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# The Canadian Engineer

*A weekly paper for Canadian civil engineers and contractors*

## Relation of Stone Aggregate Content to the Compressive Strength of Concrete

### Tests Indicate that Addition of Twenty Per Cent. of Stone Reduces Strength of Mortar by Three Per Cent., while Forty Per Cent. of Stone Reduces It by Eleven Per Cent.—Stone Bears Same Relation to Concrete as Inert Extenders Bear to Paint

By CAPT. LLEWELLYN N. EDWARDS
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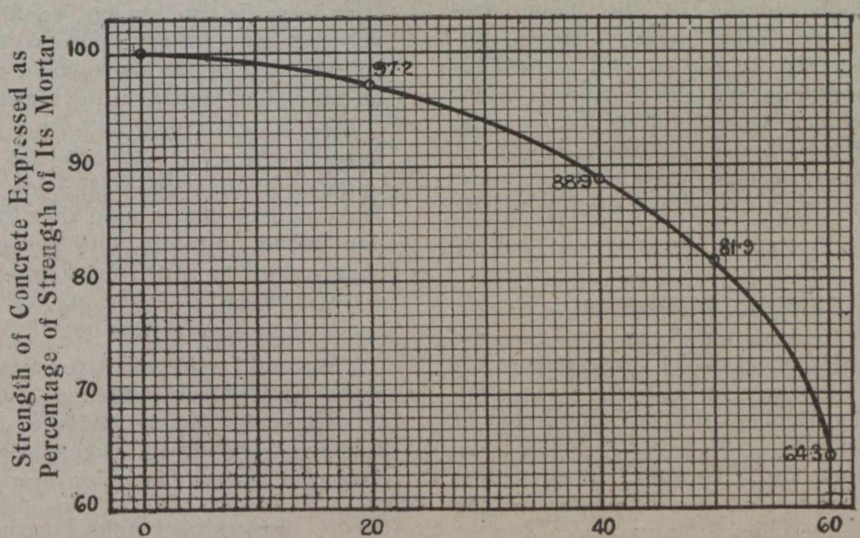
PAINT-MAKERS, in proportioning the materials of an economical paint mix, make use of certain inert materials commonly termed "extenders," since they serve the purpose of increasing the ultimate volume of paint produced per gallon of linseed oil or other vehicle material.

The use of a too great proportion of "extender" will very materially reduce the toughness, strength and other physical properties affecting the service value of the paint.



**Relation of Stone Aggregate to Total Volume of Concrete, Per Cent.**

In a somewhat similar manner and for a like purpose, concrete-makers use inert stone aggregates as "extenders" in the production of economical concrete mixes, and upon the proportions used depends, in part, the ultimate strength of the concrete produced.

The test herein described was made with the object of obtaining information relating to the effect of varying the stone aggregate content of the concrete.

All materials, except the water, were proportioned by volume reduced to a unit weight basis.

The unit weights assumed were as follows:—

One cubic foot of cement assumed at 100 lbs.

One cubic foot of sand (dry) assumed at 100 lbs.

One cubic foot of broken stone assumed at 90 lbs.

Five specimens were made for each mix, the usual test cylinders, 6 ins. in diameter by 12 ins. long, being used. These specimens were tested at an age of three months after having been cured in damp sand.

The grading of the sand was as follows:—

Sieve No. 4, 0.0% retained on sieve; No. 8, 14.0%; No. 10, 4.0%; No. 20, 14.0%; No. 30, 9.0%; No. 40, 11.0%; No. 50, 14.0%; No. 80, 20.0%; No. 100, 6.0%; No. 200, 6.0% retained and 2.0% passing.

The grading of the stone was as follows:—

1½" screen, 0.00%; 1", 20.00%; ¾", 30.00%; ½", 30.00%; ¼", 20.00%.

The water content was such as to produce a concrete in which the stones were thoroughly covered with a coating of sticky, semi-plastic mortar. All mixing was done by hand.

The cement-sand ratio of the mortar content was taken at 1:2, this being known to produce, for the sand used, a strong, reliable mortar.

The first set of cylinders made was composed of mortar only. The stone content of the succeeding sets was 20, 40, 50 and 60 per cent. of the total weight of mortar and stone aggregate combined. The quantities of these ingredients were therefore:—

First set, 160 lbs. mortar.

Second set, 128 lbs. mortar, 32 lbs. stone.

Third set, 96 lbs. mortar, 64 lbs. stone.

Fourth set, 80 lbs. mortar, 80 lbs. stone.

Fifth set, 64 lbs. mortar, 96 lbs. stone.

The average ultimate strengths obtained from the compression tests were as follows:—

First set (mortar), 3,380 lbs. per square inch.
Second set (20% stone), 3,284 lbs. per square inch.
Third set (40% stone), 2,999 lbs. per square inch.
Fourth set (50% stone), 2,769 lbs. per square inch.
Fifth set (60% stone), 2,175 lbs. per square inch.

The accompanying diagram was deduced from the above values and shows the relative strengths of the concretes expressed as percentages of the ultimate strength of the mortar alone; or, in other words, the strength-reducing effect of increasing the stone aggregate content of the mix.

The reader is cautioned against attempting to draw too radical conclusions from the above test results. He must fully recognize the fact that the stone aggregate in concrete is but one of a large number of factors tending to produce widely varying results, affecting the strength, reliability and permanence of structures composed wholly or in part of concrete. If the results obtained in this test are interpreted literally we are led to conclude that the stone mason's couplet,

"Stone upon stone makes a very poor wall,
But all mortar makes none at all,"

is mere sentiment and altogether misleading. Whereas the principles which it embodies are entirely sound and quite in accord with good concrete construction practice, for in reality concrete is but rubble masonry under another name.

Insofar as strength is concerned, the stone aggregate of a concrete will become a determining factor (1) when it is weaker in strength or lacks the toughness, hardness or other desired physical properties possessed by the mortar surrounding it, and (2) when its quantity is in excess of that required by practical or economic considerations.

Regardless of strength, it will readily be seen (1) that economy of materials, more especially the cement content of the mix, demands that the mortar portion of the concrete be not excessive, and (2) that economy of labor precludes the use of an excess of stone aggregate. From a practical point of view, to "drown the stone in mortar" means the production of a non-homogeneous concrete by reason of the irregular distribution of the stone particles, while to use a "stony mix" means a harsh, unworkable concrete which can be placed only with difficulty. Erratic field conditions and the "personal equation" of laborers, combined with "the location of the boss," are factors which too frequently produce conditions akin to an excess of stone aggregate. As a result, some structures contain "stone pockets" which greatly reduce their efficiency.

## WINDSOR SEWER TENDERS

FOLLOWING are the tenders which were received a few weeks ago for the sewer work that is to be done by the Essex Border Public Utilities Commission in Southwestern Ontario:—

Standard Construction Co., Toronto, $163,573.40; Connolly-Agnew Construction Co., Toronto, $165,382.50; Merle, Merle & Ray, Walkerville, $172,379.00.

Tom Lowes, of Mimico, formerly partner of T. Aird Murray, consulting engineer, Toronto, is the manager of the Standard Construction Co., who were the lowest bidders. All bids were rejected and the work will be let at cost plus a sliding scale fee, as adopted by the U.S. War Department. Propositions upon the latter basis were advertised for to be received up to 2 p.m. to-day.

## MR. CARPENTER'S ARTICLE

IN last week's issue, reference was made in the report of the Saskatoon meeting of engineers to the paper read by H. S. Carpenter, deputy minister of highways, Regina. A parenthetical note said: "See next issue for Mr. Carpenter's paper." We regret that contrary to expectations, our copy of Mr. Carpenter's paper did not reach us in time for this week's issue, but it will appear in *The Canadian Engineer* for August 29th, 1918.—EDITOR.

## ALUMINUM CO. SEEKS PERMISSION TO BUILD WEIR IN ST. LAWRENCE RIVER

PERMISSION to construct a submerged weir across the south channel of the St. Lawrence River near Massena, N.Y., is being sought by the St. Lawrence River Power Co. The company's application will be heard by the International Joint Commission next Thursday, August 29th, at Montreal. This application, which is being opposed by the Dominion Government through its counsel, F. H. Keefer, of Thorold, and by the Commission of Conservation through A. V. White, of Toronto, was first brought up at a sitting of the International Commission in Atlantic City last week. After hearing the representations of Judge Koonce, counsel for the United States War Department, who argued that the application should be proceeded with immediately, and of Mr. Keefer, the commission determined to hear arguments next week at Montreal, thus partially suspending the rule calling for thirty days' grace for the filing of response to an application.

### Needed to Increase Output

Judge Koonce, in pressing the immediate hearing of the application, submitted letters from the chairman of the United States War Industries Board, and the director of aircraft production of the United States, supporting the application. In the letters it was claimed that the construction of the dam would permit the Aluminum Company of America, whose plant is at Massena, N.Y., to increase its output. It was admitted that the supply of aluminum is at present equal to the demand, but the latter, it was stated, is increasing. It was claimed that construction of the dam would constitute no serious disadvantage to Canadian navigation.

Mr. Keefer asked for further delay in order to acquaint himself with what was involved in the application. It is understood that the application is being opposed by the Dominion on the ground that the construction of such a dam would interfere with navigation and that it would be granting to a private company the right to develop water powers which the government itself might later on desire to develop for the benefit of the community at large.

The St. Lawrence River Power Company was represented by Attorney Leighton McCarthy, of Toronto, and by Engineers Henry Holgate, of Montreal, and J. W. Rickey, of Pittsburg. Francis King, K.C., of Kingston, appeared for the Dominion Marine Association,.

### Government Asks Hearing, Not Approval

The St. Lawrence River Power Company claimed in their application that there is need of a weir in the waters between the Long Sault Island and the canal which leads to Grass River. Through their counsel and the counsel of the War Department, they claimed that in the three worst winter months they would be able to turn out approximately 6,000,000 or 7,000,000 more pounds of aluminum from their plants if this weir is allowed.

F. C. Keefer wanted to know whether the application is asked for by the United States Government, but Judge Koonce declared he was only asking that the application be heard without delay, and that he did not ask for the approval of the application.

The Atlantic City meeting of the International Joint Commission had been called to hear the application of the New York and Ontario Power Company, of Waddington, to do some work to improve their power plant, but before argument on that application was started, Judge Koonce asked to be heard in the other matter.

"I have had a conference with Mr. Keefer regarding a motion I want to make with his consent—" began Judge Koonce.

"I am willing that the motion be made, but I can't say that I will consent to having it granted," said Mr. Keefer.

Judge Koonce—"The motion is in the case of the St. Lawrence River Power Company and proposes that the rules demanding a thirty days' notice of an application so that a response can be put in, be suspended in this case. I do not appear for the company, but the work to be done will help the output of aluminum at Massena, New York."

### Using Half of South Channel's Flow

Judge Koonce then explained that the company had cut a canal from the South Sault Channel to the Grass River at Massena, N.Y., in 1896. Their power plant was established in 1902. He stated that 20 per cent. of the flow of the St. Lawrence River is through the south channel and that 27,000 second-feet of this goes through the canal, this amount being equal to half of the flow through the south channel.

"Every year," he said, "the plant has been compelled to reduce its output of aluminum. For some three months of the year the water flow is stopped by ice. To get a full twelve months' operation it is proposed to put in certain works. These are: (1) The construction of a movable ice weir to be used in the winter time only and which would not affect navigation; (2) to dredge the channel 150 feet wide and 50 feet deep—permits have been issued for the latter work by the United States War Department and this work has been completed; (3) to extend the dyke authorized in 1902 by the U.S. department, by building a submerged ice weir to Long Sault Island and thus to get rid of the ice jam. The first two have nothing to do with the Canadian Government, but the last has, and that is the reason why the application is being made.

"The object of this construction is to do away with the ice so that the aluminum plant can run all the year, as this is needed by the government to carry on the war. We must have increased power to get munitions to lick the Germans. The reason why the War Department is interested is because this aluminum enters into the manufacture aeroplanes, motor trucks, and camp supplies of all kinds. There is a shortage and this company supplies 60 per cent. of Great Britain's aluminum, 35 per cent. to France, 75 per cent. to Italy, and all that the U.S.A. needs.

### "Coal is Scarce"

"There are many things that must be produced by water power, as coal is scarce. The company is willing to pay the cost of constructing, which will be about $125,000."

Canadian Commissioner Powell—"What effect will that have on navigation if you put the weir in?"

Judge Koonce—"None at all. Since the rafting of timber down there has stopped, it won't do any harm. Occasionally a few pleasure boats or light draft motor boats go through, but they are not to be considered at present."

That the water in the main channel would be raised by only four inches if this work is done, and that Lock 21 would not be injured at all, was another contention of Judge Koonce. "At certain stages it will be a benefit and at no stage will it be injurious," he declared.

Commissioner Powell—"How will it relieve the ice jam?"

Judge Koonce—"I understand that the ice coming down in the winter banks up and grounds in the south channel, making a dam that shuts off the water from the power canal, and we can get no power. By building this submerged weir we form a pond which will be covered with ice, but beneath the water will flow freely at any time.

"The haste in presenting this application now was caused by the fact that the dredging operations and the other work were done in a short time, and it was not intended to do this work till next year. However, the need for aluminum for the government caused the company to want to go ahead now."

Commissioner Tawney—"Some work is already done under a permit from the Secretary of War?"

Judge Koonce—"Yes."

Mr. Keefer—"That part does not need the order of the commission?"

Again Judge Koonce declared it did not.

Canadian Commissioner Magrath—"How long will it take to build the weir?"

Judge Koonce—"Some 60 to 90 days. This application only covers the submerged weir."

### What Authority for Diversion?

Commissioner Magrath—"What authority have you to divert this water? And what amount can you take?"

Judge Koonce—"An application of the company to the State of New York and to the War Department in 1896 was made to divert this water. It did not affect navigation. They were advised to be careful not to take too much water and so affect navigation."

Commissioner Magrath—"They were not confined to any amount"

Judge Koonce—"Yes."

"What is the dredging for?" asked Commissioner Magrath.

"To prevent the ice jam," said Judge Koonce.

"And to incidentally get more water?"

"No," said Judge Koonce. "They won't take more water; maybe more at times, but not in the aggregate."

Commissioner Tawney to Mr. Keefer—"Will it be possible for you to reach an agreement to have this heard as requested by Judge Koonce?"

Mr. Keefer—"I don't know what I can do. I told Judge Koonce that Canada was vitally interested in winning the war, and that if the application for the weir is at the request of the United States Government, no doubt it would be all right. A permanent dam might affect navigation."

Judge Koonce—"They say they won't need it in the summer time."

Mr. Keefer—"Once that dam is in the river, then navigation there ceases. The point is that an application is being made to close a navigable branch of the river. If the application was from the United States Government I might consider it. Is Judge Koonce appearing for the United States Government and saying that they want this application granted?"

### Tried Two Years Ago

Judge Koonce—"I am appearing for the War Department to ask that the application be heard now and the thirty-day rule suspended. I am not asking that the application be granted."

Mr. Keefer—"Canadians are timorous in this matter. Two years ago the company tried to get a dam across the river to get power, but that charter was cancelled. It called for this very same plan. This company is taking power at Cedar Rapids, twenty miles down the river. It was carried over Canadian territory, and last year when Canada asked to have 10,000 of that horse-power back, as she needed it for war purposes, all she could get was 5,000 horse-power, and she paid a good price for it at that. And now, after that, we are asked to sweep aside our rights in this matter on the grounds that it is for war purposes. Canada got her fingers burned once, and she isn't forgetting it.

### Favors International Development

"Canadians are not generally in favor of these public rights being handed over to private corporations. They have suffered enough now, and we have to look into all these matters very carefully. I would like to have an international development of all this power in the river, but to ask us to consider to allow a private company to develop it—"

United States Commissioner Tawney—"You will have your day in court."

"Mr. Keefer—"Yes, but we would like to be prepared for it."

In answer to Commissioner Tawney, Hydraulic Engineer J. W. Rickey, of Pittsburg, for the company, stated that the latest the work could be carried on would be the middle of December. If the case were adjourned till September 5th, it would only give 75 days to complete it, and as there might be stormy weather, he thought it very risky.

Attorney Gordon, representing the company—"I am appealing for this application to be heard now on a verbal request from the government to try and get out more aluminum."

Commissioner Magrath—"You had this in mind last year. Why didn't you ask us then?"

Mr. Gordon—"We didn't intend to do this work till next year."

Commissioner Magrath—"Do you mean to say that dredging the canal will not give you more water?"

Mr. Gordon—"All the water we can use the turbines are taking in now."

Commissioner Magrath—"But, of course, you can always extend the plant."

### Commission of Conservation Interested

Arthur V. White, representing the Canadian Commission of Conservation—"The Commission of Conservation is interested in having the development of power in the St. Lawrence River protected. We need sufficient time to consider this matter properly."

Mr. Keefer—"It is just as important to keep navigation intact in this war as for the aluminum company to make more aluminum. The government of Canada is not trying to delay this matter more than necessary."

Mr. Stewart, Dominion Hydrographer—"Mr. McCarthy told me on August 1st that the application was in Washington, and would be in Ottawa right away. I got it last Friday (August 9th)."

As the commissioners could not get the opposing parties to agree to any definite time when the hearing could go on, they left the matter until the next day to decide. On the following day Commissioner Tawney read the statement of the commission fixing the date for the hearing at Montreal on August 29th.

The statement read: "That as the hearing of the application was approved of by the War Department at Washington, and as Judge Koonce, as counsel, had letters from the War Industries Board and the Aircraft Board, and as the construction of the weir was necessary for, and would increase the output of aluminum, and as it would take from 60 to 90 days to do the work, December 15th being the latest date that work could be done in the river, the rules are suspended, and to facilitate the hearing the commission has fixed on August 29th at Montreal as the date, and all responses must be filed by August 26th."

After this decision was announced, the Canadian commissioners again referred to the fact that a certain part of the work had been done already without any application to or permission from the Commission.

Commissioner Mignault, Montreal, thought that the Commission should have been notified, despite the fact that the work was in United States territory. It might affect the Canadian side, especially the dredging of the canal.

Commissioner Powell also contended that this work should have been brought before the Commission, as deepening the canal would tend to lower the water on the Canadian side of the river.

[NOTE—We desire to make full acknowledgment to the Toronto Telegram for most of the above information, especially for the verbatim portions of the proceedings at Atlantic City, which formed part of a very complete report specially written for that newspaper by one of its staff who was in Atlantic City during the meeting of the Commission.—EDITOR.]

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## ENGINEERS DISCUSS PROTECTION OF PUBLIC AGAINST INCOMPETENTS

SASKATOON, Sask., August 12th.—The fifth session of the three-day convention of engineers was held here last Saturday morning. This session ended the second general professional meeting of the Engineering Institute of Canada. The relation of the profession to the public was thoroughly debated and it was decided that steps should be taken to protect the public against incompetents, so that only qualified engineers can carry on engineering work involving the expenditure of public money. The general opinions of the western engineers coincided with the opinions expressed by the Toronto engineers at their meeting last April 25th, as reported in *The Canadian Engineer* for May 2nd, 1918.

Secretary Keith called attention to the interference of municipal officials in engineering matters. "Too often," he said, "is the work of a good engineer spoiled by interference on the part of aldermen or citizens desiring to serve a selfish purpose."

President Vaughan stated that never had there been a more notable convention of engineers west of the Great Lakes, and expressed the hope that the public would appreciate the public-spirit shown by the Institute in organizing such a gathering for the welfare of the country at large. On this, his first visit to Saskatoon, he expressed surprise and delight at what he called "the city of the future."

On Saturday afternoon the engineers who were still in the city were conducted by the mayor on an inspection trip to the municipal power house, the filtration plant, the cold storage warehouse and the government grain elevator. James R. Wilson, M.P., explained the various interesting mechanical appliances at the elevator. The engineers were taken to the top of the structure, from which there is a view of the surrounding country for fifteen miles in every direction. At the filtration plant a demonstration was given of the operation of the filters, including the washing of the beds.

## NOTES ON THE CONDITION OF SOME UNDERGROUND CONCRETE WORK IN WINNIPEG*

**By Bertram Stuart McKenzie, B.A., B.Sc.**
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IN presenting this subject for discussion, under the general title given above, it is proposed to eliminate theory as much as possible, and to cite (literally) concrete examples of deterioration under various conditions. Examples which will be given are taken from experience in the Province of Manitoba, and mainly in the city of Winnipeg. These have all come under the observation of the writer, or have been reported to him from reliable sources.

As this subject deals with underground conditions, the examples naturally divide themselves into two main classes:—

(a) Foundations for buildings or bridges.

(b) Pipes for sewers, drains or water supply.

These will be discussed in the above order and a few typical examples given.

### Foundations

(1) The first case which came under the writer's observation occurred in the footings for the columns of a seven-story building in Winnipeg. The footings consisted of the usual square stepped design. Owing to proposed increase in the loading it was considered necessary to put caissons to rock under the existing footings, and in the course of excavation for this work some rather extraordinary conditions were revealed. The first discovery was made by one of the workmen who was engaged in placing a strut between two adjacent footings. To his astonishment the concrete of one of the footings appeared to be practically a slime. The mass was so soft, indeed, that he could without difficulty plunge his hand into same and squeeze the material through his fingers. The matter was reported to the writer, who was associated on the work, and an examination of the material was made. The concrete had the appearance of lime mortar, being quite white and of a slimy consistency. There was quite a strong smell of sewage, and the inference, at first, was that there had been a chemical action by sewage from a broken drain in the vicinity, but this was not confirmed by further investigation.

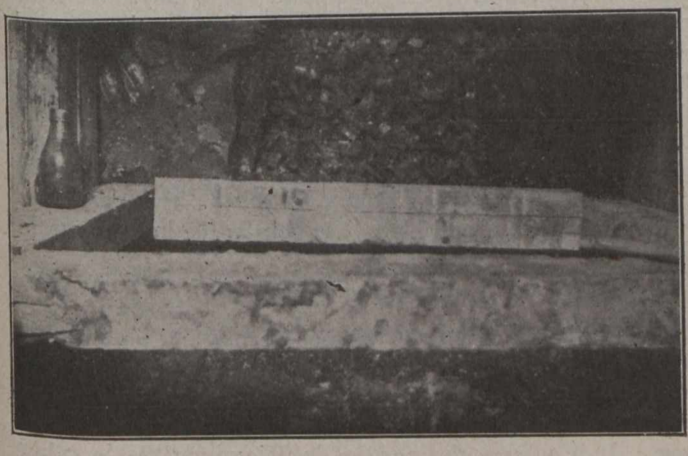

**Fig. No. 1—Caisson Under Ten-story Building Had Appearance of Pile of Broken Stone**

Other examples were soon discovered in other footings as the work proceeded, and conditions were of such a nature that the architect in charge of the work decided to remove the old footings altogether and to build the caissons up to the base plates of the columns. In one extreme case a mass of concrete fell away from the corner of a footing, and was so soft that it was possible to swing the head of a sledge hammer sideways through the mass. The disintegrated concrete, on being allowed to dry, becomes fairly hard with a white powdery surface. In the course of removing the old footings it was found that patches of this soft concrete occurred in what appeared to be otherwise quite sound masonry, thus indicating that a gradual rotting process was going on, which now appears to be most probably due to some chemical action by the ground water which had gained access to the footings. Wherever the condition was found it was observed that the concrete was very damp and porous, and the latter condition may explain the action to a certain extent.

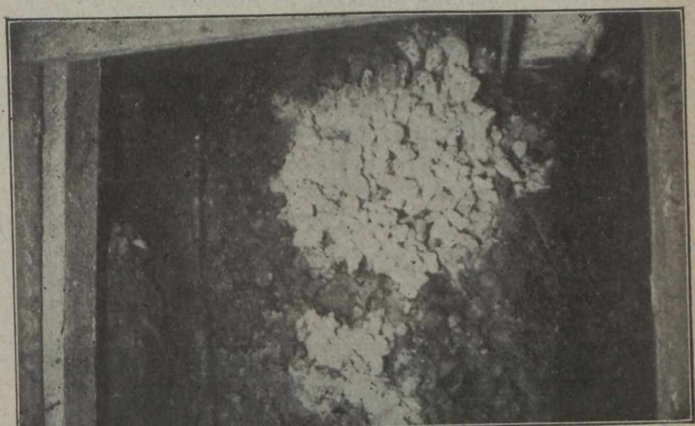

**Fig. No. 2—A Sheath of Hard Clay Adhered to Rough Parts of Caisson**

### In Clay for Fourteen Years

(2) The second example was discovered when exposing the surface of caissons which had been lying in the clay for over 14 years. These were under one of the 10-story office buildings in Winnipeg. It was found necessary, on account of settlement in the building, to excavate under these old caissons and continue same to rock. They were generally lying at a depth of about 35 ft. below ground level, and in practically every case (21 in number) water in considerable volume was found lying around the caisson and concentrated at the bottom. This water had come from under the basement floor and seeped down along the surface of the caisson. The first caisson exposed had an unusually rough surface, having the appearance of a pile of broken stone. (See Fig. No. 1.) There was a certain bond between the stones but the concrete was full of large voids.

If any mortar had ever existed in these spaces, it had entirely disappeared. It was noted that in the spaces mentioned above, a deposit of a brown jelly was often found. It was thought at first that this might be gelatinous silica, left as a residue from some chemical action, but this was not confirmed by analysis. Wherever this rough surface appeared there was discovered a curious sheath of hard clay about 1½ ins. in thickness, which showed quite a marked cleavage from the mass of sur-

*Paper read at the Saskatoon meeting of the Engineering Institute of Canada, August 8th to 10th, 1918.

rounding clay. When the surface of the caisson was smooth the sheath disappeared. (See Fig. No. 2.) The caisson has been dressed up a little to show the condition more clearly. There seemed to be some direct relation between the appearance of this sheath and the condition of the concrete surface. It was thought that there might be some chemical action going on which had caused a combination of certain elements of the cement with the clay, but an analysis of a sample of the hard clay did not confirm this. The clay analyzed as follows:—

| | |
|---|---|
| Loss on ignition | 13.33% |
| Silica | 50.94% |
| Alumina and iron | 30.85% |
| Calcium oxide | 3.87% |
| Magnesium oxide | Trace |
| Sulphur | Trace |

The condition may have been caused by pressure due to settlement of the caisson, but so far no satisfactory reason has been assigned. In some cases, at the bottom of the caisson where it had been belled out to get greater bearing surface, the concrete was practically loose stone without any bond whatever. If this condition can be produced by the action of ground water on concrete, then it is indeed full time that the question should be carefully investigated.

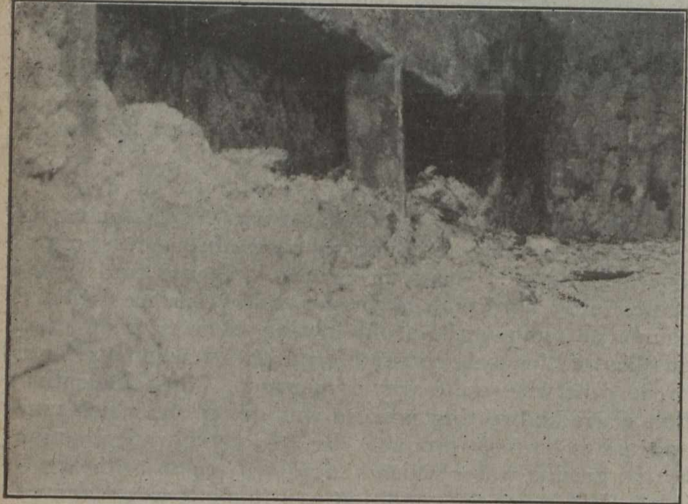

**Fig. No. 3—The Concrete Covering Disappeared from Lower Half of Beam and a Forest of Small Stalactites Appeared**

### History of the Concrete Not Obtainable

(3) The third case occurred in the foundation of the vault of the same building. This instance consisted of a mattress in which steel I-beams had been placed for reinforcement. In excavating under this mattress, preparatory to the construction of additional caissons, it was found that the concrete resembled close-packed, sandy gravel. It was quite soft, could easily be scraped away, and was water-soaked, clear through. When the underlying clay was removed, water dripped from the under surface of the concrete, and white stalactites were formed, sometimes as much as ¼ in. in diameter. The concrete seemed to have lost its character entirely, and a sieve analysis of a dried sample gave some extraordinary results. There was found no product finer than that retained on a 50-mesh sieve, and a microscopic examination of this product showed no trace of cement. It seems incredible that the cement should have disappeared in this way but it has not been established that it did not do so. In this particular case the actual history of the placing of the concrete would be of great interest, but this was found impossible to obtain. (This matter will be referred to in general remarks later on). The stalactites above referred to were analyzed and found to be calcium sulphate.

(4) The fourth case, also in the same building as the third instance, occurred in the concrete beams which had been constructed across the caissons to support the outside walls. These were reinforced with steel I-beams, or as a matter of fact the concrete served as a protective coating for the steel. In the course of an examination of one of these beams the concrete was found to be rather soft, and at one point quite a large hole was discovered. The concrete on the side of the beam was easily laid off with a pick and the steel beam exposed. The beam was found to be very wet, as water had penetrated into the heart of the beam and the resultant corrosion of the steel was quite marked. It was then decided to examine all the beams and as a result of the conditions found they were all stripped and a new concrete covering constructed. Arrangements for under drainage were also provided so that water could be kept away from the beams as much as possible.

### Steel Beam was Corroded

The photograph shown herewith as Fig. No. 3 will give an idea of the conditions found. In one of the cases, the concrete covering, if it had ever existed, had completely disappeared from the lower half. The space was spanned by a regular forest of small stalactites which had been formed by water dripping from the upper surfaces of the space. These were brown in color and on analysis were found to be composed of a combination of calcium and iron carbonate, the iron coming from the corrosive action of the water on the steel beam. On the bottom of the beam and lying also on the lower flange of the outside beam a slimy mass, similar in character to boiler sludge, was found in considerable quantity. This may have been a by-product from some chemical action by the ground water on the concrete of the beam. This case was somewhat complicated by the presence of manure which had been carelessly left on top of the caisson, where it had been placed as a protection from frost, as the chemicals in the manure might have had something to do with the condition found. The example is given, however, as a matter of interest, and a possible help in the investigation.

### Pipes and Sewers

(1) This is a matter which has been under observation for several years, both in Winnipeg and the neighboring city of St. Boniface, and was the reason for the starting of the series of experiments by the city analyst of Winnipeg. It has been the custom in Winnipeg, as in other cities, to construct sewers, either in place or by the use of pre-moulded pipe, and construction conditions are therefore subject to some variety. Conditions have developed which in several cases have resulted in a complete collapse of the pipe and a consequent cave-in of the ground surface. The first indication of disintegration is found in the appearance of soft patches in the interior of the pipe. These gradually extend until a hole develops or the pipe collapses. The appearance of the action on the interior was at first explained by the theory that it was due to the action of chemicals in the sewage, but as cases were observed in pipes which did not carry sewage, this explanation did not hold. Experiments to date ap-

pear to indicate that a much more probable cause is the action of chemicals carried in ground water on the outside. This seems to be borne out by the fact that, in stretches of pipe made of the same materials and at the same time, disintegration will be found only in certain portions, thus pointing to local conditions acting from the outside. In the city of St. Boniface this local deterioration has also been observed. In one case a sewer disintegrated to such an extent that it collapsed and caused a cave-in under a railroad crossing, whereas in other parts of the same job the pipe appeared to be quite sound. Cases have been observed where disintegration occurred within six years from time of construction, but on the other hand pipe has been in the ground for over 35 years without any sign of decay. Perhaps the most serious case in Winnipeg was the collapse of a sewer on Yale Avenue about a year ago. This was built in place and had been in service for about ten years. It collapsed without any warning, and caused a cave-in of the street above.

(2) Deterioration has also been found in manholes. These are usually constructed with pre-moulded rings. They exhibit the same tendency to deteriorate, but as in the case of the pipes above mentioned this deterioration has been local and not general. All this data seems to confirm the conclusion that outside agents are at work in certain localities.

### General Conditions

The above are given as typical examples of the trouble under discussion. Unfortunately it is practically impossible to get the true history of the concrete which has deteriorated. This is due in many cases to a lack of proper records, but more usually to a somewhat unpardonable reticence on the part of those concerned in the original construction of the concrete. It is, therefore, somewhat difficult to draw definite conclusions, and it will be impossible to get at the truth of the matter unless the concrete can be intelligently observed from its construction to its possible decay.

So many elements enter into the construction of concrete, such as materials used, the proportioning of same, time of year placed, condition of the ground and amount of ground water present, that only a series of carefully thought-out experiments can give a true line on the situation. If it is a fact that concrete constructed of carefully selected and tested materials, graded and mixed under intelligent and conscientious direction and placed under proper conditions as regards temperature, under drainage, etc., will deteriorate after remaining a few years underground, then it is full time that the Engineering Institute of Canada should take the matter in hand.

### Investigating Committee Suggested

It would seem that an effective method of handling the situation would be the appointment of a working committee consisting of a practical engineer, a chemist and a laboratory man, which committee could be so financed by the Dominion Government, or by the Provincial Governments of the three western provinces, that they could devote their entire time to an investigation of the subject. Field work could be carried on during the summer months and data gathered on which to work during the winter. Laboratory work could, of course, be going on all the time. Field experiments could also be carried on, similar to those already in progress in the Western States, but adapted to our local conditions. A certain amount of investigation has already been done in Manitoba, and an attempt made to collect data on the subject, but up to date there has not been sufficient to arrive at any definite conclusions.

### Chemical Investigations

This matter, as above mentioned, has been carried on under the direction of the city analyst of Winnipeg. Speaking generally, the work has consisted of the analysis of the clays of the Winnipeg District, samples of ground waters, and samples of deteriorated concrete, as compared with samples of sound concrete. As a result of these analyses, chemical experiments have been undertaken with the object of determining the action of solutions of the various salts found in the ground waters, on neat cement and on mortar. Solutions have been concentrated and briquettes have been steam-cured in order to arrive at results in the shortest possible time. Under construction conditions the process of deterioration is, of course, a very gradual one, taking several years before conditions become serious. In connection with these experiments some interesting results have been obtained by Mr. Thompson, who has been making experiments on the density of mortars.

Two main theories have been advanced to explain the deterioration of concrete by the action of chemicals in ground waters:

1. The formation of soluble compounds in the concrete which are leached out by the water.

2. The disintegration of the concrete due to expansion in the process of crystallization of the newly formed chemical compounds.

It has not been considered advisable to publish the results so far obtained from experiments until they are more conclusive. It is hoped that some way may be found to make the above record of facts perfectly complete, and that a full and satisfactory explanation may be reached to account for the above-described conditions of some concrete work in Winnipeg's soil.

## PUBLICATIONS RECEIVED

**Fuel Economy in the Operation of Hand-Fired Power Plants.**—Circular No. 7 issued by the Engineering Experiment Station, University of Illinois, Urbana, Ill.

**An Investigation of Twist Drills.**—By Bruce W. Benedict and W. Penn Lukens. Bulletin No. 103 issued by the Engineering Experiment Station, University of Illinois, Urbana, Ill.

**Johnson Well Screens.**—Bulletin No. 18, describing Johnson brass well screens and Johnson pipe base well screens. Eight pages, 6 x 9 ins., coated paper, illustrated. Issued by Edward E. Johnson, Inc., St. Paul, Minnesota.

**Physical Tests of Road-Building Rock.**—Bulletin No. 670 of the United States Department of Agriculture, issued June 14th, 1918, giving results of physical tests during the years 1916 and 1917. By Prevost Hubbard, chemical engineer, and Frank H. Jackson, Jr., assistant testing engineer.

**Electrolysis of Underground Structures.**—Published by the Bureau of Standards, Washington, D.C. Prepared by Samuel S. Wyer, consulting engineer, Columbus, Ohio. A digest of publications previously issued by the Bureau of Standards on the electrolysis of underground structures caused by the disintegrating action of stray electric currents from electric railways.

## COST OF LAYING PIPE*

By Geo. Wehrle
Supt. Denver Gas & Electric Light Co.

THE writer enlisted the aid of an appraisal engineer in developing his plan, and they concluded that the first and salient factor must be the man power expended in each class of work, from which can be worked out a unit cost for such class. Experience and theory were called upon for the amount of work a man would do under average conditions in a given time, which would be known as the "man power" for the class of work under discussion. This factor established, the cost of accomplishing that unit of work at a unit time-cost was computed.

### Trenching and Back Filling

It was decided that under average conditions a man would trench and back-fill 9 cu. ft. of trench per hour, and that the cost of trenching would equal twice the cost of back filling. The labor cost per hour was fixed at one cent, which gave a unit cost per cubic foot of 0.00111. A table was then worked out showing the cubical contents of one lineal foot of trench of the standard width for each size of pipe and a depth of one foot. Multiplying the cubical contents of a trench by 0.00111 gave the unit cost per lineal foot of trench exclusive of bell holes. As the cubical contents of bell holes would be constant for a given size of pipe regardless of the depth of trench, it is necessary to handle them separately.

The cubical contents of a bell hole was considered to be that contained within a space of 8 ins. wide and 18 ins. long extending from a point 8 ins. above the pipe to a point 8 ins. deeper than the bottom of the trench on each side of the pipe and across the bottom of the trench under the pipe. Reducing this to a formula, the cubical contents of a bell hole for a given size of pipe equals: $2 \times 8 \times 18 \times$ (diam. of pipe $+ 16) + 8 \times 18 \times$ (width of trench).

Dividing this result by 12, which was considered to be the length of a joint of cast iron pipe in feet, gives the cubical contents of a bell hole per lineal foot of trench. Multiplying this figure by 0.00111 gives the unit cost of bell holes per lineal foot.

The cost of trenching and back filling for a given size of pipe in any locality can be found by the use of this simple formula:

Cost of trenching and back filling $= (A \times B + C)\,D$.
A = the unit cost for trenching from table.
B = the depth of trench in feet.
C = the unit cost for bell holes from table.
D = the labor cost in cents per hour.

The variable factors are hereby reduced to two and the calculation becomes very simple.

No attempt has been made to separate the kinds of soil encountered, which might be hard, medium or easy, and the manpower is considered to be that expended in medium soil which will meet average conditions. It is believed that conditions of hard and easy soils will in most cases balance each other, but under extreme circumstances, where the kind of soil to be encountered is known and is generally of the same character, allowance can be made by establishing a ratio between known and average conditions and using it as a multiplier of the resultant obtained by using the above formula. In this way a unit figure may be obtained which will exactly meet local conditions if such accuracy is deemed necessary, but for practical use we believe the use of the formula will serve all except very remote purposes.

In finding trenching costs for screwed steel pipe the same unit cost is used as for a given size of cast iron with the omission of the bell hole.

Pavement and crib timbering costs have not been considered as they are of a very variable character and best handled individually.

### Laying Pipe

The labor of installing pipe, which in the case of cast iron covers the handling of pipe from the curb line to the trench, swabbing out, inspection and lowering into trench, and for steel pipe the work of reversing couplings, handling from curb line to trench, swabbing out, inspection and lowering into trench, was worked out by establishing an amount of pipe in lineal feet that could be handled in a given time by a standard pipe gang composed of a straw boss and a certain number of men for each size of pipe, based upon the weight of a foot of pipe of a given size and the size of gang required to handle a standard length of the pipe.

In arriving at the number of men required to handle the pipe it was considered that all pipe under 12 ins. in diameter would be lowered into the trench by means of ropes held by the men while 12-in. and larger would be let into the trench by means of a portable derrick.

A ratio of weight per man-hour was established which in the case of cast iron pipe was found to be approximately 425 pounds of any size of pipe. The number of men in the gang multiplied by this constant and divided by the weight of a foot of pipe of a given size gave the number of feet of that size pipe which could be laid by the gang in one hour. The unit cost per foot for each size of pipe was found by using a labor rate of .01 per hour multiplied by the number of men in the gang and divided by the feet of pipe the gang could lay per hour.

As but one variable enters into the calculation of finding the cost of laying pipe in any locality, that of labor cost, it is only necessary to multiply the unit figure found in column B of the chart for steel pipe or column C of the chart for cast iron, opposite the size of pipe to be laid, by the local labor rate in cents per hour.

It is the usual practice in laying pipes of the larger sizes to have a pipe gang foreman who is paid a little more than the common pipeman, but this difference in wage is inconsequent when compared with the total for the gang and has therefore not been considered, the common wage scale being used as a multiplier and the foreman counted as one of the men composing the gang.

### Jointing

The unit cost per foot for jointing cast iron pipe was calculated in the same manner as for laying except that the weight of lead per joint instead of the weight of pipe per foot was used as a base. The number of men comprising the jointing gang was first decided and then the number of joints that they could make in a given time was calculated by establishing a ratio between the weight of lead and a man-hour. It was found that this ratio was 12.5 and the unit cost worked out at a .01 per hour wage scale by multiplying the number of men in the gang for a given size of pipe by the constant 12.5 and dividing by the weight of lead required to joint that size of pipe. This figure multiplied by 12 gave the feet of pipe jointed per hour. Multiplying the number of men by .01 and dividing by the feet of pipe jointed per hour gave the unit cost per foot for jointing.

*(Continued on page 187)*

*This article, although written for the "Gas Age," contains much information likely to be of value to those who are interested in the construction and maintenance of waterworks.—EDITOR.

## COST-KEEPING SYSTEM FOR COUNTY HIGHWAY WORK*

By H. A. Sewell
Engineer, Pend Oreille County, Washington, U.S.A.

THE number and character of forms to be used in a cost-keeping system for county highway work will depend largely on the size of the county and the method of handling the superintendence of road work; but there are certain elements or principles of any such system which will apply to all cases. These elements I will group under the heads (1) Authorization of Work, (2) Reports, (3) Segregation, and (4) Summary.

### Budget of Expense

The first element under authorization of work should be a well-considered budget of expense, based not upon the usual basis of "salaries or per diem," "contracts," "labor," "team work," "materials and supplies," "tools and machinery," etc., as we generally find in the county budget; but rather upon the amounts to be allowed for all these items for construction or maintenance of each particular piece of road, or bridge, whether it be by contract or day labor, and, in addition, a fixed amount for overhead for the district or county, as the case may be, which cannot properly be charged to any particular stretch of road. No one realizes more than do I the difficulties of forming a budget under our present system of county bookkeeping, but after installing the rest of a cost-keeping system it will yearly become an easier matter to formulate an adequate and well-balanced budget. After the adoption of the budget it should be rigidly adhered to, except in cases of palpable oversight or emergency.

### Authorization Blanks and Work Orders

Having adopted the budget, the next element of authorization is some form of "authorization blank," "work order" or "job sheet," to be delivered to each man in charge of road work, for each individual job, by his superior in charge of district or county, as the case may be. This blank should show in more or less detail the work to be done and the amount to be allowed for the work.

Closely allied with the "work order" is the "requisition." Agreeable to local conditions, it may be issued to the job foreman by his superior, or by the foreman himself upon the authority contained in the work ordered. The principal object of the requisition is to prevent haphazard and unregulated purchase of material and machinery and to show who received such material or machinery. Needless to say, neither the "work order" nor the requisition applies to contract work, as the contract and specifications are sufficient authorization of the work and the bond protects the county.

### Segregation of Expenditures

The second group of elements I have classed as reports. By this I mean the segregation of the expenditures of road money so as to show on what particular piece of road the expenditure occurred, and, further than that, if possible, the exact location and nature of the expenditure. The forms to be used for these reports, and whether they shall be daily, weekly or monthly, will again depend upon the magnitude of the work and local methods of handling the same. Another important factor in designing a report is the character, education and experience of the person making the report; and great care must be exercised in not making it so complex as to cause either of the alternatives, no reports, or the loss of a good road boss.

The ideal place for the report would be on the claim vouchers or pay roll, as such a system would be simple and direct. Unfortunately, however, the vouchers and pay rolls used in this state are prescribed by bookkeepers and not by engineers, and no provision is made for segregation of time. Therefore, the next best scheme is to design a system of report which may be properly segregated and distributed.

The report or reports should show the work order number of the job, the names of the foremen and workmen, the location and exact nature of the work, and the number of hours working time.

In case the foreman is allowed to requisition materials or tools for his use or take some from stock, he should be required to render a memorandum report of such transactions. On contract work the inspector should make the reports. Traffic reports should be kept on all maintenance work where possible.

### Distribution of Costs

There is a large group of elements to be considered under the head of segregation and distribution, as there are so many heads under which costs might be segregated. Here, however, we must follow our budget and distribute costs as nearly as possible according to the items outlined in the budget, leaving any other segregation desired as a sub-segregation under the main segregation, according to overhead and roads, to be recapitulated in the summary of costs. The reports having been made as simple as possible to be and still convey the necessary information, most of the work of segregation must be done in the office, and it may be carried as far as the accuracy of the data and the local conditions render advisable.

The first question to be decided is which items are to be considered as overhead expense and which are to be charged as road expense. It is my rule to charge every expense to overhead which cannot be directly traced to some particular road or group of roads, but is of general value to the district or county and may be (although not necessarily must be) of general use. Thus, small tools may be bought for and worn out by a patrol crew on a particular section of road, yet such tools are of general value and might be used elsewhere should occasion require, and would be charged to overhead expense, heading "Tools and Machinery." The headings and subheadings should cover the principal items of overhead and the remaining overhead items should be carried in miscellaneous columns, adjoined by a blank column to show cause of outlay. Sometimes one claim paid will be segregated under several heads in several columns. "Materials and supplies" purchased in quantity, which will ultimately be charged direct to the several roads, should be carried in a stock account and, when used, should be charged to the respective roads and the amount credited to the stock account. The extent to which these accounts need be subheaded will depend largely on the magnitude of the work accounted.

The items of road expense chargeable to the several roads direct are easily classified into labor and materials, and the subheads are familiar to all. Here, for convenience, the entire crew's time for a certain period of time, depending on the report interval, may be entered together as segregated by the reports, checked against the pay rolls. If possible, different classes of work readily measured by units should be segregated and the

*From a paper presented July 24th at the Annual Convention of the Washington Association of County Engineers.

unit cost entered, as well as the entire cost of the class of work and of the whole section. For contracts, the bid prices and actual costs may both be entered if desired. Engineering and inspection on any particular road should be carried in an engineering account and charged to that road or job in the yearly summary. Bridge work may well be carried in separate accounts in a bridge ledger and charged to the road on the yearly summary.

### Annual Cost Summary

Having segregated the various items for future reference, the next question is as how to make use of them. This is through the summary, preferably annual. In the annual report or summary the divisions of the budget should be closely followed, so as to show whether expenses over-run or fall short of the budget. This is for the information of the general public. In addition to this a recapitulation should be prepared, if possible, for the benefit of highway engineers, showing unit costs of construction and maintenance, based upon convenient units. On maintenance the most convenient unit is probably the mile; and by use of the traffic reports a convenient unit is cost per year per mile per unit of traffic.

The report should, if possible, contain a statement of assets in the way of machinery and tools, based upon their depreciated value at that time, and the difference between this statement and the one for the year before should be subtracted from or added to the tools and machinery account under overhead expense, according as the asset value has increased or decreased. Where a piece of machinery is finally junked and its asset value gone, its entire cost should have been absorbed by the overhead account.

### Cost System of Pend Oreille County

The system which I have installed in the engineer's office in Pend Oreille County is based on that provision of the law which provided that the county engineer shall keep a record of the history of each road.

The authorization blanks consist of work orders and requisitions issued by the supervisor to his respective foremen and by the engineer for permanent highway maintenance. These blanks are printed in triplicate, the stub being retained by the supervisor, the next division going to the engineer's office, and the outside blank going to the foreman. In the case of a work order he keeps it, while a requisition is turned in to the person or firm providing the material or machinery, to be attached to claim vouchers. The engineer files his for future reference. Certified copies of all contracts, of course, are filed in the engineer's office, as required by law. In some cases small jobs of day work on construction or maintenance are let out to local parties on work orders. In such cases the work order numbers and classification of labor on the pay roll are usually sufficient to properly record the work, so it is not customary to require reports on such work.

All foremen employed on more than one job are required to turn in monthly industrial labor reports showing when, where and how all work is done. While at first sight the idea of having a separate sheet for each individual may appear cumbersome, it is simple for the foreman, and affords the exact information desired. It also is easily checked against the pay roll, and in a small county, at least, is easily handled in the engineer's office by placing in a letter file for each month and segregating the various reports for entry in the ledger.

A memorandum of all tool and machinery purchases and transfers is also required of all foremen on a "Tool and Machinery" report and all materials and supplies bought, or taken from stock, must be accounted for on "Material and Supplies" report. On jobs of magnitude a weekly report is required to keep a check on the work. On those jobs the foreman is usually competent to segregate work, or there is an inspector or engineer on the job; therefore a segregated report is required, thus saving an office segregation. We require a daily report from truck crews, not because of the fact that the magnitude of the work requires it, but because no report blank could be formulated which would show the elements required for a larger period than one day without being too complex to be kept in the field. We have the patrol system of maintenance on our main highways, and patrolmen are required to keep traffic reports for certain weeks.

A blank for the use of the supervisor is the Tool and Machinery Receipt, and, while not properly speaking a part of the cost-keeping system, a word of explanation may be proper on account of the close connection a check on tools has with the cost keeping. The receipt proper is the stub, and is kept by the supervisor after being signed by the foreman. Upon returning the tools, or otherwise accounting for them, the foreman receives his release in the return receipt. In case tools are to be reloaned the supervisor gives the man to receive the tools a reloan order in lieu of the tools, which he presents to the man possessing the tools as his authority.

### Overhead and Stock Accounts

The record books employed in the county consist of Overhead Account, containing the overhead expense and stock account; a Road Ledger, in which are charged road expenditures proper; a Bridge Record, for bridge expenditure, and an Engineering Account.

The Overhead Account is a bound book, with columns to show the following items: Date, Name, Warrant, Requisition No., Cause of Outlay, Tools and Machinery (subheads, No. Units, Unit Price, New Equipment, Maintenance Old), Supervision, Insurance, Miscellaneous.

The Stock Account should really be a separate book, but we keep it in the same book as overhead to save space. It comprises four columns, besides the date, name of claimant and voucher number, namely: Material or Supply, No. Units, Unit Cost and Total Cost. If it were carried in a separate book it would be more convenient to head groups of three columns with the kinds of material and supplies and place the other items as subheads. Whenever anything is taken from stock and charged to a particular road it is credited in red ink in the Stock Account. A column is also provided on the overhead page for items allowed but unaccounted by the reports or otherwise, which we hope in time will disappear.

### The Road Ledger

The Road Ledger is divided into sheets for construction and maintenance, which are arranged together for each road and placed alphabetically in the book, according to the road name. The sheets are very similar and are divided the same, except that the top of the sheet is different. The top of the construction sheet shows Character of Country, History of Road, Bridges, and Right of Way, or Damages. The top of the maintenance sheet shows Brief History of Maintenance, History of Traffic. The columns and headings are as follows: Year, Month, Section, Township, Range, Nature of Work, Width (Subgrade, Surface), Wages Per Hour (Man, Team, Foreman), Work (No. Units, Unit), Cost (Unit, Total), Material and Supplies, Powder, Caps, Fuse, Lumber, Steel, Cement, Pipe, and Blanks, all subheaded Amt., Price, Total and Grand Total, Fund, and Remarks.

The Bridge Record, besides giving a description of bridge, shows construction on the left of the page and maintenance on the right, and is divided into Construction, Date, Name of Builder, Cost, Condition, Date, Nature of Repairs, Date, Cost, Repaired by, Remarks.

The Engineering Account shows the following items: Date, Name, Warrant No., Fund, and several blank columns to be headed with road name, and a Total Column.

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## ADVANTAGES OF THE STORAGE OF WATER*

By Melville C. Whipple

LET us first consider some of the advantages that accrue from the storage of water, and following that the disadvantages and dangers accompanying its use. There are certain processes operating under natural influences which exert beneficial action. One of these is sedimentation.

### Sedimentation

When running water is arrested in its flow the force of gravity immediately exerts a greater influence toward purification. I shall use the term "purification" to include the removal of any substances which detract from wholesome or attractive properties. Gravity tends to carry downward the visible and invisible matter spoken of as suspended particles. A lake, pond or artificial reservoir is a large sedimentation basin and in it are precipitated injurious substances. The amount of material brought to the basin is often very large, as in the case of streams which carry much clay. The Ashokan Reservoir in the Catskills receives in flood time the water of streams which run red with clay material, and yet the water discharged at the gate-house contains only a trace of the amount found at the head of the reservoir. Larger particles settle more rapidly than small ones. Microscopical bodies like the bacteria settle slowly, but in the presence of larger particles many of them are carried down. It goes without saying that the longer the water is retained the greater will be the efficiency of sedimentation. In bodies of water like the Great Lakes, where long storage exists, there remains no visible trace of all the suspended matter that enters. In large bodies of water there are disturbing influences which combat sedimentation. Wind and wave action in shallow depths carry to the surface material already precipitated, but this action is spasmodic and the net effect registers a great improvement.

### Decolorization

Decolorization is another process which goes on with advantage in stored waters. It is an observed fact that a great reduction in the color of such waters occurs after storage for several weeks or months. In the Hobbs Brook Reservoir, supplying a portion of Cambridge water, the color at the upper end averaged 75 on the platinum scale during 1916, while that at the lower end averaged 18. In the Wachusett Reservoir of the Metropolitan system the reduction was from 36 to 17. Various causes contribute to this improvement. At the surface the bleaching action of sunlight causes a decomposition of the coloring matter. Experiments have shown a reduction of about 50 per cent. in a month. Below a depth of five feet the action is not appreciable owing to exclusion of light. Oxidation by beneficent forms of bacteria also plays a role; but the greatest factor of all is probably due to a neutralization of electric charges carried by the color particles. This results in their coming together to form particles large enough to settle out. The last phenomenon is as yet imperfectly understood. The total effect of all the forces operating to bring about decolorization is that water which was unattractive to sight and taste undergoes such an improvement in quality as to be available for use.

*Abstracted from paper read before the School of Public Health, Boston, May, 1918.

### Equalization

Another factor operating strongly for purification in large basins is the equalizing effect on the quality of the water. This involves no other action than that of simple mixing. Analyses, both chemical and bacteriological, of the water entering reservoirs will show that the quality varies at different times, sometimes in a striking degree. If it was not for this fact there could be no equalization of quality; but inasmuch as the water is sometimes worse than others, if a long period of storage is provided there is a mixing of good and bad water which smooths down fluctuations in the quality of the incoming streams. The effect is the same as dilution. Equalization is of special significance when taken in connection with the hygienic or bacterial quality of water. It is undoubtedly true that the germs of water-borne diseases, such as typhoid, cholera and dysentery, are not uniformly present at all times even in sewage-polluted waters where the colon bacillus of the intestine is constantly found. Attempts to isolate the typhus bacillus, for instance, are not always successful when heavily polluted waters are examined. Infection of water, then, occurs with fluctuations in intensity. This being so, it is easy to see that there is much greater danger from the epidemiological standpoint of supplying to a filter, or directly to a city, a polluted water which has not been stored. A heavy dose of infective material may be encountered at intervals when it is not expected, if storage is not made use of.

### Destruction of Bacteria

It used to be thought that the only factor operating during storage to remove bacteria was that of sedimentation. We now know that by far the greatest action is due to certain "devitalizing" processes now going on naturally, which result in the final extermination of disease-producing microbes. In temperate climates the typhoid bacillus is more often the cause of water-borne epidemics than any other organism, and for this reason it has been the subject of many lines of research study. Much is now known concerning its length of life in water, the effect of temperature upon the rate of destruction and various other matters. The researches of Dr. A. C. Houston, of the London Metropolitan Water Board, have probably been the most exhaustive along these lines and likewise as well received as any. The question of the influence of storage upon the quality of water has long been an important one to the city of London, as most of its water is derived from the Thames and other polluted rivers, the water being stored in large basins for a period of about 15 days and then filtered.

### Effect of Temperature

Very complete tests were also made by Dr. Houston to determine the effect of temperature upon the death of typhoid bacilli in water. His findings were directly opposed to some of the earlier work but are now generally accepted. From the accompanying table it is evident that temperature is an important factor and that the vitality of the bacillus persists longer with lowering temperature.

**Influence of Temperature**

| Degrees. F. | C. | | Weeks 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | 0 | ...... | 47,766 | 980 | 65 | 34 | 3 | 3 | 2 | 1 | 0.0 |
| 41 | 5 | ...... | 14,894 | 26 | 6 | 3 | 0.3 | 0.1 | 0.0 | — | — |
| 50 | 10 | ...... | 69 | 14 | 3 | 0.3 | 0.0 | — | — | — | — |
| 64 | 18 | ...... | 39 | 3 | 0.4 | 0.0 | — | — | — | — | — |
| 80.6 | 27 | ...... | 19 | 0.1 | 0.0 | — | — | — | — | — | — |
| 98.6 | 37 | ...... | 5 | 0.0 | — | — | — | — | — | — | — |

Initial number of typhoid bacilli was 103,000 per c.c. "Studies in Water Supply," A. C. Houston, page 86.

These results are both disappointing and gratifying. They indicate that the life of the typhoid bacillus is longer in the cold months of winter and early spring. At this time any dejecta from patients, if it is thrown on the ground, has its best chance of reaching the consumer. Cold weather protects the bacteria and the melting snows and rain hurry them along on their journey. On the other hand, the greatest number of typhoid cases occur in the late summer and fall. At that time the stream flow is less and the temperature is nearer the average for the year, or possibly higher, and so the typhoid microbes have a precarious time. Other forms of bacteria, except some common soil and water forms, are also found to decrease rapidly in stored water, but the disease bacteria and strictly body forms, like bacillus coli, shows a greater rate of decrease. It is apparent from the work of Houston and others that storage provides a great protective barrier for the consumer against the germs of water-borne diseases. The use of small basins is an aid in this direction, although several weeks' storage is necessary to the absolute destruction of disease-producing bacteria.

### Disadvantages of Storage

Among the disadvantages of storage is one that arises in connection with color. In all ponds and large bodies of water there are three zones marked by differences in temperature. Assuming a depth of 50 to 100 feet, we find from April to October in the upper 15 to 25 feet water of uniform temperature which is in active circulation both horizontally and vertically. Below this for perhaps 15 feet is a zone where the temperature drops rapidly, sometimes 10 degrees in a foot. The movement of water is in the opposite direction to the zone above. Finally below this middle, or transition zone, is one where there is almost no movement of water. This is the only portion of a reservoir which may be said to afford stagnant water. Everywhere else the water is in circulation. If it is necessary to use water from this zone it will be found to have a color considerably higher than the surface, and this color may temporarily increase upon exposure to air. It is due to soluble organic matter in combination with iron which has been taken up from the slime and soil at the bottom. When the iron becomes oxidized upon exposure to the air it settles out and carries much of the color with it. To a considerable degree this trouble may be obviated, for a few years at least, by removing all the vegetation, roots and mucky soil from the land which is to be covered with water. The procedure is expensive, costing over two million dollars for the Wachusett Reservoir. When the Ashokan Reservoir was built subsequently the benefits were not deemed commensurate with the cost, and no soil stripping was done, although roots were grubbed out near the flow line of the reservoir. Experience to date with this reservoir has justified the procedure. So far as matters of health are concerned, there is no objection to using water from the zone of stagnation. It may have a higher color and also a bad taste and odor, but these do not affect its hygienic quality.

### Plankton Troubles

The most serious disadvantage arising from the use of stored waters is experienced from the growth of "plankton," microscopic organisms which are larger than the bacteria, but which have no significance from the standpoint of disease. They belong very largely to the plant kingdom, and many forms are classed under the head of algae. At times their growth is prodigious and their oily secretions give rise to odors and tastes varying from "vegetable" in character to "grassy," "fishy" and "disagreeable." Light is essential to their growth, and for that reason they are mostly found near the surface. Nitrates and carbonic acid furnish a large part of the food supply. The carbonic acid is largely derived from decaying organic matter, and for this reason reservoirs and ponds containing much decaying vegetation at the bottom are prone to give trouble. The best means of combating the scourges, once they appear, is by means of copper sulphate treatment. Crystals of this substance may be dissolved in the reservoir by towing from a boat a bag or perforated pail filled with it; or a solution may be sprayed from a pump over shallow, quiet areas where the growths are most troublesome. From one to ten pounds per million gallons will be required to kill the organisms, the amount varying with the species. This amount will not prove harmful to consumers of the water. In undertaking this treatment expert advice should be sought as to the amount and distribution of the dose to be applied. The nature of the fish life must also be considered, as some species are more susceptible to the action of copper than others. There are other and larger forms of plant life which sometimes cause trouble. These are the water plants like Chara, Anacharis and the duck-weeds, which either grow attached to the bottom near the shores and in shallow places or else form masses on the surface. If these plants die and start to decompose they not only cause unsightly accumulations along the shores but they impart extremely unpleasant odors and tastes to the water. Dredging will remove them temporarily, but lining of the reservoir for several feet along the shore line with stones or cement is a more effective measure.

### Dangers from the Use of Storage Basins

Aside from the trouble caused by the growths described, which after all are "minor horrors," there are at times positive dangers from stored waters. When we divide the capacity of a lake, pond or reservoir by the amount of water taken from it each day a figure is obtained which represents the nominal period of retention in that basin. It is not correct to assume from this that all the water entering is confined for that period. Mixing is not as thorough and complete as this, except in shallow basins. I have already mentioned the zone of colder, quiet water which lies at the bottom from about April to October. There is a similar although less pronounced condition in the cold winter months, when the bottom layer is slightly warmer than the top. Water which enters a reservoir stratified in this manner does not mix well with the quiet water but tends to flow over it. The period of storage is thus shortened and the time for purification lessened by that amount. Polluted water entering the basin reaches the outlet sooner than it would if the temperature was uniform from top to bottom.

Mixing would then be more thoroughly accomplished. The general shape of the shore line and the location of the outlet sometimes afford another element of danger, and give rise to "short circuits." There may be a direct line of flow from the inlet to the outlet which does make use of the total storage available by reason of bays and coves where the water does not mix. The ideal arrangement is one which makes use of projecting portions of a shore line to cause the water flowing through the basin to pursue an irregular course. The effect is the same as interposing baffles in a small basin. Mixing is much more complete. A direct line of flow may be necessary with regular shore lines and also prove perfectly satisfactory under usual conditions. It may not afford protection under unusual conditions. A high wind for several hours or days may blow straight toward the outlet and set up a rapid movement of the water in that direction, or a sudden freshet in the spring may bring in a lot of warm water. It has been observed many times that this warm water does not mix readily with the cold water already in the basin because it is not as dense. Instead it spreads out in a sheet over the top of it. If this incoming water carries with it the microbes, say, of typhoid fever, little time is given in the reservoir for their destruction, and they may persist in the water leaving the reservoir. The combination of freshet, wind and pollution may break down the protective barrier of any storage basin.

### Conclusions as to Value of Storage

In conclusion it may be fairly said that the storage of surface waters affords a very effectual means for safeguarding their hygienic quality. The dangers arising from the use of impounded water supplies come from inability to make use of a proper period of storage under some unusual conditions, and not from the failure of the natural processes of purification to be carried on. The use of stored waters is also attended by certain disadvantages, chiefly a temporary increase of color, and the production of tastes and odors from the growth of microscopic organisms. These are overcome in large measure if artificial means of purification are later employed, such as filtration. The benefits and advantages which accrue from storage, on the other hand, are numerous and pronounced in their effect. Most important of these is the reduction in the numbers of nearly all forms of bacteria, and especially of those forms found normally or occasionally in the human and animal body. Water is not a favorable environment for the existence of any of these. Research has shown that the disease-producing bacteria, like the typhoid bacillus, succumbs in a very few weeks at the longest. Storage also improves the physical properties of water by allowing the precipitation of sediment and the removal of coloring matter, changes which render it more attractive for human consumption. The equalizing effect of large storage basins is likewise of great importance.

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Hon. John Hart, minister of finance for British Columbia, left recently for New York, where he will attend to the details involved in the taking up by the government of some $780,000 worth of bonds issued by the municipality of South Vancouver and the substitution of provincial bonds under the arrangement provided for by the legislation at the recent session of the provincial legislature. Through this the government stepped into the municipality and took over its affairs, appointing as commissioner Mr. Gillespie. The $780,000 bonds of the municipality were held by Messrs. Spitzer and Company, of New York, and the government is retiring the issue, substituting provincial bonds.

## ULTIMATE COSTS OF BITUMINOUS AND WATER-BOUND MACADAMS NEARLY EQUAL IN NEW YORK*

**By Dudley P. Babcock**
Assistant Engineer, New York State Highway Department

WATER-BOUND and bituminous macadam pavements were found to be almost equal in ultimate cost, in recent investigations of these types made by the New York State Highway Department. The results were interesting and quite unexpected, not only in that there was so small a difference between the two types, but also because it appeared that traffic tonnage has a very small effect upon the ultimate cost. Some interesting data in regard to the average daily traffic on the highways of the state were also collected.

The advent of motor vehicles and the consequent introduction of various new types of pavements have raised the question of the ultimate cost of highways, and this

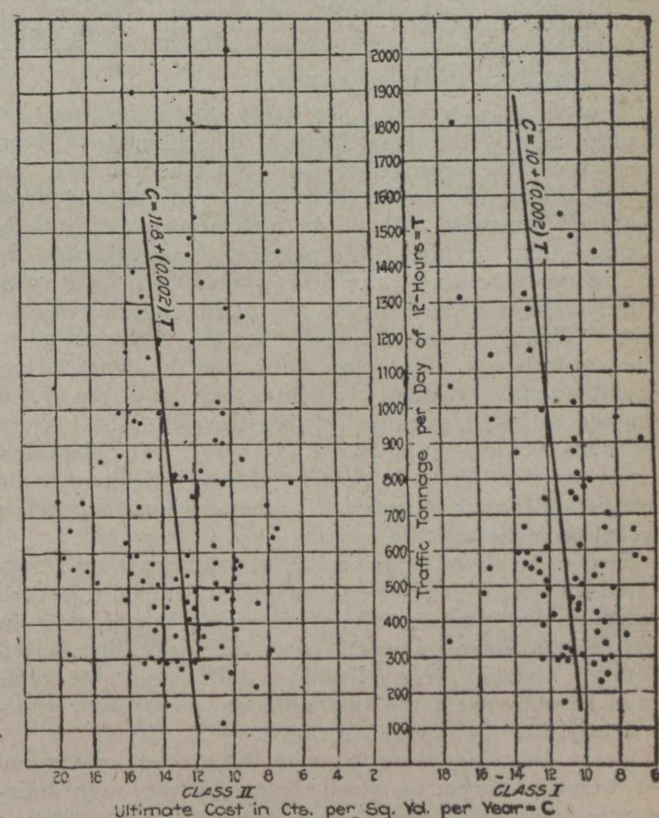


**Chart Showing Relation Between Ultimate Cost of Macadam Roads and Tonnage**

has become a vital and complex issue throughout the entire country. The term "ultimate cost" not only comprehends the first expenditure, but also covers the outlay for maintenance, repairs, and resurfacing. In other words, it is everything that its name implies from an economic point of view. More specifically, throughout the study of New York state highways which has been made under the direction of the State Highway Commissioner, the ultimate cost has been considered the amount of money spent by the people of the state per year, in order to build, repair, resurface, and at periods of time far apart reconstruct each square yard of pavement. In view of the limitations put upon it, this study does not attempt to go beyond the pavement. Notwithstanding

*From "Engineering News-Record," New York.

this fact, figures illustrating the cost of excavation, subdrainage, culverts and the like would be distinctly pertinent to the discussion.

It seemed practicable to include in the study only the shorter lived types of pavement, as water-bound and bituminous macadams, as the more permanent types, as brick and concrete, are of such recent development compared with their probable length of life that even tentative conclusions are hardly warranted. However, in the case of macadam types, many of the roads analyzed were old enough to form a basis for such conclusions. To aid in the more complete estimate of the cost of these roads, extensive statistics had been collected and were available for comparative study.

### Ultimate Cost

Treating, first, the ultimate cost, it may be resolved into the following factors:

(1) First cost per square yard; (2) length of time before this expenditure will have to be repeated; (3) interest on bonds; (4) cost of maintenance and repair per year; (5) cost of resurfacing, which is somewhat less than the first cost, inasmuch as resurfacing does not generally include the replacing of the bottom course; (6) the time interval between the resurfacings.

Factors 1, 3, 4 and 5 are easily obtainable from the records kept by the department. The number of years over which the expenditure for construction and the periodical expenditures for resurfacing may be considered to extend are more difficult of deduction. It will be assumed that the life of the pavement extends from the date of construction to the time when it will have to be entirely rebuilt at an expense approximating the original cost. Thus, if the original cost of construction is assumed to be 70c. per square yard, and the depreciation, notwithstanding ordinary maintenance and repair, is assumed to be 2c. per square yard per year, the term of the bonds would then be $70 \div 2 = 35$ years. The classification in one item of the resurfacing and the ordinary maintenance and repair obviates the necessity for distinguishing between the two.

Two methods of arriving at the ultimate cost suggested themselves, and the department grouped the roads studied in two classes. The assumptions determining the classification have in each case their peculiar disadvantages, but it was felt that a fairly equitable value would be obtained if the two methods were used independently and the results averaged.

In the first class were grouped those roads which had just been resurfaced, or which because of thorough maintenance and repair were considered "just as good as new"; with the exception of a small charge for depreciation. In the second class, those roads were grouped which had been built five years or more. They were selected irrespective of the condition of the road at the end of the period.

### Determining Ultimate Cost

Taking up the first class, the ultimate cost was deemed to be made up of (1) An arbitrary depreciation charge, which was placed at 2c. per square yard per year; (2) maintenance and resurfacing per square yard per year; which item included the summation of all maintenance, repairs and resurfacing, divided by the number of years since the original construction; and (3) interest on the first cost per square yard at 2% per year, which is approximately the net interest per square yard per year at 4% on the investment. It is made up of the annual interest at 4% on the cost per square yard, minus the average interest per square yard per year at 4% on the invested sinking fund. Considering a road with a 35-year life, this last item would be the interest per square yard on the sinking fund in the 17½ years. While 2% of the first cost per square yard does not give exactly the net interest per square yard per year, as figured by compound interest, still it is close enough for the purpose of this study.

This may be shown analytically as follows: Let $c$ = the original cost of the pavement per square yard; $d$ = the depreciation per square yard per year; $c/d$, the life of pavement = $L$; $c/2$ the total amount of money per square yard deposited in the sinking fund by the $L/2$ year. Interest rate = 4%; then net interest = 0.04c. — 0.04 $C/2$ = 0.04c. — 0.02c. = 0.02c.

### Example

A concrete example may help the reader to follow the method of analysis used with the first class. Assume that a road has just entered its eighth year, and that the original cost of the paving was 70c. per square yard; that every year 2c. per square yard has been expended for patrol, oiling, repairs, etc.; and that at the end of every seventh year it must be completely resurfaced at a cost of 42c. per square yard. Assume, further, that at the end of 35 years not only the top course but the bottom course also must be entirely renewed at the original cost. The road, having just been resurfaced, would then appear to be "just as good as new," and would be in the first class, but as a matter of fact there would be a small depreciation charge due to the fact that the resurfacing did not include the renewal of the bottom course. The ultimate cost per square yard per year would then be as follows:

| | Per Sq. Yd. Per Year |
|---|---|
| Depreciation 70c./35 .................. | $0.02 |
| Maintenance ......................... | .02 |
| Resurfacing 42c./7 .................... | .06 |
| Maintenance and resurfacing ........... | .08 |
| Net interest chargeable, 2% of $0.70 ..... | .014 |
| Ultimate cost ..................... | $0.114 |

Next, considering the second class, the depreciation was assumed to be one-half of the first cost divided by the number of years covered. This was done because some of the roads included were as good as new, others were half depreciated, and still others were in almost a worthless condition; thus, the average road might be considered one-half depreciated. Therefore, the ultimate cost of the pavement would be the sum of this depreciation per square yard per year; the maintenance and resurfacing per square yard per year; and the interest on the first cost per square yard at 2%. The last two items were figured the same as for the first class.

### Results of the Investigation

The results of the investigation, under the two classifications, of 286 macadam roads, of both the water-bound and bituminous types, are shown above in tabulated form. In the first class, 79 water-bound and 11 bituminous roads, with an aggregate mileage of 300 and 44 respectively, were studied. Under the second class, 108 water-bound and 67 bituminous roads were studied, their respective mileages being 410 and 257. Twenty-one water-bound macadam roads which had been resurfaced with bituminous coverings were studied under the assumptions for the second class, although these were not exactly applicable. The table shows the data mentioned above, the years between which the roads studied were built, the average period studied, and the average ultimate cost per

**Table Showing Results of Investigation of Roads Under Classes I. and II., Including Ultimate Costs and Their Distribution**

| Type | Class | No. of Roads Studied | Mileage | Time Limits of Original Construction (Inclusive) From | To | Average Period Years | Average Ultimate Cost per sq. yd. per Yr. Cents | Distribution: Average Depreciation per sq. yd. per Yr. Amt. Cents | % of Total | Average Maintenance and Resurfacing per sq. yd. per Yr. Amt Cents | % of Total | Average Net Interest on Investment per sq. yd. per Yr. Amt. Cents | % of Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water-bound macadam ...... | 1st | 79 | 300 | 1902 | 1912 | 6.3 | 11.4 | 2.0 | 17.0 | 7.88 | 69.0 | 1.55 | 14.0 |
| Water-bound macadam ...... | 2nd | 108 | 410 | 1902 | 1910 | 7.6 | 13.7 | 5.5 | 40.0 | 6.7 | 49.0 | 1.5 | 11.0 |
| Bituminous macadam ........ | 1st | 11 | 44 | 1909 | 1910 | 4.74 | 12.2 | 2.0 | 16.4 | 8.49 | 69.7 | 1.69 | 13.9 |
| Bituminous macadam ........ | 2nd | 67 | 257 | 1909 | 1910 | 6.3 | 14.0 | 7.57 | 54.2 | 4.48 | 32.1 | 1.91 | 13.7 |
| Water-bound macadam resurfaced with bituminous .... | 2nd | 21 | 68 | Built 1902-1907 | Resurfaced 1909-1910 | 12.7 | 13.5 | 2.6 | 19.3 | 9.6 | 71.1 | 1.3 | 9.6 |

square yard per year. The distribution of the average ultimate cost among the separate items and their percentage of the total are also tabulated.

It seems probable that the figure derived from the first class, for the ultimate cost of water-bound macadams, is under rather than over the correct value. This is due to the assumption that the top course at the end of the specified time was as good as new. This, in many cases, was probably not strictly true. On the other hand, the figure derived from the second class is more likely to be high than low. The assumption made for the latter was that the original cost of construction was half used up at the end of the specified period. It is probable that the bottom course, especially in the newer roads, was about as good as new, and that in the case of the older roads it was not more than half used up. If, then, these two classes give, respectively, results that are too low and too high, the true ultimate cost of water-bound macadams lies somewhere between 11.4c. and 13.7c.—say, 12½c. per square yard per year. The same method of analysis applied to the bituminous macadams gives an average ultimate cost of 13.1c. per square yard per year.

### Traffic Greater on Bituminous Roads

Practically all the bituminous roads constructed between 1909 and 1910 were included. The first year in which the state actively constructed bituminous macadam was in 1909, and no roads built after 1910 were taken. It was thought that subsequent construction had not been in place long enough to determine the charge for maintenance and repair. As explained under water-bound macadam, the first class included only roads which had just been resurfaced. Only 11 roads could be found which were constructed of bituminous macadam prior to 1911, and which had been resurfaced with the same material prior to 1917.

When it is remembered that the traffic on the water-bound macadams were probably considerably less than on the bituminous pavements, the ultimate cost of the latter compares very favorably with that of the former. While the first cost of the bituminous macadams was higher than that of the water-bound macadams, this was apparently offset by a relatively lower maintenance charge. The small variation in the ultimate cost between the two classes studied is remarkable, if we consider the widely different assumptions that were made. Each class was figured completely before being compared with the other.

The relation between traffic tonnage and ultimate cost was next investigated by comparing the results, as obtained by the study outlined above, with the traffic censuses of various roads which were taken by the department in the year 1914. The number of roads considered in the 1909 census was too small to use in any analysis covering the whole state. The statistics taken in 1914 and 1916 were fairly complete, and summaries of the results in number of vehicles, their tonnages, distribution, percentage of the total, and total increases and decreases are shown in the tables printed herewith.

**Table Showing Average Number of Vehicles, Their Distribution, Percentage of Total and Per Cent. Change in Period**

| Year | No. of Roads Averaged * | Average No. Vehicles per Day of 12 Hours | Horse Drawn No. | % | Autos and Motorcycles No. | % | Motor Trucks No. | % |
|---|---|---|---|---|---|---|---|---|
| 1914 ... | 510 | 352 | 168 | 48 | 172 | 49 | 12 | 3 |
| 1916 ... | 797 | 433 | 103 | 24 | 309 | 71 | 21 | 5 |
| % change in 2 yrs. . | .. | +23 | —39 | .. | +80 | .. | +75 | .. |

*Note.—The average length of roads may be taken at 3.77 miles.

**Table Showing Average Number of Tons Carried in Twelve-hour Day, Their Distribution, Percentages of Total and Per Cent. Change in Period**

| Year | No. of Roads Averaged * | Average Tonnage 12-Hr. Day† | Horse Drawn Tons | % | Autos and Motorcyles Tons | % | Motor Trucks Tons | % |
|---|---|---|---|---|---|---|---|---|
| 1914 ... | 902 | 630 | 184 | 29 | 375 | 60 | 71 | 11 |
| 1916 ... | 797 | 853 | 111 | 13 | 609 | 71 | 133 | 16 |
| % change in 2 yrs. . | .. | +35 | —40 | .. | +62 | .. | +87 | .. |

*Note.—The average length of roads may be taken at 3.77 miles.

†Based on assumption of following weights: Motorcycles = 0.2 tons; automobiles = 2.1 tons; motor trucks = 6.2 tons.

The 1914 tonnage per 12-hour day, reduced to the equivalent for a 16-ft. width of road, was plotted horizontally on a chart, and the ultimate cost per square yard per year was plotted vertically. For example, if the traffic census shows the tonnage on a 12-ft. road to be 1,200 tons per day, the equivalent tonnage adjusted for a 16-ft. highway would be 1,600 tons. Only the water-bound macadam roads were used in this part of the investigation, and the ultimate costs and tonnages of each were plotted.

The straight line which most nearly approximated the points, and which is shown on the illustration, was obtained by plotting the figures from the 79 roads included in the first class. It was found to have the equation $C = 10 + 0.002t$, where $c$ equals the ultimate cost in cents per square yard per year, and $t$ equals the traffic tonnage per day of 12 hours. The 108 roads included in the second class were plotted, and the equation resulting was $c = 11.8 + 0.002 t$. Taking a rough average of these equations we have $c = 11 + 0.002 t$, which, it is fair to assume, is the equation expressing the relation between the traffic tonnage and ultimate cost.

The large number of roads used in obtaining this equation seems to warrant the tentative conclusion that the traffic tonnage has relatively small influence on the ultimate cost of water-bound macadams. The maintenance and repair necessitated by traffic tonnage seem to be hardly more than 15 per cent. of the total cost of maintenance and repair.

### Elements of Uncertainty

The elements of uncertainty entering into these studies may be summarized as follows: All maintenance and repair were estimated to apply to pavement. As a matter of fact, a small percentage was used to clean ditches, repair culverts, etc. The traffic statistics were obtained by patrolmen, and their accuracy is doubtful. The effect of traffic on the deterioration of the pavements is probably slightly larger than the equations would indicate. This is due to the fact that the roads of heavy traffic were in most cases more easily accessible, being nearer centres of population and railroad centres, and were therefore cheaper to build and maintain. The assumption of 2c. as the deterioration rate used for the first class was purely arbitrary; however, it represents only about 16 per cent. of the total, and this compared very well with results obtained for the second class. The traffic tonnage was used for the year 1914, and was a very rough measure of the relative traffic for the entire period.

Furthermore, it may be noted that the road construction of New York State has been variable in quality, and that roads built during some periods would probably make a better showing than those built in other periods. Therefore, the figures developed are, in a considerable measure, relative, and cannot be used blindly in comparison with other work elsewhere which has been done in different circumstances and under local conditions.

In conclusion, the writer desires to state that while the above analysis is far from giving an accurate solution of the ultimate cost of highways, it is (as far as he is aware) one of the first attempts of its kind.

## FINANCING PUBLIC UTILITY COMPANIES

In view of the decision of the War Finance Corporation regarding the proposal of funds to utility companies, it has been seriously proposed in the United States to form a company for the exclusive purpose of financing utility enterprises. The War Finance Corporation declined to make loans directly to concerns of this kind, but suggested that if the utilities would make arrangement for borrowing at the banks, the Finance Corporation would then advance to the banks 75 per cent. of the amount loaned to the utilities. But the banks felt unable to enter into such wholesale financing in view of government and commercial demands.

In the present year the utility corporations of the country have maturing obligations estimated at between $100,000,000 and $150,000,000. Considerable funds, will, therefore, be required, and it is pointed out that a company with a capital of $100,000,000 could, by rediscounting in accordance with the proposal of the War Finance Corporation, provide funds up to $400,000,000. The new corporation might be dominated by banking firms which have in the past taken an active part in financing utility enterprises.

## WHAT IS SHIP TONNAGE?*

By S. M. Meeker, Jr.

When is a ton not a ton? That is the question many a man in the shipyard feels like asking after trying to explain to an inquirer what is meant by "tonnage," "deadweight capacity," "displacement," and similar terms of ship measurement that are not as simple as they seem.

A useful distinction to keep in mind is that "displacement" and "deadweight carrying capacity" relate pretty directly to the weight of water displaced by the ship at certain stages of loading, while "register tons," "gross tonnage," "net tonnage," etc., have to do with the volume of the space inside a hull, measured in cubic feet according to arbitrary rules and regulations laid down by different government bureaus and by the marine classification societies, which give vessels certain ratings as a basis for insuring their owners against loss.

### Displacement and Total Weight

Displacement is measured in tons of 2,240 pounds (except on the Great Lakes, where it is calculated in tons of 2,000 pounds), and gives the weight of water "displaced" by the vessel as she floats on an even keel in still water. It is, of course, equivalent to the total weight of the ship's structure, machinery and fittings and everything else on board of her at the time. The greater the load on the ship, the deeper she floats in the water and the greater is the displacement. Usually, when a vessel's "displacement" is spoken of the "full load displacement" is meant, when, with a full cargo on board, she is sunk down to her "load water line." A ship is designed to have her load line at a definite level which will leave sufficient "freeboard" above water to make her safe in any weather.

It would be a very difficult matter to arrive at an exact total weight of a ship and everything on board, or to weigh exactly the total volume of water she displaces, so the displacement is a matter of calculation, which hits pretty close to the true value, but can never be absolutely correct. The number of cubic feet in the part of the hull below the load water line is calculated from the design of the vessel, but this calculation cannot very well take into account the exact curvature and slight variations due to irregularity in the plating. Besides, the calculation is made to the "moulded lines" of the design, and usually no allowance is made for the thickness of the shell plating, though this adds a small percentage to the volume of the hull.

### Volume and Weight Displaced

Having figured the cubic feet of displacement when floating in salt water, it is turned into tons of displacement by dividing by 35, since 35 cubic feet of salt water weigh one long ton of 2,240 pounds. The same vessel with the same weight on board would float to a different load line in fresh water, since 36 cubic feet of fresh water weigh one long ton. As a matter of fact, the temperature of the water makes a slight difference in figuring the displacement, but we need not go into that here. Water is at its greatest density at a temperature of 39.1 degrees Fahrenheit, and as it becomes warmer the density decreases.

In talking about the shipbuilding programme of the Emergency Fleet Corporation, figures of "deadweight

*(Concluded on page 190)*

*From the Submarine Boat Corporation's Magazine.

## COUNTY COUNCIL TOURS NORTHERN NEW YORK'S GOOD ROADS

MANY converts to the Good Roads movement were secured on Saturday, August 10th, when more than two hundred Ottawa citizens toured over the northern New York State Highways as far as Gouverneur, N.Y. The tour was organized by the Ottawa Journal in co-operation with the Retail Merchants' Association and the Ottawa Motor Club. There were about fifty cars in the party, every one filled to capacity. The chief guests of honor were the members of the Carleton County Council. The party also included a number of the aldermen of the city of Ottawa, and several members of the staff of the works department, namely: Commissioner A. F. Macallum; Waterworks Engineer W. E. Macdonald; Secretary of Works Geo. H. Wilson; City Bacteriologist Joseph Race; and Deputy City Engineer Frank Askwith.

Some of the automobiles followed the path outlined by the Ontario Government as the future good road between Ottawa and Prescott, while others went around by way of Smiths Falls and Brockville. The majority of those on the tour had never before seen the state roads of New York, and all expressed keen admiration.

### Good Roads Meeting

At Gouverneur a good roads meeting was held Saturday evening in the public square; over 1,000 cars were parked there during the meeting. Among the speakers at the mass meeting were the mayor of Ogdensburg, Alderman Wm. Findlay, of Ottawa, who organized the tour; the mayor of Ottawa; the warden of Carleton County; Geo. G. Royce, a prominent farmer of St. Lawrence County, New York State; and J. K. Paisley, manager of the Central Canada Exhibition Association.

Speaking of the Prescott Road project, Ald. Findlay said that while a short time ago Ottawa people were talking about 60 miles of improved highway, to-day they are talking of another stretch of 200 miles. "We are hopeful," he said, "that it will not be long before we will have a system of improved highways throughout Eastern Ontario that will be comparable with your good roads."

The most impressive speech of the meeting was made by Mr. Royce, who cited definite figures. As a result of good roads the farmers of St. Lawrence County have more than 150,000 cattle and 30,000 horses. There are 500 miles of state highways in the county and over these there pass annually thousands of tourists.

"When the first highways were proposed, I was strongly opposed to the idea," said Mr. Royce, "because I thought it was preposterous to spend $10,000 a mile in improving the roads, but to-day, I would rather place a mortgage on my farm than have the roads removed. Ten years ago the automobile was an impossibility on our roads. A man could not drive an automobile from Ogdensburg to Gouverneur and get back the same day. Now we have a magnificent system of highways. There is one point I would like to emphasize and that is that we farmers can get our produce to market before it rots.

"We have heard talk about high taxes, but who cares for high taxes so long as we get our money's worth out of the roads?

### High Taxes Not Bothersome

"Good roads have given us farmers an opportunity to get to the towns and cities and mingle with our fellow citizens.

"It is my hope that these splendid highways will be extended throughout the length and breadth of your Dominion, that the pur of our autos may be heard in your land and that the pur of your autos may be heard in our country."

S. McClure, road superintendent for Carleton County, said: "Carleton County can afford just as good roads as they have in New York State, and perhaps is better able to afford them. The cost of upkeep of these roads is not as much as under our present system. I don't think there should be any road under 24 feet in width. This is wider than they have them here."

Warden Bower Henry, of Carleton County, stated that he had always been enthusiastic about good roads. "What I have seen on this trip," said the warden, "could not have made me any more of a good roads man. We've got to have them in Carleton County. It doesn't matter where the first one goes—to Prescott or anywhere so long as we get one, then the people will simply demand more. One good road such as we have seen in New York State will be enough for Carleton County to get a whole lot."

## TOPOGRAPHICAL SURVEYS IN CONNECTION WITH RURAL PLANNING*

By W. H. Norrish, B.Sc., D.L.S., O.L.S.

WE have all been more or less interested in these various proposed modifications of our system of surveys so as to form community or rural villages. I think, though, that most of us have been inclined to smile at the apparent futility of all such schemes which consist merely of a complicated geometrical figure, and do not take into consideration the topography of the ground. I think we are agreed that if there is to be any change, it must be based on topography, and that we do not want another geometrical system, though some of us may feel that these geometrical solutions may help, by giving us suggestions as to methods of planning rural developments. One outstanding point to be noticed in many of the proposed plans of townships is that the lots are triangular in shape and converge on community centres. I fear that the practical farmer will not take kindly to the triangular farm.

### Geometrically-Built Roads

The objections to our present system of subdividing are well known to all of us and need no comment. The quarter sections are said to be too broad, so that the settlers are too far apart and suffer from lonesomeness. Then, a quarter section is often split into halves by an unfordable river or lake, a marsh, swamp or other impassable topographic feature. Again, there are often quarter sections adjoining each other, neither of which contain sufficient good land to attract a farmer; but, if the two or more good areas could be joined together into one lot, they would make a good farm. One of the greatest objections is to the system of roads. If all the road allowances are opened there are said to be too many roads costing too much for upkeep and that the distance to travel to town is too great by right-angled roads. We also know that roads built according to geometry and not topography are anything but efficient.

Too much stress cannot be laid on the importance of good roads, and one of the greatest uses to which a topographical survey could be put would be the planning of more direct and more efficient roads. At present, when

*Extract from paper read before the 11th annual meeting of the Association of Dominion Land Surveyors.

there are obstructions on the road allowances such that they are absolutely impassible, road diversions are surveyed around the obstruction. The roads are often graded across sloughs at tremendous first cost and very high repair expenses, inasmuch as they often have to be regraded each year. When the sloughs are filled up in the spring these grades, if not absolutely impassible, are nearly so, and they are so badly cut up with the traffic that they regularly have to be repaired during the dry weather in the middle of the summer. In the meantime the farmer is able to haul only very small loads over the roads and they are probably impassible for the automobile, which is becoming of greater use to the farmer each year. After being carefully repaired during the summer, the same piece of road may be equally impassable the following spring.

### Soil Classification and Topography

It seems to me that the time has now arrived when a great deal more attention should be paid to topography and soil classification on such subdivision surveys as are carried on, and that topographical surveys should now be undertaken in the older parts of the country with the object of planning all future developments and gaining exact information as to the land which is either vacant or being held out of production.

The Department of Lands and Mines of the Province of New Brunswick commenced extensive surveys of forest and agricultural lands during the season of 1916. Their soils were classified carefully according to physical properties and chemical tests of samples were made by agricultural experts.

California has recently undertaken soil classification surveys with the primary object of properly assessing the land. The work has consisted of making soil and topographic surveys and maps to show the boundaries of the different types of soils grading them as 1, 2 or 3 of each type, or as unfit for cultivation. All areas in permanent crop such as orchards, vineyards, alfalfa, hops, etc., are shown.

The topography shown consists of streams, dry channels, irrigation or drainage ditches, levees, roads, buildings, fences, brush or timbered areas, etc.

### California's Maps

The maps are made by compass and pacing, being plotted in the field or by traverse plane-table. The finished maps on white paper with colored inks show soil acreages, acreages in each permanent crop, acreages in roads, right-of-way, etc.

These maps are accompanied by a report on the soils showing for what crops they are best adapted, a comparison of values and the irrigation or drainage possibilities.

The type of soil is considered to be the most important consideration in fixing land values. Some of the previous errors in assessment in California were that the same soil at different points the same distance from the railway was assessed much differently, and that all lands of certain districts were assessed at the same rate even though some soils were worth five time as much as others.

All deeds, recorded surveys, or approximate surveys if obtainable, or the original public land surveys, were plotted on the maps before they were sent out.

The scale used was one inch to five chains and cross-section paper was used for plotting. Other details shown were the variety of orchards or vineyards, and whether good, bad, etc., the annual crops such as hay and grain, the cost of clearing brush on timbered lands, the value of buildings, the size of irrigation or drainage ditches, the condition of roads, levees, etc., and the depth of water in wells. The soils are named in accordance with the soil surveys of the United States Department of Agriculture. Samples of soil for analysis are taken from representative areas and borings are made. Surface alkali is shown by the presence of weeds and under surface alkali by electrolytic instruments.

The cost of these soil classification surveys in California varied from 3 to 6 cents per acre including office costs. It should be borne in mind that on account of the nature of the country such surveys would probably be considerably more expensive than surveys of a like nature in our western provinces.

It seems eminently desirable that if topographical surveys are undertaken in Canada they should not be of the approximate nature of the compass pacing surveys of California but should be accurate topographical surveys which would serve the purpose of all future planning. Our standard of land surveys has in general been much higher than that of our neighbor to the south; and although our system has been modelled after theirs, it has been carried out with a great deal more accuracy. It is not advisable now to adopt approximate methods in order to effect a small saving in cost and then find in a short time that the work would have to be done over more accurately, costing in the end considerably more than if done properly in the first place.

### Add Topographers to Party

However, it seems that the California soil surveys suggest the possibility of obtaining a great deal more information from our original subdivision surveys at comparatively low cost by adding topographers to the party charged with the duty of exploring the interior of the sections. If the lines of levels now run could be extended so that the blind lines would also be levelled, the topographer with compass, hand level and pacing would be able to contour fairly well the interior of the sections. He could first run through the section on the 40-chain or quarter section lines with the compass and pacing, using the hand level to carry elevations. He would leave a mark at each small stream, pond, slough, marsh or muskeg to be traversed, and after finishing the quarter-section lines he would pace traverse these topographical features. Care should be taken to delineate the dividing line separating one class of soil from another and the soil and timber should be carefully classified.

The topographical map prepared from this information would form an admirable basis upon which to plan the development of the township; and if the topography was such that the ordinary subdivision survey did not seem to be well adapted, another plan of subdivision could be superimposed on it and the additional surveys made before allowing the lands to be thrown open for settlement. The subdivision surveys would have at least served the purpose of obtaining the topography and establishing monuments from which other lot corners could be easily established. Bench marks would have also been established for all future purposes.

### Denser Settlements Near Railways

It seems, however, that the larger and more important field for our future efforts should be in the country which is near the existing lines of railway and which is only partially settled. Unfortunately thus far our surveys have been mainly restricted to surveys of unpatented or crown lands, but I believe that in future our object should be to secure the denser settlement of the country adjacent to the railways without regard as to whether the lands are patented or unpatented.

There are four main classes of land encountered in making such topographical surveys:—

(1) Dominion lands open for homestead entry.

(2) Homesteaded lands not patented.

(3) Patented lands not being cultivated or partially cultivated.

(4) Patented lands not being cultivated, including abandoned farms, lands held by speculators, land companies, railway companies, etc.

### Dominion Government's Control

In planning the development of the country it will be noted that the first class remains under government control. Consequently the Federal Government is free to make any plans desired for the disposition of the lands. This constitutes, in my opinion, one of the strongest arguments why the Dominion Government should make such surveys and plan the development, inasmuch as there are considerable areas of these crown lands still unsettled, lying close to the railways. The fourth class of lands above enumerated are also lands over which the government could regain control. That is to say, that if these lands could not be forced into cultivation they could be purchased by the government and sold again to bona fide settlers. If purchased, it would then be possible to subdivide these lands and those of class one according to any scheme desired for the proper development of the country.

In my opinion, detailed topographical surveys in partially settled, fairly open country should be made with the plane table, equipped with the telescopic alidade. Contours should be drawn and should be controlled by adequate level lines carried from the geodetic survey bench marks or from the Topographical Surveys Branch precise level bench marks.

### Plane Table Surveys Accurate

It should be borne in mind that plane table surveys are accurate and would be well in keeping with the high class of work done on surveys of Dominion lands. In general, there are two main classes of land surveys. First there are those which have for their purpose the survey of the boundaries of parcels of land and the placing of monuments to mark the corners. The correct astronomical bearing of such lines must be determined with the transit in order that the lines may be properly retraced if part of the monuments are lost. The second class of surveys have for their purpose the making of a correct plan showing topographical features. If such surveys are made with the transit and chain or the transit and stadia, areas which are required or distances to be scaled off the plan are limited in their accuracy by the scale on which the plan is drawn and the consequent degree of accuracy with which it is possible to plot the survey.

Now, when a plane table with a telescopic alidade is used and the telescope is equipped with stadia hairs, the distances may be read just as accurately as with the stadia transit. The length of shots which can be read, equal if not exceed those of the stadia transit, for the diaphragm used in the telescopes of the International Boundary Survey plane tables are so graduated that one-eighth or one-quarter of the whole interval may be read to take side shots of topographical features of such a nature that the distance need not be read with great precision. I myself have taken a maximum reading of 4,400 feet and checking by triangulation found it to be quite accurate. In brushy country it is often a great convenience, in reading ground shots to locate contours, to be able to take one-eighth or one-quarter of the interval. This means that the rod may be nearly hidden with branches and yet a reading may be taken sufficiently accurate for a ground shot. The graduations which are etched on a glass diaphragm are so arranged that there is little chance for mistakes. That is to say, it is hard to confuse the eighth with the quarter interval, or the quarter with the half, etc.

The plane table has a great advantage over the office in the matter of plotting directions. In the field the directions are very accurately laid down on the paper for the reason that the objects themselves are sighted on, whereas in the office a protractor is used and, except with the best of plotting machines, it is not possible to plot a direction within about one-quarter of a degree.

The result is that surveys having for their purpose the making of an accurate plan are carried out with great precision by means of the plane table. Even on the large scale of 1/2,000, which is about thirty inches to a mile or 2½ chains to an inch, I have found that traverses of a mile or so usually close so well that practically no adjustment can be made. When closing on a point already fixed on the plot, the small error in closure may be immediately spread over the traverse courses and topography of a fixed nature, such as corners of buildings or other masonry structures likewise adjusted.

### Scale Best Suited

I am of the opinion that the 1 to 10,000 scale is the one which is best suited to topographical surveys with the object of rural planning and development work; and base this opinion on the purpose which such surveys are to serve and the detail which must be shown on the sheets in order to serve this purpose. On a natural scale of 1 to 10,000, one foot represents 10,000 feet on the ground, one link represents 10,000 links on the ground, or one metre represents 10,000 metres on the ground. That is to say, one of any unit represents 10,000 of the same units on the ground. With three 1 to 10,000 scales, one graduated for links, one for feet, and one for metres, survey measurements made in any of these units could be easily and quickly plotted. This means considerable convenience in revising the sheets from time to time. Location surveys of new roads, railways, drainage or irrigation works could be easily plotted no matter which unit was used for field measurements.

The 1 to 10,000 scale is about 6⅓ inches to a mile, or one inch equals approximately 12½ chains, a scale slightly smaller than that used for the field plots of stadia surveys. Diagonal scales are usually used for plotting with the plane-table, the distances being quickly and accurately picked off with dividers and plotted.

### What Sheets Should Show

A great wealth of detail can be shown on a scale of six inches to a mile.

A very complete set of symbols, such as used by the United States Coast and Geodetic Survey, should be devised so as to add to the amount of detail which can readily be shown. In addition to all natural topography and contours I think a topographical sheet should show:

(1) Careful soil notes together with the delineation of the boundary of each class of soil. To aid in soil classification, borings should be made and samples of each grade of soil analyzed. The sheet should then be accompanied by a report on the crops which could be successfully grown on each soil, and a climate report. Surface alkali should be shown and underlying alkali detected by electrolytic instruments and shown.

(2) All areas under cultivation and nature of crops. The additional areas fit for cultivation should be clearly traced from the topography and soil notes.

(3) All fences, buildings, roads, railways and other improvements, together with all survey monuments found.

(4) All areas of bush land with notes as to the probable cost of clearing, if such areas are suitable for agriculture. If not suitable for agriculture and if vacant crown lands, data should be shown which would indicate the possible use such areas could be put to, or if they would be better held as forest reserves.

(5) The name of the occupant of each parcel of land and the name of the owner. Where parcels of patented land are found vacant particular care should be taken to obtain full information, including the probable value of the land and improvements.

### Of Value to Government

The latter information would, in my opinion, be very valuable in the hands of the government. If a way could not be found to force the cultivation of the land, the government might purchase it and sell it over to an incoming settler, or arrange the purchase for him. The government would be in a position to give the settler trustworthy information and take the deal out of the hands of unscrupulous real estate agents. The province of Nova Scotia appointed a commission in 1912 to purchase vacant lands, improve them and resell them to bona fide settlers. If a policy such as this could be inaugurated the Dominion Government would regain control of the lands and where necessary to properly plan the development of the district the land might be resubdivided.

I think the time has come when the government of this country can no longer afford to leave the incoming settler entirely to his own resources and his own discretion in the choosing of land. The best of information should be at his disposal and he should have the help of capable and trustworthy government officials. It should also be noted that the survey I have suggested would show the exact amount of good land in each parcel, the class of soil and the crops it is suitable for. This would be the very best of information to give the banks in order to secure credit for the prospective settler. Care should be taken that land shown to be worthless by the survey should be held as crown lands, and no chance given to a settler to take it up and waste his time and money trying to farm it.

### Roads, Drainage and Irrigation

The uses to which a topographical survey as above outlined could be put would be many and varied. Better roads, drainage and irrigation schemes could be laid out on paper and afterwards surveyed on the ground. The system of subdivision as far as it remains under government control, or in so far as government control could be secured, might be modified where necessary to provide for the future development and settlement of the land. If deemed advisable, provision could be made for rural villages or community centres.

To revert to the details of survey, I believe that the most efficient organization for such would be to have a surveyor in charge of two or three plane-table parties and one level party to run secondary levels through the district to be mapped. An efficient plane-table party consists of a topographer, an assistant and two rod-men. The assistant would record all data in connection with traverse or station readings, so as to check the plotting in case of failure to close, would read the vertical angles and by means of a stadia slide rule compute the elevations and the corrections to the horizontal, where necessary. The rod-men, when properly trained, would sketch buildings and improvements and gather a lot of information which would save the topographer trips away from the table. My idea in arranging several parties under one surveyor in charge is to allow the chief freedom to gain all the general information possible and to plan future developments on the field sheets and report fully on his proposals. I believe the field is the place to plan and with one competent man planning from the surveys of several parties the cost would be reduced as low as possible. It has been contended that plane-table surveys are complicated, but I have not found them so, and I think one of the principal reasons is that the work is graphical and with the ground laid out in front of you it is difficult to make a mistake which does not show up immediately so that it can be corrected.

### Previous Uses of Plane Table

In the last analysis, however, the question as to whether topographic surveys should be undertaken or not may be decided from a cost standpoint. It should be demonstrated that they are worth the cost involved and this can only be done by actual work, as there are few surveys in Canada which bear any resemblance to the surveys I have proposed. Narrow strips of topography along the International Boundary have been taken with the plane table and most of it has been done on the scale proposed. On the Ottawa water supply surveys, with which I was connected, the proposed pipe line route was mapped with the plane table on a 1 to 2,000 scale and the engineers supplied with tracings from which the paper location was made, a profile drawn and the estimates made. The drainage area of approximately 150 square miles was mapped on the 1 to 10,000 scale with the contours on the higher timber-covered hills drawn from photo-topographical surveys. On the large scale pipe line maps as high as 80 acres were covered in a day showing a great amount of detail. The average was probably about 50 acres. This, however, does not give any information as to the cost in the west as the character of the country was such that it was much harder to map than the west would be, and the scale was so large that much more ground detail could be shown than on the scale I propose, and there were a great many improvements to show. The Canadian Pacific Railway used the plane-table extensively on their irrigation surveys in Alberta.

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The Paving and Mastic Co., Ltd., has been incorporated with an Ontario charter; head office, Toronto. Authorized capital, $40,000.

The Department of the Interior, through its Natural Resources Intelligence Branch, has prepared and is distributing a new illustrated report on the Peace River District, based on investigations made by an official of that branch during 1917. The publication contains interesting information with regard to climate, soil, agriculture, minerals, game, water powers, transportation and education. A map of the district showing general topography accompanies the report.

James, Loudon & Hertzberg, consulting engineers, Toronto, are preparing plans for a storage warehouse to be built on Yonge St., North Toronto. The building will be L-shaped, 50 ft. wide by 215 ft. total length. It will be mill construction, one story and basement, but provision is being made for the addition of more floors at a later date. The building will be owned by a contracting firm, so it will probably be built by the owners.

For some weeks past the United States government has been operating, through the post office department, an air mail service from New York to Philadelphia, and from Philadelphia to Washington. The mail so carried is charged with postage at the rate of 16 cents for the first ounce or fraction thereof and six cents for each additional ounce or fraction thereof, of which ten cents is for special delivery service. Such mail consists of matter of the first-class including parcels not exceeding 30 inches in length and width combined. The postage on aeroplane mail must be fully prepaid in special aeroplane stamps or ordinary postage stamps.

## THE COST OF LAYING PIPE

*(Continued from page 174)*

The cost of jointing having but one variable for any locality, that of wage, to find local cost per foot, it is only necessary to multiply the unit figure found in column C for cast iron pipe and column D for steel pipe, opposite the size of pipe to be laid, by the local wage scale for caulkers or joiners in cents per hour. As three kinds of labor are usually employed in jointing pipe, caulkers, yarners and leadmen, each of which may receive a slightly different wage, the wage of the caulkers only were used in calculating the unit figures shown in table, the discrepancy by this method being practically negligible for estimating purposes.

In jointing steel pipe the number of joints per man-hour is considered to vary as the diameter of the pipe which takes into consideration the friction to be overcome in jointing pipes of different sizes as well as the weight of the pipe per foot of length.

### Cost of Materials

The cost of pipe per foot used in tables is figured at $1 per ton for cast iron and $0.01 per foot for steel pipe, making it a simple problem to obtain local costs by multiplying by local prices.

Lead and yarn are figured at $0.01 per pound each.

Fittings and specials are not included in charted costs, as conditions often make it necessary to handle this matter individually. For general estimating where extreme accuracy is not important, the unit cost per foot of pipe may be considered as including specials.

Store expense, which should cover the cost of maintaining a pipe storage yard or warehouse, unloading from cars, checking material, etc., has been estimated at 4 per cent. of the total cost of materials. This figure was obtained by checking the cost in several cities, and while it may not hold absolutely true in these days of abnormal prices, will not prove an error of great consequence where it is considered that at this time storage labor cost also has advanced above normal.

Drayage covers the cost of transporting materials from storage yard, warehouse or cars to the job and is based upon a cost of $1 per ton-mile. Local drayage costs are obtained by multiplying the unit costs found in the tables under column E for steel pipe and column H. for cast iron pipe and opposite the size of pipe to be handled by the local cost per ton-mile in dollars.

Supervision, engineering and contingencies, which includes the time of the general foreman, watchman, waterboy, etc., the cost of preliminary surveys and estimates, running levels, lines, etc., as well as permits and overhead expenses or contingencies not otherwise classified, is estimated as 10 per cent. of the total cost of the job.

It is understood that a portion of the cost included in this classification usually is charged to operation, but must be included in valuation work where the entire cost of replacement is considered. Owing to the liability of unforeseen contingencies arising in any construction work it is good policy to use the entire 10 per cent. in all estimates as a safety factor.

Appraisal engineers may find use for these tables and data in evaluating distribution systems as present day values may be obtained as readily as actual cost figures by substitution of the prices desired.

It was considered in all calculations that each class of work is carried on continuously, but that this is not a fact in usual practice does not affect the unit costs, as units of time, money and man power were used in obtaining the unit costs, which makes the cost per foot the same regardless of whether the operations are carried on for a fraction of an hour per day or continuously.

### Cast Iron Bell and Spigot Pipe, A. G. I. Standard, 12-ft. Lengths

*Laying Pipe.*

| Size of pipe. | No. of men. | Weight of pipe per ft. in lbs. | Feet of pipe per man-hour. | Feet of pipe laid per hour. | Unit cost per foot at .01 per man-hr. |
|---|---|---|---|---|---|
| 4 | 3 | 19.33 | 21.98 | 65.09 | .000455 |
| 6 | 3 | 30.25 | 14.05 | 42.15 | .000711 |
| 8 | 5 | 42.08 | 10.09 | 50.45 | .000991 |
| 10 | 5 | 55.91 | 7.60 | 38.00 | .001316 |
| 12 | 7 | 73.83 | 5.75 | 40.25 | .00173[illegible] |
| 16 | 7 | 112.58 | 3.77 | 26.39 | .002652 |
| 20 | 7 | 153.83 | 2.76 | 19.32 | .003623 |
| 24 | 9 | 206.41 | 2.06 | 18.54 | .004854 |
| 30 | 9 | 284.00 | 1.49 | 13.41 | .006711 |

NOTE.—To find local costs per foot multiply unit cost per foot from table by the local wage scale per hour for pipemen. For water pipe, substitute weights of pipe for those given in the fourth column, and change the following columns proportionately.

*Jointing Pipe.*

| Size of pipe. | No. of men. | Weight of lead in lbs. per joint. | Weight of yarn in lbs. per joint. | Joints per hr. for gang. | Unit cost per ft. at .01 per man-hr. |
|---|---|---|---|---|---|
| 4 | 3 | 6 | .37 | 6.25 | .000405 |
| 6 | 3 | 9 | .47 | 4.16 | .000601 |
| 8 | 3 | 12 | .56 | 3.12 | .000801 |
| 10 | 3 | 16 | .65 | 2.34 | .001068 |
| 12 | 3 | 22 | .75 | 1.70 | .001470 |
| 16 | 3 | 36 | 1.06 | 1.03 | .002427 |
| 20 | 5 | 50 | 1.34 | 1.25 | .003333 |
| 24 | 5 | 62 | 1.60 | 1.04 | .004006 |
| 30 | 5 | 75 | 2.00 | .83 | .005020 |

NOTE.—To find local costs per foot multiply unit cost per foot from table by the local wage scale per hour for caulkers.

*Trenching and Backfilling.*

| Size of pipe. | Width of trench —in. | —Cu. ft. per ft.— Trench. | Bellholes. | Cost of trenching and backfilling at .01 per man-hr. —Unit cost.— Trench. | Bellholes. |
|---|---|---|---|---|---|
| 4 | 20 | 1.66 | .405 | .00184 | .00045 |
| 6 | 22 | 1.83 | .459 | .00203 | .00051 |
| 8 | 24 | 2.00 | .513 | .00222 | .00057 |
| 10 | 26 | 2.16 | .540 | .00239 | .00060 |
| 12 | 30 | 2.50 | .594 | .00277 | .00066 |
| 16 | 36 | 3.00 | .702 | .00333 | .00078 |
| 20 | 40 | 3.33 | .783 | .00369 | .00087 |
| 24 | 44 | 3.66 | .864 | .00406 | .00096 |
| 30 | 50 | 4.16 | 1.000 | .00461 | .00111 |

NOTE.—To find local cost per foot multiply unit cost per foot for trench from table by the depth of the trench in feet; then add the unit cost for bellholes from table and multiply by the local labor wage scale per hour. Formula:

[ (Unit cost trench) (depth of trench in feet) + (unit cost bellhole) ] × (Hourly wage scale in cents).

*Summary of Unit Costs.*

| Size of pipe. Inches. | —Labor— Trenching and backfilling Trench. A | Belholes. B | Laying. C | Jointing. D |
|---|---|---|---|---|
| 4 | .00184 | .00045 | .000455 | .000405 |
| 6 | .00203 | .00051 | .000711 | .000601 |
| 8 | .00222 | .00057 | .000991 | .000801 |
| 10 | .00239 | .00060 | .001316 | .001068 |
| 12 | .00277 | .00066 | .001739 | .001470 |
| 16 | .00333 | .00078 | .002652 | .002427 |
| 20 | .00369 | .00087 | .003623 | .003333 |
| 24 | .00406 | .00096 | .004845 | .004006 |
| 30 | .00461 | .00111 | .006711 | .005020 |

*Summary of Unit Costs—(Continued).*

| Size of pipe. Inches. | Materials— Pipe. E | Lead. F | Yarn. G | Drayage. H |
|---|---|---|---|---|
| 4 | .00966 | .0050 | .000308 | .00966 |
| 6 | .01512 | .0075 | .000391 | .01512 |
| 8 | .02104 | .0100 | .000466 | .02104 |
| 10 | .02796 | .0133 | .000541 | .02796 |
| 12 | .03691 | .0183 | .000625 | .03691 |
| 16 | .05630 | .0300 | .000883 | .05630 |
| 20 | .07777 | .0416 | .001116 | .07777 |
| 24 | .10320 | .0516 | .001333 | .10320 |
| 30 | .14204 | .0625 | .001666 | .14204 |

## Explanation of Summary Table, C.I. B. & S. Pipe

Column A—Cost per foot for trenching and backfilling a trench 1 ft. deep at a labor cost of .01 per hour. For local costs per foot, multiply by depth of trench in feet and by labor wage scale per hour.

Column B—Cost per foot for trenching and backfilling a trench 1 ft. deep at a labor cost of .01 per hour. For local costs per foot, multiply by local wage scale per hour. The sum of the local costs of columns A and B equals the total cost of trenching and backfilling, of which two-thirds may be charged to trenching and one-third to backfilling.

Column C—Cost per foot for laying pipe at a .01 per hour wage scale. For local cost per foot, multiply by local wage scale per hour for pipe layers.

Column D—Cost per foot for jointing pipe at a .01 per hour wage scale. For local cost per foot, multiply by local wage scale per hour for caulkers.

Column E—Cost per foot of pipe at $1 per ton f.o.b. local city. For local cost per foot multiply by local cost per ton.

Column F—Cost per foot for lead at .01 per pound. For local cost per foot multiply by local cost per pound of lead.

Column G—Cost per foot for yarn at .01 per pound. For local cost per foot multiply by local cost per pound of yarn.

Column H—Drayage cost per foot at a rate of $1 per ton mile. For local cost per foot multiply by local drayage rate per ton-mile.

Storage and handling cost assumed to be 4 per cent. of total material cost regardless of locality. Supervision, engineering and contingencies assumed to be 10 per cent. of total cost regardless of locality.

## Standard Screw Steel Pipe

*Trenching and Backfilling.*

| Size of pipe—in. | Width of trench—in. | Cu. ft. per foot of trench. | At .01 per man-hour— Cost of excavating and backfilling. Per cu. ft. of excavation. | Unit cost per foot depth. |
|---|---|---|---|---|
| 1¼ | 18 | 1.50 | .00111 | .00166 |
| 1½ | 18 | 1.50 | .00111 | .00166 |
| 2 | 18 | 1.50 | .00111 | .00166 |
| 3 | 18 | 1.50 | .00111 | .00166 |
| 4 | 20 | 1.66 | .00111 | .00184 |
| 6 | 22 | 1.83 | .00111 | .00203 |
| 8 | 24 | 2.00 | .00111 | .00222 |

To find local cost per foot for trenching and backfilling, multiply unit cost per foot by local wage per man-hour.

*Jointing.*

| Size of pipe. | Number of men. | Joints per hr. per gang. | Ft. of pipe per hr. per gang. | Unit cost per ft. at .01 per man-hour. |
|---|---|---|---|---|
| 1¼ | 2 | 9 | 180 | .000111 |
| 1½ | 2 | 8 | 160 | .000125 |
| 2 | 2 | 6 | 120 | .000166 |
| 3 | 2 | 3 | 80 | .000250 |
| 4 | 2 | 3 | 60 | .000333 |
| 6 | 2 | 2 | 40 | .000500 |
| 8 | 3 | 2 | 40 | .000750 |

NOTE.—Jointing pipe covers the work of entering and screwing up pipe in the trench. The number of joints per man-hour varies as the diameter of the pipe. To find local cost per foot, multiply cost per foot by local wage scale per hour.

*Laying Pipe.*

| Size of pipe —in. | No. of men. | Weight of pipe per ft. in lbs. | Weight of pipe per man-hour. | Feet of pipe per man-hour. | Feet of pipe laid per hour by gang. | Unit cost per ft. at .01 per man-hour. |
|---|---|---|---|---|---|---|
| 1¼ | 3 | 2.28 | 237.5 | 104.2 | 312.5 | .000096 |
| 1½ | 3 | 2.73 | 236.4 | 86.6 | 260.0 | .000116 |
| 2 | 3 | 3.36 | 238.2 | 65.0 | 195.0 | .000154 |
| 3 | 3 | 7.62 | 278.9 | 36.6 | 110.0 | .000273 |
| 4 | 3 | 10.89 | 289.6 | 26.6 | 80.0 | .000376 |
| 6 | 3 | 19.19 | 303.2 | 15.8 | 47.5 | .000633 |
| 8 | 5 | 28.81 | 302.5 | 10.5 | 52.5 | .000952 |

NOTE.—Laying pipe covers reversing of couplings and handling of the pipe from the curb line to the trench and lowering into same. The weight of pipe per man-hour is not constant due to the reversing of a variable number of couplings per unit weight of different size pipes. To find local cost per foot multiply unit cost by local pipemen hourly wage.

*Summary of Unit Costs.*

| Size of pipe. Inches. | Labor— Trenching and backfilling. A | Laying. B | Jointing. C | Material— Pipe. D | Drayage. E |
|---|---|---|---|---|---|
| 1¼ | .00166 | .000096 | .000111 | .01 | .00114 |
| 1½ | .00166 | .000116 | .000125 | .01 | .00136 |
| 2 | .00166 | .000154 | .000166 | .01 | .00184 |
| 3 | .00166 | .000273 | .000250 | .01 | .00381 |
| 4 | .00184 | .000376 | .000333 | .01 | .00544 |
| 6 | .00203 | .000633 | .000500 | .01 | .00959 |
| 8 | .00222 | .000952 | .000750 | .01 | .01440 |

Column A—Cost per foot for trenching and backfilling a trench 1 ft. deep at a labor cost of .01 per hour. For local costs per foot, multiply by depth of trench in feet and by labor wage rate per hour.

Column B—Cost per foot for laying pipe at a .01 per hour wage scale. For local costs per foot multiply by local wage rate in cents per hour.

Column C—Cost per foot for jointing pipe at a .01 per hour wage scale. For local cost per foot multiply by local wage scale in cents per hour.

Column D—Cost per foot of pipe at .01. Substitute local cost per foot.

Column E—Drayage cost per foot at $1 per ton-mile. For local cost per foot multiply by the local drayage rate per ton-mile.

Storage and handling cost assumed to be 4 per cent. of material cost, regardless of locality. Supervision, engineering, contingencies, assumed to be 10 per cent. of total cost regardless of locality.

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A new reinforced concrete coaling station has recently been completed on the Lehigh Valley, at Manchester, N.Y., which is notable not only because of the volume of storage space and capacity of the receiving and discharge facilities, but also because of a number of innovations incorporated in its construction. Duplicate receiving and hoisting facilities, an arrangement for mixing the various kinds of coal as received, and an unusual compactness and convenience in the installation, are among the special features that deserve notice. The reinforced concrete storage bin is 70 ft. by 52 ft., and is elevated on concrete columns so as to serve locomotives standing on six sets of lines, four of which pass under the structure while one passes along each end. The elevating towers are separated from the bin structure by a distance of 39 ft., the coal being transferred from the tower to the bin by means of two bridges spanning the intervening distance and forming a part of the superstructure covering the top of the bin. The elevating equipment is in duplicate. Each elevating tower receives coal from a separate track hopper 20 ft. long, from which it is fed automatically into the elevating bucket by means of a measuring coal feeder of 2½ tons capacity, this feeder being actuated by the ascent and descent of the elevating bucket. The bucket in turn is raised and lowered by an independent electric hoist, having a capacity of 75 tons per hour.

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## E. I. OF C. SEEKING CLOSED PROFESSION, SAYS MINING INSTITUTE SECRETARY

IN the August Bulletin of the Canadian Mining Institute is published the report of the last Western Branch meeting, held May 27th, 1918, at Vancouver. The address of the secretary of the Institute (Mr. H. Mortimer-Lamb), who is also the editor of the Bulletin, is included in the proceedings, and it is interesting to note that he believes that the aim of the Engineering Institute of Canada is to secure the passage of legislation whereby no engineer, "of whatever branch," will be permitted to practice his profession unless he is a member of the E. I. of C.. "If they succeed in that object," says Mr. Lamb, "then the Canadian Mining Institute might as well go out of business, since the backbone of our Institute is the technical man." The following abstract from Mr. Lamb's address shows more fully the connection in which he made his statement:—

"Another problem that the Institute must face soon, a matter that is fundamental and that vitally affects our future as an Institute, is the matter of classification. When the Institute was founded it was agreed that any one interested in mining was eligible for membership. At that time there were not enough mining engineers in the country to permit of the establishment of an organization of a restricted professional character. The same principle of wide-open membership was for many years followed by the American Institute of Mining Engineers with the result finally that the Mining and Metallurgical Society of America was organized by professional men in the United States, if not exactly as a protest, at least to fill a need that was not being supplied by the older organization. Some few years ago, however, the American Institute of Mining Engineers decided to adopt the policy of a stricter classification and as a result has gained greatly in standing, in strength and in effectiveness.

"At the annual meeting of our own Institute in Toronto in 1912, a first step was taken towards differentiating between technical and non-technical members by establishing a class of associate membership; but unfortunately nothing was done to define actually the qualifications that a candidate must possess to make him eligible for full membership. In other words, at present membership in the Institute has very little significance as defining professional status.

"This question has now become much more important, since, as you are aware, the Canadian Society of Civil Engineers has changed its name and widened its scope, and proposes—or at least that is the impression gained from reading its circulars on the subject—to induce the professional mining engineers and technical men to join that body by holding out to them the inducement of giving them professional status.

"In fact it is generally believed that the aim of the Engineering Institute of Canada, as it is now called, is to secure the passage of legislation throughout the country whereby no engineer of whatever branch will be permitted to practice his profession unless he is a member of that society. If they succeed in that object, then the Canadian Mining Institute might as well go out of business, since the backbone of our Institute is the technical man.

"When it is claimed that our Institute represents an industry rather than a profession, the fact seems to be forgotten that the mining engineer is essentially an industrialist. His business is to make a mine pay; and naturally in order to do this, he is obliged to study very carefully the business side of the matter, and consequently he is usually in a much better position to understand the conditions and voice the needs of industry than his employers, including the class of men who serve as directors on the boards of mining companies. It is the technical men in our Institute who have made our Institute."

There is but little doubt that the majority of corporate members of the Canadian Society of Civil Engineers have always favored a closed profession; and the recent radical changes in that society are generally considered to be steps toward making it the medium through which the profession shall be closed. No purely civil engineering society could secure the necessary legislation. There was too much opposition from the mining engineers, chemical engineers, architects, land surveyors, electrical engineers, mechanical engineers and other technically trained men. And there appeared to be no way in which those men could be induced to join the Canadian Society of Civil Engineers, under that specialized name, in any considerable number. Instead of appointing a committee on legislation to co-operate with similar committees from other societies, it was decided to abandon all pretense of specialization in the civil engineering field and to make an effort to enroll all of the leaders—and as many of the rank and file as possible—of the other branches of the profession. Naturally, the first step had to be the removal of the word "civil" from the name of the society. Once enrolled as members of the society, the architects, chemists, miners and others were thought unlikely to oppose the society, or institute, as the medium through which a closed profession could be effected.

The plan will succeed if the bars to membership in the Institute are sufficiently lowered; but it practically requires the Institute either to absorb in their entirety all the other engineering societies in Canada, or else to control their actions (a) by enrolling and enlisting the support of a majority of members of each society, or (b) by "packing" the membership of the other societies with loyal members of the Institute.

In any event we do not agree with Mr. Lamb that the Mining Institute need go out of business, no matter what legislation the E. I. of C. may be fortunate enough to secure. The Canadian Mining Institute has had a long and—so far as we know—honorable career, rendering specialized service in one particular field. It is unlikely that the Engineering Institute of Canada, with its many general problems and its diversified interests, will be able to supplant entirely such specialized societies as the Canadian Mining Institute. Why should it?

This is the day of specialization, and while engineers will band together in one society to attain certain broad objects, they will seek other services in other channels at the same time, and there is no reason why they should not do so without in the least being disloyal to the interests of the general society. The mining engineers who belong to the E. I. of C. will no doubt continue to appreciate the Canadian Mining Institute and the mining trade papers; the electrical engineers will still feel the need of the electrical trade journals, and possibly of the A.I.E.E.; the chemists will maintain their individuality and their subscriptions to specialized papers and societies; and the civil engineers and contractors will continue, we trust, to read those papers that are specially edited and published in their interests.

## PERSONALS

W. P. GROSS, of the staff of C. C. Worsfold, government engineer, British Columbia, has been placed in direct charge of the dredging operations on the Fraser River.

E. C. KERRIGAN, until recently purchasing agent of the St. Lawrence Bridge Co., Montreal, has been appointed general purchasing agent of the Great Lakes Engineering Works, Detroit, Mich., succeeding James S. Keightly, resigned.

SIFROY FORTIN, of Ottawa, who has recently been appointed deputy director of the Public Works Department, will succeed Alex. Martin, who has retired, as deputy chief engineer of Montreal. Mr. Fortin will take charge of the roads, sewers and surveying departments, the appointment to take effect on September 1st of this year.

H. M. FREEBURN has resigned as assistant engineer of the Pennsylvania State Department of Health to become associated with the engineering staff of Wallace & Tiernan Co., Inc., of New York City, manufacturers of chlorine control apparatus and sanitary engineering specialties. Following his graduation from the sanitary engineering course of Pennsylvania State College, Mr. Freeburn was an instructor at the institution and was in charge of experimental sewage work, later joining the State Department of Health.

## OBITUARIES

Capt. WILLIAM G. AMSDEN, son of L. G. Amsden, vice-president of the Consolidated Optical Company, Toronto, has been officially reported to have fallen in action on August 8th. Capt. Amsden went overseas as a lieutenant with the 220th Battalion a year ago last May, and had been in the fighting line for over a year. He was a graduate of the School of Practical Science, Toronto, and was engaged as engineer with the Consolidated Optical Company when he enlisted. Capt. Amsden was in his 30th year and unmarried.

Capt. O. L. CAMERON, B.Sc., died August 10th in France of wounds received during a recent battle. Capt. Cameron was a graduate of the School of Practical Science, Toronto, class of 1913, and until his enlistment last year was in charge of waste water surveys for the Waterworks Department of the city of Toronto. He enlisted with the 208th Battalion but was transferred to the 54th Battalion and reverted to the rank of lieutenant in order to get to France. He was again gazetted as captain shortly before his death. Capt. Cameron lived at 127 Barton Avenue, Toronto.

## WHAT IS SHIP TONNAGE?

*(Continued from page 182)*

tons" are very often used. "Deadweight carrying capacity," abbreviated "D.W.C.," is the difference in displacement tons between the displacement at light load (usually with no stores, coal or oil fuel on board) and the full load displacement. So the deadweight capacity is an approximate measure of the maximum total weight of fuel, stores and cargo that can be put on board a ship without sinking her below her designed load water line.

It would be somewhere near the normal proportion for a ship to have deadweight capacity equal to two-thirds of her full load displacement, so that the deadweight tonnage of a vessel of 9,000 tons displacement would be something like 6,000 tons, with a light load displacement of 3,000 tons. The launching weight of such a vessel would ordinarily be considerably less than 3,000 tons, since there would be quite a weight of machinery and fittings to be put in her after launching.

When we come to the registered tonnage of a vessel, we find that is a very different matter from deadweight tons. A "register ton" is 100 cubic feet of space in a hull. It hasn't much to do with actual weight, as is shown by the fact that a "shipping ton" for package freight is taken as 40 cubic feet, referring to a ton of 2,240 pounds, and this comes fairly close to the weight for an average cargo.

To trace the origin of the register ton of 100 cubic feet, we have to go back to the year 1854, when in connection with new legislation for shipping it was found that, under the then existing measurement rules, the registered tonnage of the entire British merchant marine was 3,700,000 tons, and the total cubic contents of the same vessels was estimated at 363,400,000 cubic feet—a ratio of 1 to 98. To keep the registered tonnage at about the same value that it had then, and to simplify calculations, the register ton was officially made 100 cubic feet of enclosed space. The United States adopted this measurement standard in 1864.

The "register under-deck tonnage" is the number of register tons of 100 cubic feet included in the total space in the ship's hull below the tonnage deck. The tonnage deck is the upper deck, on ships with two decks, or the second deck from below, if there are three or more decks.

"Gross tonnage" is the total of register tons obtained by adding to the register under-deck tonnage the volume of any permanently enclosed space for stores or cargo above the tonnage deck.

"Net register tonnage" is the gross tonnage less the space for boilers and machinery and crew's quarters.