angle of repose for moderate heights may be as much as ninety degrees. At a great enough depth, however, the squeeze is developed and there results a flow in any direction where full resistance is not encountered. It will even heave vertically from the bottom of a pit. That is only a condition where the same material will hold a greater surcharge than the angle of repose or flow at considerable depth. It is probably owing to the cohesion of nearly all materials used in fills that more wall failures have not occurred, where theoretically they should have failed. On account of the cohesion, as well as the friction of the material, to be overcome before an active lateral pressure can be developed, the point of application of the resultant pressure is probably lower than one-third the height of fill h. That being the case the overturning moment would be less than usually computed.

The Developed Pressure Theory.

On account of the great variation and lack of agreement between the analytical theory of Rankine, and the sliding prism theory as treated by Rebhann, and their break-downs, the author was led to consider earth pressure from an entirely different point of view.

The values obtained from the formula for hydrostatic pressure are considered to be beyond question. That being the case, the author was led to try out results by working with the hydrostatic pressure as a base from which to obtain all other values, corresponding to the different assumed angles of repose. Under that conception he treated the angle of repose as the angle at which flow would take place, or the angle of flow. Possibly another conception to take would be to treat it as the angle of resistance to flow, when referred to the horizontal or the angle of flow of a fluid. In fluids the pressure developed by gravity is transmitted equally in all directions. If in any case the substance is considered as losing part of its fluidity, there would then be a certain resistance to flow. If the angle of the resistance is expressed by the slope ratio or the angle ϕ, then the sine of ϕ may be considered as the amount of the resistance. Then we would consider the hydrostatic pressure reduced by the sine of ϕ into the hydrostatic pressure. Hydrostatic pressure $E = \frac{h^2\gamma}{2}$, in which h equals the height, and γ the weight of the fluid retained.

Formula for Developed Pressure Theory.

1st. For positive values of α (back batter away from the fill).

For a substance having an angle of resistance to flow ϕ, the formula would become

$$E = \frac{h^2\gamma}{2} - \frac{h^2\gamma}{2} \sin\phi = \frac{h^2\gamma}{2}(1 - \sin\phi), \text{ when } \alpha = 0.$$

When E is the pressure against a vertical plane alone and has no vertical component it may be represented by P.

The values of E at the limiting values of ϕ are as follows:

$$\phi = 0,\ E = \frac{h^2\gamma}{2}(1 - \sin\phi) = \frac{h^2\gamma}{2}(1 - \sin 0)$$

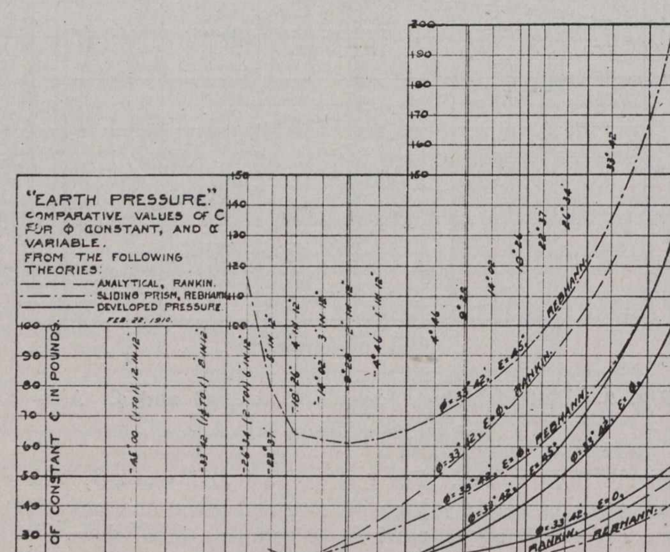


Fig. 5.—Values of C for $\phi = 33^\circ\ 42'$, and $\epsilon = 0$, $33^\circ\ 42'$ and 45°.

$$= \frac{h^2\gamma}{2}(1 - 0) = \frac{h^2\gamma}{2} = \text{hydrostatic pressure.}$$

$$\phi = 90^\circ,\ E = \frac{h^2\gamma}{2}(1 - \sin\phi) = \frac{h^2\gamma}{2}(1 - \sin 90^\circ)$$

$$= \frac{h^2\gamma}{2}(1 - 1) = \frac{h^2\gamma}{2}(0) = 0.$$

For the intermediate value of ϕ we have $\frac{O + 90}{2} = 45^\circ$,

when $\phi = 45^\circ$, $E = \frac{h^2\gamma}{2}(1 - \sin\phi) = \frac{h^2\gamma}{2}(1 - \sin 45^\circ)$

$= \frac{h^2\gamma}{2}(1 - .707) = \frac{h^2\gamma}{2}.293.$ In other words, the inter-

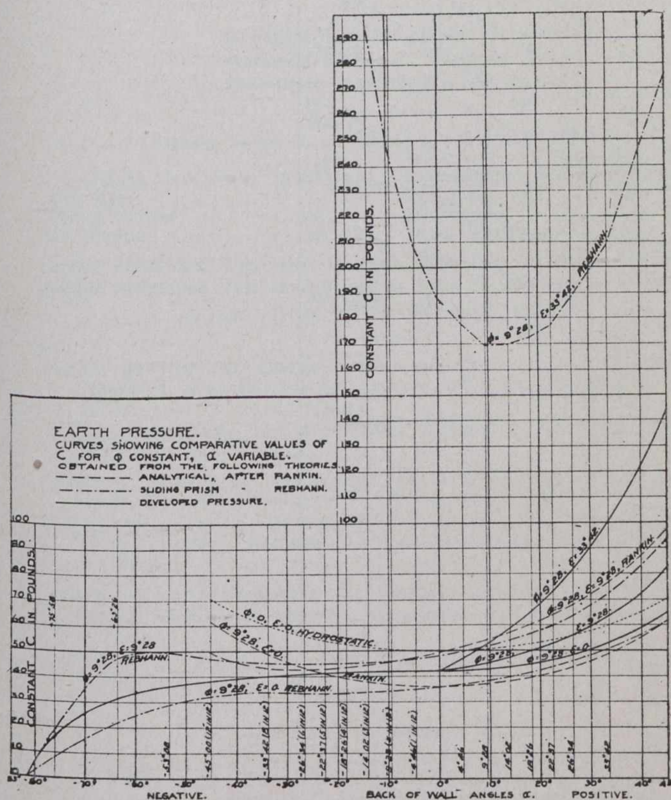


Fig. 6.—Platted Values for $\phi = 9^\circ\ 28'$, $\epsilon = O$, $9^\circ\ 28'$ and $33^\circ\ 42'$.

mediate value of ϕ gives a value for E which is a little over one-quarter that given for $\phi = O^\circ$ making E the maximum. The increase in the value of E (= C) is almost inversely proportional to the square of decrease of ϕ from the value (90°), giving the lower limit, as by the above formulae.

For back of wall batter α positive (sloping away from the fill), and $\epsilon = O^\circ$, the formulae becomes:

$$E = \sqrt{\left(\frac{h^2\gamma}{2}(1 - \sin\phi)\right)^2 + W^2e.} \qquad We = \frac{h^2 \tan\alpha\,\gamma}{2}$$

= the weight of the earth wedge carried on the vertical projection of the back batter of the wall.

In Fig. 7 is given the dimensions by which the area of the earth wedge carried over the back of wall batter may be determined. The larger diagram was originally drawn to scale with the height h as unity, and the results checked with trigonometrical formula. Referring to the sketch at top of the diagram the formula for obtaining the area of the earth wedges A B L or A B S are as follows:

$BL = AL \tan\alpha = h \tan\alpha.$

$$\text{Area } ABL = \frac{BL \times h}{2} = \frac{h \tan\alpha\, h}{2} = \frac{h^2 \tan\alpha}{2}$$

$SL = BL \tan\epsilon = h \tan\alpha \tan\epsilon.$

$SA = h + SL = h + h \tan\alpha \tan\epsilon = h\,(1 \div \tan\alpha \tan\epsilon)$

$$\text{Area } ABS = \frac{BL \times SA}{2} = \frac{h \tan\alpha\, h\,(1 + \tan\alpha \tan\epsilon)}{2}$$

$$= \frac{h^2 (\tan\alpha + \tan^2\alpha \tan\epsilon)}{2}$$

$$\text{Weight of } ASB = We = \frac{\gamma h^2 (\tan\alpha + \tan^2\alpha \tan\epsilon}{2}$$

The horizontal earth pressure P_ϵ is taken for the full height S A, and equals $\frac{\gamma}{2}(h\,[1 + \tan\alpha \tan\epsilon])^2 (1 - \sin\phi)$.

With surcharge and back of wall batter away from the fill,

$$E = \sqrt{P_\epsilon^2 + W_\epsilon^2} =$$

$$\sqrt{\left[\frac{\gamma(h\,[1 + \tan\alpha \tan\epsilon])^2(1 - \sin.\phi)}{2}\right]^2 + \left[\frac{\gamma h^2(\tan\alpha + \tan^2\alpha \tan\epsilon)}{2}\right]^2}$$

The assumed point of application of P_ϵ is at ⅓ S A = $\frac{1}{3}h_\epsilon$ romthe bottom.

DIRECTION OF EARTH PRESSURES.

The direction of the resultant earth pressure E with the horizontal equals the angle δ, and tang $\delta = \frac{W_\epsilon}{P}$

The earth pressure P is considered as acting only in a horizontal direction whether the wall carries a surcharge or not. When a mass of earth is either confined in a bin or surrounded by a mass of the same material, and indefinite in extent, the developed pressure producing squeeze, to be in equilibrium, must act and react on the particles within the mass. Consequently the net resultant of the squeeze will be at right angles to the force of gravity.

The case of material simply confined in a bin should not be confused, however, with the case in which material is withdrawn from the bottom. In the latter case, as soon as material is withdrawn from the bottom, friction is developed against the sides of the bin and the whole case is thereby modified.

Where Surcharge Gives no Added Pressure.

For a negative back of wall batter as well as for vertical back, a surcharge fill is not considered as giving any more pressure than if it ran off level or even sloped down away from the back of the wall. To illustrate, take Fig. 8, which represents a bin 40 ft. deep and 10 ft. square. For hydrostatic pressure the amount is the same, whether the fluid pressing against the side of the bin extends back from the face one foot or is of indefinite extent. The same should hold true within certain limits for granular and semiplastic substances. With a bin of the size shown and filled with a granular mass possessing little or no cohesion and incompressible, but having sufficient friction between the particles to stand at an angle of repose of 45°, there is little reason to believe there would be any more pressure on the side A B with a surcharge slope than with a level top. In the upper right-hand corner of Fig. 8 is sketched what we will term a pile of cylinders, marked 1A — 1E, 1A — 9A, etc. A common example is the piling of barrels. When piled as shown they will stand with a natural slope of 60°, and are held in this position by friction alone, as there is manifestly no cohesion. If the cylinders and the plane a c, on which they rest, were to lose all friction they would sink to the level of 1A, 1B, etc. As long as the angle of friction between cylinders in contact is greater than 30° the cylinders will remain in equilibrium. (The angle which the tangent passing through the points of contact of the cylinders makes with the horizontal is 30°.)

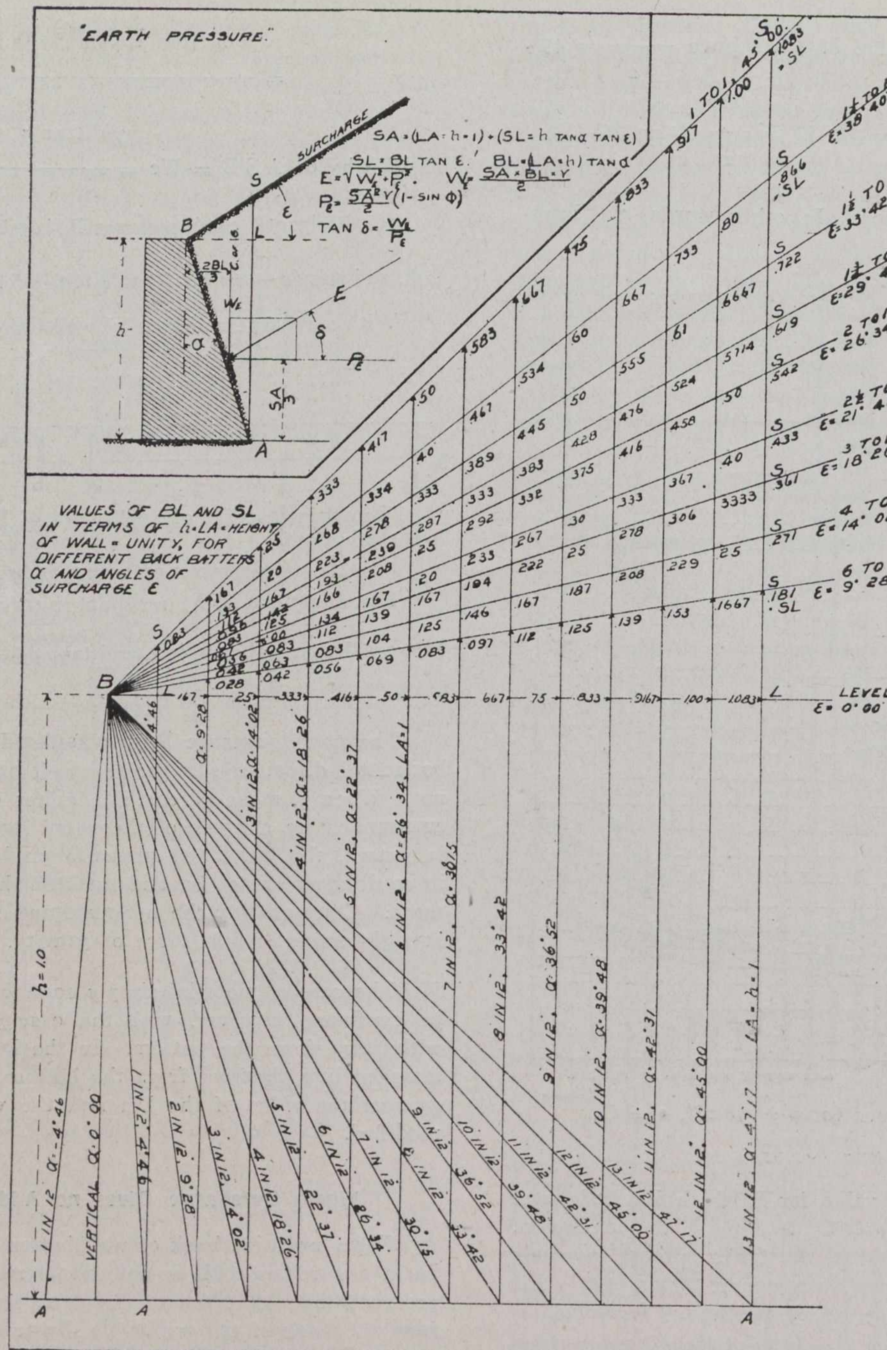
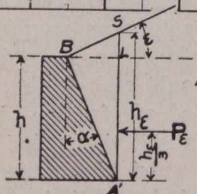


Fig. 7.—Surcharge Heights and Back of Wall Batter and Surcharge Triangle Dimensions.

HEIGHTS h_ε AND AREAS A_u OF EARTH WEDGE BACK OF WALL FOR DIFFERENT DEGREES OF SURCHARGE ε AND BACK OF WALL BATTERS α. BASED ON HEIGHT OF WALL h EQUAL UNITY.

SURFACE SLOPE OR SURCHARGE ANGLE ε	BACK OF WALL BATTERS AND ANGLE OF INCLINATION WITH THE VERTICAL α.																																SURFACE SLOPE OR RATIO OF BASE TO HEIGHT
	VERTICAL 0° 00'		1" IN 12" 4° 46'		2" IN 12" (1 IN 6) 9° 28'		3" IN 12" (1 IN 4) 14° 02'		4" IN 12" (1 IN 3) 18° 26'		5" IN 12" (1 IN 2.4) 22° 37'		6" IN 12" (1 IN 2) 26° 34'		7" IN 12" (1 IN 1.71) 30° 15'		8" IN 12" (1 IN 1.5) 33° 42'		9" IN 12" (1 IN 1.33) 36° 52'		10" IN 12" (1 IN 1.2) 39° 48'		11" IN 12" (1 IN 1.09) 42° 31'		12" IN 12" (1 IN 1) 45° 00'		13" IN 12" (1 IN 0.92) 47° 17'		14" IN 12" (1 IN 0.86) 49° 24'		15" IN 12" (1 IN 0.80) 51° 20'		
	CONSTANTS FOR HEIGHT h_ε AND AREA A, WHEN HEIGHT OF WALL h IS EQUAL UNITY.																																
	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	h_ε	A_u	
45° 00'	1.00	.000	1.08	.045	1.17	.097	1.25	.156	1.33	.222	1.42	.295	1.50	.375	1.58	.462	1.67	.556	1.75	.656	1.83	.764	1.92	.878	2.00	1.000	2.08	1.100	2.17	1.263	2.25	1.405	1 TO 1
38° 40'	"	"	1.07	.044	1.13	.094	1.20	.150	1.27	.211	1.33	.278	1.40	.350	1.47	.428	1.53	.511	1.60	.600	1.67	.695	1.73	.794	1.80	.900	1.87	1.010	1.93	1.127	2.00	1.250	1¼ TO 1
33° 42'	"	"	1.06	.044	1.11	.093	1.17	.146	1.22	.204	1.28	.266	1.33	.333	1.39	.405	1.45	.482	1.50	.563	1.55	.648	1.61	.739	1.67	.833	1.72	.934	1.78	1.036	1.83	1.145	1½ TO 1
29° 45'	"	"	1.05	.044	1.09	.091	1.14	.143	1.19	.199	1.24	.258	1.29	.321	1.33	.392	1.38	.460	1.43	.535	1.48	.615	1.52	.697	1.57	.786	1.62	.875	1.67	.972	1.71	1.071	1¾ TO 1
26° 34'	"	"	1.04	.043	1.08	.090	1.12	.141	1.17	1.94	1.21	.252	1.25	.313	1.29	.377	1.33	.445	1.38	.515	1.42	.590	1.46	.668	1.50	.750	1.54	.834	1.58	.923	1.62	1.015	2 TO 1
21° 48'	"	"	1.03	.043	1.07	.089	1.10	.138	1.13	.189	1.17	.243	1.20	.300	1.23	.364	1.27	.422	1.30	.487	1.33	.556	1.37	.626	1.40	.700	1.43	.771	1.47	.855	1.50	.937	2½ TO 1
18° 26'	"	"	1.03	.043	1.06	.088	1.08	.135	1.11	.185	1.14	.237	1.17	.292	1.19	.349	1.22	.407	1.25	.469	1.28	.533	1.31	.598	1.33	.667	1.36	.736	1.39	.809	1.42	.885	3 TO 1
14° 02'	"	"	1.02	.043	1.04	.087	1.06	.133	1.08	.181	1.10	.230	1.13	.281	1.15	.334	1.17	.389	1.19	.445	1.21	.504	1.23	.563	1.25	.625	1.27	.687	1.29	.753	1.31	.820	4 TO 1
9° 28'	"	"	1.01	.042	1.03	.086	1.04	.130	1.06	.176	[illegible]	.223	1.08	.271	1.10	.320	1.11	.371	1.12	.423	1.14	.465	1.15	.529	1.17	.583	1.18	.638	1.19	.696	1.21	.755	6 TO 1
4° 46'	"	"	1.00	.042	1.01	.084	1.02		1.03		1.03		1.04		1.05		1.05		1.06		1.07		1.08		1.08		1.09		1.10	.640	1.11	.690	12 TO 1
LEVEL	"	"	1.00	.042	1.00	.083	1.00	.125	1.00	.167	1.00	.208	1.00	.250	1.00	.292	1.00	.333	1.00	.375	1.00	.417	1.00	.458	1.00	.500	1.00	.542	1.00	.583	1.00	.625	0 0



A_u EQUAL AREA OF TRIANGLE A'BS = SA' × BL ÷ 2 = h_ε × BL ÷ 2.
h_ε EQUAL HEIGHT, FROM THE BOTTOM OF THE BACK BATTER OF WALL TO THE POINT WHERE ITS VETICAL PROJECTION INTERSECTS THE SURFACE OF THE EARTH FILL OR BACKING.
h_ε = SA' = SL + (LA' = h) = h TAN α TAN ε + h = h(1 + TAN α TAN ε). FOR h = UNITY, h_ε = 1 + TAN α TAN ε.
A_u = h_ε × BL ÷ 2 = h(1 + TAN α TAN ε)(BL = h TAN α) ÷ 2 = h^2(TAN α + TAN^2 α TAN ε) ÷ 2. FOR h = UNITY, A_u = (TAN α + TAN^2 α TAN ε) ÷ 2.
TO OBTAIN THE HEIGHT h'_ε FOR ANY HEIGHT OF WALL h MULTIPEY h_ε OF THE TABLE FOR THE GIVEN VALUES OF α AND ε BY h. FOR EXAMPE FOR h = 20', α = 22° 37' AND ε 33° 42'. FROM THE TABLE h_ε IS GIVEN AS 1.28. h'_ε = (h_ε = CONSTANT) h = 1.28 × 20 = 25.6 FT.
TO OBTAIN THE AREA A FOR ANY HEIGHT OF WALL MULTIPLY A_u OF THE TABLE FOR THE GIVEN CONDITIONS BY THE SQUARE OF THE HEIGHT h. A = $h^2 A_u$. FOR VALUES OF α AND ε AS ABOVE A_u = .266. WENCE FOR h = 20 FT, A = 20^2 × .266 = 400 × .266 = 106.4

Fig. 7a.—Tabulation of Computed Values of h_ε Correspondin g to Heignt SA of Fig. 7. Also Area Au Corresponding to Triangle BAS of Fig. 7.

(Continued Next Week.)

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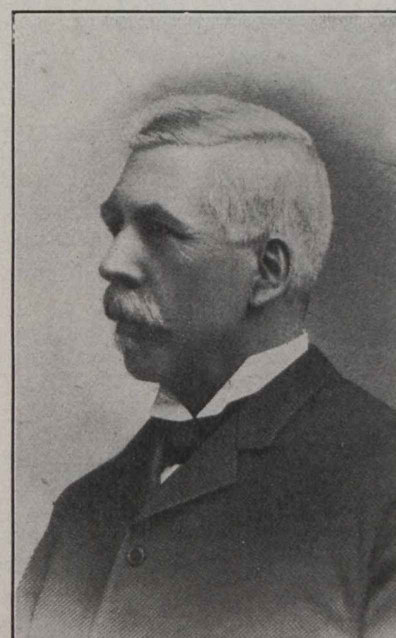
CONTENTS OF THIS ISSUE.

SIR WILLIAM WHYTE.

At sixty-eight, the strenuous man requires a rest. Some think forty-five and fifty old enough to retire from the brunt of business battle. Sir William Whyte is within two years of three score and ten, and has decided that at the end of the month he will endeavor to think less about the technicalities of running the Western Canadian section of a big railway. Since 1897, as vice-president of the Canadian Pacific Railway he has managed their lines west of Fort William. It is difficult for a transportation genius such as Sir William to disentangle himself from the web of railroad steel which he has helped to spin. So it will not be an easy task to drop a railroading experience of nearly half a century to fritter away time and think of past achievements and in pacing the deck of semi-idleness. Even had Sir William a strong desire along that line, the Canadian Pacific Railway directors would still like the benefit of his counsel.



SIR WILLIAM WHYTE,
Vice-president of the Canadian Pacific Railway, whose Retirement is Announced This Week.

When the Western vice-president reached mile-post sixty-five on the railroad of life he was approached by Sir Shaughnessy, the president, and requested to remain in office a few years longer. This was a remarkable compliment to the vice-president, for those who preside over the destinies of big railroad corporations think that at sixty-five the usefulness of their officials should be rewarded by retirement. Here are the words of Sir Thomas himself in making the announcement at Winnipeg this week:—

"The period at which the connection of Sir William Whyte, of the company, might have been severed under the regulations was three years ago. At that time, at my urgent request and solicitation, he consented to remain in the service of the company a few years longer. Sir William has now advised me that he has decided to retire and to spend the balance of his life in rest. It has consequently been agreed by the board of directors that he should retire from the active control of the lines in Western Canada on September 30th next. The Canadian Pacific will not, however, lose the great benefit of the experience of Sir William. It has been decided that he be elected to the board, and he will continue his service to the company in that capacity."

Thus Sir William Whyte, whom King George made a Knight Bachelor in June, becomes a member of the Canadian Pacific directorate His great interest in the welfare of the line will thus be maintained as it would have done anyway.

Sir William's career in Canada has been yet another example of what can be accomplished by a plodding individual who chooses a particular avocation and sticks to it. Born in Scotland in 1843, he came to Canada as a young man of twenty years of age. After seven years' service with the Grand Trunk Railway he was made freight agent at Stratford, and later promoted to London. In 1881 he became assistant superintendent of the central division from Kingston to Stratford, but in 1883 he resigned and became general superintendent of the Credit Valley Railway. He then became connected with the Toronto, Grey and Bruce Railway, which later became part of the Canadian Pacific system. In 1886 he became general superintendent of the western division, and in 1897 he was manager of Canadian Pacific lines west of Fort William. He is also a director of the British Columbia Southern Railway.

It is good to know that Sir William Whyte will still be among his friends, both Eastern and Western, that he will still remain as a friend and counsellor of the Canadian Pacific Railway and of the people of Canada. There is every wish for the restful period of life which Sir William has so well earned.

But it may be that that period will be spent in the office of the High Commissioner for Canada in London.

HYDRAULIC TURBINES.

The choice of turbines has become a very important element in the work of the hydraulic engineer of to-day. Up till recently power practice has not required a very efficient turbine. Small manufacturing establishments were prevalent in which it was not necessary to have turbines of high standard. Now, however, with the growth in size of plants and units, the problem of efficiency becomes much more important. Also with the development of streams of veritable flow and the consequent necessity of adequate storage reservoirs the power derived must be a maximum to allow of competition with steam and gas plants.

The Jonval and Girard turbines appear to be rapidly decreasing in use, with a corresponding increase in the production of Francis turbines.

It is worthy of note that, although the Francis turbine was first designed in America, its greatest development has come in Europe. Now, however, indications are that as efficient machines can be designed in America as in Europe. This has been brought about by the careful and intelligent study that has been devoted to it by American manufacturers.

Aside from the question of place of manufacture, the status of the modern hydraulic turbine is of great interest in present-day practice. Results in efficiency have been secured which are, to say the least, astonishing, and from recent papers which have appeared on this subject it would seem that the limit of obtainable efficiency has been reached. The allied subject of governing these machines has also reached a very commendable state.

There appeared a short time ago in the transactions of the American Society of Civil Engineers a paper by Chester W. Larner of intense interest to engineers interested in the design and selection of turbines. In this paper Mr. Larner notes that one of the chief obstacles in the path of progress to the present time is the scarcity of published data on the performance of turbines of recent construction. He publishes results of tests made on wheels designed by himself in which efficiencies are shown ranging up to 90 per cent. The classification of turbines according to unit speed, while showing American practice, is of immense benefit to the engineer who must make a choice of wheel for a particular condition. It would appear that at the present time the old idea of standardized wheels for all conditions is being abandoned, and that particular designs for individual conditions can be obtained from the manufacturer.

It is true, however, that later on adaptations of wheels in actual use will probably be used to a great extent. However, new designs will consist of improvements on designs and use, these improvements being based on theoretic considerations.

An article by Professor Prasil, published this week in The Canadian Engineer, contains some very interesting experiments on turbines.

While we agree that the limit of attainable efficiency has been reached and that great advances have been made in perfection of governing, still much remains to be developed and discovered in the other relations of hydraulic design, such as the placing of turbine and the regulation attainable with long penstocks and long feeder conduits.

EARTH PRESSURES.

In this week's issue there appears an exceedingly interesting article on "Earth Pressures" by Charles K. Mohler. This article was presented originally before the Western Society of Engineers, and later appeared in their journal.

We feel that this subject is of so much importance to the practising engineer that we are reproducing the article as it was given. The paper is interesting not only for being of interest to the designer as a new conception of the theory of earth pressure on retaining walls, but also as being the beginning of a discussion on the theories of earth pressure pending experiments on a large scale.

Up to this time little attention has been paid to the subject of earth pressure as applied to design from a mathematical standpoint. This is not as it should be, for all engineering design should be based on theoretic deduction reinforced by experiment. Most retaining wall design at the present time is founded on empirical formulæ, which are used continuously without regard for local conditions of soil, etc.

This article will undoubtedly help to put the whole subject of earth pressures on a better basis.

EDITORIAL COMMENT.

The Medical Health Department of Toronto are keeping an extra close lookout on the sanitary conditions of the food supply during Exhibition weeks. They are enforcing the Food Act to its limit, and as a result there are many appearances in court.

* * * *

We note with regret that a railroad bridge which was being constructed across a deep gorge at Bruil, France, collapsed last week, carrying with it thirty workmen. Practically all were killed or fatally injured. Design and erection of engineering structures in Europe are usually of such a conservative nature that this catastrophe comes as a great surprise.

* * * *

The Canadian National Exhibition grows more useful with age. For thirty-three years it has been not only a Toronto, but a national institution, and its broad scope, educational spirit and business-getting qualities have made it a show of world-wide fame. The up-to-date Canadian, British and American house cannot afford to be non-exhibitors. Folks go to the National Fair of Canada for business as well as for pleasure. From all viewpoints almost, it is one of the finest exhibitions in the world.

* * * *

The Ontario Government has decided to buy the bonds of the town of Cochrane, to enable the corporation to pay the interest and sinking fund of the debenture debt, towards erecting new public buildings. This is a commendable action. It is encouragement to stricken pioneers and a tribute to the sympathy of the Ontario ministers and the Toronto Board of Trade. We can well afford now and then to mix a little kindness with finance. Cochrane is a town hewn out of Northern Ontario bush. Soon after the first civic council was formed, the necessity for selling debentures arose. None of the members possessed municipal experience. They soon acquired knowledge and issued their first bonds successfully, obtaining par. The action of the Ontario Government will help where assistance is needed and will not be abused.

* * * *

The Conservation Commission have made an investigation of all the water-powers of Canada, and a report covering the water-power of every province will be issued before the end of the year. The work of the Commission engineers has been completed in the Maritime provinces and Quebec, and work is now being done in the West, bringing up to date, data of the water-powers there. For Ontario, the Commission relies on the work of the Hydro-Electric Power Commission. The Conservation Commission has been advised of an important change of policy on the part of the Quebec Government in respect to water-power. These powers will not hereafter be alienated in perpetuity, but franchises will be based on long terms of lease, subject to revision of rentals.

* * * *

Repeated guesses as to the location of Grand Trunk Pacific divisional points in British Columbia will cease as the result of an official announcement. The first divisional point out of Prince Rupert will be up the line about 120 miles, and the second one will be located east of Hazelton, near Aldermere, in the Bulkeley valley, and some distance west of Houston. The third divisional point is to be established west of Fraser Lake. The company's plans for the town site in the vicinity of Fort George have not been made public. If a site distant from the present town of Fort George is chosen, it is to be feared that much disappointment will be experienced by real estate buyers in that neighborhood. There will be at least one, and possibly two, divisional points on the line between Fort George and Edson, Alta. The company owns a town site at the west end of Fraser Lake, a large inland sea, and another at a point on the south shore between the east and west ends of the lake.

* * * *

Conservation of resources is becoming an important subject in England. Sir William Ramsay, K.C.B., in the presidential address at the opening of the annual meeting of the British Association for the Advancement of Science, dealt mainly with the atomic theory and the existing supply of stored-up energy. After speculating on the stored energy of radium and the possible sources of energy to be deduced from the disintegration of various substances through its agency, he proceeds to dwell on the known stores of energy, namely, the coal fields. He earnestly repeated the warnings given by scientists from time to time against the present reckless work. With the rapid increase in the output of coal the British store would be exhausted in one hundred and seventy-five years. Therefore, it was to the more economical use of coal that the nation must look for the prolongation of its life. He urged the initiation of a conservation commission like that of the United States, and legislation to control.

LETTER TO THE EDITOR.

The Editor, Canadian Engineer:

In the Canadian Engineer of August 17th, 1911, Vol. 21, Page 206, you have an item dealing with the horse power of manila rope, which to me appears to be wrong. In the last paragraph you have:

Then $800 - 205 = 595$ lbs. A part of this is balanced by the initial tension necessary to stop rope from slipping in the groove, which we have decided to be in the ratio of 1:2 $\therefore$ we have ($\frac{595 \times 2}{3} = 396$ lbs.) to be utilized in useful work.

Should it not be $595 \times \frac{1}{2} = 297.5$ lbs. to be utilized in work?

$$\therefore \frac{297.5 \times 4200}{33{,}000} = 37.8 \text{ h.p. Ans.}$$

As you have it, the ratio of the tension in the slack and driving side is 1 : 3 and not 1 : 2.

If I am wrong, I shall be pleased to have further explanation if you have an opportunity to look into it further.

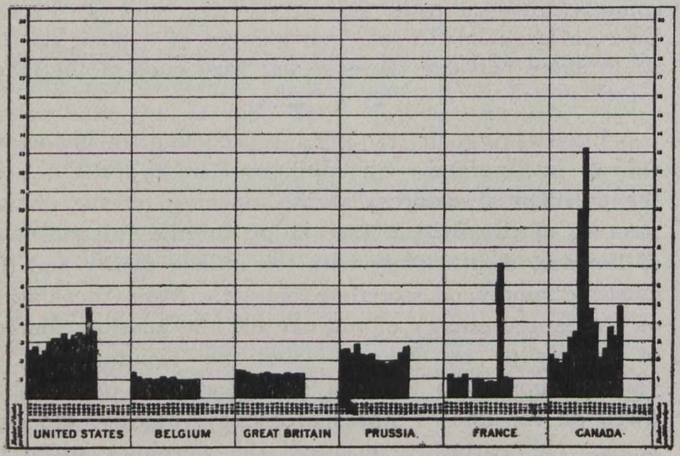
Yours truly,
J. A. MacKay.

[You will note that the ratio of tensions between the slack and driving side of rope is 1 : 2. Now there is a balance of 595 lbs. The initial tension, therefore, necessary to prevent rope from slipping is half the effective work done. Taking result of 396 lbs. utilized in work, plus one half of this, or 198 lbs., equals 595 lbs., which checks the previous result. I hope this will clear matters for you.—The Editor.]

MINE ACCIDENTS.

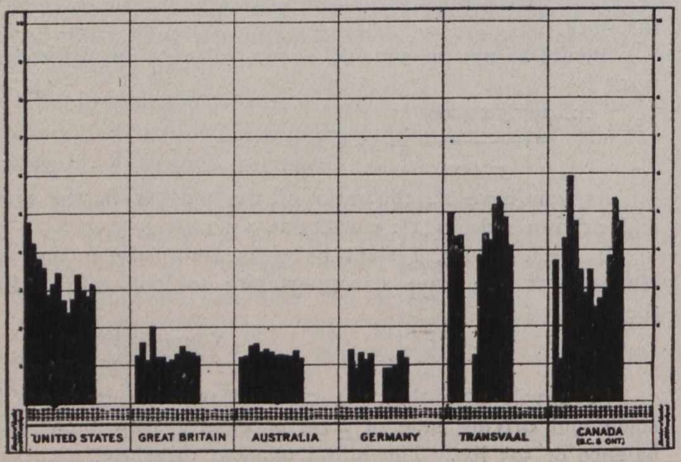
The following data and plates were abstracted from the report of the Committee on Conservation:—

This diagram shows that the death rates per 1,000 men employed in the coal mines of Canada and the United States are greater than in any other country in the world for which accurate statistics are available.



COAL MINE ACCIDENTS.
Number of Men Killed for Each Thousand Employed.

The diagram also shows that fatalities in the United States and Canada are on the increase, while Great Britain, Belgium, Prussia and France show a gradual decrease. We must interpret this in this way: (1) The danger inherent in the work can never be eliminated but could be brought down to a minimum, as indicated by the low, constant death rate in Belgium, Great Britain, and France (excepting the year 1906); (2) Coal mine explosions occur very frequently in Canada and the United States, while they are more infrequent in other countries. The causes for this loss of life are complex and neither the operators nor the miners willingly submit to them. It is not reasonable to expect that the loss of life and property can be entirely done away with; but at the same time, experience has abundantly proven that careful and impartial investigations of such conditions will point the way to remedying of at least some of the abuses. In view of the importance of the subject to the country and the public at large, such studies should be undertaken.



METAL MINE ACCIDENTS.
Number of Men Killed for Each Thousand Employed.

It is generally supposed that a great many more men are killed in coal mines than in metal mines. The following tables show that during 1900-09 the average fatality rate per thousand men employed in the coal mines of Canada was 4.79; and, for the metal mines, 3.82.

The average fatality rate in the United States during the period (1894-1908) was 3.09. This rate was considered so high that, in 1906, the American Mining Congress at Denver, Colorado, appointed a committee to draft a law for the regulation of quarrying and metalliferous mining under the criminal codes of the States, with the hope that the uniform adoption of such a law would tend to reduce the number of accidents. The report of this committee is contained in Bulletin No. 46, of the American Institute of Mining Engineers.

With the exception of the Kimberley diamond mines and the Transvaal, where native and Chinese labour are employed, the fatality rate during 1900-1909, was considerably lower elsewhere than in Canada. It requires no discussion to emphasize the importance of an inquiry into the whole subject of fatal accidents in metal mines of Canada.

An analysis of the statistics respecting metal mining accidents of British Columbia for the last ten years, shows that over twenty-six per cent. of the fatalities were caused by explosives directly or indirectly. Mr. E. T. Corkill, Inspector of Mines for Ontario, states, in the Nineteenth Annual Report of the Bureau of Mines (p. 58), that, "Accidents from explosives are the main source of danger, and were, ultimately the cause of 49 per cent. of the fatalities in 1909." An Act respecting the testing and inspection of explosives has been prepared by the Mines Branch, Department of Mines, and will be presented to Parliament this session.

TO BETTER SAFEGUARD INTERESTS OF FOREST OWNERS.

During the present session of Parliament a couple of amendments of importance to the forestry interests of the Dominion have been made to the Railway Act.

By an amendment to section 30, paragraph "f," subsection 1, the Board of Railway Commissioners are given power to require any railway company "to establish and maintain an efficient and competent staff of fire-rangers, equipped with such appliances for fighting, or preventing fires from spreading, as the Board may deem proper, and to provide such rangers with proper and suitable equipment to enable them to move from place to place along the line of railway with all due speed." The Board may also require the company "to maintain an efficient patrol of the line of railway and other lands in the vicinity thereof to which fires may spread, and generally define the duties of the company, and the said fire-rangers, in respect thereof." "The Board may require the company," the clause continues, "to make returns of the names of fire-rangers in its employ in the performance of the above-named duties and of the places or areas in which they are from time to time engaged. For the purpose of fighting and extinguishing fires, the said fire-rangers may follow the fires which spread from the railway to, over and upon the lands to which they may spread."

Another amendment of much importance is the rendering of the railway company liable for damage to "any property," instead of merely for "crops, lands, fences, plantations or buildings and their contents," by which amendment timber lands are clearly brought among those things for damage to which the company is liable.

THE MEETING OF THE UNION OF CANADIAN MUNICIPALITIES.

The meeting of the Union of Canadian Municipalities was held in Quebec on August 29th to 31st. At the formal opening an address of welcome was presented by Mayor Drouin, while Sir Francois Langelier, lieutenant-governor, and a large gathering were in attendance.

At the evening session a number of interesting papers were read. Mayor Chisholm, of Halifax, presided. An address was made by Mr. Elmer Black, president of the Editorial Review, New York, on "Old World Observation and Town Planning."

Another address was delivered by the Hon. H. B. F. MacFarland, late president for the Commission of the District of Columbia.

The meeting was closed by the election of officers, which resulted as follows: President, J. W. McCready, city clerk, Fredericton, N.B.; first vice-president, Mr. N. Champagne, controller, of Ottawa; second vice-president, W. H. Evanson, controller, of Winnipeg; third vice-president, Alderman L. A. Cannon, Quebec; honorary secretary-treasurer, W. D. Lighthall, K.C., G. S. Wilson, assistant secretary.

The choice of the next convention city was left to the executive.

THE MEETING OF THE ONTARIO MUNICIPAL ASSOCIATION.

The members of the Ontario Municipal Association held their thirteenth annual meeting in Toronto on August 31st and September 1st last.

Mayor Hopewell, of Ottawa, the former president of the association, in his opening address, drew the members' attention to some of the many problems confronting Canadian municipalities, and presented his views as how best to cope with them with a view to securing beneficial and permanent advance.

He referred to tax reform, municipal home rule, right of expropriation for parks, etc., park bonds, city and town planning and the duties of Boards of Control.

In that portion of his speech dealing with town planning, he stated that the question is receiving serious consideration in almost every intelligent community by at least a small number of people, and we are beginning to realize that to allow large centres of population to be built up haphazard and piecemeal, without any comprehensive plan or purpose, not only means for the future enormous outlay for the widening and straightening of streets, providing parks, playgrounds, etc., but also that the awful slum is caused not so much by the people as by the conditions under which they are compelled to live. For overcrowding inevitably results in unsanitary conditions, lack of sufficient pure air, unhealthy minds as well as feeble bodies. Common sense would seem to insist that in this Canada of ours, where we have so much room, we should take warning by the object lessons furnished us in the great centres of population in the new as well as the old land, and cause us to grapple with this problem in such a way that our cities that are growing so rapidly may be built and laid out along such lines as will at least provide the maximum amount of pure air and sunshine which is so necessary in the development of moral and healthy citizens, and such is the birthright of the poorest in our land. Perhaps the best manner of dealing with this question would be to induce the provinces to have prepared by competent landscape artists say twenty-five different ideal city plans, which could always be made suitable to almost any locality, and when a village is incorporated as a town, this ideal plan could then be made suitable to that particular locality and registered, and the future growth of that town or city would follow the lines of this plan. If the village never grew to be a city, no hardship could accrue to property owners in the immediate vicinity, as their farms and gardens would never be subdivided into city lots for the simple reason that there would be no demand in the market for them. On the other hand, no hardship would be experienced by property owners in the laying out of their lands into city lots, if they were compelled to do so according to a definite comprehensive registered plan. Cities that would have their own plans prepared, making provision for future expansion and growth, should be permitted to register same, and when registered, though they cover suburban property outside their present boundaries, when subdividing the same into city lots, it should be done according to this plan, so that when annexation took place, provision for the extension of public utilities, etc., etc., would be properly provided for. There would, of course, be some difficulty in working out details of such a scheme, but surely none of such dimensions as to make it impracticable.

Several addresses were read by members and others; some of the subjects dealt with being The Highway Improvement Situation in Ontario, The Local Improvement Act, County Associations, Town Planning Suggestions for Canadian Municipalities and Relations Between Boards of Light and Water Commissioners and Municipal Councils as to charges for water and light.

At the close of the meeting the following officers were elected: President, Controller F. S. Spence, Toronto; vice-presidents, Mayor Beattie, London; Dr. Fred Guest, mayor of St. Thomas; W. A. Clark, clerk of York township; W. Law, county clerk of Huron, and Mayor W. H. Schmalz, Berlin. Executive Committee: Mayors of Toronto, Hamilton and Owen Sound; City Solicitor Wm. Johnston, of Toronto; City Clerk S. H. Kent, of Hamilton; Reeve S. F. Glass, of London township; City Treasurer Bunnell, of Brantford; Aldermen Stroud and Richter, of London, and E. A. Hugell, secretary of the rural section of the association.

Mr. K. MacKay, of St. Thomas, who has been secretary of the association for several years, was again elected to that position.

ENGINEERING IMPORTS AND EXPORTS.

The Board of Trade of London, England, returns for the first seven months of the year show that the imports of iron and steel and manufactures thereof amounted to £6,101,659, or £1,511,050 more than in the corresponding months of last year, while the exports reached the value of £25,373,018, an increase of £485,396, there being for the month of July alone as compared with the same month last year a decrease of £727,055. The imports and exports of other metals and manufactures thereof were £16,044,594 and £6,322,193, which compared with last year show increases of £2,697,777 and £463,622 respectively. The imports of electrical goods and apparatus (other than machinery and telegraph and telephone wire) decreased by £46,026 and the exports by £420,556, the totals for the seven months being £795,065 and £1,542,133. The imports of machinery amounted to £3,575,125, an increase of £956,676, and the exports to £17,952,018, an increase of £1,199,728. Ships (new) were imported to the value of £48,203, an increase of £40,856, and were exported to the value of £3,220,582, a decrease of £1,636,275.

BRITISH STANDARD FOR REINFORCED CONCRETE CONSTRUCTION.

A joint committee of British engineers and architects have just finished a revision of the standards for reinforced concrete construction. Among the bodies represented in the joint committee are the Concrete Institute, the Royal Institute of Architects, the Institute of Builders, the Admiralty, the War Office, the London County Council, the District Surveyors' Association and the Municipal and County Engineers' Association. Our contemporary, "Concrete and Constructional Engineering," from which we reprint the report, notes that there are also eight appendices, dealing with the elements of design. We give the report as follows:

PREFATORY NOTE.

1. Reinforced concrete is used so much in building and engineering construction that a general agreement on the essential requirements of good work is desirable. The proposals which follow are intended to embody these essentials, and to apply generally to all systems of reinforcement.

Good workmanship and materials are essential in reinforced concrete. With these and good design, structures of this kind appear to be trustworthy. It is essential that the workmen employed should be skilled in this class of construction. Very careful superintendence is required during the execution of the work in regard to—

(a) The quality, testing, and mixing of the materials.
(b) The sizes and positions of the reinforcements.
(c) The construction and removal of centering.
(d) The laying of the material in place and the thorough punning of the concrete to insure solidity and freedom from voids.

If the metal skeleton be properly coated with cement, and the concrete be solid and free from voids, there is no reason to fear decay of the reinforcement in concrete of suitable aggregate and made with clean fresh water.

2. The by-laws regulating building in this country require external walls to be in brick, or stone, or concrete of certain specified thicknesses. In some places it is in the power of the local authorities to permit a reduced thickness of concrete when it is strengthened by metal; in other districts no such power has been retained. We are of opinion that all by-laws should be so altered as to expressly include reinforced concrete among the recognized forms of construction.

A section should be added to the by-laws declaring that when it is desired to erect buildings in reinforced concrete, complete drawings showing all details of construction and the sizes and positions of reinforcing bars, a specification of the materials to be used and proportions of the concrete, and the necessary calculations of strength based on the rules contained in this report, signed by the person or persons responsible for the design and execution of the work, shall be lodged with the local authority.

3. **Fire Resistance.**—(a) Floors, walls, and other constructions in steel and concrete formed of incombustible materials prevent the spread of fire in varying degrees according to the composition of the concrete, the thickness of the parts, and the amount of cover given to the metal.

(b) Experiment and actual experience of fires show that concrete in which limestone is used for the aggregate is disintegrated, crumbles, and loses coherence when subjected to very fierce fires, and that concretes of gravel or sandstones also suffer, but in a rather less degree.* The metal reinforcement in such cases generally retains the mass in position, but the strength of the part is so much diminished that it must be renewed. Concrete in which coke breeze, cinders, or slag forms the aggregate is only superficially injured, does not lose its strength, and in general may be repaired. Concrete of broken brick suffers more than cinder concrete and less than gravel or stone concrete.

*The smaller the aggregate the less the injury.

(c) The material to be used in any given case should be governed by the amount of fire resistance required as well as by the cheapness of, or the facility of procuring, the aggregate.

(d) Rigidly attached web members, loose stirrups, bent-up rods, or similar means of connecting the metal in the lower or tension sides of beams or floor slabs (which sides suffer most injury in case of fire) with the upper or compression sides of beams or slabs not usually injured are very desirable.

(e) In all ordinary cases a cover of ½ in. on slabs and 1 in. on beams is sufficient. It is undesirable to make the covering thicker. All angles should be rounded or splayed to prevent spalling off under heat.

(f) More perfect protection to the structure is required under very high temperature, and in the most severe conditions it is desirable to cover the concrete structure with fire-resisting plastering which may be easily renewed. Columns may be covered with coke-breeze, concrete, terra-cotta, or other fire-resisting facing.

MATERIALS.

4. **Cement.**—Only Portland cement complying with the requirements of the specification adopted by the British Engineering Standards committee should be employed; in general the slow-setting quality should be used. Every lot of cement delivered should be tested, and in addition the tests for soundness and time of setting, which can be made without expensive apparatus, should be applied frequently during construction. The cement should be delivered on the work in bags or barrels bearing the maker's name and the weight of the cement contained.

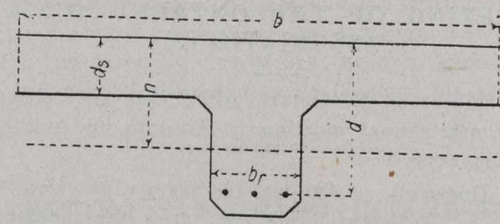


Fig. 1.

5. **Sand.**—The sand should be composed of hard grains of various sizes up to particles which will pass a ¼-in. square mesh, but of which at least 75 per cent. should pass ⅛-in. square mesh. Fine sand alone is not so suitable, but the finer the sand the greater is the quantity of cement required for equal strength of mortar. It should be clean and free from ligneous, organic, or earthy matter. The value of a sand cannot always be judged from its appearance, and tests of the mortar prepared with the cement and the sand proposed should always be made. Washing sand does not always improve it, as the finer particles which may be of value to the compactness and solidity of the mortar are carried away in the process.

6. **Aggregate.**—The aggregate, consisting of gravel, hard stone, or other suitable material,† should be clean and preferably angular, varied in size as much as possible between the limits of size allowed for the work. In all cases material which passes a sieve of a ¼-in. square mesh should be reckoned as sand. The maximum allowable size is usually ¾ in. The maximum limit must always be such that the aggregate can pass between the reinforcing

†Coke-breeze, pan breeze, or boiler ashes ought not to be used for reinforced concrete. It is advisable not to use clinker or slag, unless the material is selected with great care.

bars and between these and the centring. The sand should be separated from the gravel or broken stone by screening before the materials are measured.

7. **Proportions of the Concrete.**—In all cases the proportions of the cement, sand, and aggregate should be separately specified in volumes. The amount of cement added to the aggregate should be determined on the work by weight. The weight of a cubic foot of cement for the purpose of proportioning the amount of cement to be added may be taken at 90 lb. As the strength and durability of reinforced concrete structures depend mostly on the concrete being properly proportioned, it is desirable that in all important cases tests should be made as described herein with the actual materials that will be used in the work before the detailed designs for the work are prepared.

In no case should less dry cement be added to the sand when dry than will suffice to fill its interstices, but subject to that the proportions of the sand and cement should be settled with reference to the strength required, and the volume of mortar produced by the admixture of sand and cement in the proportions arranged should be ascertained.*

The interstices of the aggregate should be measured, and at least sufficient mortar allowed to each volume of aggregate to fill the interstices and leave at least 10 per cent. surplus.

For ordinary work a proportion of one part cement to two parts sand will be found to give a strong practically watertight mortar, but where special watertightness or strength is required the proportion of cement must be increased.

8. **Metal.**—The metal used should be steel, having the following qualities:

(a) An ultimate strength of not less than 60,000 lb. per sq. in.

(b) A yield point of not less than 32,000 lb. per sq. in.

(c) It must stand bending cold 180° to a diameter of the thickness of pieces tested without fracture on outside of bent portion.

(d) In the case of round bars the elongation should not be less than 22 per cent., measured on a gauge-length of eight diameters. In the case of bars over 1 in. in diameter the elongation may be measured on a gauge-length of four diameters, and should then be not less than 27 per cent.

For other sectional material the tensile and elongation tests should be those prescribed in the British Standard Specification for Structural Steel. If hard or special steel is used, it must be on the architect's or engineer's responsibility and to his specification.

Before use in the work the metal must be clean and free from scale or loose rust. It should not be oiled, tarred, or painted.

Welding should in general be forbidden; if it is found necessary, it should be at points where the metal is least stressed, and it should never be allowed without the special sanction of the architect or engineer responsible for the design.

*For convenience on small works the following figures may be taken as a guide, and are probably approximately correct for medium silicious sand:

Parts Cement.		Parts Sand.		Parts Mortar.
1	+	½	=	1.20
1	+	1	=	1.50
1	+	1½	=	1.90
1	+	2	=	2.35
1	+	2½	=	2.70
1	+	3	=	3.00

The reinforcement ought to be placed and kept exactly in the positions marked on the drawings, and, apart from any consideration of fire resistance, ought not to be nearer the surface of the concrete at any point than 1 in. in beams and pillars and ½-in. in floor slabs or other thin structures.

9. **Mixing: General.**—In all cases the concrete should be mixed in small batches and in accurate proportions, and should be laid as rapidly as possible. No concrete which has begun to set should be used.

Hand-mixing.—When the materials are mixed by hand they are to be turned over dry and thoroughly mixed on a clean platform until the color of the cement is uniformly distributed over the aggregate.

Machine-mixing.—Whenever practicable, the concrete should be mixed by machinery.

10. **Laying.**—The thickness of loose concrete that is to be punned should not exceed 3 in. before punning, especially in the vicinity of the reinforcing metal. Special care is to be taken to ensure perfect contact between the concrete and the reinforcement, and the pumping to be continued till the concrete is thoroughly consolidated. Each section of concreting should be as far as possible completed in one operation;* when this is impracticable, and work has to be recommenced on a recently laid surface, it is necessary to wet the surface; and where it has hardened it must be hacked off, swept clean, and covered with a layer of cement mortar ½ in. thick, composed of equal parts of cement and sand. Work should not be carried on when the temperature is below 34° Fahr. The concrete when laid should be protected from the action of frost, and shielded against too rapid drying from exposure of the sun's rays or winds, and kept well wetted. All shaking and jarring must be avoided after setting has begun. The efficiency of the structure depends chiefly on the care with which the laying is done.

Water.—The amount of water to be added depends on the temperature at the time of mixing, the materials, and the state of these, and other factors, and no recommendation has therefore been made. Sea-water should not be used.

11. **Centring or Casing.**—The centring must be of such dimensions and so constructed, as to remain rigid and unyielding during the laying and pumping of the concrete. It must be arranged as to permit of easing and removal without jarring the concrete. Provision should be made wherever practicable for spraying or rounding the angles of the concrete. Timber when used for centring may be advantageously limewashed before the concrete is deposited.

12. **Striking of Centres.**—The time during which the centres should remain up depends on various circumstances, such as the dimensions or thickness of the parts of the work, the amount of water used in mixing, the state of the weather during laying and setting, etc., and must be left to the judgment of the person responsible for the work. The casing for columns, for the sides of beams, and for the soffits of floor slabs not more than 4 ft. span must not be removed under eight days; soffits of beams and of floors of greater span should remain up for at least 14 days, and for large span arches for at least 28 days. The centring of floors in buildings, which are not loaded for some time after the removal of same may be removed in a short time; the centring for structures which are to be used as soon as completed must remain in place much longer. If frost occurs during setting, the time should be increased by the duration of the frost.

*In particular the full thickness of floor slab should be laid in one operation.

(Continued Next Week.)

THE USE AND ABUSE OF INSPECTION.*

It has been remarked that society in these days is rapidly becoming divided into two classes—the inspectors and the inspected. Engineers especially realize that there is a great amount of truth in this saying, as few orders are placed nowadays for engineering plant or materials which do not stipulate for inspection. This tends to become stricter every year, owing to various reasons, the chief being that manufacturers in selling their goods are now generally bound down both in price and time of delivery, the former being so low and the latter so short that mistakes are more liable to occur than was the case in the old days, when the manufacturer could ask and obtain his own price and could take his own time. In those days the buyer often had to take what the manufacturer gave him, and was glad to get it at almost any price. But now the buyer knows quite well in most cases what he wants, what price he ought to give, and exactly what he ought to get for that price, and his main object is to see that he gets it. It follows therefore, that buyers have come to the conclusion that their interests will be best served by employing inspectors empowered to visit the works of the contractors at all reasonable times, without notice, and to follow the course of the order through the works, testing the materials and the finished work, and checking quantities, weights, &c.

The knowledge that the inspector may visit them at any time has a good effect upon contractors in keeping them up to the mark, both in quality and time. This effect is an all-round one and does not refer only to inspected work, as manufacturers know very well that when they are constantly having inspectors in the works it is not desirable to have too much second-rate work lying about. Inspectors do not judge a works entirely by the quality of the work they get themselves, and their opinion carries considerable weight. The very fact, therefore, that a number of buyers send inspectors to any one works makes that works a more reliable place for other buyers, who do not employ inspectors, as the frequent presence of inspectors has a good effect on the general quality of the work turned out of any manufactory.

There is, of course, no attempt on the part of British firms of good standing deliberately to defraud their customers. But at the same time manufacturers cannot afford to do more than keep to the bare specification, and specifications are often interpreted differently by buyers and sellers. Then, again, the heads of a firm cannot always attend to every detail, and foremen and workmen will often scamp work, either because they are on piecework, or merely to save themselves trouble. In the matter of loose rivets in steel-work, blowholes in cast-iron pipes, and such-like, small but important defects, the inspector cannot lay the blame on the manager or foreman unless the flaws are numerous. But it is his business to find these flaws out, and if he discovers a number and sees them put right in the early stages of an order, he will find that the workmen will take more care afterwards. Again, mistakes are frequently made in dimensions, and many firms have no system of checking their finished products, even when the matter is left in their hands.

A good inspector, dealing with large quantities of materials, will save his employers many times his salary in the course of a year. But, to gain the full benefits of inspection, a good man must be engaged. An inspector cannot be an expert in everything, but he must have a very clear idea of the difference between good and bad work, and must be able to read drawings easily. Then an inspector must be firm and able to hold his own, but at the same time tactful, and his honesty must be above suspicion.

An inspector with the above qualifications, and who is also the equal socially of the managers of the works he visits, can do a great deal for the firm which employs him. At the commencement of a contract he goes through the specification and drawings and clears up any doubtful points, both with his own firm and the contractors. He also informs the contractor what kind of work he expects to get and what processes are to be employed on the various details; for instance, it is often left to the inspector to say whether holes are to be drilled or punched; whether plates are to be sheared or planed, rods and bolts solid or welded, &c. When the work commences the inspector will test the materials and see that no unavoidable delay takes place at rolling mills, and will then follow the work through the contractor's shops and see that the various processes are carried out as specified, or as he wishes, and that the finished work comes together correctly, is of the proper dimensions, and, if necessary, is properly marked for re-erection. Besides these duties the inspector is often required to verify weights, and to attend to packing and shipping marks, and occasionally to see the goods actually put on board.

If he is a tactful man and knows his business, he can get the contractor's manager and foremen to agree to his suggestions and requirements with very little trouble, and to push his work on as quickly as possible, and in the case of any alteration he acts as a buffer between the buyers and the contractors. An inspector of this kind is worth a good salary, and if employers have not sufficient work to keep a highly-paid man of their own busy, it is better for them to employ an outside independent inspector than to keep a poorly-paid man, or to send out draughtsmen or others on inspection work, as it takes a regular inspector several years to find out the little tricks by which foremen and workmen sometimes try to deceive him.

There are, however, a number of independent inspecting engineers who will offer to take inspecting work at extremely low and insufficient rates. They can only do this by employing very young and badly-paid men to do their work for them, or else by giving half the time to it that they should do. It may be taken as an axiom that in the majority of cases cheap inspection is worse than no inspection at all, as it relieves the contractor from liability without giving the buyer a sufficient guarantee that the work is properly carried out. There is, of course, certain work which can be attended to by an inexperienced inspector just as well as by an experienced one, but, as a general rule, when work which has been cheaply inspected turns out satisfactorily, it would have been just as satisfactory if it had not been inspected at all.

This brings us to the question of the abuse of inspection, about which manufacturers have a great deal to say, although it affects the buyers more than they are perhaps aware. An inspector may be very conscientious, but either through want of tact or experience, or both, he may be the cause of endless trouble between buyer and seller. Such a man walks into a works as though it belonged to him, calls the manager and foreman over the coals for the slightest cause, treats them openly as though he believes they are deliberately trying to cheat him, persists in sticking to the exact letter of the specification, and rejects quantities of material for little faults which do not matter in the least. The result of all this is that he is disliked wherever he goes, his work is delayed, and people who would not do it otherwise try to get the better of him in order to get him into trouble. Besides this, contractors who have had experience of an inspector of this kind make allowance for him in their next quotation and ask higher prices.

*Engineering.

Unnecessarily strict and minute inspection is not, however, always due to the inspector, as his employers may tie him down to the specification, and practically refuse to allow him to use his judgment at all. Certain consulting engineers are very strict in this way, and are so well known that extra prices are always charged to cover their inspection.

Another abuse of the inspection system is to send an inspector to see very small quantities of material; we have known many cases in which inspectors have travelled long distances to inspect, perhaps, 1 cwt. of ordinary quality steel, the cost of the inspection coming to two, three, or four times the cost of the material. The Government departments are probably the worst offenders in this way, the total cost of some of their small orders being out of all proportion to the value of the material or the use to which it is to be put. Considerable delay is often caused, also, by having these small orders inspected, as the inspector may have to wait days before he can visit the works, owing to pressure of more important work, and favorable opportunities of forwarding the material along with other goods are thus missed. Moreover, if the material has to be tested, the inspector may have to pay two visits to the mills, one to select and stamp the test-pieces and another to see them broken, as the mills cannot always prepare the test-bars the same day.

Then, again, inspectors are sent to examine such small items as wood screws, nails, door fittings, and other ironmongery. This is a waste of time, as the inspector cannot stamp such articles, and has no means of telling whether the goods he passed are the same as those received by his employers. The best way is to buy ordinary commercial goods of this kind on sample, and return them if not satisfactory; this gives the buyer a better hold upon the manufacturer than if he sent an inspector.

There are, of course, other and more serious abuses of inspection due to direct or indirect bribery of the inspector by the contractors. But this evil is not confined to inspection work, although a dishonest manufacturer has very much better opportunities for bribing an inspector than any other member of his customer's staff, having the inspector at his own works. Bribery, however, is not so common as it used to be, but unless the inspector is of good class and reasonably well paid, the risk of collusion may always arise.

To sum up the whole question: inspection is useful and worth while under certain conditions, but not under all conditions. It pays well to inspect, provided the inspector is a firm and tactful man with a good general knowledge of engineering and inspection, and with an honest and honorable character, and provided also that he has plenty of work on big orders and is given a fairly free hand and allowed to use his judgment in the interpretation of a specification. In other words, the inspector must be a good one and must have plenty to do, and the more costly the work that he inspects the more worth while the inspection.

Inspection, as a general rule, does not pay when the reverse of these conditions is the case: when the inspector is tactless, of weak character, without workshop experience, or badly paid. It does not pay to be very strict on small variations from the drawing or specification which do not affect the quality of the work, nor to send an inspector to pass every small order, unless for special material. It is also a question whether it pays to inspect cheap materials, such as bricks, tiles, earthenware pipes, paving, &c. These things are bought in large quantities, and the inspector usually sees them stacked in the maker's yard. It is impossible for him to examine more than a small proportion unless he sees the whole order loaded up, which might oblige him to be at the works for several days, and would add considerably to the cost of the articles. He cannot very well mark each item unless he sees them loaded up, in which case there is no need to mark, and the result is he passes them in bulk, which leaves the manufacturer free to load up all the defective items not seen by the inspector.

In the case of materials of this nature it is certainly the best way to buy on sample, without inspection, and return defective goods. This course, however, would not be practicable when the material was required for abroad, in which case the inspector should see it loaded up.

Whether a firm should employ their own inspector or not depends on whether or not they can keep him busy all the time. If they only require to have goods inspected occasionally, it is better to employ a regular outside inspector than to send out one of their own staff, unless he is fully qualified for the particular work. A firm has a better hold in some ways on its own inspector, but as the outside inspector's living also depends on the satisfactory nature of his work, he is not likely to neglect it, and a well-established outside man has a wider experience of inspection than a man who only works for one firm, and experience counts for a great deal in inspection. The more works a man visits, and the greater variety of materials he inspects, the quicker he will be to detect bad work, to suggest improvements, and to get orders through satisfactorily.

THE PRESSURE OF LOOSE CEMENT.

The pressure of loose cement against bin walls is a very indeterminate quantity, according to the paper on "Cement Stock Houses," recently presented to the Western Society of Engineers by Mr. Josiah Gibson. Mr. Gibson's observations are based on data acquired in the construction of a number of cement stock houses for the Universal Portland Cement Co. Portland cement, when it comes from the mill, is a loose, dry powder weighing about 95 lbs. per cu. ft, When dropped into the bins it becomes very freely charged with air and stands up with a level surface, like a liquid. After standing a few days its weight causes it to settle into a more compact mass from which practically all of the air has been expelled. Unfortunately its properties of internal friction are not constant and it is impossible to predict the degree of its angle of slope. When the cement is drawn from the bottom of the bin, sections of the storage space may be emptied leaving the remainder standing with almost perpendicular sides which, without warning, will cave in against the bin walls.

In one of the earlier bins to be built a series of experiments was made whereby it was decided that it would be safe to assume the cement to be a liquid of 10 lbs. per cu. ft. weight. It was soon found, however, that there was an excess deflection of the walls so designed and the assumption was increased to 20 lbs. per cu. ft. Later experiments were made by interposing some plank backed I-beams across an opening in the bin and computing the pressure from the deflection of those beams. This experiment showed that a hydraulic pressure of 20 lbs. per cu. ft. would be safe.

In the discussion of the paper this value was objected to as being too small, first, because the experiments did not care for the arching action of the cement, and second, because the stock of the falling cement, noted above, was not considered. It was generally thought that a somewhat higher assumption should be made.

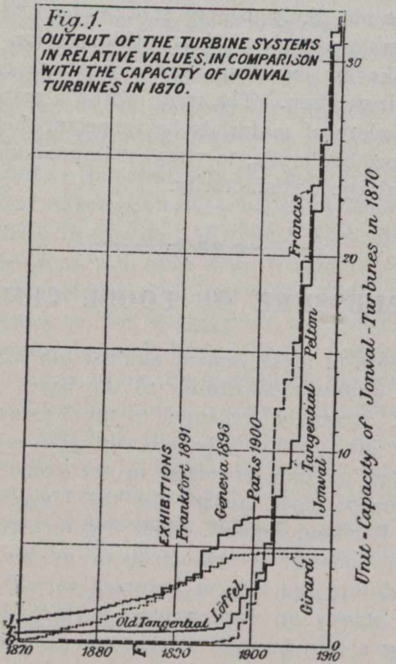
FRANCIS AND TANGENTIAL TURBINES.

Results of Experiments with Francis Turbines and Tangential (Pelton) Turbines.*

By Professor Dr. Franz Prasil, of Zurich.

At the Paris Exhibition in 1900 the direction in which the development of the design of modern water turbines had progressed in the last decade of the preceding century was clearly set forth; the old systems of the Jonval and the Girard turbine had almost disappeared; the Francis turbine and the Pelton wheel in the most varied forms of construction had stepped into their place, and the variety of these forms proved the importance that was attributed to these types.

At the Exhibition it was, indeed, possible to recognize the great adaptability of the two types to local requirements, as well as to the demands of the most varied industries. As, however, the exhibits were not subject to test, a quantitative judgment of the merit of the designs was not possible.



The increase in the manufacture of Francis turbines and of Pelton wheels, in comparison with that of the old types, is shown in Fig. 1, which was prepared for the Swiss catalogue of the International Exhibition at Turin, 1911. Since 1900 both types have developed in the direction of increase of horse-power per unit, so that their sizes have now reached as high as 16,000 horse-power per wheel. The Francis turbine is applied with success to falls of from 1 m. to 150 m. (3.3 ft. to 492 ft.); the Pelton wheel to falls of from 40 m. to 950 m. (131 ft. to 3,116 ft.). In this are to be noted not only a steady [illegible] tur-bine, but also in the efficiency of the automatic governing and the safety mechanism. Particularly for modern plants plants with long supply-pipes and conduits; with their severe specifications of high-standard reliability in the safety apparatus, these requirements made large claims upon the skill and ability of engineers. The result has been, however, a large measure of success in the production of successful designs.

The members of the Institution of Mechanical Engineers will have an opportunity of inspecting various hydro-electric plants in Switzerland, and of having the details of their construction in this special respect explained either by the engineers in charge or by representatives of the turbine-makers. To the author there falls the agreeable task of presenting some comparative tables of the results of tests which have been entrusted to him to carry out. He has endeavored in the tables and diagrams to follow such order and sequence as will make clear the influence of various arrangements of detail and proportions of dimensions. The experiments relate to installations which have been carried out at four works. The agreement of the results demonstrate that a condition of permanence in the development of the design of turbines has been reached, and that we are now near the limit of attainable dynamic efficiency and perfection in governing. For the sake of concentrating attention upon the matter of the analysis, the naming of particular firms has been avoided.

As an introduction to the description of the test results, some remarks are needed upon the methods of measurement employed.

A.—Measurement of Fall.

(a) Direct Measurement.—In the case of low-pressure turbines in open wheel-pits, the levels of the water in the head and tail-races were read off directly by point-gauges, their difference giving the working fall. The gauge-points must be fixed as near the turbine as possible. Each of the two graduated staves slides in a vertical guide forming part of a securely fixed wooden frame, and the metal points moving with them are brought down until they just touch the water surfaces. The zeros of the two scales are obtained by applying the points to the two water surfaces when they are still with a very small water-flow, the level-difference between these having been accurately determined by levelling instruments.

(b) Indirect Measurements.—If the water surfaces be inaccessible, a piezometer can often be applied for low-pressure turbines, on which readings similar to those above mentioned under (a) can be taken. With high-pressure turbines having long supply-piping and suction-tube, the pressure-fall, or fall from supply to turbine-level, can be measurerd by pressure-gauge, and the discharge or suction fall either direct as above or by help of a vacuum-gauge. In the case of the Pelton wheel only the pressure-fall comes into question. The positions at which the pressure and vacuum-gauges should be attached to the supply and discharge pipes are to be as near the turbines as possible, and where as uniform as possible a pressure distribution reigns over the cross-section of the water-flow. Readings from pressure and vacuum-gauges attached at or close to pipe bends or to the spiral casings of closed turbines are inadmissible for this purpose of determining the fall.

B. Water Measurement.

In the tests now presented the water consumption was measured sometimes by weir and sometimes by rotating current-meter.

(a) Weir Measurements.—These were in all cases carried out with sharp-edged weirs specially built for the tests, in some cases arranged with side contraction, and in other cases without side contraction. The readings were taken with precision needle-gauges with verniers reading to 1-10 mm. (1-250 in.). The calculations of the quantities were made either by the Frese formula, the derivation of which is fully described in the Journal of the Vereins Deutscher Ingenieure of 1890, or else directly from calibration curves obtained from rotating current-meters by the Hydrometric Bureau of the Swiss Hydrographic Department.

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* Paper read before the Institution of Mechanical Engineers, at the Zurich Meeting, July 26.

From the following table may be seen to what percentage the formula-calculated and the calibration-curve results agree:—

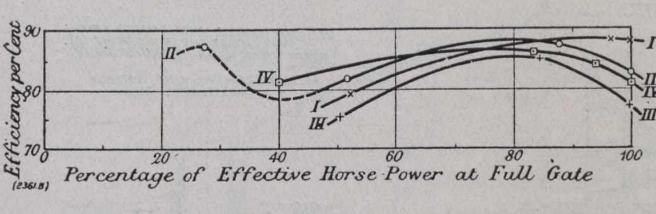
Fall over Weir		Water Flow Litres per Second: By the Frese Formula.		Water Flow Litres per Second: By the Calibration Curves.		Difference: Litres per Second.		Per Cent.
mm.	in.	litres.	gal.	litres.	gal.	litres.	gal.	
93.8	3.693	65	14.3	67	14.7	2	0.4	3.1
98.1	3.862	70	15.4	72	15.8	2	0.4	2.9
104.6	4.118	77	16.9	79	17.4	2	0.4	2.6
119.4	4.701	93	20.5	95	20.9	2	0.4	1.1
132.5	5.217	109	24.0	111	24.4	2	0.4	0.9
170.6	6.717	161	35.4	162	35.6	1	0.2	0.6
178.9	7.043	173	38.1	174	38.3	1	0.2	0.6
216.2	8.512	232	51.0	232	51.0	0	0.0	0.0
247.4	9.740	285	62.7	287	63.1	2	0.4	0.7
273.6	10.772	334	73.5	336	73.9	2	0.4	0.3
295.0	11.615	376	82.7	379	83.4	3	0.7	0.8

From one series of tests, in which simultaneous measurements were taken at two cross-sections, the following examples of the degree of accuracy of this mode of measurement are obtained:—

Water Consumption. Cubic Metres per Second Measured at Section. I.	II.	Difference. Cubic Metres per Second.	Per Cent.
4.790	4.615	+0.175	+3.6
4.630	4.650	—0.020	—0.5
4.040	3.960	+0.080	+1.7
3.610	3.680	—0.070	—1.9
2.600	2.794	—0.194	—7.5

Section I. was in the smooth cement-finished part of the underground tunnel. Section II. was in the rough stone part of the discharge channel into the river (Wildbach). With such difference of kind of section, the difference between the two sets of measurements are to be regarded as small, except in the case of the last.

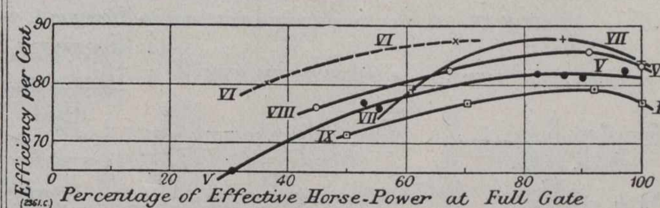
TABLE I.—Efficiency of Francis Turbines in Open Wheel-Pits.



No.	System.	Fall in Metres.	Revolutions per Minute.	Effective H.-P. at Full Gate.	a.	b.	a.	b.	a.	b.	a.	b.	Measurement of Horse-Power.
I.	Single vertical axis	4.6	100	158.3	100.0	88.1	96.8	83.6	52.7	79.4		..	Mechanically by Prony Brake.
II.	Single vertical axis	4.4	100	260.0	100 0	82.5	88.0	87.8	51.9	81.9	32.7	87.2	
III.	Single horizontal axis ..	7.0	128	434.5	100.0	76.9	84.0	85 1	50.8	75.4			
IV	Double horizontal axis	10.4	160	1250.0	100.0	81.3	93.8	84.2	78.5	86.3	40.3	81.5	Electrically.

a = Per Cent. of Full Load.
b = Per Cent. Efficiency of the Turbine.

TABLE II.—Efficiency of Francis Turbines in Spiral Wheel-Cases.



No.	System.	Fall in Metres.	Revolutions per Minute.	Effective H.-P. at Full Gate.	a.	b.	a.	b.	a.	b.	a.	b.	Measurement of Horse-Power.
V.	Single horizontal axis	42.0	411	550	97.0	82.3	82.8	81.7	56.0	76.0	30.9	75.3	Electrically
VI.	Ditto.	64.0	400	4000	..	..	..	..	68.7	87 4	36.6	80 5	
VII.	Double horizontal axis	60.0	496	2696	100 0	78.6	86.6	87.6	56.0	79.4	.	..	
VIII.	Ditto.	87.0	490	2620	100.0	83 5	91.5	85.6	67.5	82.2	45.3	76.3	
IX.	Ditto.	147.0	601	3458	100.0	77.2	92.0	79.6	70.5	77.2	50.0	71 6	

a = Per Cent. of Full Load.
b = Per Cent. Efficiency of the Turbine.

TABLE III.—DIMENSIONS AND TEST RESULTS OF FRANCIS TURBINES.

Details of Design.

No. of Turbine.	System.		Work Done.	Base Data: Fall in Metres.	Water Flow. Cubic Metres per Second.	Revolutions per Minute.	Full Load. H.-P.	Runner Dimensions: Inlet: Dia. D. Metres.	Breadth B. Metres.	Number of Blades.	B/D.	Peripheral Speed, Velocity Due to Revolutions $u = D \pi n/60$.	Velocity Due to Fall $C = \sqrt{2 g H}$.	Velocity Coefficient $K_u = u/C$.
I.	I. & II. vertical axis;	Single Open	Spinning Mill	4.6	3.000	100	142	1.25	0.300	17	1 : 4.17	6.30	9.5	0.67
II.				4.4	4.940	100	220	1.30	0.435	17	1 : 2.95	6.82	9.3	0.72
III.	III. & IV. horizontal axis	Single		6.6	5.400	127	372	1.30	0.495	16	1 : 2.62	8.70	11.35	0.78
IV.		Double	Electrical central station	10.4	11.26	172	1250	1.30	2×0.325	15	1 : 4.0	11.7	14.2	0.81
V.				42.6	1.300	428	550	0.80	0.100	15	1 : 8.0	17.8	28.5	0.615
VI.	Horizontal axis, spiral wheel-case	Single		62.0	5.000	400	3200	1.10	0.220	17	1 : 5.0	23.1	34.8	0.67
VII.				60.0	4.000	500	2500	0.90	2×0.0975	..	1 : 9.3	23.4	34.2	0.68
VIII.		Double		87.0	2.875	500	2500	0.95	2×0.110	19	1 : 8.6	25.0	41.2	0.60
IX.				143.0	2.000	600	3000	1.10	2×0.0400	..	1 : 27.5	34.2	52.8	0.65

Test Results.

No. of Turbine.	Fall in Metres.	Revolutions per Minute.	Full Load. H.-P.	Percentage of Full Gate Effective H.-P.: 100	90	80	70	60	50	40	Method: Water Measurement.	Measurement of Effective H.-P.
				Percentage Efficiency.								
I.	4.6	100	158.3	88.1	88.5	87.5	85.5	82.2	78.0	..	Rotating Current Meter.	Prony brake
II.	4.4	100	260	82.5	87.0	87.2	87.0	84.0	80 5			
III.	7.0	128	434.5	76.9	83.5	85.0	83.5	79.7	74.5	.		
IV.	10.4	160	1250	81.3	85.5	86.5	86.5	85.0	83.5	..		Electrical at Generator
V.	42.0	411	550	81.5	82.0	81.5	80.0	78.0	75.0	70.5	Weir	
VI.	64.0	400	4000	..	..	..	87.5	86.5	84.5	81.5	Rotating Current Meter	
VII.	60.0	496	2696	78.6	87.5	87.5	84.5	78.0	..	..		
VIII.	87.0	490	2620	83.5	85.5	84.5	83.0	80.5	77.7	..	Weir	
IX.	147.0	601	3458	77.2	79.5	78.5	77.0	74.5	71.8	..	"	

The weir investigated had a breadth of 1.19 m. (46½ in.), and had no side-contraction. One notes that the absolute difference is nearly constant, and is always of the same sign, so that one may conclude that either the formula or the current-meter had a constant error. For water consumptions over 100 litres (22 gallons) per second the percentage difference remains under 1 per cent.

(b) Rotating Current-Meter Measurements.—These were carried out partly by Herr Dr. Epper-Bern, Director of the Swiss Hydrographic Department, and partly by the present author or by other experimenters. The instruments used came from the workshops of Ott-Kempten, in Bavaria, and were from time to time calibrated in the Calibration Laboratory of the Confederate Hydrometric Bureau. The technical mode of using was in all cases that prescribed by the Confederate Hydrometric Bureau.

Another example of the comparison of simultaneous measurements is to be found in an article by the author, entitled "Comparative Investigations on Reaction Low-Pressure Turbines," in the Swiss Bauzeitung, 1905.

C.—Measurement of Effective Horse-Power.

In four tests a Prony brake was used and, throughout, with wooden lining to one-half of the peripheral band, with brake-cheeks round the other half, with worm tightening-gear, and with external force applied so as to cause compressive stress in the band.

In the other tests the effective horse-power of the turbine was transmitted to the generator (dynamo), and there measured electrically, due allowance being made for the previously measured mechanical and electrical efficiency of the generator. The electrical measurements were carried out by special electrical experts by help of suitable arrangments and instruments.

D.—Measurements of Revolutions per Minute.

This was effected by mechanical hand-tachometer with minute intervals, and often by direct counting with acoustic signals of time intervals.

E.—Registration of Speed Variation with Change of Load.

For this there was used the Horn tachograph.

F.—Measurement of Pressure Variation with Change of Load.

This was obtained by means of the instruments above mentioned for measurement of the falls.

Throughout the course of each test the observations were made as far as possible simultaneously, but at the same time independently.

G.—The Results of the Tests.

The results of the tests I. to IX., inclusive of Francis turbines, are collected in Diagrams I. to V. inclusive; those of the tests Nos. X. to XIII. inclusive in Diagrams VI. and VII., accompany the tables.

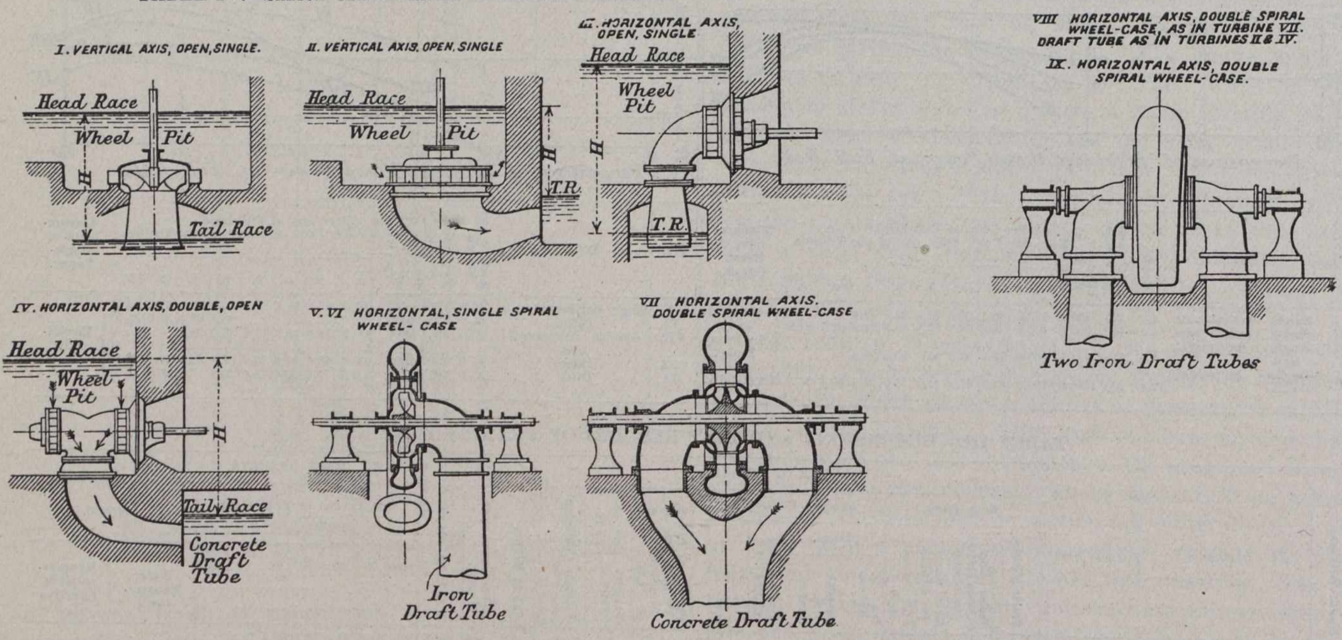
and finally the ratio $Ku = u/c$, which is the characteristic speed-coefficient of the turbine. Along the heading of Table III. are also given the efficiencies taken from Tables I. and II.

It is seen from this table that the wheel diameters of Turbines I. to IV. are nearly equal; but the ratios of width to diameter B/D and also the speed-coefficients Ku, are nevertheless different. In respect of this last coefficient, turbine I. is to be classed as "normal dimensioned normal speed;" turbine IV. as "normal dimensioned high speed;" turbine II. as "extra width normal speed;" and turbine III. as "extra width high speed."

In consequence of the equality of the diameters in turbines I. to IV., the results from them are directly comparable, and the comparison yields the following important conclusions:—

In open low-pressure Francis turbines, it is possible, even with extra width high-speed machines, to reach a maximum effective efficiency of 85 per cent. with an opening of the Fink rotary regulation gates corresponding to about 80 per cent. of full load; while with normal speed and divided

TABLE IV.—Sketch Classification of Francis Turbines I. to IX.



H.—Results with Francis Turbines.

(a) Open Arrangement.—Tables I., III., IV. From Table I. it is seen that:—

1. In turbine I. the maximum efficiency is reached at nearly full load; but in the other turbines it is found at between 70 and 80 per cent. of full load.

2. All four turbines have an efficiency of over 85 per cent. at about 80 per cent. of full load.

3. Turbine IV. maintains greater uniformity of efficiency than the other turbines.

4. The simple turbines II. and III. have similar efficiency curves, that of III. showing throughout smaller efficiency than II.

5. Turbine II. has a second maximum efficiency at about 30 per cent. of full load.

On Table III. (above) the data of the designs are given specifying the size of turbine and its rotary speed—that is, the values on which are based the calculations of the fall, the water consumption, the revolutions per minute, and the desired efficiency; also the wheel diameter D, the inlet breadth of wheel B, the ratio B/D, the peripheral speed $u = \pi Dn/60$, the theoretical speed $c = \sqrt{2g H}$, corresponding to the fall H,

inlet passages with axially moved gates still higher maximum efficiencies up to 88 per cent. are attainable.

The appearance of a second efficiency-maximum in turbine II. appears at first difficult of explanation; the cause, however, is masked by influences arising in connection with no-load running with varied gate-opening, and the phenomenon proves that in such wheels different stream-line forms may occur—a phenomenon which is also observed in centrifugal pumps.

In the upper row of sections on Table IV. (on the opposite page), the classes of the designs of turbines I. to IV. are shown.

(b) Arrangement with Closed Spiral-Wheel Cases.—The results of the tests of Turbines V. to IX. are set out on the Tables II., III., and IV., along with the important dimensions of the same arranged in tabular and graphic forms. In the lower row of sections on Table IV. their general arrangement and class of design is sketched.

From the diagrams on Table II. it may be seen that also in this arrangement the maximum efficiency is reached between 80 and 90 per cent. of full load; but the values of the efficiency for the same percentage load differ for the different turbines of this series much more than in the previously described series.

A direct comparison can be made between the Turbines V., VI., VIII., and IX.; their efficiency curves have very similar general forms. From the dimension-data given on Table III., it can be recognized that the values of the efficiencies decrease as the ratio of breadth to diameter decreases. This comparison shows clearly the influence of the greater resistance of the channels of smaller flow-surface. Still, the diagrams show here also that in this style of turbine efficiencies of 85 per cent. and more are attainable.

sure central station, in which the oil can be brought to a pressure of between 20 and 25 atmospheres. Alongside the diagrams of Table V. are placed those leading dimensions which are necessary for a criticism of the general effectiveness of the regulation, as, for example, the fly-wheel mass, the size and length of the supply-pipe, &c. It must further be pointed out that the Servo-motor of the automatic pressure-regulator of Turbine VII. is fitted with a governing gear, which is brought into action under the influence of a rise of pressure in the supply-pipe, caused by a sudden decrease of load; while in Turbine IX. a similar governing mechanism is

TABLE V.—Results of Tests of Governing of Turbines VII. and IX.

The governing of both turbines is by oil-pressure Servo-motor (relay motor).

The diagrams show the maximum change of speed with sudden charge or discharge. Observations to the left of each vertical line represent charge in kilowatts; those to the right, discharge in kilowatts.

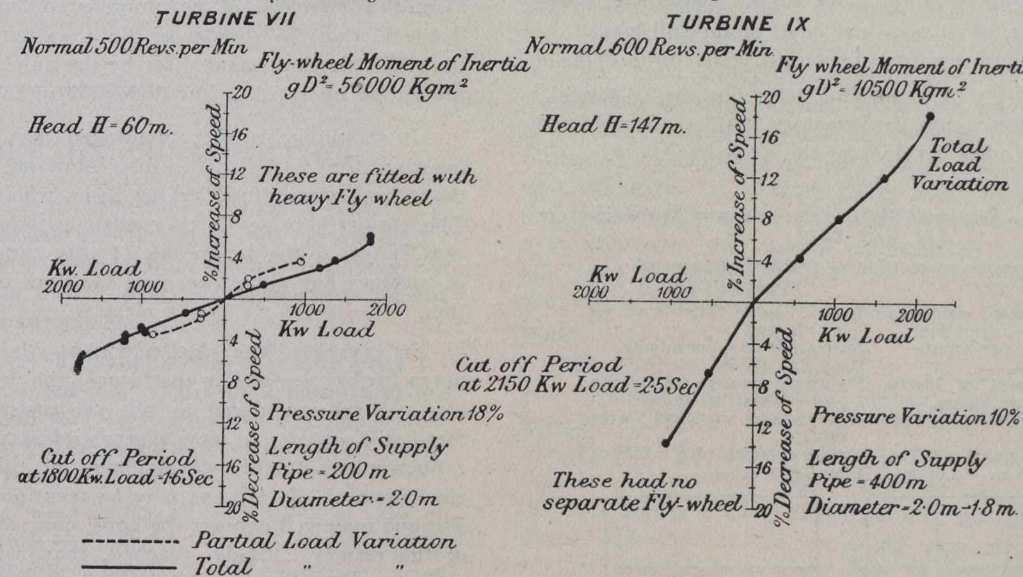
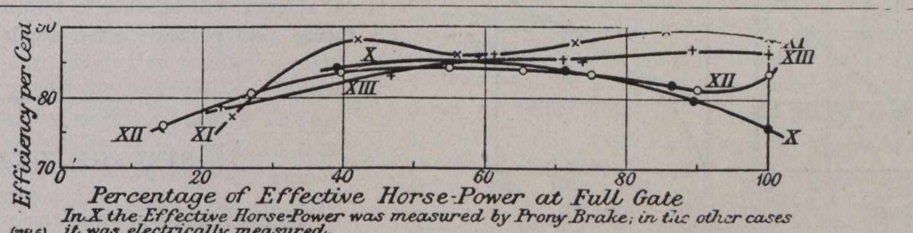


TABLE VI.—Efficiency of Pelton Wheels.



No.	Number of Nozzles.	Fall in Metres.	Revolutions per Minute.	Efficient Horse-Power at Full Gate.	a = per Cent. of Full Load. b = per Cent. Efficiency of the Turbine.											
					a	b	a	b	a	b	a	b	a	b	a	b
X.	2	90	355	326	100.0	76.0	89.3	79.7	86.5	81.6	71.4	83.6	39.6	84.2		
XI.	1	100	180	300	100 0	88.9	85.4	89.3	72.7	87.8	56.0	86.0	42 0	87.8	24.0	77.0
XII.	2	550	376	6050	100.0	83.5	89 9	81.0	75.8	82.8	55.1	83.8	27.1	80.5	14.2	75.9
XIII.	1	850	630	3710	100.0	86.2	89.4	86.9	59.2	85.2	71.2	85.1	46.7	82.9	22.3	78.5

The form of the efficiency-curve of Turbine VII. differs greatly from those of the other turbines of this series; it is however, similar to that of Turbine III. in the previous Series I. to IV. It is to be noted that the correctness of the curve is confirmed by the tests of the governing of the different units of the installation to which Turbine VII. belongs. The apparent difference is probably caused by the form of the blades; but as drawings of these blade-forms are not presented, it is not possible to form a definite judgment upon this point.

In Table V. (below) are given the results of the tests of the governing of Turbines VII. and IX. Here it is to be noted that, in the Servo-motors of the automatic-speed and pressure-regulator, oil is used as the Servo-motor fluid, and each of the two governing plants is worked from an oil-pres-

brought into action by a part of the Servo-motor moved by the automatic speed-regulator, and is again put out of action under the influence of a cataract. The very much less speed variation in Turbine VII. is apparent. The fly-wheel moment of inertia is, however, materially greater than that of Turbine IX. This circumstance, in conjunction with the quicker action of the Servo-motor on Turbine VII., which is indicated by its cut-off period, is the cause of the smaller variation in Turbine VII. In both cases the re-establishment of steady normal condition is reached in the time necessary for safe working under maximum-load variation following maximum-speed variation.

—Tests of High-Pressure Turbines.

Pelton Wheels.—On Table VI. (above) are set out in tabular and graphic form the results of tests of four high-pressure turbines—X. to XIII.—in respect of efficiency; and on Table VII. (below) the results of tests of the regulation of the Turbines XII. and XIII. of this series are stated. The wheels of these turbines are fitted with Pelton blades. The forms of the blades certainly differ from the original Pelton shapes, and are constructed as the result of study and experience of individual turbines which have been in practical use. This variation is also partly apparent in the shapes of the efficiency-curves. The important conclusions to be drawn from these series are the following:—

1. At about 55 per cent. of full load all the four turbines show efficiencies which lie between 84 and 85 per cent.

2. The most favorable efficiencies vary between 84 and 89 per cent.

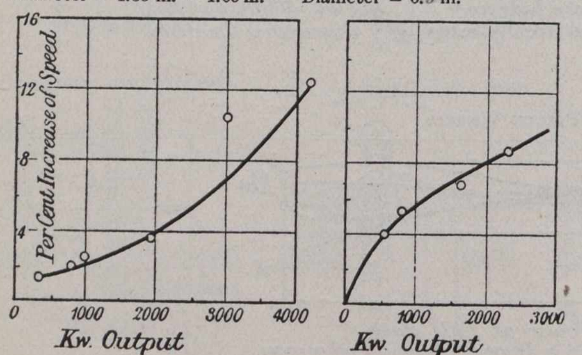
3. The efficiency is lower than 80 per cent. only under loads which are below 25 to 30 per cent. of the full load.

4. These definite results hold within wide limits of head and load (90 m. to 850 m. head, and 300 to 6050 horse-power); and it is to be noted that confirmatory results are obtained also from tests of other turbines of the same kind.

TABLE VII.—*Results of Tests of Governing of Turbines XII. and XIII.*

Both turbines are governed by oil-pressure Servo-motor.

Turbine XII.	*Turbine XIII.*
The turbine is fitted with automatic pressure regulation.	The turbine is fitted with jet cut-off gear.
Normal 375 revs. per minute.	Normal 630 revs. per minute.
Head H = 350 m.	Head H = 850 m.
Fly-wheel moment of inertia $g\ D^2$ = 55,000 sq. kg.-m.	Fly-wheel moment of inertia $g\ D^2$ = 13,000 sq. kg.-m.
Max. pressure variation, 1.8 per cent.	Max. pressure variation, 3.9 per cent.
Length of supply-pipe = 925 m.	Length of supply pipe = 2130 m.
Diameter = 1.35 m. - 1.05 m.	Diameter = 0.5 m.



The test with 3000 kw. load is questioned.

Regarding the results of the tests of the governing of Turbines XII. and XIII., set out upon Table VII., it may be noted that both turbines, as also Turbines X. and XI., are fitted with the well-known nozzles with pointed governing needles. These needle nozzles, due to Abner Doble, regulate the supply of water according to the momentary demand for power following small and gradual changes of load, by the movement of the needle which takes place under the influence of an automatic speed-regulator.

Following sudden changes in the load, very important variations of pressure arise in the long supply-pipes which accompany this design of turbine. In order to avoid these, turbine XII. is furnished with an automatic pressure-regulator with a Servo-motor similar to that of turbine IX., whose regulating mechanism is put into activity by the Servo-motor of this speed-regulator.

In Turbine XIII., the automatic pressure-regulation arising through sudden loading takes place in the following manner:—In the first instants following the decrease of load, the jet issuing from the nozzle is deflected, by the interposition of a shutter inserted between the nozzle and the wheel under the influence of an appropriate automatic regulating mechanism, for the purpose of hindering the access of the water to the wheel; through this the supply of hydraulic energy to the wheel is diminished, while the flow of water from the supply-pipe is still not decreased; no sudden rise of pressure in the pipes can therefore take place. In the succeeding time-period the shutter is gradually withdrawn again, and the needle displaced in the nozzle as necessary for the re-establishment of normal steady condition. The insertion of the needle thus follows so slowly that no important increase of pressure can arise.

Also on Table VII. there are stated the important leading dimension data alongside of the diagrams in the same manner as on Table V. The influence of the very large fly-wheel mass in Turbine XII. makes itself apparent here also, along with the smaller variation of speed. One recognizes, however, through comparison of the two diagrams upon Table VII. and Table V. that the absence of the large fly-wneel mass in Turbine XIII. is compensated for by the quickness of the governing action operated by the deflection of the jet.

It should be further mentioned that in all the turbines mentioned here the test results obtained give better values than those guaranteed by the firms who supplied the plant. The results here set forth confirm satisfactorily the proposition stated at the beginning of this paper—that the design of turbines has almost reached the limit of attainable perfection.

In regard to the efficiency there is not to be expected much further advance in the future; the problem of governing can still be considered as not yet completely solved, since there still appears in view a series of applications which will influence the further development of this problem. The electrification of railways may be mentioned as one example. But one may well express the hope, considering the experience of the results already reached, that with the help of the material and intellectual instruments now available, technical science will be able to find a satisfactory solution of these future, and perhaps often much more difficult, problems.

SEWAGE EXAMINATION.

In examining sewage the process does not differ greatly from the chemical examination of water, a description of which was given in this journal some few weeks back.

The operations which are generally gone through are the determination of specific gravity, chlorine, sulphates, carbonic acid, ammonias, total solid residue. The specific gravity may be determined by a hydrometer, but a small flask and a good balance are to be preferred. The chlorine factor is determined by a standard solution of silver nitrate consisting of 4.79 grammes of silver nitrate to the litre. Potassium chromate is used as an indicator.

To determine the sulphuric acid factor, a measured quantity is taken, say 100 c.c. or 200 c.c., and acidified with a little pure hydrochloric acid, and if necessary it is filtered; it is heated to boiling and a moderate excess barium chloride added. The liquid is boiled and allowed to cool, the precipitate collected, washed, dried, ignited and weighed.

The amount of barium sulphate multiplied by 0.3434 gives the amount of SO_3 per 100 c.c., and this multiplied by 10 gives the proportion per million. In measuring the CO_2, it is usual to use 250 c.c., but 100 c.c. will give satisfactory results; an excess of clear lime water is added the mixture (which should be made in a bottle containing a good stopper) is shaken, and the precipitate allowed to settle. The liquid is decanted and filtered. This precipitate needs very little washing. After allowing the liquid to drain away, the filter with adherent $CoCO_3$ is placed upon several folds of bibulous paper and very gently pressed. This operation partially dries it. The filter is rolled in such a manner as to enclose the precipitate, and placed in an absorption tube filled with mercury and suspended over a mercury trough. The paper is passed up the tube from below, care being taken to keep the introduction of air at a minimum. 2 or 3 c.c. of Hcl. are passed up the tube by means of a curved pipette. In contact with the $CaCO_3$ the H.Cl. will liberate the CO_2. After some hours the amount of gas may be read in c.c. and corrected for temperature and barometric pressure.

The determination of ammonia has been given in detail in this journal of June 29, page 893. The total solids are determined by evaporating 100 c.c. on a water bath.

TASK WORK ON CONSTRUCTION.

The ultimate aim of scientific management is construction work, says Sanford B. Thompson, in the introduction of task work or some similar method of laying out the work so that man will be paid in proportion to the amount of work he accomplishes.

Piece work consists in paying a man a certain price for the performance of a given job. Differential piece rates are arranged so that a man who does an extra large day's labor receives pay not only, for the total number of pieces, but is given a larger rate per piece.

In task work the time which a man ought to take to do a job when working hard and to the best advantage is fixed in advance, and if he accomplishes the work in a fixed time he receives a bonus.

Suppose, for example, it has been found from time study and a condition of the unit times that a carpenter, allowing, say, 30 per cent. for unavoidable delays and necessary rent, should make by working hard, a section of form in 9.5 minutes, If he accomplishes the work in this time or less, he should be given for the period, say, 35 per cent. more pay than if he were working simply by the day. If his day rate is $0.50 per hour, his regular pay for 9½ minutes would be 7.9c.. Adding 35 per cent would give him a price per form of 10.7c., provided he made an acceptable lot of forms in the specified time. In case he failed to make them within the time, he would receive his ordinary day's pay. If he completed 10 sections in 80 minutes instead of 95 minutes he would be paid his 35 per cent. bonus on the full 95 minutes, and would at once begin on the next task so that he would receive even higher than the figured rate, and he would have an incentive to work as fast as possible. If any of the forms were imperfect he would receive a smaller rate or else he would be required to repair them in his own time.

For satisfactory task work exact knowledge is necessary of the time required to do each branch of the work and scientific methods must be employed in fixing the tasks.

Great care must be used in setting a rate to be sure that the men can accomplish the work in the given time. If they fail to earn their bonus, they immediately become discouraged. On the other hand, if the time given is longer than necessary, the men will earn more than was planned for them and will probably start soldiering so as to prevent their employer from knowing that a wrong task has been set. Accurate fixing of tasks and rates by experienced men is absolutely essential to success.

MINERAL PRODUCTION OF BRITISH COLUMBIA.

The aggregate value of all mining in British Columbia at the end of 1910 amounted to $374,197,650, which shows an increase in ten years of $222,042,442, or about 146 per cent. over that at the close of 1900 ($152,155,208). Comparing 1905 (248,663,176) with 1900, the increase in five years was $96,507,968, or about 63.5 per cent., while the five-year period, 1905-1910, gave an increase of $125,534,474, or nearly 51 per cent., the aggregates at the end of 1905 and 1910, respectively, having been as shown above.

The quantity of lode gold during 1910 was the largest produced in any year by 12,119 ozs., the largest previous production having been in 1908, 255,582 ozs., as against 267,701 ozs. for 1910.

The net production of coal, 2,777,495 tons, for 1910, shows also a comparatively large increase of 793,579 long tons. Other materials—that is, non-metallic minerals, practically all for building purposes, are credited with a 25 per cent. increase. It is most likely these have been underestimated in quite recent years until 1910, for there has been a steadily enlarging use of materials in building and road and footpath construction in the larger cities of the coast district during several years, and this is continuing in larger degree than in the past.

Mr. William Fleet Robertson, the provincial mineralogist in commenting on the subject, says: "The value of mineral products in British Columbia for the year 1910 amounts to $26,377,066, which is considerably greater than that of any previous year. The tonnage of ore mined in the lode mines during the year was 2,216,428 tons, an increase over that of the preceding year of 158,715 tons, or 7.7 per cent., and it might also be stated that this is the largest tonnage for any year since the commencement of lode mining in British Columbia.

"This year for the first time in many years, the Coast district has the honor of first place on the list, followed in order of importance by the Boundary and East Kootenay districts, while West Kootenay, for many years the greatest producer of mineral in the province, is relegated to fourth place. The Coast and East Kootenay districts owe considerable percentage of their output to the coal mines situated within their limits, whereas in the other districts the production is almost entirely from metal mining. The total tonnage of ore was produced by the several districts in the following proportions: Boundary, 76.75 per cent; Rossland (Trail Creek division), 11.35 per cent.; Fort Steele Division (East Kootenay), 5.22 per cent.; Coast, 1.90 per cent.; others, 4.7 per cent."

Mr. E. Jacobs, of Victoria, B.C., says: "An analysis of British Columbia's mining activity during 1910 shows that there were 713 tons of ore mined a year for each man employed about the mines. In this respect, however, the districts vary very materially, since, in the Slocan, the figures show 148 tons mined to the man in a year; in Nelson district 142 tons; in Trail Creek 385 tons, and in the Boundary 1,472 tons mined to the man employed."

But copper mining is equally lucrative in this province, as will be seen from the following table, furnished by the British Columbia Copper Company, which in June alone produced 816,676 pounds of copper, against 407,040 pounds for the same month of the year previous. For the six months ended June 30, 1911, the company produced 5,144,365 pounds of copper, as compared with 2,978,227 pounds in the corresponding period of last year.

Production in detail for six months of 1911 and 1910 follows:

1911.

	Copper	Silver	Gold
January	827,272	9,545	2,376
February	767,470	8,384	2,014
March	804,542	9,690	2,711
April	952,284	13,630	3,127
May	976,121	12,703	2,880
June	816,676	11,742	2,428
Total	5,144,365	65,594	15,537

1910.

	Copper	Silver	Gold
January	656,473	7,530	2,513
February	683,234	7,627	2,560
March	891,419	9,191	2,623
April	340,061	3,611	126
May	......	....	....
June	407,040	5,221	1,550
Total	2,978,227	33,080	9,372

COMING MEETINGS.

SOCIETY OF CHEMICAL INDUSTRY, CANADIAN BRANCH.—Sept. 21, 22, 23. Toronto Dr. A. McGill, Ottawa, President; Alfred Burton, Toronto, Secretary.

MINING AND METALLURGICAL SOCIETY.—The first meeting of the New York section for the year 1911-12 will be at the Engineers' Club, New York, Tuesday evening, Sept. 12.

INTERNATIONAL MUNICIPAL CONGRESS AND EXPOSITION.—Sept. 18-30. Chicago, Ill. Curb M. Treab, Secretary, Great Northern Building, Chicago, Ill.

FOURTH ANNUAL GOOD ROADS CONGRESS.—Sept. 18-Oct. 1. Chicago, Ill. J. A. Rountree, Secretary, Birmingham, Ala.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Sept. 26-29. Grand Rapids, Mich. A. Prescott Folwell, Secretary, 239 West Thirty-ninth Street, New York City.

AMERICAN ASSOCIATION FOR HIGHWAY IMPROVEMENT.—Nov. 20-24. First Annual Convention, Richmond, Va. Logan Waller Page, President, United States Office of Public Roads, Washington, D.C.

AMERICAN ELECTROCHEMICAL SOCIETY.—September 21-23. Twentieth general meeting, Toronto, Ont.

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, C. H. Rust; Secretary, Professor C. H. McLeod.

QUEBEC BRANCH—
Chairman, P. E. Parent; Secretary, S. S. Oliver. Meetings held twice a month at Room 40, City Hall.

TORONTO BRANCH—
96 King Street West, Toronto. Chairman, H. E. T. Haultain; Secretary, A. C. D. Blanchard, City Hall, Toronto. Meets last Thursday of the month at Engineers' Club.

MANITOBA BRANCH—
Secretary, E. Brydone Jack. Meets first and third Fridays of each month, October to April, in University of Manitoba, Winnipeg.

VANCOUVER BRANCH—
Chairman, Geo. H. Webster; Secretary, H. K. Dutcher, 40-41 Flack Block, Vancouver. Meets in Engineering Department, University

OTTAWA BRANCH—
Chairman, A. A. Dion, Ottawa; Secretary, H. Victor Brayley, N. T. Ry., Cory Bldg.

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THE UNION OF NEW BRUNSWICK MUNICIPALITIES.—President, Mayor Reilly, Moncton; Hon. Secretary-Treasurer, J. W. McCready, City Clerk, Fredericton.

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CANADIAN ELECTRICAL ASSOCIATION.—President, N. W. Ryerson Niagara Falls; Secretary, T. S. Young, Canadian Electrical News, Toronto

CANADIAN FORESTRY ASSOCIATION.—President, Thomas Southworth, Toronto; Secretary, James Lawler, 11 Queen's Park, Toronto.

CANADIAN GAS ASSOCIATION.—President, Arthur Hewitt, General Manager Consumers' Gas Company, Toronto; J. Keillor, Secretary-Treasurer, Hamilton, Ont.

CANADIAN INDEPENDENT TELEPHONE ASSOCIATION.—President, W. Doan, M.D., Harrietsville, Ont.; Secretary-Treasurer, Francis Dagger, 21 Richmond Street West, Toronto.

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CANADIAN RAILWAY CLUB.—President, H. H. Vaughan; Secretary, James Powell, P.O. Box 7, St. Lambert, near Montreal, P.Q.

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CANADIAN SOCIETY OF FOREST ENGINEERS.—President, Dr. Fernow, Toronto; Secretary, F. W. H. Jacombe, Department of the Interior, Ottawa.

CENTRAL RAILWAY AND ENGINEERING CLUB.—Toronto, President, G. Baldwin; Secretary, C. L. Worth, 409 Union Station. Meets third Tuesday each month except June, July, August.

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ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, W. B. McPherson; Corresponding Secretary, A. McQueen.

ENGINEER'S CLUB OF TORONTO.—96 King Street West. President, Killaly Gamble; Secretary, R. B. Wolsey. Meeting every Thursday evening during the fall and winter months.

INSTITUTION OF ELECTRICAL ENGINEERS.—President, Dr. G. Kapp; Secretary, P. F. Rowell, Victoria Embankment, London, W.C.; Hon. Secretary-Treasurer for Canada, Lawford Grant, Power Building, Montreal, Que.

INSTITUTION OF MINING AND METALLURGY.—President, Edgar Taylor; Secretary, C. McDermid, London, England. Canadian Members of Council:—Prof. F. D. Adams, J. B. Porter, H. E. T. Haultain, and W. H. Miller, and Messrs. W. H. Trewartha-James and J. B. Tyrrell.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE.—Secretary, R. C. Harris, City Hall, Toronto.

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WESTERN CANADA RAILWAY CLUB.—President, Grant Hall; Secretary, W. H. Rosevear, 100 Chestnut Street, Winnipeg, Man. Second Monday, except June, July and August, at Winnipeg

CONSTRUCTION NEWS SECTION

Readers will confer a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand and projected, contracts awarded, changes in staffs, etc. Printed forms for the purpose will be furnished upon application.

TENDERS PENDING.

In Addition to Those in this Issue.

Further information may be had from the issues of The Canadian Engineer referred to.

Place of Work.	Tenders Close.	Issue of.	Page
Calgary, Alta., church	Sept. 21.	Aug. 31.	272
Guelph, Ont., tile drains	Sept. 11.	Aug. 31.	68
Ottawa, Ont., branch line railway	Sept. 15.	Aug. 24.	70
Ottawa, Ont., breakwater and dredging, Port Stanley, Ont.	Sept. 13.	Aug. 24.	68
Ottawa, Ont., St. Peter's Canal	Sept. 12.	Aug. 24.	70
Ottawa, Ont., Guysborough County Harbor Line	Sept. 15.	Aug. 24.	72
Ottawa, Ont., breakwater, Felizen, N.S.	Sept. 6.	Aug. 24.	241
Ottawa, Ont., breakwater, Kelly's Cove, N.S.	Sept. 12.	Aug. 24.	241
Ottawa, Ont., breakwater, Thessalon, Ont.	Sept. 11.	Aug. 24.	241
Ottawa, Ont., landing pier, Wheatley, Ont.	Sept. 13.	Aug. 24.	241
Ottawa, Ont., breakwater, French River, N.S.	Sept. 6.	Aug. 24.	241
Ottawa, Ont., station, Truro	Sept. 15.	Aug. 31.	68
Ottawa, Ont., breakwater, etc., Kincardine, Ont.	Sept. 20.	Aug. 31.	271
Ottawa, Ont., boat house, etc., Kingston	Sept. 25.	Aug. 31.	271
Ottawa, Ont., public building, Lloydminster, Sask.	Sept. 16.	Aug. 31.	271
Pt. Rose, Que., aqueduct	Sept. 15.	Aug. 31.	271
Scott, Sask., power house furnishings, etc.	Sept. 25.	Aug. 31.	68
Toronto, Ont., underground subway	Sept. 15.	Aug. 31.	72
Toronto, Ont., library work, Ontario Government Buildings, Queen's Park	Sept. 5.	Aug. 24.	241
Toronto, Ont., main drainage work	Sept. 12.	Aug. 24.	64
Toronto, Ont., steel steam screw tug	Sept. 5.	Aug. 24.	68
Toronto, Ont., steel pipe	Sept. 5.	Aug. 24.	68
Toronto, Ont., rail accessories	Sept. 7.	Aug. 24.	68
Weyburn, Sask., public building	Sept. 5.	Aug. 24.	242
Winnipeg, Man., valves and hydrants	Sept. 8.	Aug. 24.	70
Winnipeg, Man., C.I. water pipe	Sept. 5.	Aug. 24.	72
Winnipeg, Man., fire apparatus	Sept. 24.	Aug. 24.	242
Winnipeg, Man., oil and water system	Sept. 6.	Aug. 31.	272

TENDERS.

Montreal, Que.—Tenders will be received by the undersigned until September 15th, 1911, for the construction of a shed on the new Victoria Pier similar to the present wharf sheds. Tender forms may be had upon application to Mr. F. W. Cowie, Chief Engineer. M. P. Fennell, Junior, assistant secretary, Harbor Commissioners, Montreal.

Ottawa, Ont.—Tenders will be received until Sept. 12th, 1911, for waterworks supplies. Newton J. Ker, City Engineer, Ottawa. (Advertisement in this issue.)

Ottawa, Ont.—Tenders will be received until Sept. 13th, 1911, for dredging required at Fort William, Ont. Specifications and forms of tender can be obtained at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until Sept. 20th, 1911, for the construction of an extension to east breakwater and removal of L on west breakwater and dredging at Meaford, Ont. Plans, specifications and forms of tender can be obtained at the offices of H. J. Lamb, Esq., Dist. Engineer, London, Ont.; J. G. Sing, Esq., Dist. Engineer, Confederation Life Bldg., Toronto, Ont.; on application to the Postmaster, Meaford, Ont., and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until Sept. 25th, 1911, for the construction of a wharf at Red Bay, Bruce County, Ont., according to plans, specifications, etc., which may be had at the offices of J. G. Sing, Dist. Engineer, Confederation Life Bldg., Toronto, Ont.; H. J. Lamb, Dist. Engineer, London, Ont.; on application to the Postmaster at Red Bay, Ont., and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until the 13th day of September, 1911, for the supply of twenty thousand barrels of cement at the railway station at Brooklyn, Queen's County, N.S. Specifications, etc., can be seen at the offices of J. L. Michaud, Dist. Engineer, Merchants Bank Bldg., St. James St., Montreal; J. G. Sing, Dist. Engineer, Confederation Life Bldg., Toronto, Ont.; C. E. W. Dodwell, Dist. Engineer, Halifax, N.S., and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until Sept. 18th, 1911, for the construction of an immigration building at Calgary, Alta. Plans, specifications and form of tender may be had at the offices of Mr. J. E. Cyr, Supt. of Public Buildings for Manitoba, Winnipeg, Man.; on application to Mr. J. J. O'Gara, Architect, Calgary, Alta., and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until Sept. 20th, 1911, for the construction of an extension to the breakwater at Devil's Island, Halifax County, N.S. Plans, specifications, etc., can be obtained at the offices of H. A. Russell, Esq., Dist. Engineer, Halifax, N.S.; E. G. Millidge, Esq., Dist. Engineer, Antigonish, N.S.; on application to the Postmaster at Devil's Island, N.S.; and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until Sept. 20th, 1911, for the construction of pile protection work and dredging channel at Lake Ainslie, Inverness County, N.S. Plans, specifications and forms of contract can be seen and forms of tender obtained at the offices of C. E. W. Dodwell, Esq., Dist. Engineer, Halifax, N.S.; E. G. Millidge, Esq., Dist. Engineer, Antigonish, N.S.; on application to the Postmaster at Kinloch, Inverness County, N.S., and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Sealed tenders, addressed to the secretary, Dept. Public Works, and endorsed, "Tender for St. John, N.B., Deep Water Wharves," will be received until 4 p.m. on Wednesday, September 20th, 1911, for the construction of a series of wharves in the harbor of St. John, at St. John West, N.B.

Ottawa, Ont.—Sealed tenders addressed to the Secretary, Dept. Public Works, and endorsed, "Tender for Public Building, Port Perry, Ont.," will be received until 4 p.m., on Wednesday, September 6th, 1911, for the construction of a public building at Port Perry, Ont. Plans, specifications and form of contract can be seen and forms of tender obtained on application to the Postmaster at Port Perry, Ont.; at the office of Mr. Thos. Hastings, Clerk of Works, Postal Station F., Yonge St., Toronto.

Ottawa, Ont.—Tenders will be received until September 20th, for an Armory, Sarnia, Ont. Plans, specifications and form of contract can be seen and forms of tender obtained on application at the office of Mr. Thos. A. Hastings, Clerk of Works, Postal Station F, Yonge Street, Toronto, Ont., at the Postoffice, Sarnia, and at the office of R. C. Desrochers, secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Sealed tenders, addressed to the undersigned and endorsed "Tender for Public Building, Chesley, Ont.," will be received at this office until 4 p.m., Wednesday, September 20th, 1911, for the work mentioned. R. C. Desrochers, secretary, Department of Public Works, Ottawa.

Ottawa, Ont.—Sealed tenders addressed to the undersigned, and endorsed "Tenders for Dredging, Port Hope, Ontario," will be received until Monday, September 18th, 1911, at 4 p.m., for dredging required at Port Hope, Ont. R. C. Desrochers, secretary. Department of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until September 20th, 1911, for the construction of a wharf at Windsor, Essex County, Ontario. Plans, specifications, etc., may be had at the offices of H. J. Lamb, District Engineer, London, Ontario; J. G. Sing, District Engineer, Confederation Life Bldg., Toronto, Ontario; on application to the Postmaster at Windsor, Ont., and at the office of R. C. Desrochers, secretary. Department of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until September 20th, 1911, for the construction of Breakwater Extension to North Pier and Dredging at Kincardine, Bruce County, Ontario. (Advertisement in this issue.)

Ottawa, Ont.—Tenders will be received until September 25th, 1911, for the construction of a breakwater at St. Joseph, Inverness County, N.S. Plans, specifications and form of contract can be seen and forms of tender obtained at the offices of C. E. W. Dodwell, District Engineer, Halifax, N.S.; G. A. Bernasconi, District Engineer, North Sydney, on application to the Postmaster at Grand Etang, Inverness County, N.S., and at the office of R. C. Desrochers, secretary, Department of Public Works, Ottawa.

Townsites of Monteith, Ont.—Sealed tenders, addressed to A. J. McGee, secretary-treasurer T. and N.O. Railway Commission, 25 Toronto St., Toronto, Ont., will be received if mailed or delivered, before 12 o'clock noon, Wednesday, September 13th, for lots in the new townsites of Monteith and Iroquois Falls. Monteith townsite is directly opposite and to the east of the Government Demonstration Farm. Iroquois Falls townsite is the Junction City for the Porcupine camps. Maps of the townsites, with full particulars, may be obtained from Land Commissioner F. Dane, 34 Yonge Street, Toronto; Geo. W. Lee, General Agent, North Bay.

Windsor, Ont.—Sealed proposals for an intake pipe and screen well for the city of Windsor, will be received at the office of the Water Commissioners until Tuesday, Sept. 12th, 1911. Copies of plans and specifications are on file at the Water Office, Windsor, and also at the office of Smith, Hinchman & Grylls, Detroit, Mich. W. A. Hanrahan, Secretary of Water Commissioners, Windsor, Ont.

Burnaby, B.C.—Tenders will be received until October 2nd, 1911, for the supply and erection of three tanks for the municipality of Burnaby Water Supply. W. Griffiths, clerk, municipal council. (Advertisement in The Canadian Engineer).

Victoria, B.C.—Tenders will be received by the Honorable the Minister of Public Works, up to 12 o'clock noon of Thursday, the 21st day of September, 1911, for the erection and completion of a Court House at Vernon, B.C., in the Okanagan Electoral District. Plans, specifications, etc., may be obtained at the offices of the Government agents, Vernon, Revelstoke, New Westminster, Nelson; the Provincial Timber Inspector, Vancouver; and the office of J. E. Griffith, Public Works Engineer, Department of Public Works, Victoria, B.C.

Victoria, B.C.—Tenders will be received by the Honorable the Minister of Public Works, until September 13th, 1911, for the erection and completion of the several works required in alterations and repairs to the Upper and Lower Extension Schools, in the Newcastle Electoral District. J. E. Griffith, Public Works Engineer, Department of Public Works, Victoria, B.C.

Victoria, B.C.—Tenders will be received until September 20th, 1911, for the erection and completion of an east wing addition to the Provincial Home, Kamloops, B.C. Plans, specifications, etc., may be had at the office of J. E. Griffith, Public Works Engineer, Department of Public Works, Victoria, B.C.

Victoria, B.C.—Bids for a large amount of paving work will be called for shortly by the city when streets requiring some 75,000 square yards of asphalt paving will be open for tender.

CONTRACTS AWARDED.

Halifax, N.S.—The contract for the Halifax Harbor Terminal improvements has been awarded to the Nova Scotia Construction Company of Sydney, N.S.

Fredericton, N.B.—The contract for building the modern new machine shop for the Smith Foundry Company, Limited, was awarded to Mr. Thomas Myles, of St. Mary's, the contract price being in the vicinity of $15,000.

Toronto, Ont.—The Bishop Construction Company, Toronto, and Montreal, have been awarded the contract for the erection of factory building for the National Land Fruit and Packing Company, Limited, Mimico, Ontario; contract price about $25,000.00.

Windsor, Ont.—Messrs. Eliot & Reid, Market Street, Brantford, Ont., have received the contract for supplying all the labor, tools and machinery for constructing and completing a concrete outlet for Parent Avenue sewer under the Grand Trunk Railway tracks. The total cost is $7,441.

Port Arthur, Ont.—The contract for the Block Bay Bridge was awarded to Seaman and Penniman for $1,100. The city to furnish steel and build approaches.

The bridge will be 210 ft. long, 35 ft. high, main span 130 ft., two ribs; all of reinforced concrete.

Winnipeg, Man.—Messrs. Fuller & Co. have been awarded the contract for the construction of the Lord Selkirk Hotel. The building is to cost $1,250,000, exclusive of lighting, heating and ventilation apparatus.

New Westminster, B.C.—Among the tenderers for the erection of a schoolhouse at Sapperton were Messrs. Smith & Whittaker, $38,816; Browly & Martin, $40,350; Thos. Turnbull, $36,752; Chapman & Halloran, $34,072; J. C. Henderson, $34,047.75; Humbull & Smith, $38,685; Sloan & Harrison, $39,000, and W. W. Forester, $33,350. The latter tender being the lowest was accepted.

Vancouver, B.C.—C. M. Hays, of the G.T.P., announced that the contract for the construction of the last link of the 410 miles section of the main line between Aldermere and Bulkeley Valley, B.C., had been awarded to Foley, Welch and Stewart.

RAILWAYS—STEAM AND ELECTRIC.

Recent reports show that steel on the Grand Trunk Pacific has already been laid two hundred and thirty-five miles west of Edmonton, or one thousand and twenty-seven miles beyond Winnipeg, having reached the new town of Fitzhugh. Fitzhugh is a point in Jasper Park, the new national park reservation set aside by the Dominion Government, and the Grand Trunk Pacific traverses the whole length of the park as it approaches the Yellowhead Pass of the Rocky Mountains.

LIGHT, HEAT AND POWER.

St. Timothy, Que.—The plant of the Canada Light and Power Company was put into operation during the end of August last. The main electrical equipment in the powerhouse was built by Allis-Chalmers-Bullock, Limited, of Montreal. It includes three water wheel-driven alternating current generators, each 5,000 k.v.a. capacity, at 150 r.p.m., with two direct current exciters, also water wheel-driven, each 250 k.w. at 850 r.p.m., and three oil-filled, water-cooled transformers, each of 5,000 k.v.a. capacity. The electrical current is generated at 2,300 volts, and is transformed to 44,000 volts for transmission purposes. There is also a 60 k.w. motor-driven "booster" set. Mrs. E. A. Ropert, wife of the vice-president and managing director, had the honor of performing the opening function.

Chicoutimi, Que.—Work is under way on the dam and headgates in connection with the water power development by