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The Canadian Engineer

A Weekly Paper for Civil Engineers and Contractors

Effect of Water Uplift on Overturning of Dams

Theory Advanced That Water Pressure Acting Upward Replaces Portion of Foundation Reaction and That Its Overturning Effect Is Annulled by Counter Moment Produced by "Remaining Foundation Reaction"—Effect of Uplift Upon Sliding

By ERWIN MAERKER

Formerly Structural Engineer, Toronto Power Co.

THE method usually followed by engineers engaged in the design of dams (and other structures resisting water pressure), is to add the upward water pressure under a dam to the reaction of the foundation against the base of the dam, causing an additional overturning moment. The writer cannot agree with this theory, and he regards uplift as a force replacing part of the foundation reaction instead of adding to the foundation reaction.

It is not within the scope of this article to determine the amount and distribution of the uplift; that is, whether pressure due to the full head should be allowed at the heel of the dam, or a fraction thereof, or whether the pressure should diminish uniformly to zero at the toe of the dam, or vary according to a parabolic law or otherwise; but the article treats with the effect of the uplift assumed to act on the base of the dam.

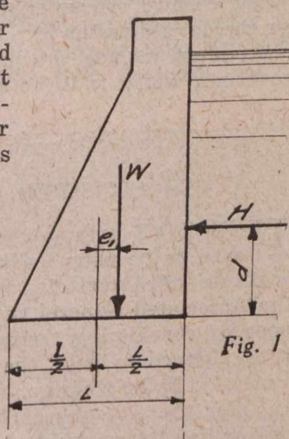


Fig. 1

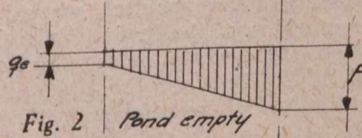


Fig. 2

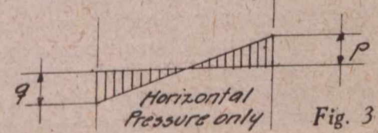


Fig. 3

Assume a block of masonry 20 ft. in height, with base dimensions of 1 by 15 ft., resting on its foundation. With a unit weight of masonry of 150 lbs. per cu. ft., the foundation reaction will be $20 \times 150 = 3{,}000$ lbs. per sq. ft.

For the sake of simplicity we will confine ourselves to vertical forces only, and omit horizontal water pressure, without in the least affecting the principle. Assume further a uniform upward water pressure of 1,000 lbs. per sq. ft., corresponding to a head of 16 ft., to act with equal intensity on the base of the block of masonry. Since the weight of the block of masonry produces a downward pressure of 3,000 lbs. per sq. ft. and the upward water pressure is only capable of exerting 1,000 lbs. per sq. ft., it is evident that the foundation reaction still in contact with the base of the block, must exert 2,000 lbs. per sq. ft. By increasing the uplift to 3,000 lbs. per sq. ft., the block will be entirely sustained by the interposed film of water between base of block and its foundation, and the block will be floating.

Fig 5 shows the uplift varying uniformly from 1,000 lbs. per sq. ft. at one extremity of the base to zero at the other extremity. The common error made is to regard the uplift as producing an overturning moment on the block, but the fact that the remaining foundation reaction is also producing an overturning moment counter to the moment of the uplift, is completely lost sight of. The two moments annul each other, and their total upward pressure is 3,000 lbs. per sq. ft., the upward water pressure substituting itself in place of the foundation reaction.

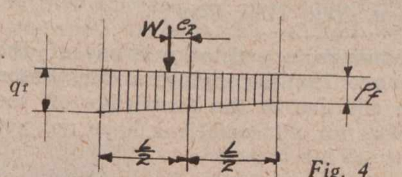


Fig. 4

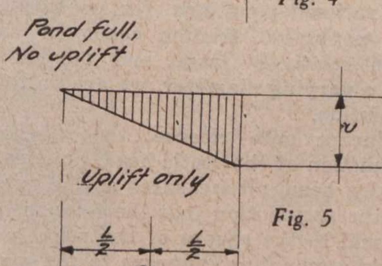


Fig. 5

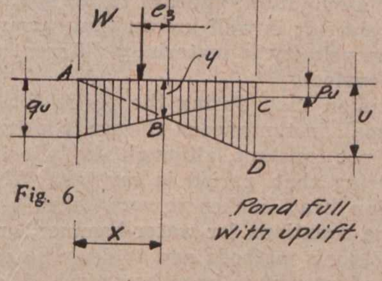


Fig. 6

How the uplift can be regarded as producing an overturning moment, and at the same time the counter-moment of the foundation reaction be wilfully neglected, is beyond the writer's comprehension. It is a case of mechanics, pure and simple.

Lamar Lyndon, in his first volume on "Hydro - Electric Power," speaking of this added overturning moment, writes:—

"How such a weird fancy could have ever obtained the importance of a standard engineering rule of design, is beyond the writer to understand, being contrary to every law of physics, mechanics and common sense."

In case the uplift exceeds the foundation reaction at the heel of the dam, there will be an excess pressure acting upward, and it is this excess pressure only which will have to be considered as producing an overturning moment. The following equations will make this clear:—

Let W = Weight of dam per foot of length.
H = Horizontal water pressure.
L = Length of base.
d = Distance of H above base of dam.
e_1, e_2, e_3 = Eccentricity.
p = Pressure at heel of dam.

q = Pressure at toe of dam.
u = Uplift at heel of dam.
W_u = Weight of dam per foot of length, diminished by excess uplift.

Subscripts e, f and u refer to "pond empty," "pond full" and "pond full with uplift," respectively.

Foundation Reaction, Pond Empty.—Pressure on foundation due to direct load plus or minus couple $W \times e_1$. See Fig. 2.

$$p_e = (W/L)(1+6e_1/L) \quad \ldots\ldots (1)$$
$$q_e = (W/L)(1-6e_1/L) \quad \ldots\ldots (2)$$

Foundation Reaction, Pond Full, No Uplift.—See Figs. 3 and 4. $Hd = pL^2/6 = qL^2/6$. Solving for p and q:—

$$p = q = 6Hd/L^2 \quad \ldots\ldots (3)$$
$$p_f = p_e - p \quad \ldots\ldots (4)$$
$$q_f = q_e + q \quad \ldots\ldots (5)$$

Also,

$$p_f = (W/L)(1-6e_2/L) \quad \ldots\ldots (6)$$
$$q_f = (W/L)(1+6e_2/L) \quad \ldots\ldots (7)$$

From this,

$$e_2 = (Hd/W) - e_1 \quad \ldots\ldots (8)$$

Foundation Reaction, Pond Full, With Uplift.—When $u \leqq p_f$, no change results due to uplift, as far as overturning moment is concerned, and equations 4 and 5 are to be used. For sliding, however, subtract $uL/2$ from W, since only that part of the dam which is in actual contact with the foundation produces friction.

When $u > p_f$ the procedure is as follows: The excess uplift BCD in Fig. 6 causes foundation reaction in Fig. 4, namely p_f and q_f, to change to p_u and q_u respectively in Fig. 6, so as to make the sum of all moments equal zero and the sum of all vertical forces equal zero.

Taking moments about A (see Fig. 6),

$$W(L/2-e_2) = uL^2/3+(q_u x/2)(x/3).$$

But $W = uL/2+q_u x/2$, and solving for x,

$$x = [6W(L/2-e_2)-2uL^2]/(2W-uL) \quad \ldots\ldots (9)$$

And

$$q_u = (2W-uL)/x$$
$$= (2W-uL)^2/[6W(L/2-e_2)-2uL^2] \quad \ldots\ldots (10)$$

From similar triangles:—

$$u/L = y/x, \text{ and } y = ux/L.$$

Also

$$(q_u-p_u)/L = (y-p_u)/(L-x).$$

And from these two equations,

$$p_u = u-q_u[(L-x)/x] \quad \ldots\ldots (11)$$
$$W - \Delta BCD = W_u = \tfrac{1}{2}(p_u+q_u)L \quad \ldots\ldots (12)$$

Since $q_u = (W_u/L)(1+6e_3/L)$,
and $p_u = (W_u/L)(1-6e_3/L)$,

$$e_3 = \tfrac{1}{6}L(q_u-p_u)/(q_u+p_u) \quad \ldots\ldots (13)$$

When $p_u = 0$, $e_3 = L/6$.

For sliding, subtract $\tfrac{1}{2}uL$ from W.

In conclusion it will be said that the uplift is usually assumed much larger than necessary. If a horizontal plane be cut through the base of the dam, the area of the voids in practice would not exceed 25% of the total area, except under extraordinary conditions, and since the water could only fill these voids, the unit uplift pressure exerted could only be 25% of the pressure assumed. The unit pressure of the dam against the foundation would then be 1÷0.75=133% of the actual contact area, since only 75% of the base area would come in contact with the foundation.

PRESSURES IN PENSTOCKS CAUSED BY THE GRADUAL CLOSING OF TURBINE GATES*

By William P. Creager
Assistant Hydraulic Engineer, J. G. White Engineering Corporation, New York City

THE theory of water-hammer in penstocks is one of the most intricate problems confronting engineers. Mr. Gibson has made a considerable addition to the knowledge of the subject; but exact solutions for all conditions have not yet been reached.

He has developed rational equations for penstocks of constant diameter and negligible friction head. In cases where friction head is relatively large, and particularly where the penstock has a varying diameter, we are still very far from a practical solution.

At any instant during gate closure, the discharge through the gate is a function of the static head, plus water-hammer head, less friction head, all measured at the gate.

Mr. Gibson makes the assumption that the friction head at the gate is proportional to the square of the velocity adjacent to the gate. This assumption appears to the writer to be only approximate, since it is well known that, at any instant during surges, the velocity is materially different at different points on the penstock.

It is the writer's opinion that, during the period $2L/a$, subsequent to a single small instantaneous closure, the friction head at the gate is not constant, although the velocity adjacent to the gate during that period is constant. This constantly varying friction head makes it very difficult to include this feature in the equations for water-hammer, and, in all probability, Mr. Gibson's methods are as close as can be obtained. It would be of interest to know how much difference the incorporation of friction head makes in ordinary problems.

For a penstock with varying diameter, auxiliary waves are set up each time a water-hammer wave passes a point of change in diameter. For this condition, Mr. Gibson's equations would not apply. His methods would apply, but they would be exceedingly difficult, if not impossible, of practical application.

It is evident that the maximum rise of pressure is materially influenced by the characteristics of the gate-closure curve. It is well known that modern turbine governors do not provide a uniform rate of gate closure throughout the stroke. It is also possible that governors of different types have different closure characteristics. Consequently, complete data for the determination of maximum water-hammer for specific cases must include the gate-closure characteristics of the governor, which is to be a part of the machinery.

*Discussion (presented to the American Society of Civil Engineers) of Norman R. Gibson's paper (see September 4th and 11th issues of *The Canadian Engineer*).

TO CONSIDER PAY FOR ESTIMATES

TENTATIVE arrangements have been made for a conference to be attended by committees from the American Institute of Architects, the U.S. Engineering Council, and the Associated General Contractors of America, for the purpose of considering "payment for estimating." At present it is planned to hold the first meeting November 17th at Hotel La Salle, Chicago.

For the Associated General Contractors, a special committee has been appointed, consisting of the following: A. P. Greensfelder, of the Fruin-Colnon Contracting Co., St. Louis; James O. Heyworth, of the Chicago company of that name; and A. E. Wells, of the Wells Brothers Construction Co., Chicago. Mr. Greensfelder is the chairman of the A.G.C.'s Committee on Methods, which had general supervision of the discussions regarding "payment for estimating."

Engineering Council has named as its delegates, Ralph Modjeski, Samuel G. Neiler and Theodore L. Condron, while the Post-War Committee of the American Institute of Architects will be represented by George C. Nimmons, Richard E. Schmidt and Frederick W. Perkins, with Henry K. Holsman as alternate.

In a report recently made by F. A. Gaby, chief engineer of the Hydro-Electric Power Commission of Ontario, the estimated cost of the proposed hydro-radial from Toronto to Bowmanville, via Pickering, Whitby and Oshawa, is given as $8,360,794; the estimated annual revenue, $1,118,003; and the estimated annual operating expenses, including 5% interest on capital expenditure, $1,076,175. Of the $1,118,003 income, $873,140 is expected from passenger traffic and $244,863 from freight.

HOUSING AND TOWN PLANNING*

By Thomas Adams
Town Planning Adviser to the Dominion Cabinet

We have a great opportunity in Canada to make our housing conditions right, because it is a new country. In older countries, like England, attention is being devoted to the solution of a housing problem that arises from bad conditions which we can prevent in this country. It is obviously a much easier operation to prevent bad conditions than it is to remedy them after they have become established.

Some idea of the enormous problem that they have to deal with in England may be gathered from the fact that they propose to build under government agency from 300,000 to 400,000 houses at a cost of from $2,500 to $4,000 each, involving a loss to the country—when they come to make up the difference between the cost of the houses and their value as an investment, likely to result from the fall in prices which will take place in a few years—of several hundred million dollars.

They are facing this loss at a time when they have not very much money to spare for anything which is not an absolute necessity. That is because the problem in England has been neglected too long. Here in Canada we are still in the formative stage as a country. Rapid as our growth has been, great as has been the development in the last 20 years, still our biggest housing problem is to prevent bad conditions of growth in the future rather than to correct the evils of the past.

We have a chance to prevent such a catastrophe as that of handing down to the future citizens of this country the evils that are characteristic of the slums of older European cities. We cannot delude ourselves with the idea that we

Government Housing Scheme at Well Hall, Woolwich

have not begun to create the germs of slums in our big cities. Without a doubt the conditions already existing in our few big cities are comparable with some of the worst conditions in European cities. These existing evils must be attacked and some remedy found for them, but it is still true that with us the greater task and the greater responsibility is to prevent the further growth of these evils by preventive measures.

In both Canada and the United States we have the beginnings of slums, and we have a similarity of conditions that enables us to compare them to our mutual advantage. One of the things of which housing experts and town planners are convinced is that the solution of the housing problem depends most largely on applying right methods of planning and developing the land, and on the extent to which these methods lessen the evils that arise from land speculation.

One of our chief tasks is the prevention of bad conditions in the new suburbs of our cities, without diminishing our efforts to remove the evils prevailing in the centres of the cities. All our cities are surrounded by scattered and somewhat disorderly developments, and one difference between a Canadian city and a city, say, in the Mother Country, is that whereas our new suburban developments are among the worst we have, the bad housing conditions in the English city have been mostly handed down from the past. With us, some of the worst conditions are those which we are creating to-day, in the form of unsanitary shacks in the suburbs of our cities. If you want to see the worst conditions in Ottawa, for instance, you must go not to "Lower Town," or to the centre of the city, but just over the city boundaries, in what is practically a "no man's land," between the city and the country, and where there is a lack of sufficient control and interest to secure proper conditions.

Workmen's Cottages at Gretna

Garden City at Letchworth

One of the movements in England of great interest to housing reformers is the Garden City at Letchworth, near London. It proves the advantage of town planning as a basis for practical housing improvement. If there is any experience in my own life which I look back upon as having the most value to me as a town planner, it is the experience I had during the few years that I was connected with the building up of that garden city. We started *de novo*; we considered the problem right from the beginning and commenced the building of a new city unhampered by existing vested interests. That scheme was started for the purpose of establishing certain principles and to take advantage of a prevailing tendency of manufacturing industries to migrate from large centres of population to rural districts, a tendency which is very prevalent in this country also.

Industrial Decentralization

I have just been making some investigations in connection with housing conditions in Toronto, and one of the things we are inquiring into is the extent to which the movement of industrial plants from the city proper out into

*Address delivered October 18th, 1919, at the Ottawa Conference of the American City Planning Institute and the Town Planning Institute of Canada.

the suburbs has affected the housing situation. You would be surprised to know how many industries have moved out of the central districts of Toronto, within the last few years, into the suburbs, where they have created a new demand for houses and new questions of transportation.

These industries have been moved into districts where they can get cheap land and transportation facilities, but adequate consideration has not been given to the question of housing for the workers.

This problem of the decentralization of industry has been in existence for the last 20 or 30 years in Britain. Big industries have been moving out of London and other large centres to the country districts, and the originators of the Garden City movement said:—

"Let us take hold of this movement. Let us start a new city and offer attractions to these industries that are looking for new locations. Let us group these manufacturers together and build houses for their employees. Let us give them up-to-date transportation and other facilities. Let us conserve the whole of the unearned increment of the value of the land created by the inhabitants for their own benefit; and see if we can establish a city which will be a model in connection with both the housing question and the land question."

Well, they have been comparatively successful: 3,800 acres were purchased at about $200 an acre. The promoters planned the site of the city, they put in an electrical installation, gas works and a pure water supply. They prescribed that there should not be more than seven or eight houses to the acre. They put all the industries in one part of the estate, where the prevailing winds took the smoke away from the town. They improved the transportation system. The worker in Garden City lives within five minutes' walk of his place of employment; no costly transportation system takes him from a point ten miles out in the suburbs to a plant in the centre of the city, requiring him to spend two or three hours a day in going to and from his work.

Planning Increases Working Time

I venture to suggest, in connection with the discussions that took place at the recent National Industrial Conference, that this is one of the matters which has a distinct bearing upon the number of hours a day that an employee can reasonably give to his work. Every year we are increasing the aggregate distance between the factory and the home of the worker. A man may work eight or nine hours a day in a factory, but if he spends two or three hours a day hanging on to a strap, going to and from his work, he is going to continue pressing for the reduction of the time he gives to productive forms of labor, and is going to continue to be a less efficient instrument of production than if he lived near his place of employment. So this very question of the number of hours that the workman wastes each day in unnecessary travelling, as a result of unregulated distribution of industries and population, has a definite bearing upon the question of efficiency and output of labor.

We cannot repeat the Letchworth experiment all over the country, but if we had in Canada a place where manufacturers were already moving and where we could organize such an industrial development, it would be an excellent thing. It would have a great value in demonstrating the efficiency of scientific organization and of planning for the purposes of solving the housing problem, the land problem and the transportation problem, and of promoting industrial efficiency.

Unearned Increment Reserved

In the Letchworth scheme, the unearned increment in the value of the land is conserved for the benefit of the community. I have said that the land for the Letchworth garden city was purchased at $200 an acre. The value of that land has now increased to $1,000 and $2,000 an acre, and the whole of that increase in value is conserved for the benefit of the inhabitants of Letchworth. There can be no private property in land in Letchworth. You can acquire a lease for 99 years, with the right to renew at the end of that period, subject to revaluation, but you cannot acquire private property in land.

The land was purchased by a company, as a trust for the inhabitants, which laid down the conditions that the whole of the increase of value due to the conversion of the land from agricultural to building purposes, should be conserved for the benefit of the community. But it has to be pointed out that the people of Letchworth have been able to make their largest profits in the earlier years of development on account of the efficiency with which they are able to distribute gas, electricity, water and the other necessities of life, because of proper planning. The control of these things is often handed over, without thought, by franchise, to private concerns.

Agricultural Belt

An important and interesting feature of the Garden City scheme is the agricultural belt round the city. The city area comprises about 1,200 acres, laid out for a population of 30,000 people. In this area there are at present about 30 factories and 13,000 people. In 1903 there were about half a dozen farm houses and laborers' cottages on the site of the city. The other 2,600 acres of the original area, with an additional 700 acres recently acquired, are reserved as a permanent agricultural belt round the city. The charter under which the city is established provides that this belt must be reserved permanently for agricultural purposes or for such recreation purposes as golf. Thus the inhabitants have a large open area all round the city which can never be built upon, and the produce is brought close to the door of the consumer. If the city increases its population over 30,000, it must extend by leaping over the agricultural belt. Thus the industry of farming is linked up with manufacturing industries in one community, avoiding the usual separation of town and country into two distinct zones with the inhabitants of each pulling against one another. The city of the future should have its farm zone, with more harmonious relations established between the workers on the farm and in the factory. Letchworth proves the practicability of the combination, and in contrast the cities of this continent show the evils that arise from the excessive degree to which they promote the separation between agriculture and manufacture.

Letchworth a Private Experiment

People are apt to assume that model housing schemes can only be carried out by philanthropists and governments with unlimited resources. The Letchworth experiment was initiated by a number of men, including Ebenezer Howard, the founder; the late Sir Ralph Neville, a judge; George Cadbury; and Alfred Harmsworth, as he then was, now proprietor of "The Times," who put a little money into the scheme at the start.

Altogether, we had little more than $500,000 when we started out to build that town. The whole of the capital that has been raised in connection with it does not amount to more than $3,000,000. That money is now beginning to receive dividends which are limited to 5%.

The main point I wish to make about Letchworth, as an illustration of practical housing, is that when you do a thing properly; when you apply social science to the development of the social forces of industry as you apply physical science to the actual operations of your industrial plants, you can secure equally good results.

In other words, the way to bring about good results in connection with housing is to do the thing in the right way, although it needs more courage, vision and trouble at the outset. I think that is one of the things we have to learn in connection with our housing experiments in Canada, if we are to be practical: That it is far better to do the thing in the right way, even if at first it appears to be more costly.

Hampstead Garden Suburb

Hampstead is a suburb of London. The Hampstead Garden Suburb is the creation of a woman, Mrs. Barnett, wife of Canon Barnett, who spent a great many years in the east of London, and came to the conclusion that the way to solve the housing problem in the slums was to get the people out into the country, out into the suburbs. So she built a garden village at Hampstead, where she mixed the rich and the poor; for, as she said, it was as much for the benefit of the one as of the other.

Well Hall Model Village

At Well Hall, near Woolwich, there was built during the war a town of 6,000 people. This town, which was built in 1915, was brought into being and occupied within nine months, this by the slow English people at a time when the whole organization of the country was devoted to the manufacture of munitions of war, the raising and transportation of troops, and other war purposes. This and other schemes were carried out as the result of investigations made under Lloyd George, who wanted to find out how to increase the output of munitions. It was decided that to ensure reasonable hours of labor, comparatively good pay and, above all, good homes and contentment on the part of the worker, so far as his living conditions were concerned, was the best way to increase output.

If it is sound policy to build good houses and provide pleasant surroundings for workmen in the middle of a war in order to increase the output of munitions, it is just as sound a policy to provide good conditions and good surroundings and to bring about contentment among our workers in order to increase the output of production to meet competition with other countries in time of peace.

Practical in Peace-time Also

Under the war strain the British people were working at high pressure, and it would not have been unnatural to say to the people that, as patriots, they should be content with conditions that were unpleasant or unfavorable in the matter of housing. But it was considered to be better, even in time of war, to follow the bold policy of building permanent and healthy homes with agreeable surroundings.

What is wanted in the development of modern industry is not so much physical strength as nervous energy on the part of the worker, nervous energy and mental capacity to manipulate complicated machinery and to deal with difficult mechanical processes.

It is more important than ever before that we should have the worker living under conditions that will cause him to be contented and that will enable him to give the greatest efficiency to his work.

And in this respect the Well Hall experiment has a lesson for us. If it is good practical policy to build garden villages in time of war, it is equally a good practical policy to build garden villages and to improve housing conditions in times of peace.

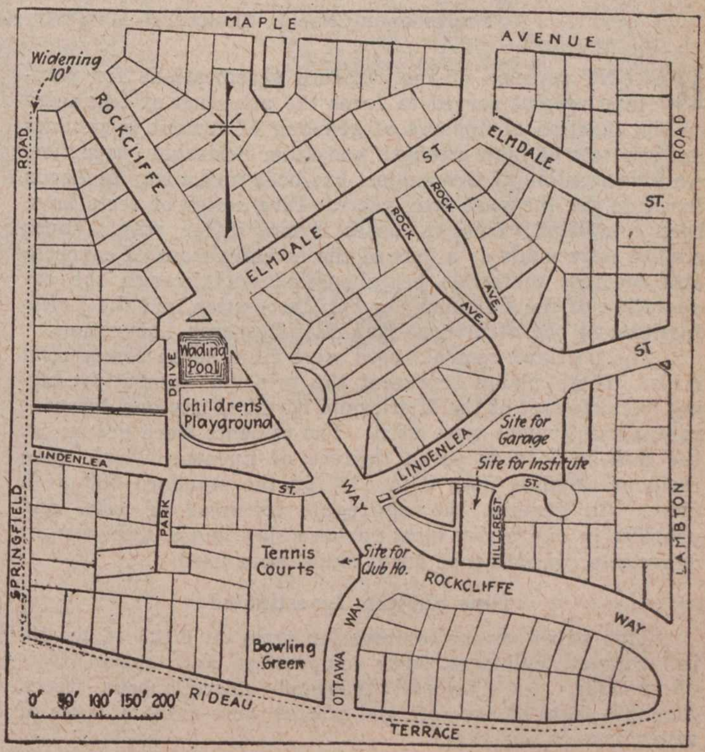
Therefore, I think we may congratulate ourselves upon the fact that the government of Canada and the provincial governments have taken the initiative in the matter of housing, with a view to dealing with the problem in the right way. Loans are made to the provinces for housing purposes. In this connection Ontario and its municipalities are heartily co-operating with a view to improving housing conditions. I am not going to deal here with the Canadian situation. I am simply trying to establish the value of good, sound methods of development as the really practical way of solving the housing question.

Inspiring Examples in Canada

I have endeavoured to illustrate some of the good examples of practical housing with the idea of suggesting to those who are dealing with this matter that they take no half-way measures, but go in for real, substantial improvements in the matter of raising the standards of housing accommodation. We are face to face with this condition in modern times: Men demand higher standards of housing at a time when costs are high, when labor and materials are expensive. But we must face that difficulty and try, by greater efficiency, to attain these high standards. We have to remember that to the extent to which we provide proper conditions, men will have greater earning power, and there will be greater efficiency and increased production.

I hope that the citing of these examples of British conditions has not produced the impression that I have endeavoured to contrast them with our bad conditions in Canada. We need the inspiration of what the "mother country" is doing to solve this problem; and we can take to heart the fact that in Letchworth, Hampstead and Well Hall, England has demonstrated one or two methods of dealing with the problem which are worthy of our consideration here. We have in Canada, as in the case of Grand 'Mere, Kipawa and Lindenlea (Ottawa), examples of proper attention to this subject which are equally good and equally inspiring.

At Lindenlea, Ottawa, we are carrying out a housing scheme under the Ontario Housing Act. At Lindenlea it has been proved that planning pays, and that when the land is properly planned great economies can be effected and ample recreation spaces provided. I think we shall be able to create there a suburb of Ottawa that will also be worthy of citing as an example. At Kipawa, on the Timiskaming river, the Riordon Pulp & Paper Co. are building a model town, which, I think, will also be an excellent example. Their houses for workmen are costing from $4,000 to $6,000. They have already erected 30 houses and are proceeding to build more. They are not content with shacks; they are not content with cheap houses; they recognize that even if it means a loss to them, they are going to have their workmen well housed and contented.



PLAN OF LINDENLEA GARDEN SUBURB, OTTAWA

These are examples of really practical housing reform, and should have the effect of inspiring our people to do more than they have done in the past in the matter of improving housing conditions and raising the general standard of living among our working people.

[NOTE.—The land for Lindenlea was bought by the Ottawa Housing Commission, and the "garden suburb" was laid out under Mr. Adams' direction. Most of the houses will be detached and they will be erected on lots having a frontage of from 30 to 60 ft. The tract of land acquired has an area of about 22½ acres, and of this over 2½ acres, or fully 10%, has been set aside for parks, playgrounds and other open spaces, including sites for a community garage and an institute. There are 168 available housing sites. The land is somewhat rocky. The street system and lot subdivisions have been planned to effect economy in street construction as well as with an eye to the best possible appearance. As shown by the accompanying plan, there is a principal street, called Rockcliffe Way, laid out as a diagonal thoroughfare. This is 66 ft. wide along its entire length. Near one end there is a short connecting road called Ottawa

Way, from which a good view may be had of the Parliament building. The minor streets are of less width, varying with the probable future traffic, and are so laid out that for the most part the lots are regular in shape, although not always rectangular. Mr. Adams states that the total cost of the land was about $66,000. Incidental expenses of some $15,000 will be incurred. Streets will be macadamized to a width of 14 to 16 ft., and it is expected that this work will be done by the city. The lots are being sold for $340 to $600 each, or 12.8c. per square foot on the average, with a range of from 10 to 15c. Lots fronting on Rideau Terrace, which has already been provided with partial improvements, have been sold at an added price of 75c. a front foot. Most of the trees will be preserved. An effort is being made to ensure the placing of electric and telephone wires at the rear of the dwellings, so that the streets will be kept free from poles. This will mean that the street lighting will have to be arranged by underground wiring, which can be carried out inexpensively as compared with underground wiring for electric services to the dwellings.—EDITOR.]

Experiments Show Effect of Fineness of Cement

Results of Over 6,000 Tests of Concrete Cylinders, 9,000 Compression and Tension Tests of Mortar, and Several Thousand Miscellaneous Tests —Summary of Paper Presented to American Society for Testing Materials

By DUFF A. ABRAMS
Professor-in-Charge, Structural Materials Research Laboratory, Lewis Institute, Chicago

RECENT revision of the standard specifications for portland cement served to focus the attention of engineers on the function of fineness of grinding of cement in producing concrete of high strength and other desirable properties. An investigation of this subject has been under way at Lewis Institute for the past four years. Five series of tests have been completed; another series is now under way. These studies were made as a part of the investigations of concrete and concrete materials being carried out through the co-operation of the Portland Cement Association and the Lewis Institute at the Structural Materials Research Laboratory.

The portland cements used were from seven commercial mills. These plants represent the principal cement-producing districts east of the Mississippi River. Fifty-one different samples of cement were used. The cements were ground at the mill to four to seven degrees of fineness, which gave residues ranging from 2 to 43% on the standard 200-mesh sieve. In general, the aggregate consisted of sand and pebbles; in one series blast furnace slag and a light-weight aggregate consisting of burnt shale were used.

Nine Subjects Investigated

This paper covers compression tests on 6,125 (6 by 12-in.) concrete cylinders, 9,000 compression and tension tests of mortar, and several thousand miscellaneous tests. Strength tests of concrete and mortar were made at ages of seven days to one year.

Definite information has been secured on the effect of fineness of cement under the following conditions:—

(a) Effect of fineness of cement on the strength of concrete.
(b) Quality of concrete, using different cements.
(c) Effect of the quantity of cement used.
(d) Effect of consistency of the concrete.
(e) Effect of size and grading of the aggregate.
(f) Variation in the type of aggregate.
(g) Effect of age of concrete.
(h) Elongation and contraction of concrete.
(i) Effect of fineness of cement on workability of concrete.

The following may be stated as the principal conclusions from the tests:—

1.—There is no necessary relation between the strength of concrete and the fineness of the cement if different cements are considered.

2.—In general, the strength of concrete increases with the fineness of a given lot of cement, for all mixes, consistencies, gradings of the aggregate and ages of concrete. The cements with residues lower than about 10% were inclined to give erratic results in the strength tests. One lot showed an abnormal increase and two others a pronounced decrease in strength, as compared with the other tests on coarser cements in the same lot.

3. For residues higher than 10%, the strength of concrete varies approximately inversely as the residue on the 200-mesh sieve.

4.—Fine grinding of cement is more effective in increasing the strength of lean mixtures than rich ones.

5.—Fine grinding of cement is more effective in increasing the 7-day strength of concrete than at ages of 28 days to 1 year.

6.—For the usual range of consistencies, the effect of fineness of cement is independent of the consistency of the concrete. The rate of increase in strength with fineness is lowered for very wet mixtures.

7.—Ordinary concrete mixtures at 28 days show an increase in strength of about 2% for 1% reduction in the residue of the cement on the 200-mesh sieve. At 7 days, 3 months and 1 year the corresponding increases in strength are about 2.5%, 1.7% and 1.4%.

8.—The decreased benefit of fine grinding of cement with the age of the concrete does not bear out accepted opinion that the coarser particles of cement do not hydrate, but indicates that the principal result of finer grinding is to hasten the early hardening of the concrete.

9.—For the richer mixtures and the consistency necessary for building construction, the fineness of the cement has no appreciable effect on the workability of concrete as determined by the "slump" test. For leaner mixtures and wetter consistencies, the finer cements showed a somewhat greater "slump" than the coarser cements.

10.—The normal consistency of cement is increased with fineness of grinding. About 0.1% of water (in terms of the weight of the cement) must be added for each 1% reduction in residue on the 200-mesh sieve.

11.—The time of setting of the cement is shortened with finer grinding. In some instances initial setting time with the Vicat needle was shortened to 5 to 10 minutes.

No Effect on Density

12.—The unit weight of cement decreases with fineness. For the cements used in these tests the weight varied from 76 (residue of 2.4%) to 108 lbs. per cu. ft. (residue 43.3%). For the usual range in fineness, the weight is lowered about ¾ lb. per cu. ft. for each 1% reduction in the residue on the 200-mesh sieve.

13.—In using 94 lbs. per cu. ft. as a uniform basis for proportioning the cements in these tests, the actual volume of cement in a batch *of the same mix* varies about 35%. If the mixtures had been proportioned in a manner that would have given a uniform *volume* of cement, the resulting concrete strength would not have been so favorable to the finer cements.

14.—The fineness of cement has no appreciable effect on the yield or density of concrete.

(Concluded on page 448)

BELLEVILLE, ONT., WATER SUPPLY*

PRIOR to 1918 the city of Belleville, Ont., with a population of about 13,000, was supplied with water by two steam pumps and one electrically operated pump, the latter being used only for domestic supply. On account of the growing demand for water, the increased cost of pumping and the condition of the steam pumps, which had been operating many years, it was decided to install new electric pumps and as soon as a duplicate transmission line could be built to the pumping station, to discard all the old pumping equipment.

The pumping station is west of the Moira river (which flows through the centre of the city) and is about one mile from the central business district. The supply is pumped through a single 16-in. main, about one mile long, to a standpipe of 360,000 gals. capacity and to the distributing mains. In the new layout, provision was made for a duplicate 16-in. supply main to be installed at a later date.

In order to properly accommodate the new electric pumps and control apparatus, the old steam pump room was enlarged and provision was made for placing the starters from the motors on a gallery to which was also carried the main valve stems and valves in the priming piping. This gallery extends around the sides of the pump room. On the back wall of the gallery is mounted the 550-volt bus disconnecting switches, meters, etc. The bus is sectional so that normally some of the pumps can be fed off one circuit and some off the other, or if necessary all the pumps can be fed off either circuit.

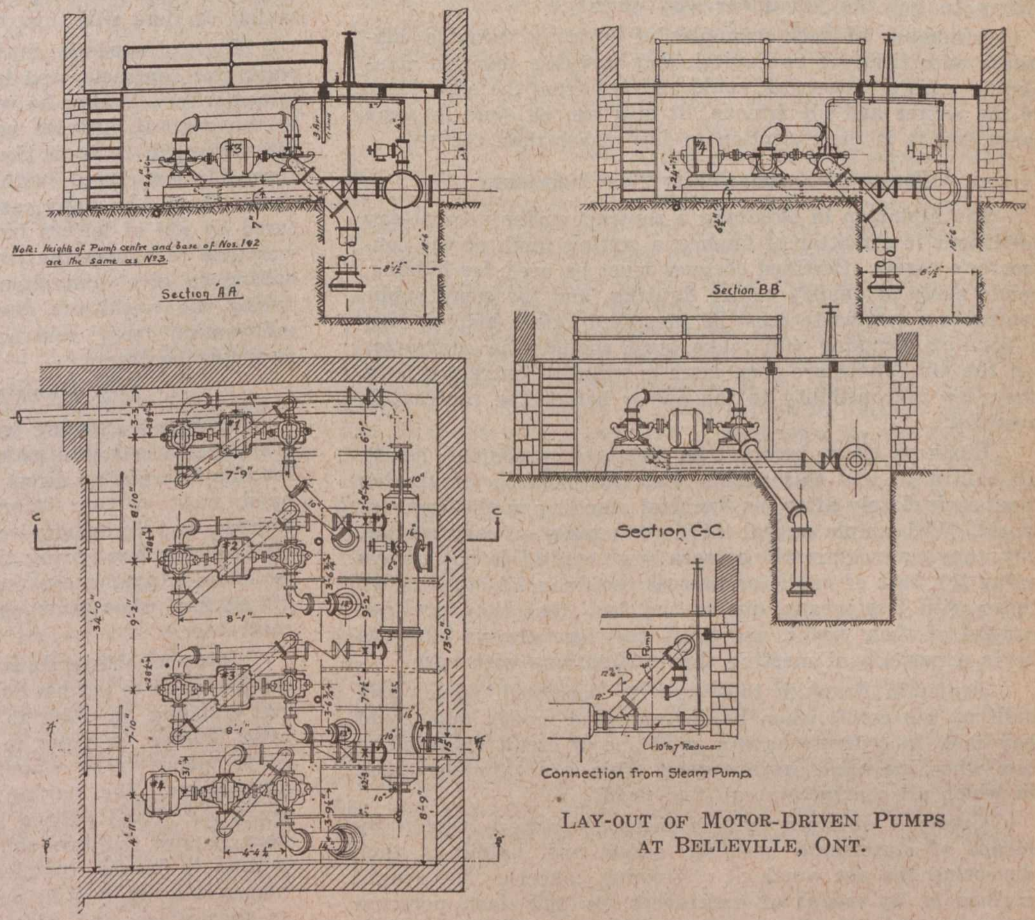
There are four pumps, one of 800 gals., driven by a 100-h.p., 3-phase, 60-cycle, 550-volt, 1,800 r.p.m., induction motor; two of 1,100 gals., each driven by a 125-h.p. motor; and one of 1,560 gals., driven by a 150-h.p. motor. All the motors are of the squirrel cage type. The pumps are designed to operate most efficiently at a head of 250 ft. (108 lbs.). They are also designed to deliver about two-thirds their normal capacities at a head of 325 ft. (141 lbs.) for fire purposes, this high pressure being required to overcome the friction in the long 16-in. main and still give ample pressure in the central business district. The small deficiency in volume for fire service can be made up by the future addition of pumps driven by gasoline engines. The pumps are all two-stage split-stage type; that is, two single-stage pumps connected in series, with the motor in the centre except in the case of the largest pump, where the motor is at one end.

The intake, which extends some distance into the Bay of Quinte, delivers through screens to a suction well in the pump room, from which the pumps discharge to a steel header located at the top of the suction well. The present 16-in. delivery main is connected near one end of this header and provision has been made for connecting a future 16-in. delivery main near the opposite end. All the water pumped is measured with a Venturi meter.

Preliminary plans have been drawn providing for a new intake and suction well from which low-lift electric pumps will deliver the water to rapid sand filters, which in turn will discharge to a clear water reservoir and to the present well.

When deciding upon the head and other characteristics of these pumps, and the location and type of electrical equipment, consideration was given to the possibility of using the pumps and equipment in a more complete water treating and pumping plant.

The transformers by which 550-volt service could be supplied to the present or future pumps from lines operating "Y" or delta connected, have been located temporarily on a pole-type structure just outside the pump house. Permanent installation of this equipment will be decided upon when a more adequate water treating and purifying system is being installed. Two independent power lines are being built to serve this station.



LAY-OUT OF MOTOR-DRIVEN PUMPS AT BELLEVILLE, ONT.

A comparison of the cost of pumping for 1916 and 1919 shows a saving for 1919 of $750. Part of the domestic pumping in 1916 was handled by the old electric pump and the remainder by steam, 600 tons of coal at $4.75 per ton being used. In 1919 all the pumping was done by the electric pumps.

The Engineers' Club of Peterborough, Ont., will hold a dinner this evening at the Empress Hotel, Peterborough. After the dinner the club loses its identity and becomes the Peterborough branch of the Engineering Institute of Canada. This dinner will therefore mark the inauguration of the new branch as well as the termination of the old club.

Sir Adam Beck was heartily endorsed last week at a meeting of the Municipal Hydro-Electric Association of Ontario, and he was urged to continue as "Hydro" chairman. Sir Adam had threatened to resign on account of his defeat in the recent provincial election, as he thought that the "Hydro" chairman should be a member of the legislature. The Association stated that a seat would be found for him, and urged Sir Adam so strongly to continue his work that he found it impossible to resist the popular pressure upon him to remain in office.

*From the October, 1919, Bulletin of the Hydro-Electric Power Commission of Ontario.

FINANCIAL STATEMENTS AN AID IN PROCURING CONTRACTS*

By Daniel J. Hauer
Construction Economist

A DECADE or two ago, a contractor who had just finished a large contract upon which no money had been made, and with his plant or outfit tied up so he could not move it, put about $250 in his pocket and went into an adjoining state to procure a new contract and get another start in his business. By sheer force of character and keen judgment, together with diplomacy in talking to and handling the engineer and other officials of the company letting it, he obtained a contract for more than half a million dollars of work. With this as an asset he was able to borrow ample money to get the job under way quickly.

A number of such examples of securing valuable contracts with little or no capital, and carrying them to completion upon a shoestring, could be cited from the experience of the writer and his friends. It still can be done in some cases, but it is the exception to-day rather than the rule.

Financial Responsibility Now Necessary

The first step in obtaining a contract under present-day conditions is a matter of finance, a setting forth of the contractor's assets. Certified cheques must be used for bidding, bonds made to qualify before figuring, and for some public contracts a certificate must be furnished before bidding that a bonding company will make bond should the contractor get the job. There are even cases in which a contractor must show his responsibility to the owner before the contract is awarded.

Finances thus become the basis of procuring nearly all contracts, and this means that the modern contractor must look closely after his financial standing in the business world. With ample capital this is seemingly an easy matter, yet many contractors who possess large capital do not always enjoy the best of credit or possess the financial standing of those with less means, due to the fact that they are not careful of their credit, and think they are always likely to be in a position of meeting their obligations with ease.

Benjamin Franklin told how he borrowed money and built up his credit when he did not need money and could pay cash, in order to have a good line of credit extended to him when his needs were urgent. This is a valuable lesson in which all contractors can find profit.

Credit is obtained by two methods to-day. One is by means of statements showing assets and liabilities, thus disclosing the net worth of a growing concern. The second method is by means of references. In this last, personal integrity and the esteem and confidence in which a man is held counts for much. In most cases these two methods go hand-in-hand, and the second is frequently the result of the first. In spite of this it is quite surprising how many contractors refuse to make statements of their financial condition.

Even Large Contractors Borrow

Only recently, as the writer was giving a statement to the solicitor of one of the large national mercantile agencies, the solicitor remarked upon the fact that a large per cent. of contractors refused to make statements, with the result that their standing was greatly reduced and their credit limited. Definite knowledge of a man's standing, even though he has only a few thousand dollars, has been proved better than meagre information regarding a man who may be worth more.

Take the question of deposits on bids, for example. If the cheque is only a few hundred dollars, almost any contractor can furnish it, but if some thousands are demanded, even the contractor who is conducting a large business may not be able to spare the sum, and must arrange to borrow the money. As this is written, an eastern state is asking for a $25,000 certified cheque with a bid. Even if a bidding bond is used instead of a certified cheque, the bonding company will want to know the financial condition of the applicant.

This likewise is true if a bond must be obtained when a contract has been awarded. If there is a maintenance clause or guarantee to the contract, the bonding company will want to know if the contractor is financially strong enough to live up to the contract he is about to make.

If the engineer, architect or owner is careful to whom he lets work, a close investigation will be made of the standing and reputation of the successful bidder. In some cases this is done before bids are asked from contractors. The only way to meet this demand for information is to have carefully prepared reports of a contractor's standing in the hands of commerical agencies and of his banker. A great saving of time will thus be effected.

Money frequently must be borrowed from banks to start new contracts, and if close relations are to be maintained with a banker he will demand information in regard to the general business policy of the contractor and what his net worth is from time to time. Some people are not favorably impressed with bank references, while others prefer them. In many cases large contracts have been captured by aid of letters from bankers saying the contractor was able to handle the transaction, or else that they were willing to give him financial assistance. In many cases during the world-war, the national government demanded information from contractors and their bankers before awarding contracts.

Lost Municipal Paving Contract

There is a growing tendency among state and city governments to look into such details, and some few are asking for this information direct from the contractor. On the other hand, most of this information is gleaned from outside sources, and frequently to the detriment of the contractor. Only during last spring the writer knew of a city refusing to award a paving contract to the lowest bidder on account of meagre information about the financial standing of the contractor.

Thus, to obtain contracts, the first consideration for a contractor is to set his house in order. He must have financial standing in order to bid, in order to get the contract after bidding, in order to make bond, and in order to purchase plant from manufacturers, especially in lease sale agreements. The making of a financial statement does not mean the actual putting of capital into his business, but it does require the furnishing of accurate and detailed information to insure confidence. Thus, indirectly it increases his capital, for by it he may obtain contracts, valuable assets in themselves, and also credit to purchase machines and supplies far beyond what actual capital would supply. It establishes more firmly his position in the business world.

*From "Successful Methods."

The John ver Mehr Engineering Co., Ltd., has moved from 154 Simcoe St. to 32 Church St., Toronto.

Declaring that high officials of the American Federation of Labor are responsible for "tendencies that threaten the foundations of the government of the United States," a union of draftsmen employed in the U.S. Treasury Department withdrew last week from the American Federation of Labor. The movement is part of a general campaign to secure withdrawal by all government employees' unions.

The Milwaukee Chapter of the American Association of Engineers has submitted a schedule of salaries for the various engineer employees of the city to the city council. The council did not take definite action on October 21st, when the request was presented, but will do so inside of a week or two. The following positions are the principal ones affected by the proposed increases:—Chief engineer of sewers, office engineer of water department, field engineer of water department, chief draftsman, division engineer of street construction, and chief estimating engineer.

AIR LIFT PUMPING*

By Chas. J. Deem
Hydro-Pneumatic Engineer, Harris Air Pump Co., Chicago

If I had been called upon to write this paper some 12 or 15 years ago, I could have conscientiously and honestly told you many things that I then believed, which time has proven might not always be the case, in regard to air lifts. In that early day of air lift pumping first entering into the commercial field, there were a great many conditions surrounding its operation that were unknown to the manufacturers of the lifts themselves.

It has been charged by many, and more especially by engineers, that the manufacturers of air lift pumps wish to surround their product with mystery. I can truly say that this is not the case. The manufacturers of air lift pumps, like any other trades-people, wish to sell all of their product that they can, and will willingly give all the information regarding its operation that will make it more popular in the deep-well pumping field. However, they are limited in this desire from the fact that no *master formula* has as yet been devised whereby infallible rules may be laid down for the proper designing of any and all installations, without any regard for the conditions that exist in the wells.

The Individuality of Wells

Some 15 years of experience have taught me that in many instances wells are just as individual in their actions as are persons. Therefore, a properly designed air lift installation, operating satisfactorily in one well, might give entirely different results when installed in another well which, to an inexperienced operator, might seem to be identical.

While experience is not absolutely essential to the pumping of water from deep wells by the means of compressed air, yet I know of no engineering field where experience counts for more or is more essential than in air lift pumping.

Some of our best engineers have branded air lift pumping as a system sadly lacking in economy, but in such cases their judgment has been based upon results obtained from improper methods of piping, in connection with inefficient air compressors. Many have also become convinced that there is no special merit in the patented air lift pumps, that home-made devices will answer the purpose just as well. However, in all my years of experience, I have never yet seen one of these home-made lifts over which a patented pump would not give excellent returns on the small amount of money invested in it.

Contrary to a popular belief, the compressed air discharged through an air lift pump does not blow the column of water upward after the first discharge. When the static head is lifted from the working head of the well by the first inrush of air, the water is forced out of the pipe in a solid column. After that, the compressed air passing through the pump reduces the specific gravity of the water in the discharge line of the pump. This consequently moves upward by the expansion of the air bubbles, aided by the greater weight of the solid column of water surrounding the discharge line.

Should Avoid Large Bubbles

In an economically designed air pump, it is imperative that the formation of large bubbles of air be avoided, for these have a tendency to rush upward without lifting the proper amount of water for the stored energy that they contain. Therefore, the pump should divide the air into small streams or jets, creating as many small bubbles as possible in order to give the best economy. The slip of these bubbles constitutes the chief loss in the energy of the air lift. It is figured that this varies as the square root of the volume of the bubbles. Therefore, the smaller the bubbles, the more efficient the air lift.

Of course, one of the foremost things to be considered in the installing of a pumping plant is its efficiency. I presume there is no one word in the English language to-day that is used more in manufacturing and engineering circles than the word efficiency. It is a good strong word, but may be figured from so many different bases of calculation that all conditions in connection with the apparatus must be thoroughly understood before the percentage of efficiency that is claimed for it can be valued. The only true way I know to figure the efficiency of a pumping plant is that at the end of the year the column in the ledger headed "operating costs" be added up and the results calculated from its total. In this column we will also find, if we note down the items such as repairs, break-downs and their attendant losses, and read between the lines the worries that were caused thereby, we can also determine just how efficiently the system has or has not caused trouble.

Workable Efficiency Required

In travelling over the country I find that water works superintendents and manufacturers are more and more demanding workable commercial efficiency from their pumping machinery. They realize that by installing some very closely adjusted high-speed apparatus in their wells, they may be able during its short life to pump water very cheaply per thousand gallons, but that in about nine cases out of every ten, such a pump is sure to cause trouble sooner or later, more often sooner; and that the small amount saved per thousand gallons pumped during the course of the pump's successful operation, is far more than offset by repairs, shut-downs and pulling of wells.

To give some idea of the faith that the underwriters of the country have in the reliability of the air lift system, I will, with Mr. Judd's permission, tell his experience with them in reference to his discarding of deep well pumps and the installing of air lift systems in the city wells here in Mason City. The Board of Underwriters in Chicago granted him 30 points on the key rate of insurance for the fire protection the increased yield of the wells would afford the city, and they gave him 130 points because of the reliability of an air lift pumping system. This is something that should be weighed very carefully, for if there is any institution in the wide world that figures from exact statistics, it is the underwriters. They do not guess, they know.

As I said before, no one has yet been able to figure a master formula for the installation of the air lift any more than has some noted doctor been able to write a master prescription that will cure all diseases to which flesh is heir. However, the manufacturers of air lift pumps have at quite a great expense gathered data from laboratory tests and field experience that enable them to construct formulas which cannot be universally applied to all conditions, yet can define and introduce certain rules which enable them to calculate the requirements for a proposition when the exact data are known.

Exact Data Sometimes Lacking

When exact data are lacking, conditions are usually *assumed* and a lift installed. Then, from results obtained, the engineer, by basing his judgment on experience, can proceed to pipe up the well so as to get economical results. To give an illustration of this:—

Some years ago I installed an air lift in a flowing well on a ranch in southwest Texas. The well was 8 ins. in diameter, about 600 ft. deep and flowed about 20 gals. per min. The owner of the ranch had only a small compressor, its maximum capacity being 30 cu. ft. of compressed air per minute. A 6-in. pump was installed 2 ft. in the well, and this 30 ft. of air delivered to it. The head of the well dropped 20 ft. from the surface and the well yielded 530 g.p.m., accurately measured over a knife-edged weir. Of course, this was phenomenal. Never before or since have I seen such a small volume of air deliver so much water from a deep well.

Only the week before last, at Fort Dodge, Iowa, we installed a 6-in. pump in a flowing well located on an island in the Des Moines river. The well was 8 ins. in diameter, 500 ft. deep and flowed 21 gals. per min. The same size pump was located 200 ft. from the surface, and we delivered to it 200 cu. ft. of air. The working head of the well dropped 150 ft. from the surface and yielded 80 g.p.m. This proved

*Paper read before the Iowa Section of the American Water Works Association at Mason City, Iowa.

to be a very uneconomical installation, yet, to all outward appearances, the conditions in the second well were the same as those in the first, and the results almost beyond comparison.

It is in this second well that experience would have been necessary to have properly piped it up had the city decided to use it. However, they had plenty of other water available, so the well was abandoned. But an air lift could have been installed in it in such manner that, figuring from the current input at the motor of the compressor to the water discharged in the reservoir, it would have shown 30% efficiency. This could have been obtained by installing a 3-in. air lift and taking 50% submergence, or, in other words, by placing the lift as far below the working head of the well as we were going to lift the water. This would have yielded one gallon of water for 0.63 of a cubic foot of air at 67 lbs. pressure.

Misleading Results

Of course, the starting pressure in this well would have been greater than that of the other wells of the system, yet this could have been offset by the use of an auxiliary air line to lift the head of the well. Had the original installation in this well been let stand, anyone wishing to speak disparagingly of air lift pumping could have in all honesty cited it as an expensive mode of pumping water. On the other hand, some manufacturer wishing to extol the virtues of his pumps, might have honestly printed a glowing advertisement of the results obtained in the well first described. Both would be equally misleading. The first is a result from what might be termed a freak well, while the installation of a 6-in. pump in the second well would be improper for the best results obtainable by the air lift system. I only cite these two wells to illustrate my point that each well forms an individual problem and that the same installation in all wells would fail to pump them properly just as would the same medicine fail to cure all men suffering from disease.

One reason why the air lift pump proves valuable in many parts of the state of Iowa, or for that matter in any other part of the country where the water contains as much iron and sulphur as it does in this locality: When a well is pumped by air, the water undergoes a complete aeration, for the air and water are mixed under pressure and this tends to throw off the sulphur gas and precipitates a great deal of the iron. One of the principles on which the iron-breaker works is aeration.

Also, many of the wells in this part of the state pump a great deal of sand, and as the air lift has no moving parts in the well, grit has no effect upon it. Any number of wells may be pumped from a central plant and there is no limit to the quantity of water that can be handled, and with a properly designed system, the extra cost of pumping wells located a mile from the power plant is not material. It has been stated that an air lift system requires little or no attention aside from keeping the compressor in proper running order. While this is practically true, and cited as one of its many advantages, yet sometimes it works to a disadvantage, because it will continue yielding water for years without giving any trouble, yet there are times when the system becomes unbalanced and the working heads of the wells recede (which changes the percentage of submergence), thereby reducing the yield of the well and increasing the amount of air required.

If the wells were checked up once or twice a year, and changes made to meet the new conditions, a great deal might be saved in operating cost. Sometimes very little things cause quite a great loss in economy. Not so long ago, I was called to a plant where a battery of five wells was being pumped from one compressor. The compressor at its maximum speed was barely large enough to pump the amount of water required. The operator told me that when the plant was first installed it gave excellent results. But there had been a decided falling off in the yield of the wells. The system was well designed and should have given good results. Upon investigation I found that two of the wells were much weaker than the other three and that they operated at about 15 lbs. less pressure than the other wells. When the engineer had balanced the system, he had set the regulating valve at the well head of these two weaker wells so as to admit only enough air to pump the water that they would economically yield, and, of course, had left the valves wider open on the strong wells.

When starting the system, the operator discovered that many times these two weak wells did not come in. Their static head being the same as the stronger wells, and therefore being supplied with much less air, did not start so easily. In order to overcome this he had very thoughtlessly taken a wrench and opened the valves of these two weaker wells. Any force follows the line of least resistance and the larger part of the volume of air rushed into the weaker wells, where it could not lift the amount of water that it could have done in the stronger wells. Therefore the system was out of balance and giving poor results, through no fault of the air lift or the man who installed it. When air lift systems are excessively costly to operate, I think it might safely be concluded that there is a good cause, and that the chances are that the trouble might be easily removed.

A great many mistakes are made when installing air lifts, especially by novices in the business, in reference to the size of the pump to be used to deliver economically a certain volume of water. In order to make that as plain as possible, I will give a concrete example:—

For instance, if we wanted to lift 150 g.p.m. from a well with a working head 80 ft. below the surface, the most economical pump to be installed would be a 3½-in. lift at 65% submergence. Under these conditions this pump should yield one gallon of water for every 0.3 cu. ft. of air at 67 lbs. pressure. As you can easily figure, the pump would be located 229 ft. from the surface. Now, suppose instead of being able to get 65% submergence, we can only get 40% submergence. In order to deliver 150 gals. per minute under these conditions a 4½-in. pump should be used, and one could expect a gallon of water for every 0.59 cu. ft. of air at 25 lbs. pressure.

By a little figuring one can ascertain that it required one and one-tenth more horse-power to raise the water in the second instance than it did in the first, and I gave it, hoping to be able to show that even though conditions be vastly different in various wells, a properly designed air lift can be made to yield good results. But, of course, there are places and conditions under which some other type of pump should be used.

As you can note from this example, as the submergence decreases, the size of the discharge line should increase. But this is only a general rule, and the conditions in the well to be pumped entirely govern the ratio of the change to be made.

Variable Discharge Lines

Of late years some firms have been advocating a variable discharge line. I mean by that, some firms wish to start with a smaller pipe and expand toward the point of discharge, the theory being that by allowing the compressed air more space in which to expand, it will lend more of its energy toward lifting water. On the other hand, some firms advocate turning this type of installation upside down, as it were; that is, they reduce the line toward the point of discharge, the theory being the same as the reason for choking the muzzle of a rifle in order to keep all the gases behind the bullet until it leaves the barrel.

Of the two systems, so far as observation has gone, the latter is to be preferred. I have seen it produce excellent results under some conditions; that is, by getting more water by greater economy than would be possible to get from a uniform discharge line made of our standard pipe sizes. I suspect that the friends of the expanded discharge line system will challenge this statement and point to some installations which they claim to be very successful. I have seen one or two of these, but they have been invariably installed in excellent wells that yielded large quantities of water very economically, not because of the system of expanding the discharge line, but in spite of it. However, improvements are being made in the system of piping, and each year shows more practical results than the preceding one.

Another improvement in the air lift system that I wish to mention briefly is what is known as the booster pump. This pump, or tank, is located on the well top and automatically separates the air and water as it is discharged from the well, retaining just enough pressure from the separated air to force the water to the point of discharge. This is indeed a great improvement when the water must be transferred long horizontal distances toward the point of discharge. This point may be at the surface or at an elevation. Hitherto when horizontal distances had to be considered, unless the water was delivered to an elevated tank and allowed to flow by gravity, the air would get ahead of the water in the discharge line, thereby materially reducing the efficiency of the system. However, the booster very efficiently overcomes this condition.

I have given no tangible data on the air lift, but from the varying conditions that exist in all wells, any statements regarding the air lift system as a whole must be of a general nature. Some manufacturers have, at no little trouble and expense, conducted exhaustive systematic tests in natural wells, or in artificial wells constructed for the purpose of maintaining any desired submergence by feeding water into them. The data that they thus gained is authentic for the conditions under which it was gathered. However, in the field nature does not make a habit of supplying her wells with water by pouring it in at the top. So we revert to the same premise from which we started. That is, each well presents a separate problem.

Another thing that has materially aided in the efficiency of the air lift system is the perfecting of air compressors by the various manufacturers. The standard compressors now offered on the market in nearly every instance operate on from one-third to one-fourth the horse-power that was required by the machines built some ten or twelve years ago. Not only is the economy of these machines much greater, but also the mechanical parts have been greatly simplified, thus bringing the air compressor into the realm of most economical machines.

U.S. ENGINEERING COUNCIL'S COMMITTEE ON CURRICULA OPPOSES PRESENT ADOPTION OF SIX-YEAR ENGINEERING COURSES

Under date of August 21st, 1919, the secretary of the American Institute of Electrical Engineers referred to the U.S. Engineering Council a portion of a report presented at a meeting of the Development Committee of that institute. The portion of the report so referred to the Engineering Council read as follows:—

"There is a universal recognition of the fact that engineers do not participate as actively or as prominently in public affairs as they should, and that both the public welfare and their own individual advancement would be promoted if this condition could be rectified. There are two general reasons believed to be responsible for the existing condition: One, a lack of any general organization of engineers which would facilitate their co-operation; and second, too great technical specialization in the engineering curricula of our technical schools and colleges, which tends to narrow the vision of the engineering student and start him on his career with an exaggerated idea of the importance of specialization and an insufficient appreciation of the part he must play in public affairs. The second reason, namely, a possible modification of the engineering curricula of our technical schools and colleges, while perhaps of underlying and fundamental importance, was nearly crowded off the Lake Placid program by the press of other matters. It was, however, the unanimous view of the members attending the sessions that this matter should receive early and thorough consideration by the institute, and the following preamble and resolution were presented and adopted:—

"'As the individual engineer cannot look for greater public recognition or individual advancement than his training and fitness warrant;

"'And, in the belief that the bigger development of the profession consists in broader social and public service by publicly minded engineers;

"'Recognizing that on the one hand young engineers are employed for too long a period at work which does not stress their capabilities, and, on the other, that the demands of industry for ever-increasing numbers of technicians must be supplied;

"'And having in mind the excellent precedents established by the medical and legal professions;

"'This committee would welcome the establishment at the earliest date practicable of a normal six-year collegiate course in engineering, two years of which at the least should be devoted to training in the humane arts and sciences, including, for example, political science, economics, history and general letters, the last four years being devoted to sound training in the sciences and in only the fundamentals of diversified engineering.

"'With or prior to such a development we would endorse a program for the marked extension of vocational training in the industrial centres in order that the needs of industry may be met.

"'To the accomplishment of these ends this committee requests the appointment of representatives to serve on a Joint Committee of Engineering Organizations to promote such a national educational program as shall provide for the future necessities of the engineering profession consistent with the needs of society.'"

This report was referred by Engineering Council to its Committee on Curricula of Engineering Schools. At a meeting of that committee held October 15th, the recommendations of the Development Committee of the American Institute of Electrical Engineers were considered, and the following report was sent to Secretary Flinn of Engineering Council:—

"While your committee is not prepared to recommend a six-year course for the colleges of engineering, your committee calls particular attention to the fact that a six-year course was inaugurated at Columbia University some few years ago, practically on the same plan as in the case of the schools of law and medicine, the technical studies of the engineering portion of the course being concentrated on the last three years and based upon three years devoted to studies leading to the B.A. degree.

"The Massachusetts Institute of Technology is also conducting a six-year course in engineering, this being in addition to, and without interference with, the regular four-year course. A somewhat similar program, although perhaps less formal, is followed by the majority of the students in the Harvard University Engineering School, who first take their bachelor's degree in Harvard College, followed by two years in the engineering school. This problem is also being studied and experimented on by other universities.

"Your committee suggests that, as these practical experiments with the six-year course will furnish information not now available, any final recommendation can well be deferred until the results of these experiments can be studied and appraised.

"Your committee is now prepared to report unfavorably on the proposition to substitute the six-year course in place of the four-year course generally in the colleges.

"Your committee strongly endorses the proposition to extend and enlarge the facilities for vocational training, particularly in the great industrial centres; this educational work, however, to be carried on without interfering with the courses in engineering.

"Your committee also favors universal military training under proper regulations.

"Your committee does not agree that military training and vocational training should be combined, except so far as the vocational training would be found to be naturally involved in the military training."

AN EXPERIENCE WITH A BROKEN 24-IN. WATER MAIN*

By S. L. Etnyre
Superintendent, Council Bluffs (Iowa) City Water Works

MOST water works men, no doubt, have had more or less experience in the breaking of water mains, and yet I am sure they are ever interested in finding out what the other fellow's experience has been; to know what effect such a break had upon the service; damage done by the water; cause of the break; etc. Before entering upon our recent experience with the blowing up of a 24-in. main, I will briefly describe its history and its importance in the operation of the plant:—

This main was laid on Broadway, in the year 1882, running from the Broadway Pumping Station at 37th St. to 21st St., a distance of 8,500 ft. From this point to 8th St. is 5,323 ft. of 20-in.; thence to the high-level storage reservoirs, 5,200 ft. of 16-in. Up to 1915 all the water for the city was supplied through this 24-in. pipe. On account of the importance of this main, and owing to the fact that with increased consumption the pressure materially increased, it was found necessary to lay an auxiliary 16-in. main from the Broadway Station to 21st St., and this was completed in 1915. With the reservoirs' storage, it was calculated that the 16-in. would supply the city in the case of any mishap to the 24-in. Two 24-in. valves were cut in the Broadway main and a drain laid into the sewer from the main at its lowest point.

Four Breaks in Thirty-Five Years

In 1884 the Broadway main broke at 30th St., a section 12 by 24 ins. blowing out at the bottom. No flaws were noticeable. In 1908 this main broke at 28th St. A triangular section 18 ins. at the base and 6 ft. long blew out at the side. No flaws were noticeable. In 1909, on the west side of 34th St., the pipe broke as if pulled apart. No flaws were noticeable.

The normal pressure carried by this pipe was 105 lbs. Our last break took place October 6th, 1919, on the east side of 34th St., a 12-ft. section splitting on its side for its entire length. The pressure dropped suddenly from 125 lbs. to 17 lbs. The volume of water escaping through this break was enormous, resulting in the drop of pressure all over the city, and many parts—even at moderate elevations—were without water until the valves were closed. From measurements taken at the high-level reservoir, making allowance for the normal city consumption, over 1,000,000 gallons had run out through this break. Fortunately, however, there was no material damage to private property.

The pressure chart at the pumping station plainly showed the time of closing the valves. Some time was lost in this work by the breaking of a 24-in. valve stem. Pumping to the city through the 16-in. main was started immediately upon the closing of the valves. The drain valves into the sewer were then opened, and when the pipe was broken into, it was found to be entirely free of water. It is also remarkable that all valves proved to be water-tight. The defective section was broken up with sledges and replaced with a new length, and the main was ready for service within 15 hours from the closing of the valves. During the time the repairs were being made, less than 1% of the consumers of the city were without water, and but for the breaking of the valve stem above referred to, less than one-half of the 1% would have been without water.

Original Casting Well Preserved

Pieces of the broken pipe show that the original casting is well preserved, although a casting defect is indicated at one point. A careful examination of the fracture, however, does not warrant the assumption that this condition prevailed to any extent. The thickness of the shell along this line of fracture was a good average with the rest of the pipe, being approximately 1 in. The question that now naturally suggests itself is, "What was the reason for this break?" Of course, the water pressure was partly responsible, but that is not the complete answer. We know by looking at the pressure chart that it was not caused by "water hammer." The thickness of the shell seems adequate for the pressure it had to carry; it was a good grade of metal and no evidences of serious flaws on fracture line or elsewhere were found when broken into small pieces.

*Paper read before the Iowa Section of the American Water Works Association.

UNIQUE MEMBERSHIP CAMPAIGN LAUNCHED BY AMERICAN ASSOCIATION OF ENGINEERS

WITH arrangements made for the largest sales organization that ever sold an engineering commodity, the American Association of Engineers announces a membership drive during the first two weeks of December. A letter from the secretary of the association says:—"There will be 9,000 salesmen, 90 branch sales offices, and 4 district sales offices. That summarizes the sales organization of A.A.E. If every salesman makes a sale, that is 9,000 sales; if every branch office turns in 100 applications, that will be 9,000 more.

"The method to be employed is similar to that used in obtaining subscriptions to the Liberty loans.

"The 90 clubs and chapters will divide their members into membership teams, each with certain territory to cover, and under the supervision of a team captain. The drive will be handled for each chapter by a drive commander who will keep in direct touch with the national headquarters of the association by telegraph. He will make telegraph reports of the number of applications obtained each day. A force will be maintained at the national headquarters to tabulate the returns and to advise the chapters of their standings.

"For the purpose of competition, chapters and clubs will be divided into two groups: Those having more than 100 members at midnight on December 13th, when the drive ends, and those having less than 100 members on that date. A special gavel will be presented to the chapter or club in the latter group which has the greatest percentage of increase of membership during the drive. Of the chapters having 100 or more members at the end of the drive, official A.A.E. colors will be presented to the one that has obtained the greatest percentage membership increase during the drive.

"The three members securing the greatest number of applications between the first and thirteenth of December, inclusive, will be awarded respectively a life membership in A.A.E., a collection of books to the value of $100, and a watch of the value of $50. The captain of the membership team in each chapter or club which obtains the greatest number of applications of all the teams in that chapter or club, will be awarded a solid gold, engraved, A.A.E. watch fob. Individual chapters and clubs may award special prizes to their members. The referee in the drive is Isham Randolph, consulting engineer of Chicago.

"With a membership of almost 8,500 at the end of October, it is probable that the American Association of Engineers will easily pass this year the 10,000 membership mark which was set last spring as a goal for 1919."

The Franklin Institute, acting through its Committee on Science and the Arts, has awarded its Edward Longstreth "Medal of Merit" to John Walter Ledoux, of Swarthmore, Pa., for the Simplex Venturi Meter, manufactured by the Simplex Valve and Meter Co., Philadelphia, Pa.

The Wallace & Tiernan Co., Inc., 349 Broadway, New York City, manufacturers of chlorinating apparatus for sterilization of water supplies and sewage, have recently made a change in their representative on the Pacific Coast. Their interests will hereafter be taken care of by Alexander Bell, with office at 709 Mechanics Institute Building, San Francisco, Cal. Mr. Bell will handle all installations on the Pacific Coast and will keep emergency outfits in stock.

H. W. Nelson's Plan of Payment for Estimating

Rules and Procedure Whereby Each Project is Considered Separately—Fundamentals to be Observed in Estimating—Statement Submitted by Mr. Nelson to Committee on Methods of the Associated General Contractors of America

ESTIMATING costs and establishing prices is an overhead expense involved in any merchandising, but the cost of doing so is generally nominal, if not insignificant, and can be justifiably distributed. The cost of figuring or estimating work to be peformed in accordance with special specifications to meet each case, however, differs materially from establishing a price on each of a thousand hats, all made from the same material and from the same pattern. The Nelson Form for Choosing Bidders and Awarding Contracts has, therefore, been suggested to meet special conditions; to more justly distribute the cost of competition and estimating, and to make each project bear its own proportion of the cost.

It is submitted with the thought that there are three main factors entering into the relations between the purchaser and the seller, viz.:—

1. Quantity and Quality of Materials.
2. Character of Labor and Personal Service.
3. Price to be Paid for Both.

The first factor can be determined and somewhat definitely set forth in the form of plans and specifications to be furnished by the purchaser to the seller, upon which the seller can base his price.

The character of the labor and personal service rendered by the seller or expected by the buyer varies as much as human nature varies, and cannot be so definitely or exactly set forth.

The price, or third factor, can be based definitely upon the materials, but must necessarily vary upon the Personal Service, depending upon the value placed upon it by either the seller or the buyer; therefore—

The purchaser should be allowed to exercise his recognized personal liberty in choosing the party with whom he wishes to enter into a contract, basing his choice upon price, his own confidence in the seller, his own judgment of the seller's qualifications or experience necessary to render the service he wants, or any other factor that he may himself consider most important.

And when the purchaser desires competition to enable him to make comparisons or decisions based upon a combination of all three factors, competition which involves labor and expense on the part of the seller, then the purchaser shall purchase that competition at a fair and just price, just as he purchases anything else.

Fundamentals in Awarding Contracts

Under the Nelson form of choosing bidders and awarding contracts, it is the intent:—

First—That the buyer may have just as much fair competition as he wishes to pay a reasonable and fair price for; that he, alone, desires the benefit of competition, and that no one buyer should pay for competition received by another—an abuse that exists under present methods.

Second—That when and after the buyer has chosen his competition in a fair, unprejudiced manner, and has further paid a just and reasonable price for said competition, he shall be under no moral or other obligation to the bidders; that he may make his own decision, based upon his own opinion of the qualifications of the bidder or the bidder's price, or a comparison of both.

Third—That the buyer may, as he chooses, select a limited or large number of bidders. If the work is of a private nature, he may wish to choose a very limited number, if he wants competition at all. If the work is of a public character, he may necessarily wish to give every qualified public citizen bidder an opportunity to compete, but without the necessity of paying more for the competition than he may consider the competition is worth.

Fourth—If the work be of a public nature, the buyer may have good reasons for first selecting a limited number of bidders because of their residence near the work to be done, or because they may be familiar with or may have had previous experience with the work, or for sundry justifiable reasons.

Fifth—That when the buyer, in case of public work, has then chosen his preferred bidders, he may give every other public citizen who is qualified to bid an opportunity to compete by chance or lot for consideration as a bidder, limiting the number to be chosen in accordance with the value of the competition to him.

Sixth—That the bidder shall in no way be considered as an engineer, but solely in the light of a bidder and contractor capable of doing work in accordance with complete plans and specifications; and that, therefore, in every case where bidders are expected to bid in competition, they (the bidders) shall be furnished by the buyer with plans, specifications, drawings and instructions covering the work to be performed as completely and specifically as commercially possible, with sufficient details to enable a bidder to fully understand what he is expected to figure and bid upon.

Seventh—That if a buyer cannot or will not provide complete detailed plans and specifications for the work, but wants estimates, measurements, figures or advice of a professional nature, then he (the buyer) shall consider such work in the light of a professional service, and it shall not be considered proper, fair or just to ask for competitive price bids, but that the charges for such professional service shall be left solely and strictly for adjustment between the buyer and seller, either before or after the work is done. Approximate estimates shall not be considered binding upon either party involved.

Reducing the "Gamble" to a Minimum

That under no circumstances shall the amount of a competitive bid be altered or the intent of the bid be changed so as to equivalently alter the amount after the bid has been submitted and before the contract has been let.

That no reductions or additions shall be made in bids for the purpose of meeting lower bids or because of proposed changes in plans and specifications. That under such proposals by the buyer, either new bids, based upon new plans and specifications, shall be asked and paid for—or—the contract shall be let and mutually satisfactory arrangements then made between the buyer and seller. That what is now known as "shopping" or "peddling" bids shall be discountenanced by both buyer and seller.

Such a system would place the expense of estimating where it belongs, i.e., as an expense against the job for which it is incurred. It would place the owner or architect under obligation to no one. He could, with fairness to all, let the contract to whomever he chose. The contractor could thus eliminate much more of the "gamble" in bidding, which would, in turn, benefit the material dealer and manufacturer, the bonding companies, and the bankers. The fact that owners and architects could choose their contractors as they saw fit without obligating themselves to choose the lowest bidder should not operate to increase graft or unfair discrimination. Crooked building committees or architects are the exception and very far from the rule, and there would not be any occasion for private owners to select contractors except on merit. Let the best man win, everything considered, not price only. At any rate, the possibilities for graft under such a system are not as great a menace to contracts as the evils of present-day competition and wasteful estimating.

Quantity Survey and the Nelson Form

The "Nelson Form of Choosing Bidders and Awarding Contracts" should not be construed as conflicting with the "Quantity System" or "Unit Systems." The Nelson Form should be equally as just and fair if used in connection with the "Quantity System" as without.

The only way in which the "Quantity System" could affect the Nelson Form would be to reduce the bidder's compensation, because some of his work and service would be absorbed by the "Surveyor," and, of course, if the quantities are guaranteed by the surveyor, it would more materially reduce the bidder's compensation, if not eliminate it.

Many of the best, most successful and responsible contractors are opposed to "Quantity Systems" and "Unit Systems" for the reason that their universal and complete use would place the sale of building material in the hands of manufacturers and jobbers, and take it out of the contractor's hands altogether; and, therefore, the contractor under such conditions would be reduced to a contractor of labor only, if, indeed, he could exist at all. And when it is understood that the handling of labor is generally fraught with more trouble and less profit than anything else in the contracting business, it can be readily understood that many of the good contractors say, that when that time comes, they will use their investments and ability in some other business.

Many architects are opposed to the "Quantity System" in this country at this time, because they think its use would delay the preparation of plans and specifications. They say that the American builder is inclined to wait until the very last minute before deciding to build; that he will plan and figure upon erecting his building for two years, then go to the architect and expect to move into it the next week.

The architect rarely has half enough time to do his work and do it as well as he wants to.

They say that if a quantity survey were to be made of each set of building plans and specifications, it must be nearly correct in every detail, and that the quantity estimator would require as much time as the architect to do his work right, and that altogether the time consumed between getting the commission for the architectural work and letting contracts would be two or three times as much time as the architect can get from his client.

And again it is contended that "Quantity Estimating" is essentially a new profession, and that it will be necessary to train men especially for that work; that while it may be possible to have the work done in the next few years in metropolitan cities, it will be many years before it can be accomplished in more sparsely populated centres.

The writer feels that from an ideal standpoint, "Quantity Survey" is something to be looked forward to with earnest eagerness, and is progressive enough to feel that there is great hope.

However, it will take time to bring it into practice, and when we have educated the public to appreciate that in the majority of times they get just what they pay for, and when we have converted the impulsive, impetuous, careless, "plan-nothing-ahead" present-day American builder into a safe, conservative, "plan-everything-ahead" builder, then we will have the more efficient, safe and sane method—"quantity system," and the quantity estimator will be here. Then, perhaps, the present-day American contracting gambler's successor will be the conservative quantity engineer. And that is all the subject really amounts to. Reduce the gamble and do more engineering. For "quantity estimating" is a professional engineering service.

In the meantime, during this generation, why not do everything we can to protect ourselves and the deserving present-day contractor from the unscrupulous ones by adopting a just method of competing which will not interfere with a higher and better class of engineering, such as the "quantity system" will give.

EXHIBIT A

Average of all bids or estimated net cost of contract	Approximate square root of figure in column one	†Number of bidders to be selected Figure in column two multiplied by .04	*Amount to be paid each bidder Figure in column two multiplied by .7	Total cost of competition Figure in column three multiplied by figure in column four
$ 50,000.00	224	9	$156.80	$1,411.20
60,000.00	245	10	171.50	1,715.00
70,000.00	265	11	185.50	2,040.50
80,000.00	283	11	198.10	2,179.10
90,000.00	300	12	210.00	2,520.00
100,000.00	316	13	221.20	2,875.60

Explanation

†Not less than two. As many more bidders may be selected as the buyer wishes to compensate.

To determine the total number of bidders, estimate the amount of the contract in dollars sufficiently high (Clause 3, Public Work); compute the square root and multiply by .04.

To determine the amount to be paid each bidder, add all bids (including any and all alternate figures asked for and received), divide the sum by the number of bids to get the average, then take the square root and multiply by .7. In case of fractions, the next highest whole unit number shall be used. Carefully read Clause 11, "Paying for the Competition."

*The multiplication factor .7 is not set or established. It is the intention of this form that this factor should be determined or established by the seller individually or collectively in the same manner in which he sets the price upon any merchandise or service.

Where it is necessary for the bidder to incur travelling or other incidental expenses it is the intent of this form that he shall receive remuneration for same in addition to regular compensation provided for in Exhibit A. The bidder shall, however, make arrangements with buyer for such special compensation, and have same accepted before bidding.

The Contractor Who Bids for Nothing

I am also frequently asked the question, "How are you going to prevent contractors from evading the practice if it is established?" By educating the contractor to better business methods, and by educating the architects and owners for their own good to refuse to consider contractors whose business methods are not correct. Those who can't be educated can do no good anyway. How could you prevent a man from giving his clothes away if he were foolish enough to do it? But when consumers and their representatives learn that they are really paying less for competition and getting a better class of competition one way than another, they will soon adopt the former. It was a long time before the "one-price-to-all" idea was adopted in selling merchandise. It came all at once and is now in almost universal use. Some merchants still dicker, but the better ones do not. Some contractors may bid without charging, but the better ones will not when they understand the advantages of this plan to them. Some contractors would also like to see their competitors charge for bidding so that they themselves can offer to bid and figure free of charge. But such men harm themselves mostly. At least, they or their practices are not the ones we should follow.

I believe the only solution of the problem is to have a national association of some kind, which is not organized for personal profit, take hold of it. They could inaugurate a system whereby the local organizations could, through their secretaries, put the system in force and collect compensation. The national organization in this way could collect from each local organization a small percentage of the compensation, and, I believe, thereby build up a very strong national organization financially, and in that way could keep the contractors together.

THE NELSON FORM

Rules and Methods of Procedure

PUBLIC WORK

1. Procuring Applicants to Bid Upon Public Work

If the work is of a public character, it is conceded that every public citizen who is qualified to bid shall be given consideration. Therefore, the buyer shall advertise in all recognized local newspapers simultaneously for a fifteen-day period of time at least, setting forth that he intends to let a contract, requesting all those who wish to submit bids to file an application. Such advertisements shall clearly state the character of the work and its location. The application from bidder shall be in the hands of the buyer upon a certain date, and not less than fifteen days from the date the first advertisement appears. Immediately upon receipt of the application, the applicant shall be given a receipt therefor.

2. Approving the Applications from Bidders

Known incompetency, lack of experience in the class of work contemplated, insufficient organization, or insufficient capital or equivalent to carry out the contract, or unsatisfactory previous experience with applicant, shall all be considered good, just and sufficient reasons for non-consideration by the buyer and his refusal to approve the application. All other applications shall be approved and given consideration. It shall, however, be considered obligatory upon the buyer to immediately and fully state his reasons for failure to approve an applicant if called upon to do so.

3. The Number of Bidders to be Selected

The minimum total number of bidders to be selected shall be determined by taking the square root of the estimated net cost of the proposed contract in dollars and multiplying by .04 as shown (Exhibit A), or thus: If it is estimated that the contract cost will be $10,000, the square root of which is 100, multiply by .04, which gives 4 as the minimum number of bidders to be selected. In case of fractions, the number nearest the next highest whole unit shall be selected. It is obvious from the intent of this form that the buyer may have as many additional bids as he may want, provided he wishes to pay for the cost of such additional competition, and with the further provision that he fairly choose such additional bidders, as provided for in Clauses 4 and 5. Should it be found that the buyer, in case of public work, intentionally or unintentionally, has estimated the contract more than 10% lower than the lowest bid, it shall be considered good and just cause for complaint on the part of the uninvited public citizen bidders, on the grounds that the buyer has kept his estimate low so as to exclude bidders or reduce the number of bidders considered legitimate for public work under this form.

4. Preferred Bidders Selected by Buyer

The buyer may, at his discretion, or if he chooses for good and sufficient reasons to do so, select and invite one or more preferred bidders, but the number of such preferred bidders shall in no case exceed a number equal to one-half of the total number of all bidders selected. It shall, however, be obligatory in case of public work upon the buyer to immediately divulge or make public the names of such selected bidders, if requested to do so, and to give his reasons for selecting them.

Because a certain contractor is selected as a preferred bidder it shall not indicate that he is to be or shall be given preference in awarding the contract, but rather that the privilege given the buyer to select a limited number of bidders is more for the purpose of enabling him to obtain low but meritorious bids.

5. Bidders Chosen by Lot

The remaining number of bidders to be invited after the preferred ones have been chosen (Clause 4) shall be chosen by drawing lots thus: The names of all applicants (except those who may have been selected as per Clause 4) who have made written request upon regular form and have been approved by buyer as per Clause 2, shall be placed on stiff blank cardboards not smaller in size than one inch wide by three inches long. These cardboards, with the names of the applicants clearly written or printed upon them, shall be placed in any convenient opaque receptacle not less than five inches deep, closed on all sides and bottom, but open at the top. Then a totally disinterested or blindfolded party shall draw from said receptacle a number of cards, no more nor less than the number of bidders to be chosen by lot. The names of the applicants appearing upon the cards drawn shall be duly selected as bidders. This drawing shall be at all times open to the public or interested applicants.

6. Notifying Bidders and Bidders' Agreement

When the required total number of bidders have been chosen, all applicants shall be notified. The applicants who have been selected to bid shall then be given all necessary plans, specifications, drawings and instructions. They shall also be given a "Bidders' Agreement," which, after acknowledging receipt of plans, etc., binds the bidder to abide and conform to all rules and regulations set forth in "The Nelson Form for Choosing Bidders and Awarding Contracts," and the buyer to pay for the estimate the amount stipulated in the above-mentioned "Nelson Form," based upon the average of all bids within the stipulated time after letting contract.

These plans and the "Bidders' Agreement" may be handed to bidders in person or sent to them by United States registered mail, and no contracts shall be let or bids opened except as provided for under Clause 8 and Clause 9, until all invited applicants or their substitutes, as provided for under Clause 7, shall have returned signed "Bidders' Agreement."

7. Failure to Submit "Bidders' Agreement"

Should one or more bidders fail to return the "Bidders' Agreement" within fifteen days of registered mailing date of the notification, then the buyer may, if he so desires, choose other bidders to substitute for them under the same method described under Clauses 4 and 5, as the case may be, by or under the form by which the defaulting bidders were selected, and an extension of the time set for opening bids may be made.

8. Defaulting Bidders and Failure to Submit Bids

Failure on the part of one or more bidders (after they have submitted signed "Bidders' Agreement") to submit their bids in due time or in correct form shall not in any way obligate the buyer to defer or delay the awarding of the contract.

9. Failure to Secure Stipulated Number of Applications

Should the total number of applications from bidders after advertising the stipulated time not reach the number provided for in Clause 3 or Exhibit A, then the buyer shall reserve the right to open bids and let the contract with the number of bidders that have made application, without in any way violating any of the rules, terms, agreements or intentions of this form.

10. Awarding the Contract

If the buyer or buyers be acting in the capacity of public servants, or in behalf of organizations, they shall, in accordance with the intent and meaning of this form, award the contract on the basis only of serving the best interests of the public or their constituents, as the case may be. No personal prejudices shall be shown or personal preference given, but the award shall be based solely and only upon the basis of procuring the best material and service at the lowest cost. All bidders, however, to receive full compensation for estimating and furnishing competition, in accordance with Clause 11.

11. Paying for the Competition

After all bids have been received and opened, the buyer shall within ten days (whether or not contract has been awarded) pay to each and all bidders (who have bid in strict accordance and complied with all of the demands contained in the plans and specifications and all forms accompanying same, and whose bids do not exceed by more than 25% per cent. the amount of the bid upon which the contract is awarded, or the lowest legitimate bid if contract is not awarded) a sum equal to the square root of the average of all bids received multiplied by .7 substantially as shown in table (Exhibit A), thus: If the average of all bids received shall be $90,000, the square root of which is $300, multiply $300 by .7, which equals $210, the amount which shall be paid to each competing bidder in payment for the labor and expense involved in estimating and as a complete waiver of all obligations. In considering the amount of each bid, the total bid, including the sums of all alternate estimates asked for by the buyer, whether they be additions or subtractions, shall be considered, and the amount to be paid the bidder shall be reckoned thereon as well as upon the total bid; as, for example, if the bidder is requested to estimate upon a brick building with alternate estimate upon stone and another alternate estimate upon frame construction, then, assuming that the bidder's figure is $20,000 upon the brick building, $30,000 upon the stone, and $15,000 upon the frame building, then the sum-total, or $65,000, shall be used in determining the sum to be paid the bidder. Should certain bidders refuse or neglect to figure or bid upon alternates, they shall be paid upon the basis of their actual bids only.

A certificate of payment shall, upon request, be given to each bidder, properly filled in, signed and sworn to by the buyer before a qualified notary public, setting forth that the competition has been conducted in accordance with this form, and that the amount credited or paid to the bidder has been reckoned and computed in strict accordance with this, the "Nelson Form of Choosing Bidders and Awarding Contracts," its true intent and meaning.

PRIVATE WORK

1. Selecting Bidders for Private Work

If the buyer of the work to be figured upon is acting as a private individual, then he may choose his own method for selecting bidders, and he may select as many or as few as he may choose or wishes to compensate.

2. Awarding the Contract

If the buyer be a private owner, he, his architect, his engineer or other form of representative shall reserve the right to make contract with any bidder he may choose, provided, however, that he shall fully compensate all invited bidders in accordance with Clause 3.

3. Paying for the Competition

Paying for the competition in connection with work of a private character shall be done exactly as provided for in connection with public work and as shown and set forth under Clause 11, Public Work.

The Sub-Contractor and the Material Man

In putting this plan into actual operation, the Quad City Builders' Exchange, including the Master Builders of Davenport, Iowa, Rock Island, Moline, and East Moline, Illinois, adopted the following regulations applying to sub-contractors and material men:—

. . . .

Second.—That this body shall recommend the following minimum factors as a basis for compensating bidders in accordance with the Nelson Form:—

General Building Contractors.—.5 or 50% of the square root of the average of all bids.

Sub-Contractors and other Principal Contractors.—.2 or 20% of the square root of the average of all bids.

Third.—That the above factors shall be used when bids are given to owners, their representatives, or to other contractors when such other contractors are not in competition.

Fourth.—When one contractor, however, renders a bid to another contractor who is in competition, it is arbitrarily assumed that the contractor giving the bid will, on the average, give four bids on the same work which he will have to figure or estimate only once. Therefore, under such sub-bidding conditions (and only under such conditions), the compensation shall be one-fourth of the regular compensation, or as follows:—

General Building Contractors.—.125 or 12½% of the square root of the average of all bids.

Sub-Contractors and other Principal Contractors.—.05 or 5% of the square root of the average of all bids.

Fifth.—Building material manufacturers or distributors shall not receive compensation for making unit prices on material. For example, if a price is quoted upon 10,000 brick at $9 per thousand, or 5,000 yards of sand at 60 cents per yard, etc., such bidding shall not deserve compensation; but if such bidder is expected to estimate the material required to do the work intended and then guarantee the quantities or capacities to be sufficient, then he shall be considered in the light of a contractor and receive compensation.

Sixth.—That when the owner, or his representative, furnishes the bidder with guaranteed "quantity surveys"—or, in other words, with a unit of material upon which the bidder needs only insert unit prices and is relieved of the necessity of guaranteeing the quantities to be correct—then the amount of such unit list or quantity survey shall be deducted from the amount upon which the bidder is compensated.

BRITISH COLUMBIA TECHNICAL ASSOCIATION

THE British Columbia Technical Association held its first banquet on October 21st, in the University Club, Vancouver. The gathering took the place of the regular monthly meeting of the association at which it has been customary to deal with purely business matters. The executive intend hereafter to combine every business meeting with a social function. About one hundred civil, electrical, mechanical and mining engineers, chemists and architects were present. The chair was occupied by E. G. Matheson, professor of civil engineering of the University of British Columbia, who gave an interesting address, in the course of which he outlined the great part in the world's work which had fallen to the lot of technically trained men. He reviewed the activities of the association and stated that while the organization is only about eight months old, the membership is about 250, and that a total of 300 is expected by the end of the year. The secretary-treasurer of the association is R. Snodgrass, Board of Trade Building, Vancouver.

EFFECT OF FINENESS OF CEMENT

(Continued from page 438)

15.—Concrete of all mixes and consistencies showed expansion in damp sand or water storage and contraction in air.

16.—The change in length of concrete specimens stored in air or water is independent of the fineness of the cement and the consistency of the concrete. The lean concretes are slightly less affected than the rich mixtures.

17.—The type of aggregate had little or no influence on the relative effect of fineness of cement on the strength of concrete.

18.—The tests included showed an intimate relation between the strength of the concrete and the water-ratio of the mixture. The lower the water-ratio (so long as the concrete is plastic and the aggregate not too coarse), the higher the strength, and vice versa. This confirms the results of other concrete tests made in this laboratory. Increasing the quantity of cement in a given mixture enables us to secure a concrete of equal workability with a lower water-ratio, hence a higher strength.

19.—In ordinary concrete mixtures (say 1: 5 to 1: 4, requiring 20 to 25% cement, by volume) increasing the cement content by 1% (to 20.2% for a 1: 5 mix), gives an increase in strength of about 1%.

20.—One per cent. increase in cement is more effective in increasing the strength of concrete in lean than in rich mixtures.

21.—One per cent. increase in cement is somewhat more effective in increasing the early strength of concrete than at later periods.

22.—The effect of increasing the quantity of cement is independent of the consistency of the concrete.

23.—Tension tests of briquets do not give a correct measure of the relative merits of different cements as determined by compression tests of mortar and concrete.

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PRINCIPAL CONTENTS

WATER PRESSURE UNDER DAMS

IN an article upon another page of this issue, Mr. Maerker calls attention to what he terms a "fallacy in the design of dams subject to upward water pressure." He points out that the overturning moment due to the upward thrust of water near the heel of a dam should not be added to the overturning moment due to the horizontal water pressure unless the upward thrust is greater than foundation reaction. He bases his argument on the fact that the upward thrust due to water simply replaces an equal amount of foundation reaction. He admits, however, that the stability of the dam is impaired by the upward thrust of water, owing to the lowering of the resistance against sliding. Allowance would have to be made, therefore, when designing the structure, for this danger of failure through sliding.

Whether the allowance be regarded as a provision against overturning or against sliding, probably makes but little practical difference. In either case basic assumptions must be taken that may vary greatly in their actual accuracy, and the results might not be such as to warrant the refinement suggested by Mr. Maerker.

Nevertheless it is always interesting to discuss the reasons for assumptions, as it leads to a clearer understanding of the various features of design. Engineering should be based upon scientific laws to as great an extent as possible. It should be empirical only where absolutely necessary through lack of accurate knowledge, or else where advisable in order to save mathematical computations which, if carried out, would yield no adequate return.

While Mr. Maerker's article may not change any of the assumptions used in designing dams and similar structures, it will cause many engineers to give further thought to the subject, which alone will prove beneficial regardless of whether these engineers do or do not find themselves in agreement with the theories advocated by Mr. Maerker.

The amount of the upward thrust, the area against which it acts, and the line of its distribution, must all be assumed, and in order to be reasonably safe the engineer must make considerable allowance for more than average conditions. The precautions taken by standard engineering practice in the past have no doubt been warranted, and Mr. Maerker would probably insist upon just as much material being used in a dam designed according to the method he suggests, as in a dam designed in accordance with present standard practice.

ENGINEERS FAVOR EMPLOYMENT ACTIVITIES

RESULTS of a referendum recently held by the American Association of Engineers, asking the opinion of the membership as to how the income of the association should be distributed amongst the ten main activities of the association, indicate that of all the things which the members believe to be important, the employment service is the most popular.

The vote proves that the members desire to have about 17% of the income spent on this service. It is interesting to note that compensation was second with about 16%. The official publication, promotional work, publicity, legislation, protection and prevention of abuses, membership, civic welfare, and ethics and practice, were next, in the order named.

Mining engineers voted the greatest percentage to employment, while the least percentage voted to employment was by those engineers employed by educational institutions. Government engineers voted more to be spent on publicity than did any other class of members. The greatest desire for development of the organization appears to lie in the educational group, for those engineers voted 3% more for promotional work than did any other class of engineers.

Public utility employees voted the greatest amount to be spent on legislation, although engineers employed by states ran a close second. Legislation was least desired by government engineers, who voted a full 3% less than those employed by public utilities.

Engineers in private practice voted the greatest amount to be spent on civic welfare work. The least amount voted to this work was about 3%, voted by mining engineers. Engineers in private practice voted a greater amount to be spent on protection and prevention of abuses than did any other class of members.

Municipal engineers voted the most money to be spent on compensation, while railroad engineers, engineers in public utility work, and engineers employed by states, followed in the order named. The complete results of the ballot follow:—

Employment, 17.4%; compensation, 16.3%; association's publication, 14.8%; promotional work, 10.9%; publicity, 9.8%; legislation, 8.8%; protection and prevention of abuses, 8.1%; membership campaign, 5.8%; civic welfare, 4.5%; ethics and practice, 3.6%. The percentage named in every case is the average of the votes cast by the members, and therefore represents the average opinion of the membership as to the percentage of the association's income that should be spent for the various activities.

The result of the vote, as regards employment activities, is no surprise. Just as self-preservation is the first law of nature, the first and basic desire of all engineers—and of everyone else for that matter—is to be ensured of a good market for their abilities. Ethics, membership campaigns, etc., are naturally regarded as of minor importance compared with employment. At the same time, legislation, publicity and other activities have a basic effect upon employment, and in the last analysis may count for more than the direct assistance rendered by a society's employment bureau.

The obligation upon every individual to purchase Victory Loan bonds may not be so apparent as it was during the war, but it is just as real. Depression and unemployment would surely follow the country's failure to absorb the much-needed loan.

PERSONALS

THOMAS R. LOUDON, who was recently relieved of his military duties after having been in the army since November, 1915, has returned to private practice in Toronto and, in partnership with C. S. L. Hertzberg, has formed a new firm, Loudon & Hertzberg, consulting industrial and structural engineers. Mr. Loudon was born September 1st, 1883, in Toronto and was educated in the public schools in that city and at the University of Toronto, where he graduated in 1905, with the B.A.Sc. degree in civil engineering. For one year after graduation Mr. Loudon was engaged in design of gas engines for the McVicker Engine Company, of Galt, Ont. In 1907, he was appointed lecturer in civil engineering at the University of Toronto, and has retained his connection with the university since that date. In 1912, he was appointed assistant professor of applied mechanics, and while he was in the army he was gazetted by the faculty as an associate professor. He has resumed his lectures at the university. Mr. Loudon is the author of "Applied Statics," which he originally wrote as a series of articles for *The Canadian Engineer*, and which has since been used as a text-book by the University of Toronto and other educational institutions. Before the war he was a frequent contributor to *The Canadian Engineer*, and for a time acted as an associate editor of the paper in regard to structural steel and its production. From the beginning of his connection with the university, Mr. Loudon has at all times been in touch with outside work. From 1907 to 1912 he assisted the late T. C. Irving in the inspection of structural steel work for the Standard Inspection Co., of which Mr. Irving was manager, and later for the Robert W. Hunt Co., which absorbed the Standard Inspection Co. and of which Mr. Irving became vice-president. Mr. Loudon also acted as consulting metallurgical engineer for a number of enterprises, chief of which was the Moffatt-Irving Co., Toronto, for whom he acted as consulting and designing engineer, in association with J. W. Moffatt, from 1910 to 1912. This company was organized for the purpose of making experiments in the electrical smelting of iron ore. In 1912 Mr. Loudon became a member of the firm of James, Loudon & Hertzberg, consulting engineers, Toronto, and for the following three years was engaged in various structural and municipal undertakings. In November, 1915, he enlisted as lieutenant in the 2nd Field Company, Canadian Engineers, and was appointed on the staff of Military District No. 2 as an engineering instructor. In May, 1916, he was gazetted captain and adjutant of the 1st Construction Battalion, and went to France with that unit, arriving at the front in October, 1916. He attained his majority on the field before the end of that year, and served as second in command of his battalion until he was invalided home in May, 1918. In 1917 that battalion became the 1st Railway Troops. It was engaged in general engineering construction, chiefly bridges and standard-gauge and light railway work. Major Loudon was mentioned in dispatches for his work at the front. In October, 1918, after he had recovered from his injuries, he was apointed in command of military engineering construction in British Columbia, from which position he was honorably discharged in June of this year.

HADDIN & MILES, LTD., consulting engineers, have moved their head office from Winnipeg to 209 Eighth Ave. W., Calgary, Atla.

MAJ. P. EARNSHAW, of Toronto, has been appointed instructor in civil engineering at the Royal Military College, Kingston, Ont.

F. P. JONES, vice-president and general manager of the Canada Cement Co., Ltd., has resigned from the directorate of the Canadian National Railways owing to pressure of other work.

J. L. ENGLEHART, chairman of the Temiskiming & Northern Ontario Railway Commission, has resigned owing to ill-health. Mr. Englehart has been chairman of the commission since its formation, 14 years ago.

J. C. REILLY, acting general secretary of the Association of Canadian Building and Construction Industries, left Montreal last week for a four weeks' tour of Western Canada. Mr. Reilly will hold organization meetings in Winnipeg, Regina, Calgary and Vancouver. He may also visit Saskatoon and Edmonton.

J. A. ELLIS, Director of Municipal Affairs of Ontario; LAWRENCE VEILLER, secretary of the National Housing Association, New York City; and W. J. DONALD, secretary of the Board of Commerce, Niagara Falls, N.Y., will be among the speakers at the town planning convention to be held November 27th and 28th in Hamilton, Ont.

ENGINEERING INSTITUTE ELECTIONS

AT a meeting of the council of the Engineering Institute of Canada held October 28th, 1919, in Montreal, the following elections and transfers were announced:—

Members.—F. L. Butler, Winnipeg; W. L. Ketchen, Timiskaming; R. L. Peek, St. Catharines; A. H. White, Brooklyn, N.Y.

Associate Members.—A. N. Ball, Regina; F. M. Barnes, St. John, N.B.; H. F. G. Barnjum, Prince Rupert, B.C.; E. H. Beck, Toronto; Sydney Bowen, Morrisburg; L. L. Brown, Vancouver; A. W. L. Butler, St. Catharines; Neil Campbell, Ottawa; E. D. W. Courtice, Chatham; H. R. Cram, Ottawa; F. A. Danks, Toronto; H. W. L. Doane, Halifax; J. G. Dryden, Halifax; R. L. Fairbanks, Port Arthur; K. C. Fellowes, Niagara Falls; A. G. Graham, Vancouver; Byron Hallock, Winnipeg; S. W. Johnston, Niagara Falls; Grover Keith, St. John, N.B.; R. F. Macdonald, Sault Ste. Marie; R. H. Mather, Montreal; H. W. McKiel, Sackville; J. W. McLellan, New Glasgow; D. A. S. Mutch, St. Catharines; W. F. Oldham, Winnipeg; E. R. Pease, Montreal; W. H. Stuart, Hanna, Alta.; H. S. Tawse, Aberdeen, Scotland; W. C. Taylor, Stonewall; A. R. Whitelaw, Campbellford; J. R. Wood, Evesham; E. M. Wynn, Niagara Falls; A. G. Young, Toronto.

Juniors.—E. W. G. Chapman, Halifax; L. H. Cookson, Bathurst; K. L. Dawson, Halifax; W. S. McDonald, Calgary; J. M. Poole, Halifax; E. G. Timbrell, Ottawa.

Transferred, associate members to members.—Charles Brakenridge, Vancouver; P. P. Brown, Vancouver; J. C. Craig, Vancouver; W. A. E. Grim, Vancouver; J. C. Holden, Winnipeg; W. H. Magwood, Cornwall; D. M. Mathieson, Toronto; R. G. Saunders, Toronto.

Transferred, juniors to associate members.—R. S. C. Bothwell, Toronto; Arthur Desrosiers, Detroit; A. D. F. Kerrisdale, B.C.; J. M. Gordon, Toronto; C. E. Hogarth, St. Catharines; F. C. Knight, Montreal; L. P. Macrae, Victoria; W. P. Murray, Lachine; J. B. O. St. Laurent, Ottawa; R. A. Spencer, Montreal; C. St. J. Wilson, Halifax.

Transferred, students to associate members.—R. M. Calvin, Ottawa; W. E. P. Duncan, Milton; R. R. Hepinstall, New Orleans, La.; A. A. Richardson, Peterborough.

Transferred, students to juniors.—G. F. Alberga, Montreal; J. F. Brett, Montreal; W. McG. Gardner, Montreal; B. A. Johnston, Winnipeg; G. W. F. Johnston, Ottawa; G. F. Layne, Cheshire, England; W. G. Mawhinney, Selkirk; D. E. McPherson, Winnipeg.