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MISSING

The Canadian Engineer

A weekly paper for civil engineers and contractors

Town Planning Includes "Sunlight Engineering"*

Streets Should Generally Run Northeast-Southwest or Northwest-Southeast Instead of Being Square With the Cardinal Points—Main Streets Built Up With Skyscrapers Should Be North-South if Building Heights Cannot Be Limited

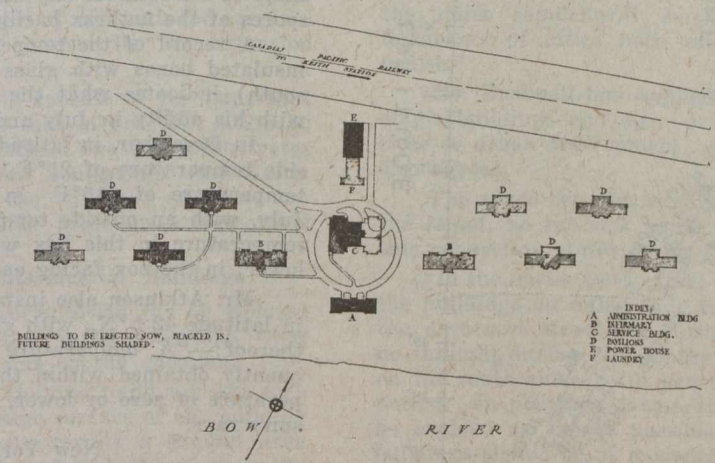
By H. L. SEYMOUR

Engineering Assistant to the Dominion Housing and Town Planning Adviser

IN an address delivered a few weeks ago, your president, C. A. Bigger, said:—"Astronomy is one of the oldest and most interesting of the sciences; the intellectual progress of a nation usually corresponds with its advancement in the study of this science;" and in speaking of the heavenly bodies,—"The sun as the source of light and heat, is essential to our existence, hence as time progresses, the work of astronomers may be said to be directed to its study with more interest than that accorded any other body."

I have chosen for my subject one that readily permits me to link up astronomy with town-planning. When you are as enthusiastic as I am about town-planning you will know that everything of value that you have learned has a place there; town-planning is a sort of melting pot for all your knowledge, refining it into the pure gold of usefulness.

I wish to recall briefly to your attention some well-known astronomical and other facts about the sun. I then hope to show you that these points should be considered in the determination of the direction and width of streets; height, orientation and density of buildings; and similar matters of more or less importance in planning. Some of these facts undoubtedly have been considered in some cases, and the lay-out or orientation of buildings has been influenced thereby. But I believe I am correct in stating that it is only recently that the application of such facts has been a matter of careful study.



CENTRAL ALBERTA SANITARIUM, SHOWING PROPER ORIENTATION OF THE BUILDINGS

How much weight should be given to this question of sunlight that I am going to discuss, must be a matter of judgment in each case; there may be factors or conditions that make it of small importance. But in some instances it is of great importance, and in general, to the town-planner is given the problem of the scientific utilization of sunlight in his lay-out of streets and buildings.

For the purpose of this paper I propose to consider the light derived during the day under the classifications of (a) daylight or skylight, and (b) sunlight, and it is the latter with which we are mostly here concerned. "Skylight comes from all directions of the heavens; sunlight from only one direction, constantly varying with the revolution of the sphere,"—Atkinson in his "Orientation of Buildings," to which work I am indebted for a great deal of the information in this paper.

The astronomer has been searching the heavens with telescopes of ever-increasing size and power to bring to our knowledge far distant heavenly bodies. A similar search has been made by the bacteriologist with high-powered microscopes of also ever-increasing magnification. These now disclose many small forms as cleverly hidden from us in the past as were the distant stars. Just as the astronomer feels certain that there are many bodies which he has not yet seen, so is it with the bacteriologist in his work. The latter, however, generally has various means of verifying his presumptions,—for example that of letting a bacterium indiscernible with the microscope, produce under favorable conditions a colony of such proportions that it is readily seen by the naked eye.

In this connection, the few brief points I wish to make here are that this interesting study of bacteriology has demonstrated that there is no death but a constant change of life from one form to another, this being made possible by the action of myriads of bacteria. Now some of these bacteria and allied organisms go about their work in a way that appeals to us; they make fertile our fields, enable us to make such everyday articles as bread and cheese, or silage for cattle; dispose of sewage; in fact enter largely into all natural operations.

But some bacteria are not so friendly. I forget how many different kinds of organisms some expert recently discovered attending one case of influenza,—but every contagious and infectious disease is caused as a rule by a specific bacterium or similar organism. Diphtheria, influenza, pneumonia and tuberculosis are infectious diseases that may be caused by bacteria present in the air. And in many diseases ordinarily described as contagious, bacteria may be exhaled by the patient.

The oxidizing action of direct sunlight and its accompanying drying properties are the greatest natural agencies in destroying disease or pathogenic bacteria. This point I wish to emphasize, because I feel that in the final analysis, it is the strongest scientific argument that can be advanced, so far as housing is concerned, for direct sunlight.

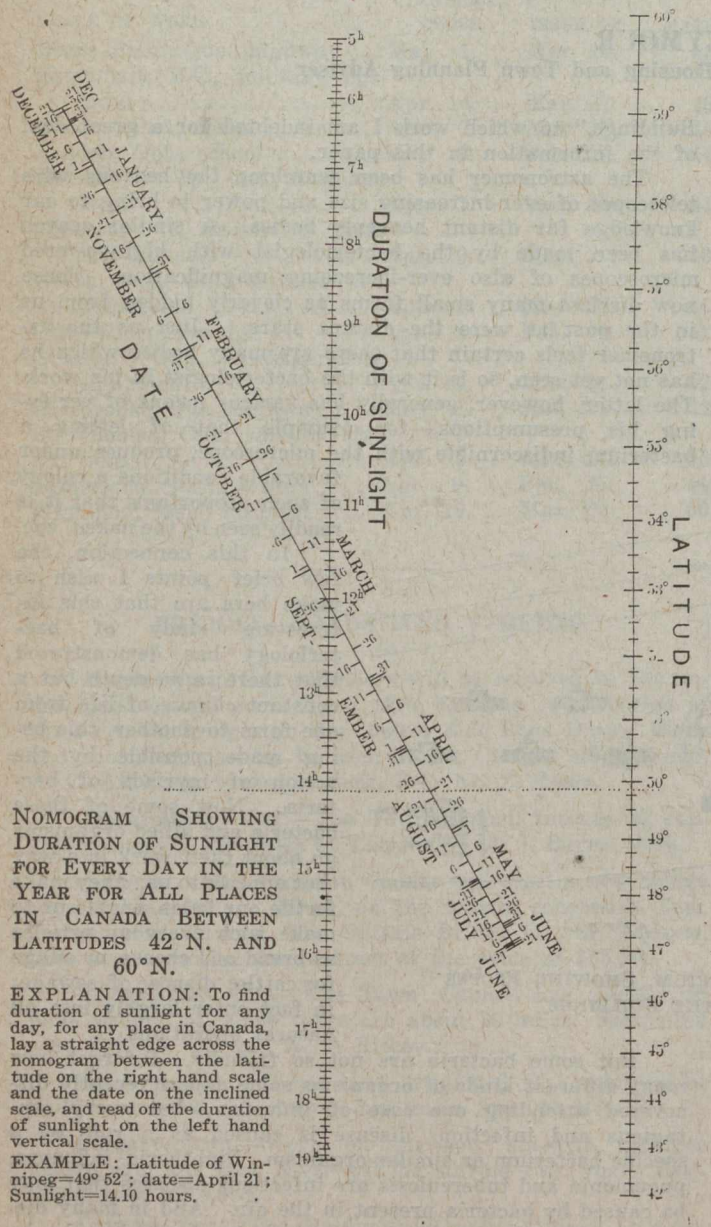
In a cubic metre of air taken from over the ocean there was found only one bacterium. In the same amount of air taken from a Paris hospital there were 79,000 bacteria. In the open air of the country, there are many less than

*Read before the Royal Astronomical Society, Ottawa Branch.

in the city air, which as a rule is shut off from direct sunlight.

"Second only to air is light and sunshine essential for growth and health, and it is one of nature's most powerful assistants in enabling the body to throw off these conditions which we call disease. Not only daylight but sunlight; indeed fresh air must be sun-warmed, sun-penetrated air. The sunshine of a December day has been recently shown to kill the spores of the anthrax bacillus." (Healthy Hospitals, Sir Douglas Galton, Oxford, 1893). This latter is no mean performance when one remembers that bacterial spores or "seeds" are protected with a hard casing which render them much more difficult to destroy than the parent bacteria.

Besides being nature's great preventative for the spread of disease, we all have felt the exhilarating effect of sunlight and know its general effect on public health and



NOMOGRAM SHOWING DURATION OF SUNLIGHT FOR EVERY DAY IN THE YEAR FOR ALL PLACES IN CANADA BETWEEN LATITUDES 42°N. AND 60°N.

EXPLANATION: To find duration of sunlight for any day, for any place in Canada, lay a straight edge across the nomogram between the latitude on the right hand scale and the date on the inclined scale, and read off the duration of sunlight on the left hand vertical scale.

EXAMPLE: Latitude of Winnipeg=49° 52′; date=April 21; Sunlight=14.10 hours.

sanitation, and having the matter brought to our attention, we can realize what would be its effect on the removal of snow in the winter and generally on street traffic conditions.

"Unquestionably one of the first requisites for a healthy building is abundance of sunlight. Not only the exterior wall surfaces of the buildings but also the surface of the ground around them should have the direct rays of the sun for as long a time as possible each day," says Atkinson.

If you do not agree with his conclusions, I have no time for further argument. But I assume that you do, and will pass on to the considerations of the astronomical data.

The path of the sun during the four months from April 21st to August 21st, resembles more nearly his path at the summer solstice than at the equinoxes, and similarly his path during the four months from October 21st to February 21st, more nearly his path at the winter solstice than his path at the equinoxes. Or, the condition of the winter solstice may be considered as fairly typical of the period of the four months from October 21st to February 21st. For the northern climes this is the period for which special planning is necessary, as can be judged from the following reasons, with which you are all very familiar but which will bear some elaboration.

Reasons for Special Planning

1.—At the winter solstice, the days are the shortest, which means that the total possible amount of sunlight that may be received per day is the least in the year. From the accompanying nomogram, prepared in the surveyor-general's office, the duration of sunlight in Canadian latitudes can be quickly determined. The effect of latitude on the length of the day is readily apparent:—

	Lat.	Duration of sunlight
At the summer solstice	42°	15.25 hours
" " " "	60°	18.90 hours
At the winter solstice	42°	9.10 hours
" " " "	60°	5.85 hours

2.—At the winter solstice, the sun's rays are most oblique. As you know, the intensity of heat and light received from the sun is greatest as the rays become most nearly vertical. We find then that not only the total amount, but also the intensity, of the sunlight received in winter is less than that received in summer. That we should plan to conserve all the sunlight we receive in the northern climes in the winter is the obvious conclusion. If we do this, we will be amply rewarded. We must remember that Sir Douglas Galton makes the statement that "the sunshine of a December day has been recently shown to kill the spores of the anthrax bacillus."

A record of the temperatures in two sun-boxes (small insulated boxes with glass fronts, one faced east and one south) indicates what the December sun can do compared with his ability in July and the other months.

In December, in latitude 42° 40′ N., with an actual outside temperature of 25°F., there was recorded a maximum temperature of 115°F. in the box facing south, while in July, with an outside temperature of 90°F., the maximum temperature in this box was only 112°F., or actually 3°F. lower; in the box facing east, 122°F., or but 7°F. higher.

Mr. Atkinson also instances the case of a small "shack" in latitude 42±°N., with glass front facing south, and says thereof:—"A temperature of over 100°F., has been frequently obtained within this building with an outside temperature of zero or lower, entirely from the warmth of the sun's rays."

New York's Skyscrapers

3.—At the winter solstice, the shadows cast are the longest and cover the greatest area. In this connection some facts are of interest as to some of the New York skyscrapers. These facts and others in this paper are abstracted from recent papers by Messrs. Swan and Tuttle on "Planning Sunlight Cities" and "Sunlight Engineering in City Planning and Housing."

At noon December 21st, the Woolworth Tower, 791 ft. high, casts a shadow of 1,635 ft. in length.

The Equitable Building at the same time, being 493 ft. high with a ground area of 1.14 acres, casts a shadow 1,018 ft. long, covering an area of 7.79 acres, with the result that the fronts of facades of many tall buildings are completely shaded all day.

The street on the north of the Equitable Building is 34 ft. wide. If this north and south street were built up of Equitable Buildings, then "not a single window within 447 ft. of the street level would receive a ray of direct sunlight on December 21st."

At noon on December 21st the altitude of the sun is, at the places named, approximately as follows:—At the equator, 66.6°; at Winnipeg, 16.6°; at Edmonton, 13.0°.

On east and west streets, if the whole south front of buildings on the north side are to receive sunlight at noon, December 21st, then the width of the street must be:—At the equator, 0.43 the height of buildings on south side; at Winnipeg, 3.33 that height; at Edmonton, 4.33 that height.

Or the shadow cast at Winnipeg is in length 7.77 times that at the equator; at Edmonton, 10 times that at the equator (at noon, winter solstice).

As the condition at the winter solstice is evidently the most unfavorable for sunlight planning, and because, as shown, such condition obtains to a great extent from about the middle of October to late in February, this condition should be the one to receive the greatest study. If ample sunlight can be provided for this period of four months, our problems, with few exceptions, are solved.

Orientation of Detached Buildings

How should a detached building be constructed and oriented so that not only the exterior wall surfaces, but also the surface of the ground around them shall have the direct rays of the sun for as long a time as possible on December 21st?

For our investigations let us first take the case of a cube with sides of say 25 ft., this being fairly typical of a small dwelling house, and consider its condition as to sunlight at noon, December 21st, if it be located in latitude 42° north (Canada's furthest south point). As we build our house further north, the conditions, of course, become more unfavorable.

By orienting our cube, or building, with sides northeast-southwest, etc., every side receives sunlight; there is no area of perpetual shadow—and shadow curves indicate that more sunlight is received in the vicinity of the building. It would appear that for a detached building the latter position is preferable.

By adding extensions to our cube or square building, we get another typical building, the "L." The axes of the building should still be at an angle of 45° with the cardinal points, and the interior angle formed by the extension should face the south.

The matter of orientation is considered an important one for hospitals. Fig. 2 shows that in practice, Atkinson is upheld by our Canadian architects. The figure illustrates the layout of the Central Alberta Sanitarium near Keith, Alta. Note the orientation of the buildings and how important is the placing of a north point on architectural plans.

Orientation of Rural and Residential Buildings

Having established the best orientation for an isolated detached building, the next matter is to determine what effect the grouping of buildings has on the question.

Until the shadows cast by adjoining buildings are such that all sunlight is cut off from some surface of the building under consideration, or until there results a ground area or areas of perpetual shadow, there would appear to be no advantage in changing the orientation of buildings considered favorable for isolated conditions.

Buildings on a north-south street must be much further apart than on northwest-southeast and northeast-southwest streets, if minimum standards of two hours or less of completely lighted walls are enforced for southern exposures.

It would appear, then, that streets in an open rural or residential development, and where no important factor dictates otherwise, should preferably be placed so that buildings thereon and with faces parallel thereto, have their sides at an angle of 45° with the cardinal points.

This means that streets in such a development should run northeast-southwest and northwest-southeast, and not north-south and east-west as is the general custom.

The plan of the townsite of Kipawa, P.Q., published on page 261 of the February 27th issue of *The Canadian Engineer*, shows an actual case in course of development. This townsite was planned by Thomas Adams. It will be noticed that the development is so open that each house and even every building in the business section can be treated as a separate unit, so far as sunlight and shadow are concerned.

The streets are not square with the cardinal points, but run in directions that permit a desirable orientation of buildings. For example "The Avenue" is practically a northwest-southeast street, and "Hillside Road" a northeast-southwest street. It is only fair to add that Mr. Adams' position is, I understand, that frequently there may be other factors that make it desirable to face buildings in other directions. In such cases, having provided for sufficient open spaces between buildings to avoid objectionable shadows, the important thing is to design the disposition of rooms to suit the particular orientation. But I think that it will be admitted that a building with its sides angling somewhat with the cardinal points will receive sunlight, as a rule, on all its faces, and if square with the cardinal points is sure to have one unlighted wall, a condition to be avoided where possible.

Writing in 1864, Horace Bushnell, in his essay on "City Plans (Work and Play)," said:—

Orientation of Attached Buildings

"It is also a great question, as respects the health of the city, in what direction, or according to what points of the compass, the streets are to be laid. To most persons it will appear to be a kind of law that the city should stand square with the cardinal points of the compass—north, south, east and west, and where this law appears not to have been regarded, how many will deplore so great an oversight, and even have it as the standing regret of their criticism. Whereas, in the true economy of health and comfort, no single house or city should ever stand thus, squared by the four cardinal points, if it can be avoided. On the contrary, it should have its lines of frontage northeast, southwest, northwest and southeast where such disposition can be made without injury in some other respect; that so the sun may strike every side of exposure every day in the year, to dry it when wet by storms, to keep off the mould and moss that are likely to collect on it, and remove the dank sepulchural smell that so often makes the tenements of cities both uncomfortable and poisonous to health."

Mr. Bushnell has applied the considerations that affect single buildings and open development to the conditions of close or urban development. With this conclusion, Atkinson also agrees.

The space between rows is, in many cities, the width of the street, no set-back being insisted on. Mr. Atkinson in this connection states in his "Orientation of Buildings":—

"In the north-south street the distribution is symmetrical, the buildings on either side receiving an equal amount. In the east-west street the north face of the street receives no sunlight during six months of the year, and the buildings on the south side are in perpetual shadow during the same period. In planning towns, the east and west street should be avoided as far as possible and, where unavoidable, the buildings should be of moderate height and built in detached blocks. In the checkerboard plan, the best distribution of sunlight is obtained when streets run northeast-southwest and northwest-southeast."

Conditions Alter Cases

Messrs. Swan and Tuttle have approached the whole matter from a different angle—not starting with a study of detached buildings—and have considered a development almost entirely on New York lines, where closely placed or contiguous high buildings face only on the main and not, to any extent at least, on the cross streets. The main street will receive most sunlight when it is oriented north and south. This conclusion is supported by many useful tables prepared by Swan and Tuttle. And it is shown that while no sunlight may be received all day on an east-west street as far south as latitude 30°, yet in latitude 50° north, under the same conditions, a north-south street receives over an hour of sunlight.

"Blocks improved with houses in rows or with apartment houses, then, should have their length parallel to north-and-south streets and their breadth parallel to east-and-west streets." But such a development is generally

neither economical or desirable, even though very common. Mr. Adams has submitted, in his "Rural Planning and Development," alternative schemes of development, resulting in almost square instead of long narrow blocks. Assume these buildings for the moment to be attached in rows, to be in height one-half the "street" width between these and similar buildings on opposite sides of the street, and to be located in Winnipeg, latitude 50° north. Then we find from Messrs. Swan and Tuttle's tables that on December 21st, houses near the centres of the sides of the block (or sufficiently far from the street intersections to be uninfluenced by sunlight conditions there) will have their fronts exposed to direct sunlight for:—

Blocks with sides square with cardinal points.		Angle of 45° with cardinal points.	
North side	0 h.	Northeast side ..	0 h. 22 m.
East side	1 h. 52 m.	Southeast side ..	2 h. 39 m.
South side	0 h.	Southwest side ..	2 h. 39 m.
West side	1 h. 52 m.	Northwest side ..	0 h. 22 m
	3 h. 44 m.		6 h. 02 m

Evidently the angle of 45° with cardinal points is to be preferred, though as the height of building and latitude increase, the advantages disappear.

If east and west streets are to be built up, there seems to be no doubt among the authorities that buildings should be detached.

"The amount of sunlight obtained on east and west streets in private house districts may be effectively increased by staggering the buildings in such a manner that no house is directly back of one in front in the same block."

Raymond Unwin, the author of, I believe, the best architectural work on town planning, states that many people desire a south front to their house, in which case east-and-west roads are generally necessary. Though, "in France, where a road runs north and south, and it is desired to give the houses a southern frontage, one often sees little rows of houses placed with their ends to the roads, access being obtained by a simple pathway."

Disposition of Rooms and Windows

It has been pointed out that the disposition of rooms should be arranged for each particular orientation. In connection with east-and-west roads with detached buildings facing south, Mr. Unwin points out that such houses need a greater frontage, since all the best rooms must be on the south side. When the houses are on the south side of the road, with a north aspect. careful planning may result in an attractive type of house with the best rooms away from the dust and noise of the street and overlooking the garden.

Attached houses require a greater frontage on east-and-west streets than on north-and-south streets. Mr. Unwin instances the type of cottage having a living-room, sitting-room and scullery, with the bedrooms above. The frontage, he states, should be from 20 to 23 ft., if the aspect of the house is east and west or thereabouts, and from 25 to 28 ft. if it is north and south. In the first case the living-room may face east and sitting-room west, or vice versa. But in the second case, both living-room and sitting-room should face south. For attached houses on the north side of an east and west street, an extra 3 ft. or so is required for an entrance unless the passageway be dispensed with.

Thickness of Walls

The main object of having the walls of our buildings well lighted by the sun is, of course, that the sunlight may enter into the rooms, through the windows.

Much of the light may be cut off due to the thickness of the wall and the construction of the window accessories. In the tables prepared by Messrs. Swan and Tuttle, this important factor is considered. When the sun's rays are striking obliquely on the wall, very frequently no direct sunlight is able to reach the rooms on this account.

The wall may be well lighted and yet but little sunlight penetrate into the rooms. In latitude 42° north, a room with southern exposure gets a great deal of sunlight on a winter day, while in summer it receives but little.

From Swan and Tuttle on windows:—"By a beveling of the window opening, a window set in a thick wall can, within limits, be made to admit as much sunshine as one set in a thinner wall. The position of windows within rooms is also of importance. Thus a window, the top of which is situated near the ceiling, permits a deeper penetration of the sun's rays into a room than one the top of which is placed some distance below the ceiling. The sunshine volume in rooms with windows opening to either the east or the west may be considerably increased by having the windows located as near as possible to the south wall of the room. Windows opening to the south should be placed as near the middle of the front wall of the room as practicable."

General Conclusions

Detached Buildings.—Isolated detached buildings should be constructed with their walls not square with the cardinal points of the compass but at an angle therewith,—preferably 45°.

Detached buildings as usually grouped in rural and residential districts should be oriented as above, the streets on which they face running northeast-southwest and southeast-northwest.

Attached Buildings.—Square blocks should usually be oriented so that streets make an angle of 45° with the cardinal points.

Long narrow blocks with high buildings should have their lengths on streets running north and south.

Houses fronting on east and west streets should, if possible, be detached.

Disposition of Rooms and Windows.—As a rule, whether attached or detached, when fronting on east and west streets houses require a greater frontage than houses on a north and south street.

In general the disposition of rooms and windows should be planned in relation to the orientation of the building.

Height of Buildings and Width of Streets.—There is an intimate relation between the height of building and the width of street; and this relation must receive consideration, particularly in high latitudes.

To illustrate the above conclusion and because of its general interest, I submit a paragraph from "Rural Planning and Development" by Thomas Adams:—

"Heights of building should have some relation to the width between buildings, and in rural areas a low standard of height can be fixed with advantage to owners of land. This is needed not only to secure light and air, but to prevent traffic congestion in the suburbs in towns and on rural territory surrounding them. We should determine the question of light and air to buildings by fixing a minimum distance between all buildings on opposite sides of streets without regard to the width of the street itself, by limiting the amount of land in the subdivision which should be occupied by actual building and by requiring a minimum angle of light to all windows. Apart from special cases, where the evil of high buildings has already been established, no buildings should be higher than the width of the streets facing them, and rural municipalities at least have power to adopt this standard. Ample justification can be given from every point of view, including that of the interests of real estate, for such a limitation."

For desirable results the street plan and building plan should not be considered separately, but "must be conceived and perfected in harmony."

All of the above conclusions are general and may to a large extent be negatived by peculiar conditions of a local nature.

Alcide Chaussé, architect, Montreal, has removed his offices from 367 Beaver Hall Square to 72 East Notre Dame Street.

In reply to a recent question in the British Columbia house, the provincial minister of railways stated that the government had advanced $1,000,000 to the Pacific Great Eastern Railway since it was taken over by the province; $500,000 of this was advanced November 23rd, 1918, and $500,000 February 5th, 1919.

The Engineer's Library

REVISED EDITION OF TRAUTWINE

THE Trautwine Co., Philadelphia, Pa., now have on press the first issue of the twentieth edition (140th thousand) of "Trautwine's Civil Engineers' Pocketbook." Proofs have been sent to *The Canadian Engineer* of the new pages that have been added to the nineteenth edition. About 400 pages of new type have been added, relating principally to matters connected with railroads. This is the first revision of Trautwine since 1909. In the last edition of the work, only 70 pages were devoted to certain railway subjects to which 327 pages are devoted in the present edition.

In this new material as a whole, and notably in that relating to track, liberal use has been made of the standards and recommended practice of the American Railway Engineering Association.

New tables of curved radii (with their logarithms), of long chords, of middle ordinates, and of one-degree curved functions, are given. The description of resurvey of curves is new.

In the preface of this new edition, the authors state that extraordinary precautions have been taken against the occurrence of typographical and other errors. This includes also the preparation of illustrations. In the articles on railroad curves, and on turnouts and crossings, the illustrations are in two colors in the case of a few complicated figures where such distinction is desirable for increased clearness.

The table of contents and index have been considerably enlarged and extensively changed.

The authors did not attempt a revision of the entire work, but concentrated upon the rewriting of such of the important articles as could be properly handled in the time available. They have even refrained from attempting discussion of all matters pertaining to railroads, and have confined themselves almost exclusively to the modernization and extension of the articles on certain railroad subjects, and the introduction of new matter on others.

In addition, the rules relating to the ellipse have been modernized and extended. A new Isogonic Chart is shown, and the table of Azimuths of Polaris has been revised to cover present dates. All known errors throughout the book have, of course, been corrected.

There is an advance of 20 per cent. in the price of the work, but this is fully taken up by the increase in the number of pages in the book. The increase in cost of paper and printing has apparently not been taken into account. The new edition will consist of 1,528 pages and cover, 4 by 6½ ins. The Renouf Publishing Co., Montreal, are the Canadian selling agents, and Chapman & Hall, Ltd., London, are the English representatives.

PUBLICATIONS RECEIVED

TIDE TABLES for Nelson, Hudson Bay, and tidal data for Hudson Strait and James Bay for the season 1919, are published by the Department of Naval Service, Ottawa, (W. Bell Dawson, superintendent of the Tidal and Current Survey), 8 pages and cover, 6½ by 9¾ ins.

ARMY WATER SUPPLY TRUCKS.—Four page folder in two colors, 8½ by 11 ins., issued by Wallace & Tiernan Co., Inc., 349 Broadway, New York City, showing six views of the water-pumping, purification and laboratory trucks supplied by that company to the United States government during the war. These trucks were always ready for action, and accompanied the American troops at all times, so as to assure absolutely pure water from polluted streams. After filtration through Roberts' pressure filters, the water was chlorinated by liquid chlorine, controlled by "W. & T." apparatus. Each truck had its own complete equipment of filters, chlorinator and pumps, and also contained a small room splendidly outfitted as a laboratory, with all materials and apparatus necessary for thorough tests of water.

THIRTEEN BIDS AT PETERBOROUGH

THIRTEEN bids were received last week by the city council of Peterborough, Ont., for the construction of the proposed Hunter Street bridge, which has been designed by Frank Barber, Toronto, as consulting engineer.

No official information has as yet been given out regarding the tenders, but it is unofficially understood that quite a few of the bids were upon a cost-plus basis, although some lump-sum bids were received, and that the latter were somewhat less than $300,000. The council held several meetings last week, but came to no decision regarding the contract on account of the uncertainty of some of the members as to the amount of land damages involved in the construction of the bridge. Further information has now been secured regarding the damages, and another meeting of the council will likely be held at an early date for the purpose of deciding whether a lump-sum or cost-plus bid should be accepted, and then to award the contract.

Alternative proposals were submitted to the council for two concrete bridges of other designs than that prepared by Mr. Barber, and also for a steel bridge. These were not given very much consideration by the council, owing to the fact that no definite tender was received for the steel bridge, but merely an approximate estimate of cost; and in regard to the alternative bids on concrete bridges, the majority of the councillors were of the opinion that all bidders should have tendered on the official designs and specifications.

COMPENSATION OF RAILWAY ENGINEERS

IN response to the request of Engineering Council, engineers were granted a hearing on March 31st, and following days, at Washington, D.C., by the Wages and Working Conditions Board of the United States Railroad Administration. Classification and compensation of technical engineers on the staffs of the railway systems under United States government control were discussed and many statistics were presented.

The American Association of Engineers acted jointly in the matter with the Engineering Council and were represented by Secretary Drayer and five other members. Engineering Council was represented by M. O. Leighton, who is in charge of the Council's Washington office, and by two other members.

The first day's session was devoted chiefly to the interests of civil engineers, and the second day more particularly to mechanical, electrical and signal engineers.

Owing to the lack of witnesses available to Engineering Council and the American Association of Engineers, Chairman Gaines, of the board, arranged for the appearance of engineers connected with the government railways, and these engineers acted as witnesses from time to time. A few regional directors also gave their opinions.

A clear case seems to have been established for the feasibility and desirability of classifying the technical engineering positions of the railway staffs and for establishing standard compensations for them, possibly with a provision for a minimum salary for inexperienced men and a maximum for experienced engineers in the several ranks.

A bill has been passed by the Quebec Legislature authorizing that Quebec Streams Commission to spend an additional $100,000—making a total of $300,000—for the purpose of erecting storage dams on the Ste. Anne River.

UNIT PRICE AND COST-PLUS SYSTEMS OF CONTRACTS FOR PUBLIC WORK*

By Alexander W. Graham
State Highway Engineer of Missouri

THE cost of construction always has been and always will be the engineer's main problem. The purchaser demands high-grade design and construction, but he does not want to pay one cent more than is absolutely necessary. The purchaser also demands that the cost of the construction be known in advance. Very often the engineer is told that a certain amount of money is available for this or that piece of construction and is instructed to proceed without delay.

If the engineer is confronted with the limited-fund problem he will naturally turn to the unit price contract, as he knows the number of units to construct, and if he secures a proposal whose unit prices are not above the estimate he naturally feels that the work will be done for the available funds. At this point the old standard clause, which we all insert in our specifications, which states that the contract be let to the lowest and best responsible bidder, etc., presents itself.

The Lowest and Best Bidder

Under the system of competitive bidding, contracting is a guess proposition. There is nothing to prevent persons without experience or organization, but who can secure financial backing, from submitting bids much lower than those submitted by reputable contractors, and in a number of cases the lowest bid will be one that is below the actual cost of the work. Now enters the clause in our specifications relative to the lowest and best bidder. How many of you have ever been able to convince the purchaser that the lowest bid was not the best? Invariably the purchaser takes the position that, as the contractor has furnished a gilt-edged bond, and that competent inspection has been provided for, why is it necessary to pay more for the work?

The engineer knows that an inexperienced contractor can not and will not do the work as well as an experienced man would, and yet the purchaser, very often not familiar with construction work, is hard to convince that he will get value received by paying more than the lowest bid entails.

It is human nature to think that the other fellow's game is much easier than the one in which we are engaged. Therefore at practically every letting there will be found at least one bidder who is bidding for the first time, taking for granted that the reports that he has heard concerning the enormous profits to be derived from the work proposed are true. He is willing to be contented with small profit, or none at all, in order to learn the business and is certain that the reason for his bid being so much lower than any other is that the other fellow is expecting enormous profit. The engineer knows, however, that with an inexperienced contractor he can not get the class of work he desires, no matter how many competent inspectors are employed. As soon as the work gets well under way the contractor begins to realize that he is bound to lose money, and then comes the "battle royal." Every clause in the specifications is scrutinized and every contention possible is raised. The invariable result is a spirit of getting as good work as possible, get through, and forget it.

To approve a bid other than the lowest is more difficult on public work than on work being done for private interests. We all know how reasonable and fair the public is to its officials (?). If a contract is let to any other than the lowest bidder the public knows that something is wrong—some one is getting something he is not entitled to.

Our Old Friend, "Liquidated Damages"

When a contract is let to an inexperienced contractor, the usual result is that he fails to complete the work within the specified time limit. Now comes our old friend, "liquidated damages." We all camouflage by stating that the sum mentioned in the specifications is not to be construed as meaning a penalty but as liquidated damages. How many of you have ever seen this clause enforced? We all know that during the time the work is being done that one can always find countless reasons why the work was delayed. No matter who was to blame, the average man is willing to believe the contractor's statement concerning the causes for the delay. Attorneys seem to disagree as to whether you can compel a contractor to pay a sum of money for not completing a piece of work within the time specified. The courts are not inclined to look with favor upon fixing a penalty for non-performance. The use of the words "liquidated damages" does not remove the difficulty; if the court thinks that in fact the sum stated (or any provision named) is in effect a penalty, it will refuse to sustain it.

How Should Damages Be Computed?

There are two cases where "liquidated damages" seem to meet the approval of the courts. First, where the parties to a contract have in advance computed, ascertained, and agreed upon a sum as "liquidated damages." Second, where the amount of damage can not be definitely determined and a sum is fixed and stated as "liquidated damages." In this second case, however, the sum so fixed must appear to the court to be reasonable; otherwise the court will regard it as a penalty. The question in my mind, then, is how to arrive at the amount of the damage. To me it is rather intangible, especially so in highway work. We know that if the road is not finished that it is more or less of a damage to the public, but how much is the damage? You may suggest that the engineer compute the damage, state the amount in the specifications, and when the contract is awarded the signing of the contract settles the question. But does it settle the question? In construction contracts where blank forms are provided for a number of bidders, it can hardly be maintained that the parties have beforehand computed and ascertained the damage. Does it not more often mean that the contractor has entered into the agreement, "for better or for worse," trusting that he will be able to finish the work on time, and if not, expecting to have reasons to show that the time should be extended, or be able to prove that the amount stipulated is excessive and should be construed as a penalty? It is noticeable that this problem will generally occur when the contract has been let to inexperienced or irresponsible contractors, and this again emphasizes the fact that more attention should be given to the award of the contract. If the contract has been awarded to a reputable contractor, 90 per cent. of the difficulties have been eliminated, because the contractor knows what to do and how to do it. He knows that the sooner he can complete the work the more profit he can expect, besides gaining a reputation which will be valuable in the future. Again, we all know how much easier it is to adjust differences of opinion regarding the specifications if the work is going along nicely and every one satisfied with the class and progress of the work.

Cost-plus Form of Contract

I will now attempt to discuss a form of contract which seems to be considered by some authorities as the panacea for all construction ills, which is the cost-plus form of contract.

One of the principal arguments used in favor of this form of contract is that the purchaser assumes the risks which are thrown on the contractor by the unit-price form of contract. It would seem, then, that the inexperienced contractor is eliminated. It gives the purchaser the power to select the contractor on the basis of past efficiency, and to leave to him the carrying out of the work just as its design is left to the engineer. It is claimed that this can be safely done in spite of the percentage form of contract, because, should the contractor fail in point of cost, time, or quality to meet the requirements of the work, he would injure his reputation and diminish his chances of obtaining future business and his ability to secure higher returns. From the above we may assume that contractors will be compelled to apply for work in much the same manner that engineers apply for positions. Going a step further we may expect agencies to come into existence whose work will be to list and classify contractors

*Excerpts from paper read before the Chicago Road Congress.

in order that it may be possible to secure the proper type of contractor for the work contemplated.

Just why it is assumed that a contractor will take more interest in the work, perfect a more efficient organization, and do the work for a smaller cost if the purchaser and not himself pays the bills, is difficult for me to understand. I remember one cost-plus job, on which I happened to be a member of the engineering staff, the contract of which provided that the contractor furnish certain power equipment, the cost of maintenance being borne by the purchaser. Shortly after the work started it seemed that every boiler of the work had flue trouble, which spread over the work until everything and everybody seemed to be afflicted with the "flu."

Must Not Censor Expenditures

I am convinced that for this type of contract to be successful, the purchaser must select a contractor in whom he can place perfect confidence and turn the job over to him. If the purchaser is doubtful as to whether he is being treated fairly and places a representative on the work to advise him concerning the expenditures of the contractor, endless friction will result. It might be suggested that the engineer in charge of the work be given the authority to act in this capacity but I am not inclined to think this feasible. The engineer might act as auditor and be in position to say that the expenditures claimed were correct, but to give him the authority to say that whether or not the contractor shall make certain expenditures, or to pass on the question as to the number and salaries of employees, etc., is wrong. It is rather unusual to find two men whose ideas coincide in regard to the handling of construction work. Therefore, I say again, that the contractor must be given full authority to act as he deems best. Now, we are confronted with the same problem as in the unit price form of contract which is the problem of knowing whether you have selected a contractor in whom you can place implicit confidence. I may have the wrong idea concerning human nature, but I am inclined to the belief that the average man puts forth his best efforts when the efforts affect his pocketbook. It is claimed that the contractor will use every effort to keep the cost down in order that he may build up a reputation which will enable him to secure further business. This may be true if inexperienced or irresponsible contractors are employed on this form of contract that some one will have to pay the cost.

"Select Contractor? Excuse Me!"

Permit me again to say that the solution of contract trouble lies primarily in the selection of the contractor. I am certain that if funds are available to allow a cost which will give a responsible contractor a fair return, and if our laws will permit public officials to select the contractor, I would be willing to accept either type of contract. I feel, however, that before public sentiment will favor public officials being given the authority to select the contractor, that an educational campaign will need to be conducted. At the present time it will be charged that this system invites various abuses and we know there are many legal difficulties in the way of adopting such a system on public work, besides the great political difficulty of obtaining as good management by government bodies which supervise construction work as there is by private ownership; and until the public has been educated as to the value of this form of contract and is willing to put such responsibility on its officials, "excuse me."

CORRECTION

IN the February 13th, 1919, issue of *The Canadian Engineer*, it was announced that the contract for two 52,500 h.p. turbines for the "Hydro" development at Queenston, Ont., had been awarded to the Wellman-Seaver-Morgan Co., Cleveland, Ohio. It has been called to our attention that certain comments made in connection with this announcement were unintentionally misleading, particularly in the matter of the statement that the Allis-Chalmers tender was high, and the Wellman-Seaver-Morgan and the I. P. Morris tenders were both in the neighborhood of $250,000 per unit, and that the final decision was made entirely upon relative advantages in design. We are now advised that there was no choice in any important particular between the designs of the various manufacturers tendering, as all of the tenders were based upon the full specifications issued by the commission; also that the prices quoted did not vary within any wider range than would naturally have been expected for such large units, after making due allowance for the natural divergence of opinion which exists between manufacturers regarding overhead costs and margin of profit.—EDITOR.

TORONTO ENGINEERS APPOINT COMMITTEES

To Grade Salaries, to Establish Standard Fees and to Consider Means of Finding Employment for Disengaged Engineers

THREE sub-committees have been appointed by the executive committee of the Toronto Branch of the Engineering Institute of Canada. The first is to consider the ways and means of finding employment for disengaged engineers and for the advancement of others. This committee has elected E. T. Wilkie as chairman and W. Cross, secretary. It is now organizing its investigation and hopes to present a report soon.

The second sub-committee was appointed to consider the feasibility of drafting a scale of fees for services rendered by consulting engineers. This committee is presided over by Frank Barber, and the secretary is W. S. Harvey.

The third committee is considering the problem of grading the salaries of engineers according to their responsibilities and duties of office.

The executive committee considers that it is due to the public and to the engineers that these matters should be put upon a satisfactory basis. It is well known that bureaus have been organized by the trade and labor unions and by the governments, but these do not adequately provide for the needs of engineers. The other subjects are equally important to the public, because competent service merits reasonable remuneration.

MAY FILTER WINNIPEG'S NEW WATER SUPPLY

TROUBLE is being experienced, it is said, in connection with the new Shoal Lake water supply that has just been completed at Winnipeg, owing to the presence of Crustacea in the water. Various little animals in the water multiplied so rapidly in the city's reservoir within less than a week, that it was necessary to empty the reservoir and to allow the water to flow into the sewers, says the Winnipeg "Telegram."

Dr. Douglas, the city's medical health officer, has submitted a report stating that the Cyclops and other forms of animal life in the water are objectionable but not harmful to public health. He informed the members of the Water Board that in his opinion the water should not be turned into the mains until the Crustacea are removed from it but also said that the citizens are so keen to get the new water supply that "perhaps it might be well to let them have it and see what sort of a howl would be made."

It is quite possible that a filtration plant may have to be constructed before the new supply can be made available to the public. It is said that in 1914 City Chemist Blackie reported that there were various forms of objectionable animal and vegetable life in the Shoal Lake water that were visible to the naked eye.

It was suggested at the city hall that the water should be turned on and that householders should be supplied with small filters that can be attached to the taps so as to strain out the Crustacea.

WHERE POWER IS AVAILABLE

DURING the census of central electric stations in Canada that was taken recently by the Dominion Water Power Branch in co-operation with the Dominion Bureau of Statistics, "a special effort was made to obtain accurate data regarding blocks of electrical power that are for sale in the various parts of the Dominion, and the price thereof," states J. T. Johnston, chief engineer of the Dominion Water Power Branch.

Mr. Johnston has tabulated this data as follows, the first column giving the name of the company or municipality which has power for sale (the abbreviation "Mun." standing for municipality), the second column giving the amount of power that is for sale, and the third column quoting the rates.

After the name of the company or municipality, there appears in each case (w), (f) or (h), indicating respectively whether the primary power is water, fuel or Ontario Hydro-Electric Power Commission's system. For more detailed information, manufacturers and other prospective users of power should apply directly to the company or municipality concerned.

The following table omits one column of information which has been prepared by the Dominion Water Power Branch, giving the names of the railroads that serve the various districts in which power is available, but otherwise it is complete as issued by the Dominion Water Power Branch:—

British Columbia

Kamloops Mun. (w)	1,000 h.p.	1 to 2c. per k.w.hr.
Kelowna Mun. (f)	250 k.w.	2 2/3 to 6c. per k.w.hr.
Nelson Mun. (w)	1,000 k.w.	
Revelstoke Mun. (w)	350 k.w.	½ to ¾c. per k.w.hr.
Salmon Arm Mun. (f)	70 k.w.	8 to 16c. per k.w.hr.
Spence's Bridge Electric Light & Power Co., Spence's Bridge (w)	150 h.p.	
Western Power Co. of Can. Ltd., Vancouver (w)	7,500 k.w.	$12 to $20 per k.w.
Vernon Mun. (f)	400 k.w.	5 to 1½c. per k.w.hr.
British Columbia Electric Railway Co., Vancouver (w)	6,200 k.w.	2 to ½c. per k.w.hr.

Alberta

Calgary Mun. (f)	10,000 h.p.	2 to ¾c. per k.w.hr.
Calgary Power Co., Ltd., Seebe (w)	14,000 h.p.	
Lethbridge Mun. (f)	1,000 h.p.	6 to 2c. per k.w.hr.
Vermilion Mun. (f)	200 k.w.	

Saskatchewan

Arcola Light & Power Co., Arcola (f)	100 h.p.	Day load.
Davidson Mun. (f)	100 k.w.	$2 per h.p.-month.
Humboldt Mun. (f)	150 h.p.	10 to 5c. per k.w.hr.
Kindersley Mun. (f)	55 k.w.	12½ to 16c. per k.w.hr.
North Battleford Mun. (f)	400 h.p.	
Regina Mun. (f)	5,000 k.w.	
Saskatoon Mun. (f)	1,000 k.w.	1 to 5.4c. per k.w.hr.
Swift Current Mun. (f)	600 k.w.	5 to 2c. per k.w.hr.
Weyburn Mun. (f)	150 k.w.	

Manitoba

Neepawa Mun. (f)	50 k.w.	9 to 4c. per k.w.hr.
The Pas Mun. (f)	100 k.w.	9c. per k.w.hr.

Ontario

St. Lawrence Power Co., Ltd., Cornwall, Ont. (w)	1,000 h.p.	6 p.m. to 6 a.m.
Stormont Electric Light & Power Co., Ltd., Cornwall (w)	100 h.p.	
Dunville Mun. (h)	300 h.p.	$33 per h.p.
Fenelon Falls Mun. (w)	275 h.p.	$10 per h.p.
Kaministiquia Power Co. Ltd., Fort William (w)	10,000 h.p.	$25 per h.p.
The Galetta Electric Power & Milling Co., Ltd., Arnprior (w)	300 h.p.	$20 to $25 per h.p.
Hawkesbury Electric Light & Power Co., Ltd., Hawkesbury (w)	1,500 h.p.	$25 to $30 per h.p.
Kenora Mun. (w)	.....	
The Mattawa Electric Light & Power Co., Ltd., Mattawa (w)	150 h.p.	
Orillia Mun. (w)	2,500 h.p.	$20 to $15 per h.p.
Parry Sound Mun. (w)	‡175 h.p.	$7 per h.p.
Pembroke Electric Light Co., Ltd., Pembroke (w)	1,200 to 1,500 h.p.	$18 per h.p.
Renfrew Mun. (w)	200 h.p.	$20 per h.p.
Sauble Falls Light & Pr. Co., Wiarton (w)	50 h.p.	$12 per h.p.

Quebec

The Amqui Electric Co., Amqui (w)	300 k.w.	$30 per k.w.
Coaticook Mun. (w)	100 h.p.	$20 per h.p.
Farnham Mun. (w)	530 h.p.	$20 per h.p.
Grand Mere Mun. (w)	.....	
Hull Electric Co., Hull (w)	*1,200 h.p.	$15 to $20 per h.p.
The Ottawa & Hull Power & Mfg. Co., Ottawa (w)	10,000 h.p.	$15 per h.p.
Basin Electric Light & Power Co., Ltd., Montmagny (w)	50 h.p.	
Montreal Light, Heat & Pr. Cons'd. (w)	.....	
Southern Canada Power Co., Montreal (w)	.....	$40 to $25 per k.w.
National Hydro-Electric Co. Ltd., Montreal (w)	200 h.p.	
St. Jerome Mun. (w)	§250 h.p.	$35 per h.p.
Sherbrooke Mun. (w)	6,900 h.p.	

New Brunswick

Edmundston Mun. (w)	150 h.p.	6c. per k.w.hr.
Richibucto & Rexton Mun. (w)	160 h.p.	6c. per k.w.hr.
The Eastern Electric & Development Co., Ltd., Sackville (f)	.....	10 to 3c. per k.w.hr.

Nova Scotia

Canada Electric Co., Ltd., Amherst (f)	300 h.p.	
Daley's Electric Light Plant, Digby (f)	100 h.p.	
Nova Scotia Tramways & Power Co., Ltd., Halifax (f)	3,000 h.p.	†8c. per k.w.hr.

‡Day and off-peak load. §Day service.
*In May, 1920. †25% to 55% discount.

PROVINCIAL HIGHWAY SURVEYS

By John T. Ransom
Surveyor, Department of Public Highways, Ontario

SURVEYS are necessary in the preparation for improvement of any highway. The character or class of surveys depends upon the nature and extent of the proposed improvements. Provincial highway surveys, like railroad and many other types of surveys, are made for two purposes, namely, engineering and land.

If it were possible to make the land survey separately from the survey for engineering purposes, the work of either survey could be carried on to the best advantage, but the necessity of speeding up construction and the necessity at the same time of procuring lands to widen the existing roadways sufficiently to provide for the construction and maintenance of roads suitable to the demands of a Provincial Highway System, make it impracticable to separate the surveys, at least in the first stages, and for any particular highway a survey party as a unit must be organized to conduct a survey sufficient for the requirements of all engineering and land purposes.

Of the many methods of procedure open for surveys of highways, three commendable methods are briefly outlined as follows:—

First Method

(a) Field.—Preliminary survey.
(b) Office.—Preliminary plan.
(c) Office.—Determination of location of new centre line and grades made upon plans.
(d) Field.—Inspection of proposed lines and grades.
(e) Field.—Staking out of alterations, if any, made to plans, fence line and limits of new highway location. Monumenting.
(f) Office.—Final plan.

Second Method

(a) Field.—Preliminary survey (proposed centre line carefully located and marked on ground).
(b) Office.—Preliminary plan (made to conform with requirements for final plan).
(c) Field.—Inspection of proposed location as staked out. Required alterations, if any, noted on plan.
(d) Field.—Staking out survey. Monumenting.
(e) Office.—Final plan (preliminary plan amended).

Third Method

(a) Field.—Preliminary survey (proposed centre line and new limits of highway carefully located and staked).
(b) Office.—Preliminary plan.
(c) Field.—Inspection of location as staked out. Required alterations noted.
(d) Field.—Correction surveys and monumenting.
(e) Office.—Final plan (preliminary plan amended).

The first method of procedure as outlined above is quite unlike the other two methods in practically every respect. It is slow and sure, but too expensive a method to be applied to the ordinary run of provincial highways and suitable only for certain stretches of road.

The success of the third method depends entirely upon the location as staked out. If it is well done and few amendments or alterations are necessary, a great saving has been effected and the progress of the improvements to highway accelerated. If, however, the location has been poorly made and a large number of alterations required, the survey would prove not only expensive, but a set-back to the progress of the contemplated improvements to the highway.

Careful Inspection is Necessary

To insure the success of this method, or the certainty of the initial location as staked out being satisfactory over a sufficiently high percentage of the road, a careful inspection of the route is necessary, and an approximate location, or the governing features for the location, decided upon, before the issuing of the instructions for the survey or the commencement of same. With this provision, unless a decided change in policy affecting the location takes place before the adoption of the plans and location as final, this method of survey should prove the most economic and of the greatest assistance to the other departments of the work.

The second method is a compromise between the other two.

The second and third methods are alike in that time and attention are given in the preliminary survey to the location for the proposed new highway, and the plans drawn of the preliminary survey, with amendments only required thereto, suffice for final plans. They are unlike in respect of the manner of staking out the limits of the highway.

The second method has the advantage in that no staking is done unnecessarily, and all stakes when planted are in their final position. The preliminary survey and plans can be completed more rapidly than in the third method, although upon the completion of the preliminary survey and plans, no markings exist on the ground to point out the new proposed limits. A second survey is certain of being necessary for the planting of stakes.

A draft of "general instructions," adaptable to provincial highway surveys made along the lines as suggested in the third method, follows. Consistent with the heading, these instructions are general, and intended only to be used and applied in the interpreting and for the simplifying of the "special instructions" which are necessary to be issued for each particular survey. An outline of the prints necessary to be dealt with in the "special instructions" is also given.

"Special Instructions"

Official name and description of highway; points of commencement and completion; reports daily, etc., address, etc.; preservation of records; returns, field books, plans, etc. (instructions to be filed with field notes); general instructions: (a) party, number and of whom composed, etc.; (b) equipment, where obtained, signature, care and responsibility, etc.; (c) data, responsibility for obtaining same, etc.; (d) object of survey, extent and character defined, proposed width and cross-section of highway, etc.; (e) survey; (f) monumenting; (g) plans; report upon completion of survey.

"General Instructions"

Party.—The survey party should number all told either seven or twelve.

Party of Seven:—Chief,—qualified land surveyor (keeps field notes, location); transit and levelman,—qualified as an instrument man (keeps level notes); rear chainman,—must be able to read a tape or chain quickly and accurately, and have a good eye and judgment; front chainman,—smart and good walker; tapeman,—active on feet; stakeman,—must be able-bodied and capable of swinging sledge hammer; chauffeur.

Party of Twelve:—Chief,—qualified land surveyor; transitman,—thoroughly competent (keeps field notes of location); transitman's assistant,—careful, ordinary helper (able to carry and set up instrument and give line); rear chainman; front chainman; tapeman; stakeman; property man,—intelligent, smart man, good writer; levelman,—thoroughly competent (keeps level notes); rodman; tapeman; chauffeur.

Equipment.—Transit and tripod; 2 pickets (heavy and light); 2 alloy 100-ft. chains; two 50-ft. steel tapes (graduated in tenths); 1 metallic linen 50-ft. tape; 6 refills; sledge; axe; 2 electric torches; black paint; octagon tool steel drill; heavy steel bar (for winter work only); and for level party:—level; rod; 50-ft. metallic tape (in tenths); hatchet; chisel; white paint.

The following data are to be obtained before commencing the survey:—From office,—route plan, Department of Interior plan of area showing meridians of longitude and parallels of latitude, any other department plans of road, plan of proposed cross-section of provincial highway, geodetic bench marks, special and general instructions; from Surveys Branch,—municipal surveys, township plans and surveys,

village and town plans; locally,—registered plans, information from local surveyors; ordinance land plans.

Objects of Survey

To locate and mark on ground, centre line of proposed highway; to mark out the new proposed limits of highway; to establish by level suitable and sufficient bench marks along highway; to obtain sufficient information to plot a complete profile of the centre line of road, with all information re levels of culverts, bridges, buildings, structures, etc.; to plot complete cross-sections of road at every 100 ft. station and at all critical points in profile; to obtain information and measurements sufficient to prepare a plan for registration purposes, showing:—

The names of owners affected or abutting on highway; frontages and amount of widening; the location of new centre line and new limits of highway with respect to former registered plans and surveys, and with respect to original or old and established limits of road; all markings found, markings made or planted, land ties, etc.; all necessary measurements and bearings; position and ownership of poles, railways, houses, sheds, structures of any kind, wells, fences, trees, etc.

General Routine and Organization

Chief of party with at least two assistants should first of all lay out stations or points governing location of centre line.

While chief is thus engaged, the level party can bring along the levels, the property man can obtain the owners' names and identify the property lines, and 2-in. x 2-in. x 24-in. wooden stakes can be distributed along the route at points where they will be required.

If party consists all told of seven only, then the chief, with other members of party, including levelling party, later can carry on actual location survey, planting stakes, and obtaining all information necessary to survey.

If, however, party consists of twelve, while chief is laying out centre line or otherwise engaged, and while level party is carrying on levels, the location party continues with the survey, planting stakes, etc.

It is important that each member of the party, in a general way, has his own specific duties. After a few days trial it becomes quite evident what particular position each man is best fitted for.

All members of party should be instructed to refer all owners and outsiders asking particular questions re survey and widening, etc., to chief of party.

Location of Centre Line

By term centre line (C.L.) is meant the centre line of proposed new travelled roadway. This C.L. is intended also to be C.L. of the new limits of highway, except in the case of a highway upon which allowance is made for an electric railway, in which case more width is allowed between C.L. and limit of highway on the radial side of the C.L. than on the other. The line run and marked on the ground is for convenience in all cases the C.L. of proposed new travelled roadbed, but although always termed C.L. it is not, as explained in case of highway with radial, midway between the new limits of highway.

Traverse stations or points of intersection (P.I.'s) should first be selected carefully by chief of party so that courses of traverse will be suitable to define the centre line of the proposed new limits of right-of-way and at the same time the centre line of the proposed new roadbed. Careful consideration and due weight is to be given to present position of roadbed, ditches, embankments, culverts, bridges, buildings or other structures, rows of trees and electric railway lines, if any.

It is desirable to straighten out the roadway where it can be done without adding unreasonably to the cost of construction, utilizing to best advantage the existing ditches, if any, and old roadbed, and as before pointed out, taking into careful consideration other existing features, especially valuable trees and improvements. If trees are to be left standing, it would appear that generally C.L. should pass at least 25 ft. from same, preferably from 38 to 50 ft., according to particular cross-section of highway being laid out.

It is very necessary that the C.L. is laid down (so far as possible) to meet with the approval of the owners whose lands abut the highway. This will obviate the necessity of later making resurveys to change or adjust the C.L. to suit owners from whom land may be required for widening purposes and facilitate the procuring of such land for widening.

Trial Line Sometimes Necessary

Through thickly settled districts and where there are many houses standing close to road and many valuable trees to be considered, it is almost necessary to run a trial line measuring offsets to houses and trees, or any other particular features to arrive at a (location of) C.L. that will best fit the course and allow for the maximum widening with least destruction and expense.

The locating of angles, especially sharp angles on the brow of steep grades, should be avoided. In many instances, by moving the necessary angle or intersection point 50 or 100 ft. from brow of hill along the flattest grade, the angle in the road, although not much more noticeable to the eye, will be much safer for travel.

Better visibility and location at sharp angles may often be obtained by shifting one or both C.L. courses or tangents away from the corner.

The radius of curve to be adopted for a curve at any angle in road will be governed entirely by the existing conditions; the minimum radius to be, however, 300 ft.

For an intersection angle of less than 10 degrees, the limits of the highway will not be curved but run to an intersection.

A principle that generally it is well to follow is to avoid laying out new right-of-way in such a manner that a deep widening is required from an owner on one side of road while land is added to another owner on the opposite side of road, unless owners have been consulted and are agreeable. An equal widening on both sides of road usually appeals to the different owners. Where, however, there is the same owner on both sides of road, more freedom of choice for position of C.L. is given.

Standard Width Not Binding

In place of deviating or shifting C.L. to allow for obtaining land for widening according to standard cross-section or to lessen cost of widening by avoiding costly moving of buildings or other obstacles, in some cases it will be found preferable to lay out the C.L. to best advantage for the general purposes and to allow the building or obstacle to encroach upon the proposed plan of cross-section. The standard width is desirable, but is not absolutely binding.

In the case of one or more important trees noticeably standing out nearer to C.L. than the general line of other trees, it might be found suitable and advisable, depending largely upon general conditions, to allow roadbed to swing out clear of trees, that they may remain standing, but to continue limits of highway straight on through.

The foregoing deals practically only with the adjusting and improvement of the old road location, or what might be termed the "ironing out" of the irregularities in the present road location, and with the defining on ground of the new location. There will be places, however, where for safety and economy it will be advisable to deviate altogether from present position of road and open up a new right-of-way. These places are usually quite evident on the ground, and at such points or places complete information should be obtained regarding all features that would affect the relocation of the road. Generally, in these instances, with complete information at hand, the best location can be made upon a plan and then transferred to ground.

Limits of Road at Angles in C.L.

At the angles in C.L. or P.I.'s of tangents or courses, an iron bar 1 in. x 1 in. square and 12 ins. to 24 ins. long is driven to flush with road surface, the short bar being used only when found too difficult to drive the 24-in. bar. Reference stakes 2 ins. x 2 ins. x 24 ins. marked 15 to P.I. with black paint are to be driven in firmly on either side of road at 15 ft. offset from P.I., reference measurement to be taken also to any nearby prominent objects not likely to be disturbed by new road construction.

At P.I., when intersection angle (Δ) is less than 10 degrees, and a curve is not necessary in limits of road, wooden stakes 2 ins. x 2 ins. x 24 ins. are planted at the points of intersection of the limits of highway by a line passing through the P.I. and bisecting the angle that is read and recorded in the field notes as the angle for that particular station or P.I.

An error can easily be made when measuring or laying off the "split angle" and the transitman should always follow the same routine, i.e., sight on backsight with vernier set at zero and turn off angle to right (clockwise), the angle being half the angle read and recorded in his notes as the angle for the station. This rule is simple, but important and should *always* be followed.

At Curves

When intersection angle (Δ) is 10 degrees or over, a suitable curve is chosen and the B.C. and E.C. of same is located. Chainage will be carried through, however, along the tangents from P.I. to P.I.

Stakes are then planted on the new limits of highway directly opposite the B.C. and E.C. on C.L. The C.L. B.C. and E.C. are occupied by transit for this purpose and a right angle is turned off C.L. in each case, and proper width of highway allowed for. Reference stakes are driven 15 ft. from C.L. at B.C. and E.C. and marked with black paint 15 B.C. and 15 E.C. respectively. These reference stakes are particularly useful for construction purposes.

The curves on limits of road are run in on ground only when buildings or other important features stand close to limits of road or in case a property line or limit of another road intersect the curve.

At points of intersection of curve by property lines or road lines, it is necessary that wooden stakes be planted.

It might be noted that it is generally best practice to actually run the curve of the limit of the road, not the C.L. curve. To obtain tangent when set up at B.C. of curve, it is convenient to sight on the E.C. with vernier set at ½ Δ. Turning then into zero brings line of sight along tangent and required deflection angles may be turned off directly and curve run in.

Where Stakes are to be Planted

Wooden stakes 2 ins. x 2 ins. x 24 ins. shall be planted along the proposed limits of highway when same is intersected by property lines, township lot lines, fences marking limits of road or limits of road if readily located.

For the purposes of this survey, the approximate location of intersecting lines or limits is all that is required. The stakes are (generally) to be planted as closely as possible to the C.L. of the intersecting fence. The pluses on C.L. chainage opposite these stakes are to be obtained as closely as possible, however, although through farm lands the use of the transit is not considered necessary. The stakes planted do not necessarily mark off an owner's frontage, but merely define the limits of proposed new highway.

Wooden stakes shall be planted also at every angle and at B.C.'s and E.C.'s of curves in limits of highway.

Stakes shall be planted for reference and construction purposes at distances of 15 ft. from P.I.'s, B.C.'s and E.C.'s and any important points along C.L. and shall be marked with black paint, 15 to P.I., 15 B.C., 15 E.C., and 15 C.L., respectively.

Measurements, Where and How Taken

The survey is to commence at a particular and well defined point and chainage is continuous from said point to point of completion of survey.

The chains and tapes to be compared with provincial land surveyors' standard.

The chainage is to be accurately made along the courses or tangents of the proposed new C.L. of highway with a 100-ft. alloy steel chain.

A tally or wooden stake 1 in. x 1 in. x 12 ins. to be driven at side of road opposite each 100-ft. station at a convenient offset; the number of stations and number of feet offset from C.L. to be marked on two sides of same. In case profile only is being run of C.L. it is not necessary to place these stakes at any particular offset.

A 50-ft. steel tape is to be used for measuring in to establish stakes or limits of highway or in making any particular tie measurements.

A 50-ft. metallic tape is sufficient for other measurements.

Sufficient measurements are to be taken to plot position of existing fences, guard rails, walls, hedges, limits, trees, poles, buildings, sheds or other structures, wells, and railways, within the road limits, or within such a distance of same that the location of such features would have to be considered in connection with the construction or widening of the road.

All measurements to objects off C.L. to be made at right angles to C.L. and the plus on C.L. to be noted (the right angle to be ascertained by use of tape), only reliable tapeman with good judgment to be trusted with ascertaining the correct pluses on chain.

The plus of the point of intersection of C.L. by the production of any line upon which a stake has been planted, is to be carefully ascertained and noted. This will assist in plotting in on plan the direction of intersecting lines.

The plus on C.L. opposite all drives and all culverts, bridges, drives, etc., are also to be noted.

Reading and Recording Angles

The angle to be measured and recorded at any P.I. is not the intersection angle (Δ) but is the angle measured in a clockwise direction between the backward and forward sights without transitting the telescope. The angle is measured as follows:—

Backsight on last traverse station or P.I. with vernier set at zero. Unclamp vernier plate and turn to right, or clockwise, and bring line of sight upon forward traverse station or P.I. The angle is then read and is recorded as read and is the angle for that particular P.I. or station.

For rough check and for greater accuracy, the angle should be repeated. With a 6-in. horizontal circle, doubling the angle gives sufficiently accurate results. However, with a horizontal circle less than 6 ins. in diameter and reading to single minutes, the angle should be repeated at least three times. Very little would be gained by just doubling.

Precautions to be Observed for Best Results

Never read on a doubtful sight. Take time to send a man to identify the sight. It is necessary that backward and forward sights be both in position before any pointings are made for angle measurement.

Angles should be read quickly. No more time should elapse between the pointings than is absolutely necessary to turn and point the instrument. This applies to repeating measurements as well as first angle measurements.

When reading vernier, allow the light to fall on vernier from one direction only with respect to instrument. (This can be arranged by shading).

It is important that each and every angle is to be measured and read in the same manner, and with the same degree of precision. It is then reasonably possible to apply corrections to bearings of lines between stations where checks have been obtained.

Bearings

All bearings are to be astronomic; that is to say, the direction of all lines is referred to the astronomical meridian.

Since the Provincial Highway Survey extends over such a distance of longitude that it would be inconvenient to refer the bearings of the survey to a single meridian, the survey is divided into portions, each portion having a separate reference meridian.

The reference meridians chosen are the meridians having a longitude of an even ten minutes of arc apart.

In general, all bearings shall be referred to the nearest meridian of an even ten minutes of longitude as 79°,-79°-10',-79°-20',-79°-30', etc.

The position of any point with respect to these meridians, or with respect to the parallels of latitude, are to be ascer-

tained by reference to the Department of Interior Sheets of Canada. The convergence is scaled off these sheets.

At point of commencement of survey, the bearing of a traverse line or course is ascertained and established by astronomical observation and from this bearing all the bearings of traverse are computed, using the angles read at each P.I. Although observations are taken at intervals along the route and corrections to the bearings ascertained, the table or list of computed bearings is not altered or corrected, but another list or set of corrected bearings is computed and entered up alongside of original computed field bearings.

Midway or thereabouts between the reference meridians, a certain course of survey will have two bearings, one referred to the easterly reference meridian and one to the westerly reference meridian. Both bearings will be recorded for the course. The angular change in the bearings in passing from one reference meridian to another will be ten times the sine of the latitude.

The bearing given for any line is the angle that the line or its production makes with the nearest 10-minute meridian, and such angle will be measured and recorded as the angle measured to right (clockwise) from north around through east, south, west, etc. The angle or bearing may have any value from 0° to 360°.

Definitions of Azimuth and Bearing

In connection with these surveys the definitions of the words azimuth and bearing as given by the Surveyor General of Dominion Lands are adopted. They are as follows:—

The azimuth of a point B from another point A is the angle formed by the vertical plane containing A and B with plane of the astronomical meridian passing through A, such angle being reckoned from north, round either east or west, to 180°. It follows that, except in the case of a meridian or the equator, the azimuth of a straight line changes as the initial point moves along the line and that a direction is not defined by an azimuth unless the initial point is specified or implied.

The bearing of a point B from another point A is the angle formed by the vertical plane containing A and B with the plane of a fixed astronomical meridian which may or may not be the astronomical meridian passing through A, such angle being reckoned from north, round through east, south and west, to 360°, east being 90°, south 180°, west 270°, and north 360° or 0°. It follows that a straight line has the same bearing at all its points, but except in the case of a meridian or the equator, a direction is not defined by a bearing unless the meridian to which the bearing is referred is specified or implied.

Apart from the mode of reckoning the angle, the difference between the azimuth and the bearing of a line is that the azimuth is the angle of the line with the meridian of its initial point, while the bearing is the angle of the line with the meridian adopted for reference of all the bearings of the survey.

Astronomical Observations

For uniformity in practice and for purposes of future reference, it is advisable that all observations and reductions be made and recorded in a similar manner.

The tables supplied by the Department of Interior of Canada for use of Canadian land surveyors are the most convenient available, and the method of using is very fully outlined in a booklet supplied with the tables.

As a rule standard time is so readily obtained when engaged upon these surveys that no difficulties should arise on account of correct determination of time.

The observation of the transit of time stars across the vertical circle of polaris in both positions of the horizontal circle often is the quickest method of observation and gives more accurate results than other methods generally in use although entailing slightly more computations. When the surveyor has not many observations to take and has sufficient time to make the computations, this method of transit of low declination time stars across the vertical or polaris is recommended. The watch correction is at the same time accurately determined.

(Concluded in the next issue)

CHLORAMINE AND CRENOTHRIX*

W. F. Monfort and O. A. Barnes

THE application by Rideal of chloramine as a sterilizing agent for water and sewage has led to renewed interest in the reactions of chlorine with ammonium salts and with ammonia. Much earlier work has since been repeated in the hope of developing control of the reactions and prevention of losses. The fundamental work of Raschig has been commonly overlooked.

Chloramine (chloroamine, monochloramine) is formed (Raschig 1907 Chem. Zeit. 31, 926) by treating dilute solutions of hypochlorites with dilute ammonia, which Raschig expresses in the following equation: $NH_3+NaOCl=NH_2Cl+NaCH$. "By subjecting such a mixture to distillation in a vacuum at about 40°, after adding $ZnCl_2$ solution to remove free ammonia and sodium hydroxide, there is obtained a concentrated solution whose analysis yields values agreeing with the formula NH_2Cl. From concentrated mixtures under greatly reduced pressure, chloramine is often obtained as pale yellow globules floating in the aqueous distillate. Because of instability in concentrated form, no attempt was made to obtain it pure. Chloramine escapes readily from its aqueous solution, has the odor of nitrogen trichloride and vigorously attacks the eyes." (C.A. 2, 1533).

Decrease in Available Chlorine of a Chloramine Solution

Hours.	Chlorine—parts per million.	Cubic centimeter nitrogen evolved from 50 cc. sol.
0	1003.443	0
1	1003.443	0
2	1003.443	0
3	1003.443	0
4	984.68	0.01
5	980.86	0.05
6		0.09
7	975.12	0.12
8		0.15
8.5	965.56	
10		0.17
11.5		0.27
17	889.08	
19	879.52	
20		0.37
21	869.96	
22		0.44
23	860.09	
24	850.	0.51
25	850.84	
26		0.63
28		0.69
29	841.28	
32		0.73 73
51	707.44	
54		1.6
73	554.48	
76		2.5
98	430.20	
101		3.25
145	296.36	
148		4.10
170	213.00	
173		4.50

With ammonia and sodium hypochlorite in equivalent amounts (in 1/3 normal solution) there is some decomposition; liberation of nitrogen or reversion to ammonia is hastened by the presence of hydroxylions.

If calcium hypochlorite in equivalent amounts be substituted for sodium hypochlorite, the reaction may be thus understood:—

$$2\ CaOCl_2+2\ NH_4OH=2\ NH_2Cl+CaCl_2+Ca(OH)_2.$$

*Read before the Illinois Section, American Water Works Association.

With strong solutions reacting there is here a tendency to produce nitrogen trichloride and nitrogen.

It is apparent that a solution of chloramine of only relatively low concentration can be prepared; that if stronger solution of bleach and of ammonia are used, the reaction must take place in the presence of considerable amounts of diluting water.

Experiments were undertaken to determine the stability of chloramine solutions of different strengths. Two methods of determining the velocity of the reaction: (1) the content of chloramine remaining in the solution after the lapse of each period of test, and (2) the total volume of nitrogen evolved in a gas burette at the end of each period.

The amount of nitrogen evolved is a function of the rate of disappearance of available chlorine, which finds expression in the equation:—

$$3\ NH_2Cl = N_2 + NH_4Cl + 2\ HCl.$$

A series of determinations was made of the rate of decomposition of chloramine solutions of different strengths.

DECOMPOSITION OF CHLORAMINE SOLUTIONS

Hours.	Available Chlorine, Ppm.	Loss.	Available Chlorine, Ppm.	Loss.
	Series —1—		—2—	
0	10,200	0	8,160	0
1	7,275	28.68	7,388	9.46
2	6,900	32.35	7,013	14.06
3	6,413	37.13	6,619	18.88
7	4,875	52.26	5,438	33.36
11	3,844	82.90	2,194	45.76
24	1,744	82.90	2,194	73.11
32.5	1,125	88.97	1,819	77.71
53.5	300	97.06	469	93.03
	Series —3—		—4—	
0	6,120	0	4,080	0
1	5,513	9.92	3,750	8.09
2	5,250	14.21	3,638	10.83
3	4,988	18.50	3,516	13.82
7	4,350	28.92	3,169	22.33
11	3,788	38.10	2,897	29.00
24	2,175	64.46	2,016	50.59
32½	1,538	74.87	1,603	60.71
53½	563	90.80	863	78.85
	Series —5—		—6—	
0	3,060	0	2,040	0
1	2,775	9.31	1,875	8.09
2	2,700	11.76	1,844	9.61
3	2,625	14.22	1,813	11.13
7	2,391	21.86	1,706	16.37
11	2,231	27.09	1,638	19.71
24	1,688	44.84	1,350	33.82
32½	1,397	54.35	1,194	41.47
53½	853	72.12	863	57.69

The most concentrated solution used (10.2 grains available chlorine per liter, or .2877 normal) foamed vigorously at the start; the succeeding one less and so through the several series, with the velocity of the decomposition diminishing in each case as the period of experiment was prolonged, as indicated both by the volume of gas evolved and the concentration of available chlorine. A precipitation of calcium hydroxide varied in the series of reactions from very heavy in the first to relatively slight in the last.

From these data it is apparent why the application of chloramine should be made under such conditions that the concentration of the mixed reagents shall not exceed 1 part per million. A solution even of this low concentration should not be stored longer than 24 hours and is best made up as used. Not only do hydroxyl ions in solutions prepared from bleach and ammonia reduce the stability of chloramine; their reaction with bicarbonate ions in the treated water convert the latter to bivalent carbonate ions, and cause a copious precipitation of calcium carbonate.

$$\overline{CH} + \overline{HCO_3} = H_2O + \overline{\overline{CO_3}}$$

This has resulted in incrustation of feed pipe and of lines carrying the treated water from the point of applying chloramine.

Some experiments were carried on in preparing chloramine with dilute chlorine water and dilute ammonium compounds, NH_4CH, $(NH_4)_2$, CO_3, etc., with varying results. While it is theoretically possible that some chloramine might be formed under these conditions the diverse possibilities of reaction, indicated by Bray and Dowell (J. Am. Chem. Soc. 39, 905), offer little hope that direct addition of ammonia and liquid chlorine to a water can be so controlled and distribution of the sterilizing agent made so efficient as to insure the full chlorine equivalent in chloramine.

Oxidizing Power Not Increased

Rideal (J. Roy. San. Inst. 31, 33, 1910) found that when chlorine was introduced into sewage it was rapidly consumed, but that after free chlorine had entirely disappeared there persisted a strong germicidal power. The same results were obtained when bleaching powder was added to a water containing a small amount of ammonia. It seemed probable that the ammonia did not increase the oxidizing power of chlorine, since readily oxidizable organic matter in water absorbed much less chlorine from ammonia and hypochlorite than from hypochlorite alone. Furthermore the bleaching effect on dyestuffs indicated that ammonia and bleach together had only two per cent. of the oxidizing (bleaching) power of hypochlorite alone. While chloramine has little oxidizing value, it is still able to displace iodine from potassium iodide, giving the usual starch-iodide reaction; its chlorine can be precipitated by silver nitrate, and its ammonia equivalent determined with the strongly alkaline Nessler's reagent. Rideal showed that chloramine has a phenol coefficient of 6.6, three times that of chlorine.

According to Dakin (Proc. Roy. Soc. Lond., Series B. 89, B. 614, pp. 232-251) the germicidal value of hypochlorite in sewage is due to chloramine derivatives produced by the action of chlorine on amino acids and proteins. The proteins present in sewage contain amino groups which may react with chlorine to form substituted chloramines containing the NCl group. When chlorine or bleaching powder is added to sewage, there may occur a primary oxidation and a secondary formation of toxic chloramines from the reaction of amino bodies. When chloramine is added to sewage the initial rapid oxidation is eliminated, and the germicidal action begins at once. Dakin attributes the latter action to the chloramine group.

It is possible that proteins of living cells may so react, and that the killing of micro-organisms by hypochlorites is due to chemical changes of this character within the living cell, either by direct action of the germicide or by secondary products of similar nature.

Action of Chloramine on Crenothrix

The pronounced success of chloramine treatment in destruction of vegetative bacterial cells suggested its application to an especially troublesome water pest. Crenothrix is one of the "iron bacteria," so called because of their occurrence in iron-bearing waters. It belongs with the true bacteria (eubacteria). Its cylindrical cells are united in unbranched threads, enlarged toward the free end, covered with a thick sheath which becomes infiltrated with ferric hydroxide. Reproduction takes place by division of cells in three planes, with the formation of round gonidia. It is still in dispute whether the organism receives its energy from oxidation of ferrous to ferric iron (Winogradsky, Proc. Zool. Soc. Lond., 1913, Pt. 2, 430) or whether the separation of ferric hydroxide is an independent mechanical phenomenon not connected with the life processes of the cell. (Molisch and Ellis.)

It occurs in numerous sections of the State of Illinois in surface waters and in some well supplies, as at Freeport and Champaign-Urbana. In 1917, the latter supply was rendered unsightly and unfit for some domestic purposes by the development and decay of the organisms in the distribution system.

(Concluded on page 378)

The Canadian Engineer

Established 1893

A Weekly Paper for Civil Engineers and Contractors

Terms of Subscription, postpaid to any address:

One Year	Six Months	Three Months	Single Copies
$3.00	$1.75	$1.00	10c.

Published every Thursday by
The Monetary Times Printing Co. of Canada, Limited

JAMES J. SALMOND, President and General Manager
ALBERT E. JENNINGS, Assistant General Manager

HEAD OFFICE: 62 CHURCH STREET, TORONTO, ONT.
Telephone, Main 7404. Cable Address, "Engineer, Toronto."
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PRINCIPAL CONTENTS

WATER WORKS BIOLOGY

POSSIBLY the last place in which the average engineer would seek information concerning directly technical problems, would be a museum of natural history. But in the museum at South Kensington, England, there is a small exhibit that is of very great interest to water works engineers and officials.

For those unable to visit Kensington, a 58-page illustrated pamphlet, forming No. 7 of the Museum Economic Series, and procurable post free for thirty cents (address Cromwell Road, London, S.W., 7), gives an explanatory account of the exhibit. The monograph, which should interest an even wider circle of readers than those immediately concerned in water works problems, is from the pen of R. Kirkpatrick, assistant in the Department of Zoology.

Water supply problems divide neatly into halves. Collection, storage, treatment and distribution are not solely engineering in character. The determination of suitable quality is more properly within the province of the chemist, biologist and bacteriologist. The engineer co-ordinates and uses many departments of knowledge and is indebted to many expert quarters, but it is his privilege to design apparatus for the special treatment demanded by the research undertaken by other scientists.

No natural water supply is absolutely sterile when it reaches the consumers' taps, unless it has been treated. All raw water is more or less contaminated before or after collection. The selection of a good water supply means the limiting of deleterious organisms to the lowest practicable amount; and upon the elimination of disease-producing bacteria by filtration and chlorination, depends the public health to a greater extent than is generally realized.

The available evidence points to the fact that all life begins in water, and this may account for one of the great difficulties in water supply,—the ease with which undesirable organic aliens breed and multiply in so convenient a medium. A suggestion of what London's water supply was like when distributed untreated, is given in a short appendix to the above-mentioned monograph. A pamphlet published in 1827 stated that the author had sent Grand Junction water to several eminent doctors. One of these, a Dr. Hooper, in his reply described the tap water in his own house:—"Scarcely a week passes that I am not presented with a leech; a shrimp-like skipping insect near an inch in length; a small red delicate worm, which I believe is lumbricus fluveatelis; or some other animalcule; and the water is mostly opaline, muddy or otherwise impure."

Sand filtration, invented by James Simpson, was introduced in 1829. "At the present time, after due storage or disinfection, four-fifths of the water supply of the seven million inhabitants of water London, passes through a thin living film of diatoms and bacteria spread over 10.7 acres. This supply is derived from and traverses areas that are admittedly sewage polluted. Despite this fact, the general health of the metropolis has for long been a source of pride to Londoners, and almost of wonder to the world. This is true, not only as regards sickness and death from all causes but also as regards the incidence of those diseases which are liable to be water-borne."

The interest of the biologist in the surface film of the sand filter is unquestioned, and great emphasis is quite properly laid upon this living organic carpet which affords protection from pestilence. The author of the monograph states that "the subject of the biology of water works is vast and has manifold aspects," and quotes G. C. Whipple, who in the "Microscopy of Drinking Water," a book dealing with only one branch of the biology of water supply, states that a bibliography of works relating to the subject would occupy at least a hundred pages.

The aim of the Kensington exhibit and also of the pamphlet, is to show broadly the relation of natural history to water supply, the animals and plants which may be associated therewith, and biology in relation to water purification. The collection includes diagrams and models of sand filters, filter surface carpets, corroded and blocked pipe sections, blocked water meter strainers and pressure filter nozzles.

The monograph is a complete guide to the exhibits. The account of the biological investigations into the Hamburg water supply, during an outbreak of cholera in 1892, is particularly graphic. As an instance of the very worst possible conditions of water supply, it must surely be unparalleled. The water pipes supplying Hamburg were an animal Eldorado. Sand filtration, undertaken in 1894, remedied the whole matter. The pipe population died,—perhaps of starvation.

Mr. Kirkpatrick also tells of troubles at Torquay in 1910, and at Cardiff in 1913. In the former case, no trouble had been experienced for 50 years; in the latter, a 36-in. main was encrusted with a luxuriant growth of sponges, some with finger-like processes 8 ins. long. An enormous accumulation of mussels at Hampton-on-Thames reduced the diameter of a 36-in. main to 9 ins., 90 tons of shells being removed at one cleaning. The town of Ypres before the war had water troubles. Whenever a street hydrant was opened, masses of shells, Polyzoa, worms, etc., were blown out.

A plant named crenothrix, classified with bacteria, is possibly the most dreaded water supply pest. It thrives where iron and organic matter are present in solution. Whether the presence of iron in this "iron bacteria" is a chemical precipitate, or due to the vital activity of the protoplasm, has been the subject of much controversy, but it is certain, says Mr. Kirkpatrick, that it spreads with great rapidity, blocks mains and causes endless trouble and anxiety. Some further light is thrown upon the subject of Crenothrix in the article, "Chloramine and Crenothrix," on page 374 of this issue.

The city of Winnipeg is now said to be having difficulty with animal growths in its new water supply, and investigations being made there may be of considerable interest.

Letter to the Editor

STEEL FOR PARAVANES

Sir,—I am sure that you and your readers will be interested in the following item appearing in a recent issue of the Engineering Supplement of the London "Times":—

"One of the navy's secrets that has been disclosed since the cessation of hostilities is the use made of otters or paravanes (called P.V.'s for short) in enabling ships to pass through mine-fields with almost complete immunity. These devices were towed in pairs, one on either side, from a point as low down as possible on the ship's bows, in such a way that they were not in the ship's wake but stood out obliquely away from the hull. When a mine-mooring cable was encountered it was forcibly deflected from the ship and along the whole length of the towing rope until it came to the paravane itself. Here it encountered scissors or shear blades which, although it was made of steel 1½ ins. in diameter, cut it as easily as a pair of scissors cuts a piece of string. These blades, which were only 10½ ins. long, with a section about 1½ ins. wide by ½ in. thick, had to be made of exceedingly fine and strong steel, and after long and extensive tests by the Admiralty, the 'Triumph Superb' high-speed steel, manufactured by Messrs. J. J. Saville and Company (Limited), of Sheffield, was exclusively adopted for them. The whole efficacy of the paravanes, so far as mines were concerned, depended on these cutter-blades, for if through becoming blunt or breaking they failed to cut the cable the mine would remain submerged and dangerous, whereas if it was released and rose to the surface it could be immediately detected and destroyed."

When one realizes that the size of cable anchoring the German mines was 1½ ins. diameter, the efficiency of the paravanes was most astonishing.

Messrs. J. J. Saville and Co. were placed on a special list by the authorities in England due to this and other special tool steels which they were able to invent, which very largely enabled England to really become supreme in many engineering features.

Stainless tool steel, for valves and aeroplane parts; "S.V.L.," high tensile, air-hardening steel, for extremely high stress, shocks, abrasion under heavy pressures, parts exposed to extreme heat, etc.; and "W.P.S.," a non-abrasive die steel for punching and stamping without hardening, doing from six to ten times as much work as formerly hardened cast steel.

As the secret of these steels is released, commerce will be immensely benefited in their application.

C. R. PECKOVER,
of Baines & Peckover.

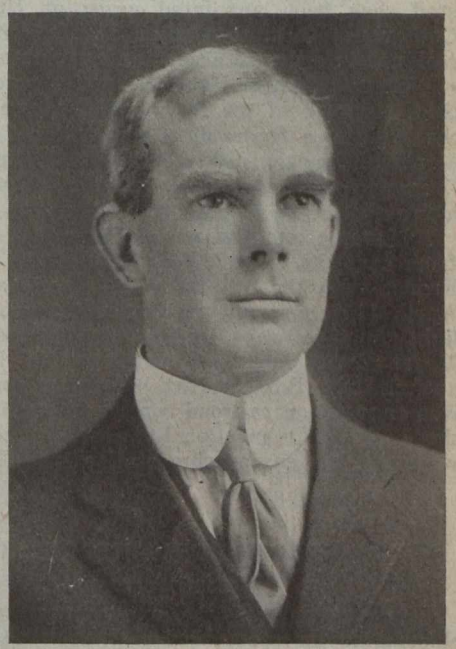
Toronto, Ont., April 1st, 1919.

The Pittsburgh Chapter of the American Association of Engineers now has a paid secretary. This is the first chapter outside of national headquarters at Chicago to have a secretary giving all of his time to the work. F. E. N. Thatcher has been selected for the position.

Hon. J. D. Reid, Minister of Railways and Canals, has presented a resolution to the railway committee of the House of Commons, which, if passed, will compel companies obtaining railway charters to construct their lines within reasonable time. He proposes that during the first year every company should grade and provide ties for 25 miles, and that at the end of the second year, 25 miles should be in operation, and an additional 25 miles each succeeding year until the charter rights are exhausted. The Minister of Railways asks that a clause of this nature be inserted in the charter of every railway company hereafter incorporated by the Federal government.

PERSONALS

WILLIAM GREGORY CHACE, chief engineer of the Greater Winnipeg Water District, is now finishing the work on which he has been engaged since October, 1913, in connection with the new water supply for Winnipeg and nearby municipalities. The conduit and distributing systems are complete, and unless it should be decided to filter the water before supplying it to the citizens, the new Shoal Lake supply will probably be turned on within the coming week. Mr. Chace was born May 16th, 1875, in Grantham Township, Ont., and was educated at the St. Catharines Collegiate Institute and the School of Practical Science, Toronto, graduating with honors in mechanical and electrical engineering, class of 1901. Before attending college, Mr. Chace worked for five years in shops and as a school teacher. For two years after graduation he was employed in the electrical engineering laboratories of the University, and in 1903 became field draftsman in the office of the late Cecil B. Smith on the construction of the hydro-electric plant of the Canadian Niagara Power Co., at Niagara Falls, Ont., later becoming resident engineer in charge of improvements to the hydro-electric works of the International Railway Co. In 1905, Mr. Chace became electrical engineer for the T. & N.O. Railway, and the same year prepared estimates on the cost of hydro-electric development on the Winnipeg River by the city of Winnipeg. In June, 1906, Mr. Chace was appointed assistant engineer of the Hydro-Electric Power Commission of Ontario, for the purpose of reporting on the Upper Ottawa River and its tributaries, and in October of the same year he went to Winnipeg to prepare specifications for the Point du Bois power plant. In April, 1907, Mr. Chace became a partner in the firm of Smith, Kerry & Chace, consulting engineers, Toronto. During the following eighteen months he prepared various engineering reports, assisted in the arbitration of the division between the cities of Port Arthur and Fort William of the assets of the electric railway serving both cities, and prepared the tender submitted by the McGuigan Construction Co. to the Hydro-Electric Power Commission of Ontario for the construction of the first 110,000-volt transmission line, this tender being the successful one. From October, 1908, to the end of 1911, Mr. Chace resided in Winnipeg and served as chief engineer of the Municipal Power Construction Department, in charge of the design and construction of the municipal power plant. From January to May, 1912, Mr. Chace was assistant general manager of the Mount Hood Railway and Power Co., of Portland, Ore., and from July, 1912, to June, 1913, he was president and chief engineer of the Crane Falls Power and Irrigation Co., Boise, Idaho, engaged in building irrigation canals and pumping stations. In October, 1913, Mr. Chace was appointed chief engineer for the Greater Winnipeg Water District, engaging in the construction of a 97-mile conduit for the purpose of carrying 100,000,000 Imperial gallons of water daily from Shoal Lake to Winnipeg, at a capital cost of over $13,000,000. Mr. Chace is a director of the Peace River Oil Co., and of the Assiniboine Club. He is a fellow of the American In-



stitute of Electrical Engineers, a member of the Institute of Electrical Engineers of Great Britain, and a member of the Engineering Institute of Canada. Mr. Chace recently organized "Research and Development, Ltd.," a Manitoba corporation which proposes to initiate new industries based mainly upon the natural resources of the province.

H. W. APPLETON, formerly with Robert W. Hunt & Co., Ltd., and recently works manager of the Toronto Plate Glass Importing Co., has joined the staff of Burns & Roberts, Ltd., Toronto.

LIEUT. CHAS. L. COULSON has been appointed city engineer of Welland, Ont. He went overseas with the 98th Battalion, and is now in England, but will be discharged from military duties without delay.

B. F. LAMSON, of the Welland ship canal engineering staff, has been appointed assistant city engineer of St. Catharines, Ont., to succeed D. H. Fleming, who recently resigned in order to accept an appointment at Owen Sound.

GEORGE ROGERS HECKLE, formerly general manager and chief engineer of the Raymond Concrete Pile Co., Ltd., and the Ambursen Hydraulic Construction Co., of Canada, Ltd., Montreal, has opened offices at 120 Broadway, New York City, and will engage in private practice, specializing in hydro-electric developments and general foundation work.

MAJOR CECIL EWART, of Edmonton, Alta., has returned from overseas on the "Melita." Major Ewart has been in France with the 8th Battalion, Canadian Engineers, since April, 1917, engaged in the construction of standard and light gauge railways, bridges, etc., for the 2nd British Army. Major Ewart has been mentioned in despatches and was awarded the D.S.O. Just before enlistment, Major Ewart was engaged on railroad construction work in the west with the J. D. McArthur Co., Ltd., and for ten years previously was with the engineering staff of the G.T.R.

CHLORAMINE AND CRENOTHRIX

(Continued from page 375)

In carrying on the experiments upon the action of chloramine on crenothrix it was impossible to plate the treated water on media, as is done with ordinary water bacteria, since no medium has been discovered upon which it can be surely grown.

Chloramine was first tried on water from the University well, which furnishes an iron-bearing water already inoculated with crenothrix. The first tests demonstrated in duplicate 800 cc. samples, the germicidal action of 1 ppm. available chlorine in freshly prepared chloramine. At the end of a week there was no growth in the treated samples, while control samples, untreated, showed an abundant reddish growth on the bottom.

In later series 11-liter samples were used: one set with chloramine in amounts equivalent to 0.5, 0.75 and 1.0 parts per million; a second with bleaching powder equivalent to 1 part available chlorine per million. Control samples stored without treatment showed an abundant growth at the end of one week. At the end of three weeks water treated with bleach alone showed a velvet growth, identified as crenothrix by microscopical examination. Samples treated with 1, 0.75, and 0.5 parts per million of available chlorine in chloramine gave no growth at this time nor within six months thereafter. The odor in the last-mentioned samples was pleasant, noticeably better than that of untreated or bleach treated samples; nor was there at any time a noticeable taste, save in those which had received the largest application of chloramine (1 part per million), in which there was a slight flavor as of chloramine. In the controls and in bleach treated waters taste and odor were offensive.

These tests were repeated with similar results. Chloramine addition corresponding to 0.5 part per million was effective in preventing development of crenothrix; the residual matter did not become offensive even after prolonged storage.

These results, gotten in a small way, indicated that the acute troubles arising from crenothrix in iron-bearing waters may be eliminated by the germicidal action of chloramine, thus reducing the problem of treatment to one of iron removal without complications. It was intended to apply the experiment in a large way at the 2 million gallon plant of the Champaign-Urbana Water Company immediately after the conclusion of the first experiments. There was at the time (January, 1918), difficulty in commanding a supply of ammonia and of reliable "bleach."

CONSTRUCTION NEWS SECTION

Readers will confer a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand or proposed, contracts awarded, changes in staffs, etc.

ADDITIONAL TENDERS PENDING

Not Including Those Reported in This Issue

Further information may be had from the issues of *The Canadian Engineer* to which reference is made.

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Toronto, Ont., water mains	Apr. 19.	Apr. 3.	43
Winnipeg, Man., gravel	Apr. 14.	Apr. 3.	48
Winnipeg, Man., hospital	Apr. 16.	Mar. 27.	50

BRIDGES, ROADS AND STREETS

Brantford, Ont.—The estimate of expenditure to be made on the system of county roads has been submitted to the County Council, and is divided as follows: Road construction, County, $39,072.64; province, $44,581.75. Bridge construction