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MISSING

The Canadian Engineer

A Weekly Paper for Civil Engineers and Contractors

Design of Motor-Driven Centrifugal Pumps

Typical Characteristic Curves for Different Types Under Identical Conditions—Non-Overloading Pump Shows Maximum Efficiency When Motor Is Under Maximum Load—Induction Motor Designed Under Full Load Conditions Is the Most Economical Drive

By A. T. CLARK
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WATER works engineers who have to prepare specifications for pumping units consisting of centrifugal pumps direct-connected to electric motors, have many problems to solve which are not clearly understood by either young electrical engineers or young hydraulic engineers.

The quantity of water required per day and the pressure required at the pump have first of all to be decided upon.

The quantity of water required is controlled by the size of the population to be served and is easily ascertained.

TYPICAL CHARACTERISTIC CURVES OF DIFFERENT TYPES OF PUMPS

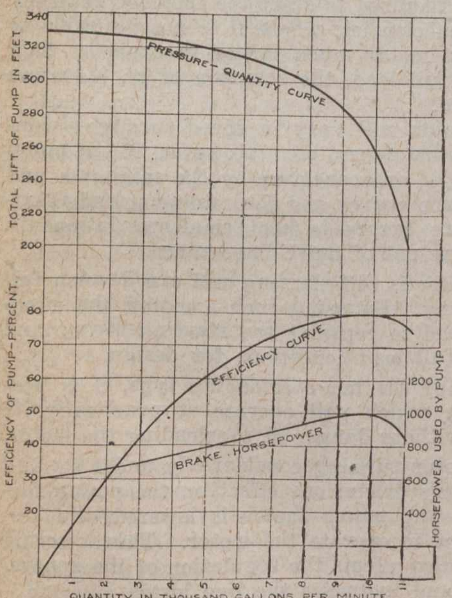

FIG. 1—NON-OVERLOADING TYPE

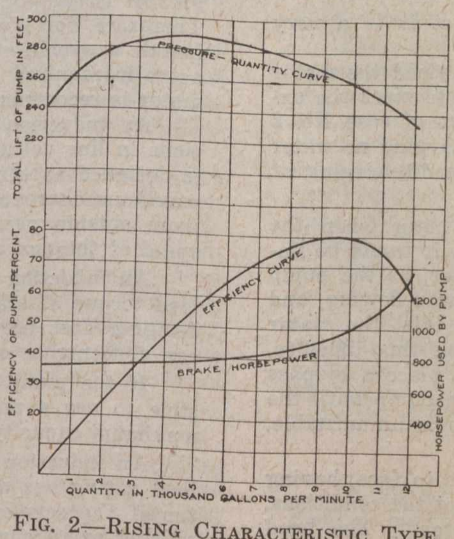

FIG. 2—RISING CHARACTERISTIC TYPE

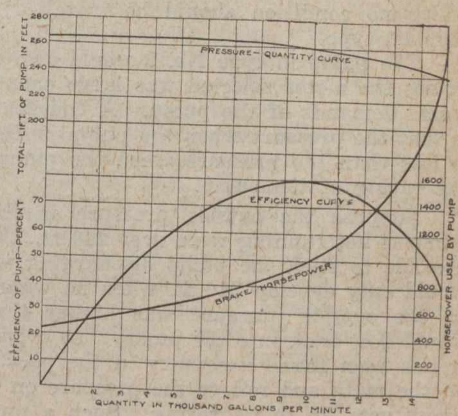

FIG. 3—FLAT CHARACTERISTIC TYPE

The pressure required at the pump should be selected to supply water at sufficient pressure at the most remote or highest point on the service under conditions of maximum consumption over the service. This is a problem of pipe friction and other losses. Where a reservoir exists on the service, the reservoir acts as a governor and the pressure developed at the pump must be sufficient to overcome all friction losses in the main or mains, and maintain the level of the water at normal elevation in the reservoir.

In a city where several pumping units serve one reservoir through certain mains, and it is desired to place an additional unit in the service, it is essential that a new main be also installed of sufficient capacity to carry the additional water pumped by the new unit, otherwise the existing mains would require to carry the additional water from the new unit as well as that from the existing units. This condition would create a much larger friction loss in the mains and the pumps would require to develop a larger pressure to overcome this loss. However, these are well-known facts and do not require to be discussed in this paper.

It is supposed that the water works engineer has decided on the rate of flow required and on the head to be developed. He has now to decide whether he shall specify the motor and pump in separate specifications. If he does so, he is accepting all responsibility that the two will work in harmony, and unless he is familiar with the characteristic curve of the pump and his specifications are rigid enough to force the manufacturer to adhere to the curve, he will run into difficulties.

Let Figs. 1, 2 and 3 represent typical characteristic curves of different types of pumps. Suppose these pumps are running under identical conditions and discharing 10,000 gals. per min. against 260 ft. head, and that the efficiency in each case is 80% as shown by efficiency curves.

Let the pressure at each pump fall to 240 ft. head. This might be caused by a fall in level of the reservoir, caused by a sudden demand on the system. Under this new balanced condition, pump No. 1 will deliver 10,400 gals. per min. at 240 ft. head; pump No. 2, 11,600 gals.; and pump No. 3, 15,100 gals.

Under the first condition, the horsepower used in each case was $10{,}000 \times 10 \times 260/33{,}000 \times 0.80 = 1{,}000$.

Under the new conditions the horsepower used in case No. 1 was $10{,}400 \times 10 \times 240/33{,}000 \times 0.795 = 950$ h.p., where $10{,}400 \times 10$ = weight of water in lbs. per minute; 240 = feet through which water is raised; 33,000 footpounds per minute = one horsepower; and 0.795 = efficiency of pump.

In case No. 2 the horsepower used was $11{,}600 \times 10 \times 240/33{,}000 \times 0.68 = 1{,}240$ h.p.

In case No. 3 the horsepower used was $15{,}100 \times 10 \times 240/33{,}000 \times 0.40 = 2{,}740$ h.p.

Examining these results it can be easily understood that in practically every case a pump with a characteristic similar to type No. 1 is preferable. A considerable change in the pressure will only slightly change the quantity with only slight change in the horsepower required to drive the pump.

It is quite possible to construct a pump which will not under any condition overload the motor. The horsepower required is a function of the product of the quantity pumped, the head developed and the efficiency. If the characteristic curve is so steep that the head drops quickly with increased quantity and the efficiency remains high, then with careful design the point of maximum efficiency can be made the point of maximum load on the motor. Such a pump is very valuable, as fluctuations of the pressure cannot overload or injure the motor.

In case No. 3, the load on the motor increases from 1,000 h.p. to 2,740 h.p. with only a drop of less than 8% in the pressure. Such a pump is a menace in any plant and under no condition should be installed; yet it is a very common type.

The pump in type No. 2 would also overload the motor unless the motor selected was large enough to meet the extreme demands of the pump. A bad feature of case No. 2 is that the pressure when the pump is discharging no water is less than the pressure when the pump is discharging at the rating of the pump.

Suppose the outside pressure in the main when the pump is not running were over 240 ft., then it would be impossible to start the pump discharging water, as the pump would only develop 240 ft. when no water was flowing, and as the outside pressure was higher than this, the water would flow back into the pump. To overcome this difficulty, it has been found necessary in the past to place a by-pass on the main and relieve the pressure on the pump until the pump gets up to its rating. Such a pump is an unstable, unsatisfactory proposition.

The next consideration the engineer has to face, having decided on the type of pump required to meet the conditions, is the selection of a suitable type of motor. The head developed by a pump varies directly as the square of the speed at which the pump is run. Suppose that the motor driving a pump fluctuates 5% in speed either way, then the head developed will fluctuate approximately 10%.

Figs. 4 and 5 represent characteristic curves of two pumps. In each case curve No. 1 represents the curve for minimum motor speed and curve No. 2 represents the curve for maximum motor speed.

To clearly understand the effect of speed fluctuation, suppose a pump is started up with the discharge valve closed and the valve is gradually opened up, then the curve showing the pressure on the pump side of the valve and the quantity pumped is the characteristic curve of the pump. A curve showing the pressure on the opposite side of the valve can also be plotted against the flow. Such a curve (A B) is shown on Figs. 4 and 5. The difference between the characteristic curve and curve A B at any point, represents the head lost in passing through the partially opened valve.

Due to variations in service demand, the pressure outside the valve will vary. If the demand increases, the pressure will fall.

Let curve A B represent the maximum outside pressure, and curve C D represent the minimum outside pressure, then the area E F G H intercepted between characteristic curves Nos. 1 and 2 and curves A B and C D, will show the total variations in pressure and flow which can be caused by variations in motor speed and variations in service demand.

It is desirable that this area be kept as small as possible, otherwise the motor will require to be of very large capacity to meet the maximum demand, and as the average demand is usually very much lower than the maximum, then the motor will usually be very much under loaded.

The area of fluctuation shown under Fig. 4 is much less than that indicated in Fig. 5. This again shows the importance of the characteristic curve of the pump.

If a synchronous motor be used, then the speed will not vary and only outside variations in the demand will affect the load. Unfortunately, a synchronous motor is not self-starting and requires to be started by some other source, such as an induction motor, bars in the pole pieces of the motor or otherwise. Even with auxiliary starters, it is out of the question to attempt to develop a large starting torque and this fact limits the design of pump, as a pump which requires a low starting torque must be designed. Such a pump will not develop as high an efficiency at full load as a pump which is designed without regard to the necessary starting torque.

The reason for this is that for high efficiency a fairly wide impeller, through which the water will flow slowly, is necessary. Naturally the wider the impeller, the greater is the power required to start the impeller rotating. Therefore, for high efficiencies, where it is not desirable to install a synchronous motor much larger in capacity than actually required at full load, the selection of an induction motor is recommended.

CHARACTERISTIC CURVES OF TWO PUMPS, SHOWING WORKING AREAS

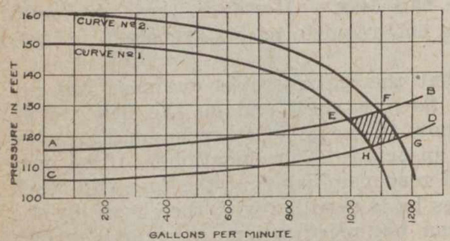

FIG. 4—DROPPING CHARACTERISTIC TYPE

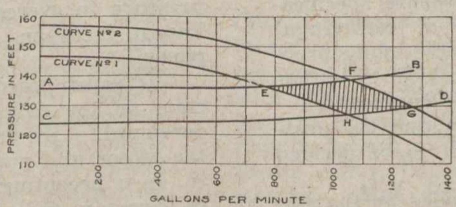

FIG. 5—FLAT CHARACTERISTIC TYPE

An induction motor will vary in speed through variations in line voltage, frequency, etc. However, if the pump is designed so that the area enclosed by the minimum and maximum characteristic curves and the minimum and maximum outside pressure curves is kept small, variations in speed of the motor are not of much importance.

An induction motor is self-starting and can develop full load torque at starting. By using such a motor, the pump designer does not need to consider the starting torque and can concentrate on full load conditions for design.

If the pump is of the non-overloading type, it is possible to use a motor which will operate at practically its maximum capacity without danger of overloading the motor.

An induction motor running considerably under its full load rating has a very deleterious effect on the power factor of the service. The power factor is lowered, thus requiring extra current to operate the motor. This lowering of the power factor also affects the regulation of the generators on the system and increases the line losses.

For the above reasons, it is bad practice to use an induction motor which is too large for the service demanded. A non-over-loading type of pump is essential for good service in order that the motor may be kept small.

No attempt is made in this paper to indicate the most suitable detailed design of pump, but the engineer should pay particular attention to the class of pumps and service in which the manufacturer tendering on his specifications has had experience.

After examining the characteristics of the pump, the engineer should examine the detailed designs to ascertain the accessibility of all interior parts of the pump, the kind of materials to be used, the efficiency guaranteed and all mechanical details.

The corporate title of Gunn Richards, Ltd., efficiency engineers, Montreal, has been changed to W. B. Richards & Co., Ltd.

AMERICAN WATER WORKS ASSOCIATION

Thirty-Ninth Annual Convention in Buffalo Last Week Had Record Attendance—Next Convention to be Held in Montreal

THE thirty-ninth annual convention of the American Water Works Association, held last week in Buffalo, was a complete success. From very small beginnings in 1881, this organization has grown to be an important factor in connection with the design, construction and operation of water works plants and exerts considerable influence in that particular branch of engineering. During this long period the association has always been most intimately linked up with all movements that have been in the best interests of sanitary engineering. Since its founding the association has had but three secretaries, the present officer, J. M. Diven, having filled this position since 1902.

Monday, June 9th, was devoted to registration and the "getting together" of the delegates as they arrived from practically all sections of the United States and Canada. A glance through the list of delegates shows conclusively that the association's membership is very widely scattered, touches every state of the union and every province in Canada, as well as many points in foreign countries. The association's membership practically circles the globe.

Entertainment, Then Business

On the evening of the first day, a most delightful function was held at Hotel Lafayette, where the Water Works Manufacturers' Association acted as hosts at a reception and dance for the members and guests who up to that time had registered. The ball-room of the Hotel Lafayette was cleared and dancing was indulged in until a late hour, after which refreshments were served.

A pleasant surprise on this occasion was the arrival of the well-known band of the Shredded Wheat factory of Niagara Falls, N.Y., accompanied by a pipers' band from the same city. This item was not on the program but it added immensely to the pleasure of the evening.

Tuesday morning, June 10th, at 9 o'clock, the convention proper got down to business, the first item on the program being an address of welcome by the Hon. Arthur W. Kreinheider, Commissioner of Public Works for the city of Buffalo.

At this session Leonard Metcalf, of Boston, read a paper dealing with the effect of the war period, 1914-1918, and public control upon the water works of the United States. This was listened to with a great deal of interest by a large audience and was highly appreciated by those present.

Round Table Discussion

Following Mr. Metcalf's address a round table discussion on means of "Preventing Hydrant Damage by Motor Vehicles and Remedies Therefor," was indulged in as well as a general discussion on the "Placing of Post Fenders Around Hydrants;" "The Moving of Hydrants from Curb to Building Line," together with an exchange of experiences, all of which brought out some very interesting points that will probably prove helpful to the water works men who were present.

In the afternoon of the same day the meeting opened with a paper by John Knickerbocker, president of the Eddy Valve Co., on "An Investigation of Question of Flanges for Light Cast-Iron Pipe." An excerpt from this paper appears on another page of this issue.

Papers Read at Convention

Following this paper Nicholas S. Hill, Jr., who is chairman of the "Committee on Private Fire Protection Service," presented the report on that subject.

The evening session opened at 8 o'clock, with a paper by H. F. Wagner, chemist of the Bureau of Water, Buffalo, on "Buffalo Water Supply, with Special Reference to the Filtration Problem." At this session George C. Andrews, Water Commissioner of Buffalo, N.Y., read a very interesting paper on "The Reduction of Water Consumption by Means of Pitometer Survey and Constant Inspection," an abstract of which appears on another page of this issue. Another paper read at this session was that of D. A. Decrow in which he went into a description of the development of the "Unaflow" pumping engine. This was particularly interesting inasmuch as arrangements had been made by a local pump manufacturer for the display of an engine of this type, especially for the inspection and information of the delegates to the convention. This engine was the centre of interest on the occasion of the delegates' visit the following day to the Porter Ave. pumping station where it was again interestingly described by Mr. Decrow.

At this same session a paper by John Oliphant, of the Sullivan Machinery Co., on "Air Lift and Water Purification" was read by a substitute, Mr. Oliphant being unavoidably absent on account of sickness. This paper will appear in an early issue of *The Canadian Engineer*.

By courtesy of the American Water Works Manufacturers' Association, the ladies of the party were that evening tendered a party at Shea's Theatre.

Montreal Gets 1920 Convention

The Wednesday morning session opened with a paper by John A. Kienle, the genial hard working secretary of the American Water Works Manufacturers' Association, on "The Relation of the Chemical Industry of Niagara Falls to the Water Works." This was illustrated by a large number of interesting slides and was thoroughly appreciated by his hearers, of which there were many.

Incidentally it might be in order here to refer to the unusual interest that was taken in the meetings of the convention. Almost every technical session of the convention was well attended in spite of the fact that the room, being situated in the corner of the building and between two car lines, was not the best place in which to hear the speakers.

Following Mr. Kienle's paper there was a symposium by government officials and others on the trend of prices; reports of officers, standing and special committees, as well as a report of the committee on electrolysis.

Invitations were received from the following cities for the holding of the convention next year: Philadelphia, Pa.; San Francisco, Cal.; Detroit, Mich.; Tampa, Florida; Asbury Park, N.J.; Atlantic City, N.J.; Washington, D.C.; Saratoga Springs, N.Y., and Montreal, P.Q. Under the association's constitution it is necessary for any city or place to receive the convention that it should have a majority of the votes cast. There being 121 votes cast, it required 61 votes in order to swing the convention. After the votes had been taken the scrutineers reported that Montreal had secured 62 votes, the nearest other city being Detroit, which polled 29, so that the next place of meeting will be Montreal.

Visit to Pumping Station

On the afternoon of Wednesday, June 11th, the city of Buffalo provided a sail on Lake Erie on the steamer "Canadiana." After sailing around the lake for about two hours, the boat pulled alongside the Porter Ave. pumping station of the Buffalo water works, but unfortunately was unable to land owing to the shallowness of the water. This did not, however, prevent the local water works officials from seeing to it that the 500 delegates and guests who took the trip should see the plant, for immediately upon returning to the city dock, automobiles were provided which took the delegates to the pumping station, where a very pleasant hour or or two were spent looking over the plant. Refreshments were served and return was made to the city by motor cars. A group photograph was taken on the steps of the pumping station.

That evening the ladies of the party were guests of the Water Works Manufacturers' Association at the Lafayette Hotel, at a card party, while the men were invited to a smoker at the Hotel Statler.

The first session of Thursday, June 12th, was devoted to the reading of papers by William H. C. Ramsay, on "The Water Distribution Systems of Industrial Housing Problems for Shipbuilders"; and Dabney Maury, on "Water Supply for the Cantonments and Other Construction Division Activities." In the afternoon the Water Works Manufacturers' Association took the delegates and guests to Niagara Falls, from which point they returned at their convenience and the evening was left open.

The convention officially closed at noon of Thursday, although on Friday, June 13th, there was one session of an informal character.

There were very few changes so far as chairmen of the standing committees are concerned. Lieut.-Col. Geo. A. Johnston again heads the Finance Committee, W. W. Brush takes the place of Mr. Davis as chairman of the Publications Committee, and Frank C. Jordan was appointed chairman of the Membership Committee.

Officers Elected

The new officers elected for the coming year are as follows: President, Carleton E. Davis; vice-president, Capt. M. G. Worrell; treasurer, James M. Caird; trustees (term expiring 1922) W. H. Randall and J. C. Jordan.

Too much praise cannot be given to George C. Andrews, Water Commissioner of Buffalo, chairman of the local entertainment committee, and his associates, for the very excellent manner in which they handled that end of the convention. They were ever at the beck and call of the delegates and their kindly and willing disposition to put themselves at the call of the visitors had not a little to do with the success of the convention. The Buffalo convention will long be remembered by all of the delegates and guests who were privileged to be there. Buffalo has set a standard which other cities will find it difficult to exceed. Every courtesy was shown the visitors and each member of the local committee tried to outdo the others in the warmth of the welcome.

A most important feature of the convention this year was the exhibit hall. Every available inch of space was taken—in fact, some exhibitors felt that their space was insufficient adequately to display their goods. It was a busy place all week, and those who went about it were really inquirers. Probably it was because the war was over and there was a different environment on that account, but whatever it was, there was an atmosphere of genuine interest in the exhibits on the part of the delegates.

There were more individual exhibitors than have characterized any other previous convention. Sixty-eight members of the Water Works Manufacturers' Association were there with their representatives, which is a record, the largest number on any previous occasion having been fifty-two.

List of Exhibitors

The following firms had space: American Manganese Bronze Co., of Holmesburg, Pa.; Arnold Hoffman & Co., Inc., New York City; Birch Hintz Manufacturing Co., Chicago; Bingham & Taylor, Buffalo, N.Y.; Buffalo Meter Co., Buffalo, N.Y.; Builders' Iron Foundry, Providence, R.I.; Carbic Manufacturing Co., Duluth, Min.; Central Foundry Co., New York City; Chicago Bridge & Iron Co., Chicago and Bridgeburg, Ont.; H. W. Clark Co., Matton, Ill.; Darling Pump and Manufacturing Co., Williamsport, Pa.; Du Pont De Nemours & Co., Philadelphia Pa.; Eddy Valve Manufacturing Co., Waterford, N.Y.; Electro Bleaching Gas Co., New York; Flower Valve Manufacturing Co., Detroit, Mich.; Ford Meter Box Co., Wabash, Ind.; Gamon Meter Co., Newark, N.J.; Garlock Packing Co., Elmira, N.Y.; Hayes Manufacturing Co., Erie, Pa.; Hersey Manufacturing Co., South Boston, Mass.; Hauck Manufacturing Co., Brooklyn, N.Y.; Kennedy Valve Manufacturing Co., Elmira, N.Y.; Lock Joint Pipe Co., Ampere, N.J.; Leadite Co., Philadelphia; Lead Lined Iron Pipe Co., Wakefield, Mass.; Worthington Pump and Machinery Co., New York; Mueller Manufacturing Co., Decateur, Ill., and Sarnia, Ont.; Modern Iron Works, Quincy, Ill.; Multiplex Manufacturing Co., Berwick, Pa.; National Meter Co., New York City and Winnipeg, Man.; Neptune Meter Co., New York and Toronto; Sullivan Machinery Co., Chicago and Toronto; New York Continental Jewell Filtration Co., New York and Montreal; Pennsylvania Salt Manufacturing Co., Philadelphia; Pitometer Co., New York; Pittsburg Filter & Engineering Co., Pittsburg, Pa.; Pittsburg Meter Co., East Pittsburg, Pa.; Pittsburg Des Moines Steel Co., Pittsburg and Chatham, Ont.; Renssalear Valve Co., Troy, N.Y.; Ross Valve Manufacturing Co., Troy, N.Y.; A. P. Smith Manufacturing Co., East Orange, N.J.; Simplex Valve and Meter Co., Philadelphia, Pa.; Thomson Meter Co., Brooklyn, N.Y.; Union Water Meter Co., Worcester, Mass.; United Brass Manufacturing Co., Cleveland, Ohio; United Lead Co., New York; Wallace & Tiernan Co., New York; Waterworks Equipment Co., New York; R. D. Wood & Co., Philadelphia, Pa.; Flexible Armoured Hose Co., Buffalo, N.Y.; W. & L. E. Gurley, Troy, N.Y.; United States Rubber Co., New York.

The approximate number of active members, associate members and guests who registered at the convention was nine hundred.

ASPHALT ASSOCIATION NOW FORMED

REPRESENTATIVES of the principal asphalt-producing companies of the United States and Canada have completed the organization of "The Asphalt Association." Its purpose will be to disseminate information, with particular reference to highway and street paving, co-operating with city, county and municipal officials and with scientific bodies and colleges seeking to bring about the most effective methods in the use of asphaltic materials.

The officers elected for the ensuing year are as follows: President, J. R. Draney; vice-president, W. W. MacFarland; treasurer, N. G. Luykx.

The secretary, who will be the active officer in charge of the affairs of the association, is J. E. Pennybacker, formerly Chief of Management of the U. S. Bureau of Public Roads, and during the war period, secretary of the U. S. Highway Council.

The New York office will be 15 Maiden Lane. Offices will be established soon at Chicago and Atlanta and ultimately in Canada and other cities in the United States.

The south sewage interceptor, for which the Essex Border Utilities Commission let contract last October to the Shand Engineering Co., has been started, and the contractors recently installed a Parsons trench excavating machine. A layer of water-bearing sand, about 4 or 5 ft. thick, is on top of soft, blue clay. Contractors have previously experienced difficulty in laying sewers in that vicinity through neglect in not using tight sheeting to protect the work. The Shand Engineering Co. expect to follow up the machine closely with sheeting, and they state that they believe that they will be able to make a record in sewer construction in excavation of that type.

Tenders are being received until June 28th, by F. P. Brady, general manager eastern lines of Canadian National Railways, for grading for double track divisions between Ste. Rosalie and Charlotte, Chandier sub-division; also for grading for double tracking at Moncton, N.B., on the St. John sub-division, a distance of about 3½ miles. Grading for one additional main line track for about 9¼ miles on the Amherst sub-division from Springhill to Maccan will be done, and also similar work on the Truro, sub-division, a distance of about 7½ miles between Truro and Belmont. Plans and specifcations are on file at the offices of the general manager of eastern lines at Montreal; of the chief engineer at Moncton; resident engineers, Levis or Truro.

Plans for the filtration plant at Ojibway, Ont., have been completed by Morris, Knowles, Ltd., consulting engineers, of Windsor, Ont., and a small amount of construction work has been done in an experimental way, but no contracts have yet been let for work on a large scale. The Essex Border Utilities Commission is considering a combined water supply system for the various municipalities in the district, and it is expected that the matter will be voted upon by the people at an early date. The citizens will be asked whether they are in favor of consolidating the existing works under one management, with one large system eventually for the entire district. It is hoped that by combining the systems greater economy in operation can be attained, together with better supervision of the supply.

BUFFALO WATER SUPPLY, WITH SPECIAL REFERENCE TO THE FILTRATION PROBLEM*

By H. F. Wagner
Chemist, Bureau of Water, Buffalo, N.Y.

IN a great many cases when people express their ideas of a pure wholesome water it is in very indifferent and unconcerned terms. Yet three-quarters of the earth's surface, comprising the seas, rivers and inland lakes is covered with it in various degrees of purity. It is in the air as vapor. In the frigid zones the year around and in large sections of the temperate zones in winter it is present in great quantities as snow and ice. It is the principal constituent of plants and animals, and all rocks and minerals hold their percentage of water. In fact it is so essential to our daily livelihood, and generally so easily obtained and in such unlimited quantities, that few give it a thought other than it is necessary to existance. As to the purity, too many are apt to think lightly of it, and inclined to discourage steps advocated to obtain a purer supply, even in this late day of scientific knowledge and research. Security is felt in the fact that contaminated water can be drunk with a certain degree of impunity by healthy persons, and also that habitual users of water polluted by faecal material in some cases do become immune from certain diseases. However, should the health become impaired, and the organs of the body fail to work as usual, it is then that the active germ, too often, gets in its deadly work.

Chemical Characteristics

Not only is the purity of water to be considered from the bacteriological standpoint, but also as regards its chemical characteristics. The amounts of salts known as mineral solids dissolved in a water and upon which its palatableness depends will to a large extent influence a decision as to its wholesomeness. Waters containing large proportions of magnesium or sodium salts are purgative as is generally well-known. Very hard waters have caused constipation and dyspepsia and the origin of other ailments have been laid to the same source. The great variety of waters on the market are dependent upon their mineral or non-mineral content to make good the claims of those promoting their sale. The so-called lithia waters find favor because of the lithium salts supposed to be dissolved in them as do the sulphur waters for their sulphur content. Carbonated waters, whether they be natural or artificial, owe their sparkling brilliancy and refreshing properties to the carbon gas absorbed and which become so tasteless and unpalatable upon standing exposed long enough to allow the gas to escape. Distilled water is flat and unpleasant to drink because the distilling process removes the dissolved mineral matter as well as expells the air held in solution. Fortunately not many of our principal sources of supply are so affected as to render them unfit for use as potable waters. Our chief concern is to protect them from pollution or if polluted to treat them scientifically in order to render them safe for all purposes.

These lines which I have just read, gentlemen, are simply a few of the guiding factors influencing the labors of the water analyst. The rest of this paper is devoted to an account of the water supply and system of Buffalo and its possible future developments.

Niagara River Inlet

The Niagara River Inlet, or intake, up to 1914 was the only source of supply of the city of Buffalo. It was first built in 1870, enlarged in 1895 and reconstructed in 1906. These earlier periods were in that age when it was held that running water purified itself. The current here is from 8 to 10 miles per hour, and it was thought that a pure water would be obtained. The structure itself was quite a notable task for that period. Its foundation is laid upon the bedrock of the river and extends up stream for about 25 feet in a triangular-shaped mass of stone and cement, to break the force of ice floes which strike here with considerable force. The intake was intended to supply the pumping station at Massachusetts Avenue, but during the last few years it proved wholly inadequate for the rapidly growing demands upon it. In the winter and spring time when ice was running in the river it often became plugged with slush and anchor ice, so that gangs of two and three hundred men were required to work with shovels, scoops and steam lines in order to keep the water level in the suction well. This supply also often became heavily contaminated by the harbor waters. Since the new crib, called the Emerald Channel Inlet, was completed at the head of Niagara River, in Lake Erie, with tunnels to supply both the Massachusetts Avenue station and the new station at Porter Avenue, the old intake has been abandoned.

Emerald Channel Intake

The Emerald Channel Intake, started in 1905 and completed in 1914, is a model of its kind. It is a circular structure, with an outside diameter of 110 feet. The enclosing wall is of concrete, 20 feet, leaving an interior chamber 70 feet in diameter. From the bottom of the lake and extending 2 feet above the mean water line, concentric steel shells ⅜ in. thick, incase the concrete wall inside and out. This wall extends 15 feet above the lake level. On the top, and set back 5 ft. from the edge, leaving a balcony clear around, is a brick wall 8 feet high. An ornamental iron railing encircles the balcony. The whole interior is roofed over with concrete, covered with tile, and the other, half-way with heavy glass, all supported by steel trusses. The water is admitted into the interior chamber by 12 ports, 6 by 6, and are opened and closed by stem operated gates. It has been found, however, that by keeping them open and thus lessening the force of the current flowing into the interior, that there is less danger of anchor and slush ice plugging the gates. By this practice there is scarcely any preceptible current and the water is at lake level. In the centre there is a shaft 12 ft. in diameter which extends 60 ft. below the surface and connects with and carries the water to the tunnel leading to the pumping stations. This is a 12 ft. arched tunnel driven through limestone rock and has an 18 in. concrete lining.

This tunnel is intercepted on shore by a second shaft, from which part of the water flows to the pumps at Porter Avenue by open canals and the rest is carried by a 9 ft. tunnel to the Massachusetts Ave. Station. There are installed on the pier, two 100 h.p. boilers for furnishing heat and also to run a 10-kilowatt generator, which provides current for lighting the building, including the fixed signal light, which the government requires to be maintained as an aid to navigation. The Massachusetts Avenue Station is 640 ft. in length and 102 ft. in width and a modern fireproof building throughout. It houses six 30-million gallons vertical triple expansion pumps and two electric pumps of 25 million gallons each. The electric pumps have been in disuse for several years, and it is not expected that they will be put in operation again. The steam pumps are operated with 150 pounds of saturated steam, which is produced by 16 horizontal tubular boilers of 300 h.p. each, and four Heine water tube boilers of 600 h.p. each. At the present writing, but one pump at this station is in operation. The others, however, can be thrown into service at short notice should they be required.

Porter Avenue Station

The bulk of the water is supplied by the new station at Porter Avenue, which was put into operation in 1914. This plant, I believe, is the largest of its kind under one roof, and was constructed and equipped at a cost of about two-and-one-half million dollars. Then engine room is 95 ft. by 364 ft. and foundations are laid for eight pumps. Up to the present, five have been erected and are in use. The boiler room is to the rear of the engine room and there is space for 16 boilers. Eight are installed at present and are the sectional water-tube boilers of 750 h.p. High pressure steam is utilized at this station of about 250 pounds and

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*Paper read at the 39th Annual Convention of the American Water Works Association, June 9th to 13th, at Buffalo, N.Y.

100° of superheat. From this data it can be seen that the total pumping capacity of the two stations is about 380 millions, and by the addition of three more pumps we could furnish over 400 million gallons of water.

Distribution System

The distribution is through two systems—the high and low. The initial pressure on the high service ranges from 80 to 90 pounds and on the low service 42 to 50 pounds. The high-pressure system, in general, takes care of the newest and highest sections of the city, while the low, the older and lowest sections. In all, water is distributed through over 600 miles of pipe, from 1½ to 60 ins.

As a gauge to the rate of pumping and to minimize the pulsations of the pumps there is located in the north-eastern section of the city a steel water tower 40 ft. in diameter and 85 ft. in height. It stands on an elevation of 106.31 feet above the lake level, and when filled to a depth of 75 ft., holds 704,970 gallons. In the eastern section of the city, we have what is known as the Prospect reservoir. It covers 20 acres of land, and when filled to a depth of 30 ft., holds 116,313,827 gallons. At this stage the water surface is 113 ft. above the pumping station. The tower is supplied by the high service and the reservoir by the low, and by keeping the water in them at certain levels, a constant and uniform pressure is obtained throughout the city. In other words, the speed of the pumps and number in use at any time is dependent upon the height of the water in these reserve supplies. This information is phoned to the pumping stations every half hour and action taken thereon accordingly.

As to the purity of our water supply I think I am quite safe in saying that, without any treatment at all, it is as good as any that is available to cities having Lake Erie as their source of supply. The greatest contamination occurs during the summer months and a large percentage is due to freight and passenger vessels, which generally use the north channel entrance to Buffalo harbor, which course takes them within less than 1,000 feet of the inlet crib and on the upper side.

Contamination by Excursion Boats

Upon the opening of the summer resorts, a short distance above on the Canadian shore, several excursion boats ply back and forth from Buffalo hourly. These boats carry thousands of people daily and with no restrictions or discrimination for the disposal of their sewage. This constitutes a great menace, as excreta from this source may easily pass into the water supply and in a fresh and virulent state. The shore drainage adding to the pollution, while considerable, is not necessarily excessive, as there are no cities of any size above us whose sewage might find its way into our water supply. There are several streams flowing into the lake within easy radius of Buffalo, but they are small and tendency is for them to follow inshore as the extensive use of floats has proven. In the winter time, after navigation closes and especially after the ice has formed, the water is of a most excellent quality. The bacteria count obtained on 37° agar is very low. There is one aspect, however, which has to be given weight, and that is with reference to the condition arising as a result of the hundreds of fishermen who go out on the ice to fish. The excreta which these people leave upon the ice is a constant menace to the water supply, more so at thaw periods and acutely so when upon the coming of spring the ice breaks up and all is carried in the direction of the crib. It can be seen, therefore, how most of the contamination occurs at uncertain periods. This condition makes it necessary that chlorine be added to the water in sufficient quantity to take care of the high wave at all times even though the dose may be in excess of that actually essential three-quarters of the time.

Chlorinating Apparatus

Owing to the fact that the chlorine treatment has been elucidated many times before on occasions similar to this, I have not gone extensively into details. Our chlorination apparatus is located at the intake pier, where the chlorine solution is injected into the mouth of the 12-ft. arched tunnel. This, therefore, affords a run of over a mile in a leak-proof tunnel and ideal conditions for sterilization. We are using a chlorinating apparatus formerly manufactured by the Electro Bleaching Gas Co., and is the float meter type. The float in this apparatus is about 3 in. long, and has never caused us any trouble from sticking, as has been the case where the small indicator was used. Our chief trouble with this apparatus has been caused by the clogging up of the pressure reducers, which require taking apart every once in a while and cleaned. Generally, it is necessary to replace the old diaphragms with new ones when this is done.

The amounts of chlorine used ranges from an average of .16 parts per million to an average of .28 parts per million. These figures are equivalent to about 1 pound and 2½ pounds per million gallons.

Standards of Safety

I do not believe in any set and fixed standard for a safe water. In other words, the same standard is not applicable to any two waters, and when such is aimed at there is certain to be a variation, one from the other, in actual practice. A set standard will be hard to abide by because of the great difference in the kind and character of the pollution, or, while the standard may be too severe in some cases, it is not severe enough in others, and, therefore, misleading. A standard is no sooner proposed for certain conditions than it is at once grasped and applied to a great variety of conditions. Our standard and procedure is that the bacteria count on 20° agar is a gauge of the efficiency of the sterilization plant, and means nothing as to whether the water is safe or not. The real knowledge is obtained from the test for organisms of the Bacillus group. Of the different kinds of media in use, I do not believe we are far enough advanced to say standard media—I prefer lactose peptone bile. Our own standards are that we aim to eliminate gas formers to the extent that negative tests are obtained on four out of five 5 c.c samples of the treated water.

To sum up the various points which have been gone over, it is evident that we have a most excellent water system, in that we have an adequate distribution system, an abundant supply and of fine quality, from the bacteriological and chemical viewpoints. Physically, the condition of the water is open to severe criticism from 10 to 15% of the time. This brings us to the subject of filtration. A glance at a map will show that Lake Erie lies to the west by south-west from Buffalo. It is from this direction that come the winds which render our water supply turbid, and when we are told that we need a filter plant. These winds prevail principally during the fall months, when our highest turbidity occurs. Compared to some waters, this is not at all bad, as 250 parts in a million is about the maximum. It consists principally of very finely divided clay, the percentage of organic matter being very small. Generally, the sediment is offensive for from three to six days at a time, for the sediment is quite heavy and settles rapidly as soon as the disturbing element is removed, and the second day after a blow the water has improved 50%. In all, the water is noticeably turbid from 30 to 60 days of the year.

Suggested Filter Site

In planning for a filtration plant in Buffalo, consideration must be given to the following points: First, do the prevailing conditions of the water as herewith set forth warrant such an expenditure? Secondly, the water consumption must be reduced to a reasonable figure and waste reduced to a minimum before such a project is feasible. Lastly, and perhaps the most difficult problem, is the suitable location for a filter plant. When the waterworks were originally laid out it seems the idea that Buffalo might have such a plant was not thought of, or at least no provision was made for its possible location. As to the proposition that the water be pumped to an elevation outside of the city and returned by gravity, I would explain that we are here handicapped by the flat nature of the country around us. To secure an

(Concluded on page 559)

ECONOMICAL SECTION OF WATER CONDUIT FOR POWER DEVELOPMENT*

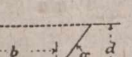
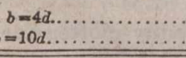
VERY little information has been published regarding methods of determining the economical section of a conduit for supplying water to a power plant. For this reason a paper prepared by Cary T. Hutchinson, consulting engineer, New York, for presentation at the spring meeting of the American Society of Mechanical Engineers is of particular interest.

In what follows a formula for the best slope and size of conduit is deduced, which takes into account in a practical manner the construction costs, the value of the power recovered, and the rate of returns expected on expenditures made, as well as the other physical conditions of the problem. The resulting relation between the best area and the quantity of water is shown in Fig 2, for chosen values of factors entering the problem, and it is pointed out how, by a simple modification of the graphs of this figure, the relation for other costs and unit prices can be easily determined. One interesting result is that for a flume, or for any conduit, for which the increment cost for increasing the capacity by a relatively small amount is proportional to the surface, the best speed of flow of the water is constant, independent of the size of the conduit.

The economical section is evidently that resulting in the greatest net earnings of the power plant under the conditions controlling the market where the power is delivered. Inasmuch, however, as this section must be determined in advance of complete knowledge of market conditions, it is clear that only an approximation can be made, and that a ready method to determine the variation in net earnings for a large range of sections and shapes of water conduit may be useful.

Assuming that a certain shape and slope of water conduit is fixed upon provisionally, the question is whether some change either in the slope or in the shape or size of the section will result in an increase in net earnings. Any increase in the dimensions of the conduit will obviously entail an increase in construction cost, and hence an increase in annual charges. This increase in annual charges is limited, practically speaking, to interest, amortization and profit, inasmuch as only small changes in a quantity which itself is a small part of the total are under consideration. For instance, under ordinary conditions the loss in the water conduit may vary from, say 5 per cent. to 10 per cent. of the total power; it is a variation of possibly 25 per cent. one way or the other in this 5 per cent. or 10 per cent. that is involved.

TABLE 1—VALUES OF SECTION CONSTANT (a) FOR VARIOUS SECTIONS

Shape of Section	Hydraulic Radius	Cross-Section	Section Constant	
			a	$\sqrt{a}$
Semicircle, radius = r	$r/2$	$\pi r^2/2$	2π	2.51
Square, side = d	$d/3$	d^2	9	3.00
Half-square, depth = d	$d/2$	$2d^2$	8	2.83
Hexagon, half-full, depth = d 	$d/2$	$\sqrt{3}d^2$	$4\sqrt{3}$	2.55
Prism: 				
Tan a = 1/1.5, b = 4d	0.72d	5.5d^2	10.6	3.26
Tan a = 1/2, b = 10d	0.83d	12d^2	16.0	4.00

It is therefore evident that no increase in operating charges, or maintenance or repairs need be considered, and that the changes in design of the conduit should carry charges only for interest, amortization and profit. An allowance for profit on the additional expenditure must be included, since every dollar invested should earn its share of profit as well as its fixed charges.

The increase in power resulting from an increase in the size of the conduit brings in a certain addition to gross earnings. Against this, in theory, should be charged the costs of operation and maintenance on the additional equipment and machinery required to deliver this power to the market; but for the same reasons stated, in considering the water conduit all these charges against the additional gross earnings may be ignored in this analysis, as they are negligible in amount, due to the fact that the increase in the power output is small. There would, in fact, be no increase in operating charges, and under practical conditions there would be no increase in equipment, and therefore no increase in fixed charges on equipment.

The matter then reduces to the comparison of the additional gross earnings from the power recovered by an increase in the size of the conduit on the one hand, and the additional interest, amortization and profit on the cost of the enlargement of the conduit on the other.

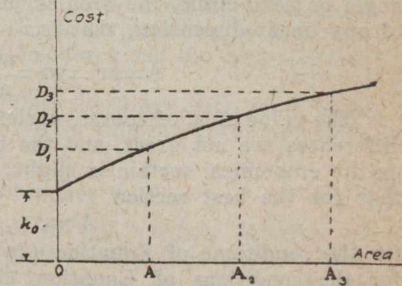


FIG. 1—RELATION BETWEEN SECTIONAL AREA OF CONDUIT AND COST

The determination of additional power is simple, involving merely the overall efficiency from the water to point of delivery. A consideration of the value of this increased power is a matter of judgment on the part of the engineers and executives of the enterprise, giving attention to the market conditions under which the power is sold, and particularly to the load factor.

The determination of the additional cost of the conduit, however, is more difficult, inasmuch as this cost depends in theory not only on the area of the cross-section of the conduit, but also upon its shape; that is, upon the hydraulic radius of the wetted perimeter. The relation between the area and the wetted perimeter differ, for example, for a rectangular, a circular or a hexagonal conduit, and cannot be expressed in a simple equation to cover all shapes of conduit. The practical way to handle the problem is to fix upon one shape of conduit, determine the economical area and slope for this shape and then follow out a similar procedure for such other shapes as may be practicable in the case under consideration. This determination being made for the several possible shapes, the best result is then selected.

The procedure indicated in the foregoing general discussion can be expressed symbolically as follows:—

Let Q=flow in sec. ft., taken as constant.
L=length of conduit, ft.
A=area of conduit, sq. ft.
s=slope of conduit, ft. per ft. of length.
r=hydraulic radius of conduit, ft.
w=wetted perimeter of conduit, ft.
v=speed of flow, ft. per sec.
C=constant in the Chézy formula.
e=efficiency from water to point of delivery × 0.085.

Then the power loss p in the conduit in kilowatts will be

$$p = eQsL \quad \text{.....................} (1)$$

In this equation s is the variable, and any change of p is due to a change of s and is expressed by

$$dp = eQLds \quad \text{....................} (2)$$

If m is the annual value of one kilowatt under the ruling conditions, then

$$mdp = meQLds \quad \text{..................} (3)$$

is the added gross (and net) earnings due to the change in s.

As to the cost of increasing the capacity of the conduit, the flow is assumed to be given by the Chézy formula

*Excerpt from paper read before the spring meeting of the American Society of Mechanical Engineers.

$$v=\frac{Q}{A}=C(rs)^{0.5}\dots\dots\dots\dots(4)$$

The best size of conduit is to be determined for a known value of the flow Q; that is, in Equation (4) Q is to be taken as constant. In this case,

$$\frac{d\,Q}{d\,s}=0$$

$$\frac{dA}{ds}=-\frac{2A}{5s};\quad \frac{dW}{ds}=-\frac{1w}{5s};\quad \frac{dr}{ds}=-\frac{1r}{5s}\dots\dots(5)$$

With Q constant, a change in s can be offset by a change in either A or r, or in both; that is, either the size or the shape of the conduit can be varied to keep Q constant.

There is no way of expressing a general relation between A and r, but for any chosen shape, as, for example, a rectangle or semi-circle, the area is proportional to the square of any linear dimension; that is,

$$A=ar^2=wr=\frac{w^2}{a}\dots\dots\dots\dots(6)$$

The value of a, of course, varies, but for usual forms the differences are not great, and the influence of changes in a on the economical section is slight; in fact, it can be shown that for the best section

$$A\sim a^{1/7}$$

for the conditions of Equation (7a). Table I. gives values for the conditions of Equation (7a). The accompanying

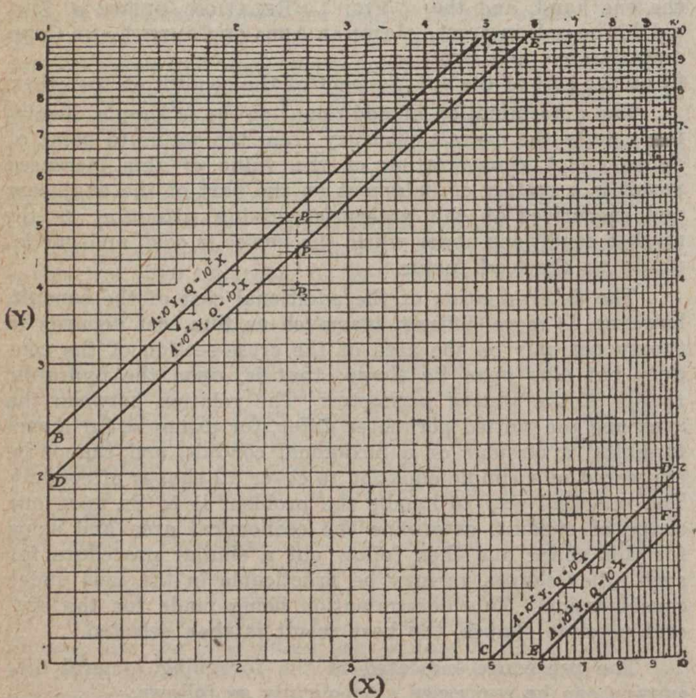


FIG. 2—LOGARITHMIC GRAPH OF EQUATION 18 FOR VALUES OF Q FROM 100 TO 10,000 SEC. FT.

table gives value of a for the usual shapes. For preliminary calculations a=9 may be used.

The cost of a water conduit can be expressed as a constant, representing the cost of a large part of the preliminary work and plant, plus an amount depending on the size and surface area. In general, the cost per foot may be expressed by

$$D=k_0+kA^n\dots\dots\dots\dots(7)$$

where D=cost per foot, dollars

k_0=constant part of cost per foot

k =a constant

n =an exponent whose value lies between 1 and 0.5.

In any specific case, when all the conditions are known, estimates of the total cost per foot of the conduit should be made for three or more different cross-sections; plotting these values will enable both k and n to be determined.

For example, let Fig. 1 represent the cost per foot for a certain conduit; then k_0 is given at once by the curve, and from

$$\frac{D_2-k_0}{D_1-k_0}=\left(\frac{A_2}{A_1}\right)^n$$

n is determined. Each pair of points should be used and the value of n found. The values of n and k_0 being known, k may be obtained from

$$k=\frac{D_1-k_0}{A^n}.$$

Other methods could be used. The gist of the matter is that the accurate way is to make detailed estimates for several cross-sections and determine the constants from an analysis of these estimates.

Two extreme cases simplify the formula: First, when the increment cost is proportional to the area, as in a heavy rock cut, then

$$D=k_0+kA\dots\dots\dots\dots(7a)$$

and, second, where the increment cost is proportional to the surface, or the wetted perimeter, as for a flume, then

$$D=k_0+kA^{0.5}\dots\dots\dots\dots(7b)$$

These are considered later.

If i represents the total rate of returns expected on all expenditures on the property, including interest, amortization and profit, then

$$I=iL\ (k_0+kA^n)\dots\dots\dots\dots(8)$$

gives the total returns from this investment, and a change ds in s calls for a change in returns of

$$dI=niLkA^{n-1}\frac{dA}{ds}\ ds\dots\dots\dots\dots(9)$$

or, from Equation (5)

$$dI=-\frac{2niLkA^n}{5s}\ ds\dots\dots\dots\dots(10)$$

This saving, due to an increase in s, must be at least equal in value to the power lost, and indeed should exceed it by some margin; this margin can be included in the overall rate of return i, and therefore

$$dI=mdp\dots\dots\dots\dots(11)$$

Substituting in (11) from (10) and (3), there results

$$5meQs=2kniA^n$$

Substituting further from (6) and (4), namely,

$$s=\frac{v^2}{C^2r}=\frac{v^2}{C^2(A/a)^{0.5}},\ \text{and}\ Q=Av,$$

giving finally

$$A^{n-0.5}=\frac{2.5mea^{0.5}}{nikC^2}v^3\dots\dots\dots\dots(12)$$

This may also be written

$$A^{(n+2.5)}=\frac{2.5mea^{0.5}}{nikC^2}Q^3\dots\dots\dots\dots(13)$$

If

$$N=\frac{2.5mea^{0.5}}{nikC^2}\dots\dots\dots\dots(14)$$

then

$$A^{(n+2.5)}=NQ^3\ \dots\dots\dots\dots(15)$$

The best way to handle this equation for engineers is by logarithmic plotting. From (15)

$$\log A=\frac{\log N}{(n+2.5)}+\frac{3}{(n+2.5)}\log Q\dots\dots\dots\dots(16)$$

When n is known, this can be readily plotted for any range of Q desired. As an illustration, assume:—

$$m=\$10,\ e=0.67\times0.085=0.057$$
$$i=0.15,\quad C=120$$

then

$$N=\frac{10^{-3}\times2}{nk}$$

If, further, n=0.75 and k=$0.10,

$$n=10^{-2}\times2.67$$

and

$$\log A=\frac{\log 10^{-2}\times2.67}{3.25}+0.925\log Q$$
$$=-0.485+0.925\log Q\dots\dots\dots\dots(18)$$

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REDUCTION OF WATER CONSUMPTION BY MEANS OF PITOMETER SURVEY AND CONSTANT INSPECTION*

By George C. Andrews
Water Commissioner, Buffalo, N.Y.

IN 1897, the Buffalo common council decided it more advantageous to its citizens to install more pumps and give practically an unlimited supply of water than to control consumption by means of meters. It is hardly necessary to add that this decision was made contrary to sound engineering advice. Free water is a slogan that often appeals to the unthinking. It would be interesting to speculate on what that decision has cost the citizens of Buffalo in the past twenty-two years. Suffice it to say that, in 1903, the Bureau of Water had a bonded debt of $3,699,382, while it was $12,141,524 in 1917. From that date until 1917 it was a race between the unchecked waste, both in mains and in houses, and the pumps.

In 1903, there was one pumping station, with a daily capacity of 183,000,000 gallons. In 1917, there were two pumping stations with a combined daily capacity of 330,000,000 gallons. Coincident with the increased pumping capacity, large distributing mains were laid. During this period the per capita consumption had ranged between 302 and 339 gallons per day. Of this practically 100 gallons was for industrial use.

Commission Introduced Economies

In 1916, the city government was altered and a commission of five men elected to govern the city. Their platform was an economical and efficient city government, and one of the early efforts was an investigation as to means to reduce the city water consumption. As all water used must be pumped from Lake Erie, against a head of 140 to 204 feet, a reduction in pumpage would make an immense saving in coal used for fuel. Various methods were considered, and in the spring of 1917 it was decided to have a pitometer survey made of a small section of the city with the idea of covering the whole city later, should this section show satisfactory results. The question of metering was considered but rejected on various grounds, some of which were: Popular local prejudice against metering; length of time to completely meter city, there being over 76,000 unmetered and active services, while the pitometer method promised early results; extensive changes in plumbing required should meters be installed in many of the poorer types of dwellings; and heavy initial investment required for meters.

To faciliate the work and also that definite records could be obtained of water consumption in different points, the city was divided into ten sections, none of which were similar in character, and work was completed by sections.

City Divided Into Sections

Section 1 includes manufacturing use and poor, good and high grade residential districts.

Section 2 is an old residential section with most of the buildings ante-dating the modern sewer and water service. In this section the toilets are usually of the so-called anti-freezing type installed in a shed in the rear of the house. The waste in this section was tremendous.

Section 3 is a section of the city sub-divided in the 90's, when water mains, sewers and services were laid. This section is only now being developed. The residences built are of fair construction. In this section the rock lies close to the surface and in many streets water mains and house services are laid in the sewer trench. The value of the pitometer was proven in this section as ever-leaking unfinished supplies which were discharging into the sewers were discovered and stopped. Along Fillmore Ave., quarries had been opened years ago and water from a broken 16-inch main discharging into the face of the pit had for years furnished excellent water for men and teams working in the quarry.

Section 4. Principally high class residential, such as the Delaware Park section. Western portion, however, heavy manufacturing use of water and poor class dwelling. 75% of this section is built on rock strata close to the surface.

Section 5. High class residential principally, with eastern portion of middle class dwellings. No manufacturing use of water.

Section 6. This section takes in the heart of the business section of the city. Northern portion is composed of middle class dwellings but 80% of water is used commercially.

Section 7. Poorer class dwellings and large manufacturing use of water. All the big packing houses and stockyards are included in this section.

Section 8. This section includes most of the water front of the city, with large manufacturing plants and commercial use of water. Poor class of dwellings and the oldest section of the city.

Sections 9, 10. Middle class dwellings with some large steel mills on the outskirts. Also railroad yards are large consumers in these sections.

Theory of Pitometer Survey

The theory of a pitometer survey is briefly described as follows: A certain section of the mains is isolated by closing all but one of the boundary valves. A special corporation cock is inserted on the main, feeding this district through the open valve. The main is traversed and the velocity of the water determined by the instrument inserted in the main, through the corporation cock. Gaugings are recorded on sensitive paper for 48 hours, and from the velocities shown, the flow computed. As all the water entering this section passes the instrument the amount measured must be the consumption of the district. The interesting or indicating feature of these records is the relation between the minimum night rate, which is usually found between 12 and 3 a.m., and the total 24-hour consumption A high night rate, unless accounted for industrially, means leaky fixtures or breaks in mains.

As the isolation of a section is apt to leave some industries just within and without the district short on water pressure, causing complaints of low pressure, a map is kept in the office of the Superintendent of Maintenance, on which all valves closed are indicated by a red-headed pin. By this means one can, at a glance, determine if a complaint of lack of pressure is due to the pitometer work, or to some other cause. These pins for closed valves are corrected each morning.

Determining Consumption by Sub-divisions

After the total measure of a district is made, sub-division work is started. Sub-division is the determination of the consumption block by block, and is always done at night. The pitometer is set at the gauging point and the district shut off block by block, the time of each shut off being noted. By comparing the time with the consumption shown on the photo chart at the corresponding time, the rate for each block can be determined. This is a very important feature of the pitometer work, as by comparing the consumption for the different blocks one knows immediately where the inspection of fixtures will give the greatest result. It is an especially valuable feature for the control of the house waste after a survey has once been made. By means of the pitometer and proper sub-division, house to house inspections can give results twice as quickly as though no pitometer were used, as efforts will be confined to blocks where the sub-division indicates the greatest results are to be obtained.

Immediately after the sub-division work was completed, inspectors were placed in the district and house to house inspection made.

To make the survey, an engineer in charge and four assistants were employed. Three trucks with gangs of four were constantly engaged and one clerk assigned to this work, to keep the records. Twelve of the regular city inspectors made the house to house inspections. Later, as

*Excerpts from paper read at the 39th Annual Convention of the American Water Works Association, June 9th to 13th, at Buffalo, N.Y.

more of the city was covered, twenty temporary inspectors were engaged.

One of the assistant engineers made the district measurements and two were constantly engaged on sub-division. One assistant engineer tested the meters and fire lines. During the winter months two men worked in the office.

The inspection for house waste is of great value, and a large percentage of the total waste eliminated is directly due to inspection. However, proper control must be exercised or the results will be indifferent. From 1906 until 1915, the department employed men to stop house waste, but had no control over same by means of district measurements. During this period the per capita consumption was practically stationary, although the annual consumption increased.

Three Inspections, then Shut-Off

As the sub-divisions showed waste in practically every block, a system of inspection records was developed. Inspectors worked in pairs and report on every house and service made. Where leaks were discovered, a repair notice was left. Two weeks later a second inspection was made of all places where notice to repair was served. If repairs had not been made at that time a second repair notice was left and a reinspection made three days later, at which time water was turned off ,unless all plumbing was in good shape. The years of unlimited use and waste of water had rendered most people indifferent to the condition of the plumbing in their houses and at first considerable complaints were made at the so-called arbitrary ruling of the bureau. However, these soon ceased as the results of the survey became apparent and in the majority of cases splendid co-operation was secured.

The inspectors tested, first the house fixtures and then if these were O.K., tested with the aquaphone at the curb box for service leaks. If house waste was found, the stop cock at the house was closed before testing for service leaks. On their inspection report blanks, leaks were listed as service, faucet, toilet, etc., and a notice showing the nature of the leak served. A record of the number of people on each service was also reported. After the house inspection in a district was completed, the pitometer was again used to record the flow in different blocks in the sub-division. Where the night rate was still excessive, investigation for underground leaks was started. The determination of underground leaks is largely a matter of skill, judgment and experience. By sub-dividing by blocks the leak can be located as to block, but then the operator must find same by skill and judgment. If service pipes and boxes have been installed the aquaphone can give one the approximate location, and by driving a steel rod to the main the leak can be closely located. In only a few cases was it necessary to excavate more than one hole to find the leak.

Water Discharging into Sewer

Probably the most difficult work in this line was on Northland Ave., in section 3, where a night rate of 755,000 gallons was shown on one block. As there were practically no houses, and only one factory, which was metered and did not account for but a fraction of the flow, all indications pointed to a large joint leak, or cracked pipe. In this street the pipe is laid in the sewer trench, which was excavated through rock. When the street was paved in 1893, house services had been placed every sixty feet. No large main leak was encountered, but seven service leaks were discovered and shut off at the main, which accounted for 700,000 gallons, or practically the entire waste. The corporation cocks had in nearly every instance been destroyed and water was discharging directly into the sewer. No indications of these leaks appeared on the street surface.

As work was completed in each division a permanent map was filed in the office, showing gauging points for instrument and valves on boundary points. On this map is recorded date of first measurment, 24 hour consumption and minimum night rate, and same record of second measurement. It is the intent of the Bureau of Water to continue the pitometer work as a special department and regular measurements will be taken at varied intervals, and these maps will facilitate the work greatly. All inspectors reports are filed by streets and can be instantly referred to. As soon as a section was completed a full report on same was submitted by the enineer-in-charge. This report gave a general summary of the work with certain specific recommendations to meet the conditions for the sections. These reports are filed so as to be available for future reference.

The report for section 4 showed as follows:—

Total flow before inspection, per 24 hours	17,936,000 gallons
Minimum night rate	14,912,000 gallons
Per cent. of night rate to total flow	86.2%

Inspection of all buildings on this section showed: 3,444 leaky fixtures, divided as follows: Faucets, 1,064; toilets, 2,380.

It also disclosed 280 leaky services, which were repaired by the owners; 8 unfinished supplies which were discharging into the sewer were dug up and plugged. Also, one broken 6-inch main was uncovered and repaired.

After the house inspection and underground work was completed a remeasurement was taken with the following results: Reduction in daily consumption 3,780,000 gallons; reduction in night rate 3,910,000 gallons.

Work Done Hastily

On account of the desire to reduce the pumpage as quickly as possible, so as to conserve coal, as a war measure, no intensive work was attempted and the city surveyed as rapidly as consistent with good work. It is highly probable that the results in this section could have been bettered had more time been devoted to it. However, by extending the work rapidly large leaks in other districts were detected and stopped in the time which might have been devoted to more intensive work in this section. It is expected that the work to be done in this section this summer will materially better the above result.

Starting in July, 1917, which was coincident with the start of the survey, each month shows a decrease in pumpage when compared with the same month in the preceding year except for the extremely cold months of December, 1917, and January and February, 1918.

Our first section was surveyed in 1917, and this year remeasurements have been taken. These show that there is a more or less gradual return of the waste first eliminated, depending wholly on the character of dwellings. In all sections the consumption was less than it was two years ago at the time of the first measurement. In one case the result showed only 10% increase over the first remeasurement. I estimate that effects of the result of the survey will be from one to three years as far as house waste is concerned. All underground leaks stopped are a permanent saving.

In the sections completed, the house waste stopped is estimated at 18,000,000 gallons, while the underground waste stopped was 12,000,000 gallons by actual measurements.

It is our intention to measure and sub-divide the entire city once in two years, and to completely inspect as often. Of course, measurements and inspections will be made oftener in the sections where waste is greatest. To more fully control waste in these sections meters will be placed gradually.

Results of Survey

However, to quickly reduce our pumpage was imperative. I know of no other way which would have given results so quickly. To install meters would have taken from three to five years and the reduction would not have been felt for some time, at least not for the first six months, when the size of the bill would have brought the waste of water home very forcibly to the householder.

Nine tenths of the city has now been covered by the survey with the following results:—

33,278 leaky fixtures reported and repaired; 1,860 leaky services reported and repaired; 52 unfinished supplies found wasting 3,587,000 gals. per day; broken mains and leaky joints wasting 4,376,000 gals. per day, found and repaired.

The services, broken mains, unfinished supplies and leaky joints repaired account for 12,000,000 gallons waste per day, permanently stopped.

The pumpage has been reduced except in times of extremely hot or cold weather, to less than 125,000,000 gallons per day, as compared to over 160,000,000 gallons per day in 1917. Figuring the cost of pumping at $6.24 per million gallons, the average cost for the last three years, the annual saving is $68,328. Against this is the estimated charge of $25,000 per year to maintain the Pitometer Division of the Bureau.

To date the survey has cost $96,931, much of which represents permanent investment in equipment and records, or for professional services.

Including the pay of temporary inspectors, who will be employed each spring, it is estimated that the annual cost of continuing the work will be $25,000 per year.

From the survey made and results obtained it is evident that to a certain extent the house waste can be greatly reduced by house inspection controlled by pitometer measurements. When used in conjunction with selective metering the most flagrant house waste can be eliminated and the consumption reduced nearly to that obtained by universal metering and done at less expense. The pumpage can be reduced at least 20,000,000 gallons by the installation of 10,000 meters on house services where tremendous waste has been found by the survey. The installation of these meters is now proposed. A further reduction is not deemed advisable until a filtration plant is built.

THE "UNAFLOW" PUMPING ENGINE*

By D. A. DeCrow

THE "Unaflow" steam engine derives its name from the fact that the steam travels over a path into and through the steam cylinder in one direction; it does not counter-flow or return over its own path.

The "Unaflow" engine is not particularly new in principle but its successful development as a practical and economic commercial machine is quite recent and its adaptation to reciprocating pumping engine practice new. A number of inventors during the past thirty of forty years have been attracted by the "Unaflow" principle but none of them have until quite recently succeeded in perfecting its development so as to make it successful economically and commercially.

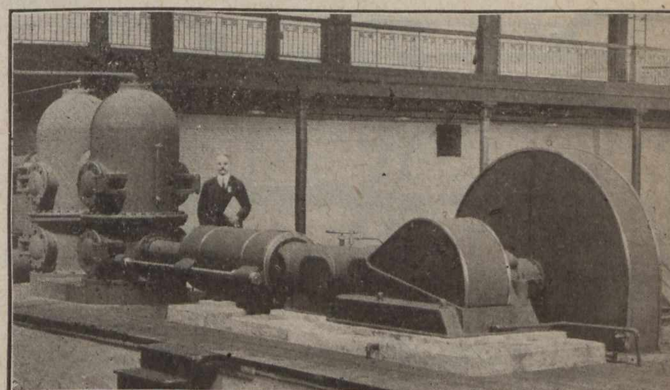
While he does not seem to have been the first, J. L. Todd is possibly the most prominent of the early inventors who attempted to apply the "Unaflow" principle to the steam engine. His first patent was a British patent issued in the year 1885. He was not able to make it a mechanical or commercial success though he spent many years and much money in the effort. About 1895, he apparently gave up trying to make a success of the pure "Unaflow" and adopted the "Dual" or double exhaust engine which was a combination of the "Unaflow" and counter-flow type; he, however, did not appear to have followed the right lines in the development of his "Dual" exhaust engine to make for unqualified success, for it has not come into general use.

After these early and on the whole unsuccessful attempts, interest in the "Unaflow" engine died out for a considerable period, but quite recently investors have been attracted to it and much experimental work has been done; Professor J. Stumpf took it up actively, overcame previous difficulties and to him undoubtedly falls the honor of making the first practical and commercially successful application of its principles to modern steam engine practice; his inventions and adaptations have been generally recognized. During the period directly previous to the beginning of the late war, many of these "Unaflow" steam engines were constructed in England and on the continent for various kinds of power service, but in the United States it has not until recently been developed and adapted for power units in conformity with American practice, activity along these lines having been restricted greatly by reason of war requirements on the engineering and manufacturing resources of the country. The war is now over, rapid progress is being made in its development, many power units have been and are being installed and a number are in successful operation.

Broadly speaking the general principle of the "Unaflow" reciprocating steam engine is that of utilizing the heat energy of the steam in the cylinder during the period of its admission, expansion and flow in one direction, the expanded steam being released or exhausted through ports or openings uncovered by the travel of the cylinder piston at that period of its stroke most remote from the point of admission; the comparatively cold expanded or exhausted steam does not counter-flow and pass through ports at or near the admission or hot end of the cylinder.

A typical "Unflow" steam cylinder and a typical set of indicator cards from a condensing "Unflow" engine are shown by the accompanying sketch.

In this sketch the piston is at one end of the stroke with the exhaust ports uncovered, the arrow indicating the path of the steam through the cylinder. It will be noted by examination of the indicator diagram that steam is admitted into the cylinder for only a very minor portion of the stroke and is then cut-off, the work performed during the remainder of the stroke being due to the expansion of the steam after the inlet valve closes. The exhaust opens when the piston, which is much longer than the ordinary engine steam piston, travels past and uncovers the exhaust ports midway between the two ends of the cylinder.



"Unaflow" Pumping Engine Installed in Porter Ave. Station, Buffalo, Especially for Inspection by Delegates to Water Works Convention.

Beginning with the steam in the cylinder there is practically no change of temperature until the point of cut-off. After cut-off, expansion takes place with a consequent drop in temperature and at this time condensation begins, due to the changing of heat into work. As the cylinder head is jacketed with high steam no condensation takes place on the walls of the head, but the condensation is on the wall of the piston, which is comparatively cool and adjacent thereto, so that at the end of the stroke when the piston uncovers the exhaust ports the moisture of condensation is mostly at the exhaust end of the cylinder, and as the steam expanding away from the cylinder head rushes out through the exhaust port, it carries the moisture with it.

At this time there is a sudden drop of temperature in the cylinder due to the sudden drop of pressure, but as the inlet end of the cylinder is dry it does not lose its temperature, the flow of heat from a dry surface being slow and there is not sufficient time for any perceptible drop in temperature of these dry walls. The exhaust port is covered by the piston on the return stroke, trapping in the cylinder comparatively dry steam partially superheated; as the walls of the cylinders have retained their heat, the heat of compression is not absorbed either by moisture or by cold walls as in the case of a counter-flow engine and the

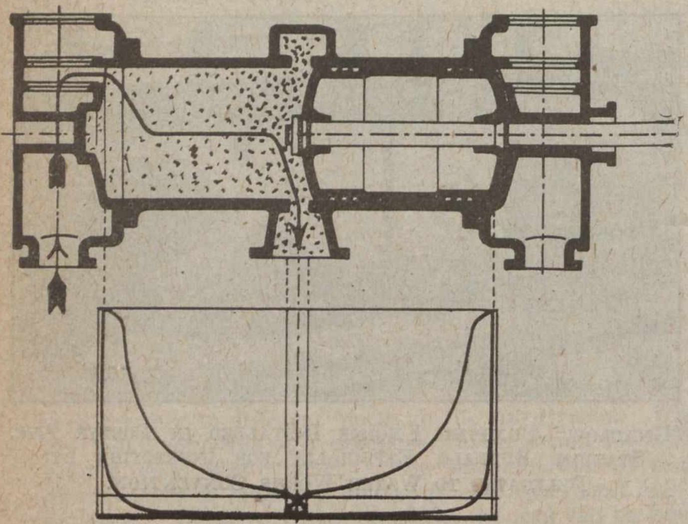
*Paper read at the 39th Annual Convention of the American Water Works Association, June 9th to 13th, at Buffalo, N.Y.

steam remaining in the clearance is heated by compression to a temperature above the temperature of the initial steam; when the valve is opened to start the next stroke the live steam rushing in goes into a clearance space in which the steam entrapped is hotter than the entering steam, hence no initial condensation. Owing to the complete removal of all of the mixture on each stroke, the well-known heat losses caused by the presence of water in counter-flow engines are avoided.

Eliminating initial condensation permits an economical high ratio of expansion in one cylinder. For normal working conditions about sixteen expansions have been found to give best results.

It is also evident with the use of exhaust ports in the cylinder instead of the usual exhaust valves, leakage losses at the exhaust valves and all of the added clearance space and surfaces which necessarily follow from the use of a special exhaust valve, are eliminated. It has been found practical to reduce the clearance space in condensing engines to three per cent. of the swept volume of the piston.

Some of our manufacturers of "Unaflow" steam power engines have guaranteed as low as ten pounds of steam per indicated horse-power per hour, and some of the tests of European built engines have shown well under nine pounds.



TYPICAL "UNAFLOW" STEAM CYLINDER AND INDICATOR CARDS

Taking into consideration its simplicity, for with a single cylinder substantially the same economy is obtained as with the best types of compound or triple expansion steam engines, the "Unaflow" engine marks a distinct step in advance of the other types of reciprocating engines.

The advantageous features have attracted attention to its desirability as a motive power for reciprocating pumping engines.

To develop a pump that could be combined with and utilize the advantageous features of the "Unaflow" engine requires that due consideration be given to proper channels for passing the desired amount of water to and through the pump with the least practicable amount of deflection and disturbance of the flow. This can be attained by incorporating the "Unaflow" principle in so far as it will apply to a pump. The pump should be provided with passages ample and direct so there will be no reversal of flow, with plungers properly proportioned and formed to cause a minimum disturbance, with suitable suction and discharge air chambers properly located with pump valves that will deflect the direction of flow as little as possible, that will operate quickly and quietly at all pressures and economic speeds of the engine, and furthermore, that will be durable and lasting in operation.

The engine illustrated is of the horizontal extended type (so-called), having one steam cylinder and one double acting plunger pump; its normal working water pressure is 100 pounds per square inch; the suction lift is approximately fifteen feet plus the friction in about sixty feet of suction pipe; these are not particularly favorable working conditions, rather the reverse; it (the engine) may be duplex or triplex which would double or triple its capacity, it also may be of the opposed or interposed types, horizontal or vertical.

The normal steam pressure at the Porter Avenue Station is 325 pounds per square inch with 100 degrees Fah. superheat.

The outstanding features of the "Unaflow" pumping engine are:—

Simplicity of construction; low cost of production as compared with compound and triple expansion reciprocating pumping engines; high duty or economy in the use of steam, not only in the large, but in the small units. For instance, the three million gallon unit above mentioned is expected to develop a duty of one hundred and eighty million foot pounds per 1,000 pounds of steam, and to maintain this duty more nearly under variable loads than any other known type.

FLANGES FOR LIGHT CAST IRON PIPE*

BY JOHN KNICKERBOCKER
President, Eddy Valve Co., Waterford, N.Y.

THE question of flanges for light cast-iron pipe has come up for discussion at different times, but up to now no final action has been taken.

The American Society of Mechanical Engineers, at its meeting December 3rd to 6th, 1918, received a report from its committee on light flanges, in which report a "Proposed Low-Pressure Standard for End Flanges, Bolting and Body Thicknesses, 50 lb. Working Pressure," is given.

The flanges proposed for 50 pounds working pressure by the American Society of Mechanical Engineers are of the same thicknesses and diameters and have the same diameters of bolt circles, and the same number of bolts, as the American standard flanges for 125 pounds steam working pressure; but the bolts are of smaller diameters than the sizes used in the American standard flanges for 125 pounds steam working pressure.

The American standard for flanges for 125 pounds working pressure became effective January 1st, 1914, through the recommendation of the American Society of Mechanical Engineers.

It is surely desirable to arrive at some standard or standards as soon as possible for light flanges, provided the standard or standards would meet with the approval of the engineers, the users and the manufacturers of cast-iron pipe, valves and fittings.

It is a serious question whether the standard flange suggested by the American Society of Mechanical Engineers for pipe for 50 pounds working pressure is not too heavy and will not cause casting strains and shrinkage where the flange meets the pipe.

Take for example the 30-in. pipe. The class A, American Water Works Association pipe measures 88/100 in. thick. Would it be good foundry practice to cast a flange measuring 2⅛ in. thick to this thin pipe, and if the pipe were increased in thickness about ⅛ in. to 1 in. thick, the thickness proposed by the American Society of Mechanical Engineers for 50 pounds working pressure, would not the flanges 2⅛ in. thick be too heavy for the pipe?

The American Gas Institute pipe thickness for 30-in. pipe is 85/100 in. Taking the inside diameter of the flange at 31.7 ins. on this 30-in. pipe, as 31.7 ins. is the outside diameter of the pipe, the weight of the American Gas Institute flange is 102.4 pounds and the flange proposed by the American Society of Mechanical Engineers for light pipe is 215.5 pounds, which is over twice as much as the American Gas Institute 30-in. flange. If the American Gas Institute flange is heavy enough for class A pipe, then for each

*Paper read at the 39th Annual Convention of American Water Works Association, June 9th to 13th, at Buffalo, N.Y.

flange 113.1 pounds would be wasted if the American Standard flange were used; besides the poor casting that might result from casting such a heavy flange on a light pipe.

If a flange 1.67 ins. thick were used on a 30-in. class B pipe, taking the outside diameter of the pipe as the inside diameter of the flange, it would weigh 169.38 pounds. The American standard flange on this pipe, would weigh 215.5 pounds, showing a saving of 46.12 pounds per flange.

Would it not be a good idea for the committee of this association which has this matter in charge to endeavor to take it up with like committees from the New England Water Works Association, the American Society of Mechanical Engineers, the American Gas Institute, the Cast-Iron Pipe Manufacturers, the Committee of Manufacturers on Standardization of Fittings and Valves, and such other organizations as might wish to be represented?

BUFFALO WATER SUPPLY, WITH SPECIAL REFERENCE TO THE FILTRATION PROBLEM

(Continued from page 552)

elevation anywhere near sufficient for the purpose it would be necessary to go out at least fifteen miles into the country. The enormous expense that would be incurred in securing the right-of-way and in constructing a dual pipe line of the size which would be sufficient for the purpose would place too heavy a burden upon the resources of a city the size of Buffalo.

I believe, however, that a solution to this problem will eventually be found, as I have here very briefly outlined. Directly to the south of the Porter Avenue pumping station, the grounds being separated by Jersey Street only, is a large tract of waterfront land which is at present used for a dumping grounds. Part of these lands are covered by the harbor waters, but can be easily reclaimed by a retaining wall and subsequent filling in. I believe that this would make the best location, and, in fact, all that could be desired for a rapid sand filtration plant. The water could be diverted to the filters by short extensions to the existing canals and raised to the required height by low-duty pumps. After passing through the filters the water would be permitted to return to the original suction wells by gravity and distributed through the present system.

ECONOMICAL SECTION OF WATER CONDUIT FOR POWER DEVELOPMENT

(Continued from page 554)

Fig. 2 is the logarithmic graph of Equation (18) for values of Q from 100 to 10,000, in four parts; for the line BC the ordinates are to be multiplied by 10 and the abscissae by 100; for CD, by 100 and 100; for DE, by 100 and 1,000; for EF by 1,000 and 1,000—all as indicated by the figure. From this figure, Table II. is readily computed.

TABLE II.—VALUES COMPUTED FROM FIG. 2

Q.	A.	V.	r.	s. (Ft. per 1,000.)
100	23	4.35	1.60	0.830
500	100	5.00	3.34	0.520
1,000	191	5.22	10.50	0.180
2,500	450	5.56	16.70	0.128
10,000	1,650	6.08	33.30	0.077

Two special cases are of particular interest: First, when n=0.5 and the increment cost is proportional to the surface; this would approximate the case of a flume or a concrete-lined canal in earth. Here

$$A^3 = NQ^2$$

and, since v=Q/A,

$$v^3 \frac{1}{N} \text{ .... } (19)$$

or there is one best speed of flow independent of the size of conduit. This is a somewhat surprising result.

The second case is when the increment cost is proportional to the amount of excavation, as for costly rock cut; here n=1.0, and

$$A^{3.5} = NQ^3 \text{ .... } (20)$$

This can be solved either by plotting, as in Fig. 2, or as follows:—

$$A^{0.5} = Nv^3 \text{ .... } (21)$$

$$Q = Av$$

Calculate $A^{0.5}$ and A from (21), assuming values for v; then find Q, which can be plotted to A.

Variations in A resulting from other values of the unit costs than those used in plotting Fig. 2 can be easily taken into account without replotting these curves. Put

$$N' = fN$$

then

$$\log N' = \log f + \log N$$

and a length equal to log f/ (n+2.5) added to the ordinate of the curve at any point will give the value of Y for N′=fN. If f is less than unity the length is to be subtracted. For example, for the point P of Fig. 2, Q=2,500, A=450, v=5.56.

If f=1.5, then P is the point where $PP_1 = \frac{\log 1.5}{n+2.5} = \frac{\log 1.5}{3.25}$

If f=1/1.5, P_2 is the point. These values are given in Table III.

TABLE III.

N.	Q.	A.	V.
$10^2 \times 4.00$	2,500	510	4.90
$10^2 \times 2.67$	2,500	450	5.56
$10^2 \times 1.78$	2,500	395	6.32

The usefulness of this analysis is limited by the accuracy of the determination of n, and this in turn depends upon the definite knowledge of construction costs.

CUTTING PAVEMENT SAMPLES

BY A. W. SWAN

Canadian Ingersoll-Rand Co., Ltd., Sherbrooke, P.Q.

GROWING demands for better roads have made it necessary for engineers and road commissioners to examine the existing roadbeds and to study the composition and character of the material used. It is also desirable to take and preserve samples of new roads as constructed, so that the wearing quality can be compared from time to time.

To cut a block out of any road with a pick or chisel is not satisfactory. It is almost impossible to get a solid piece representing the complete thickness of the material. The samples are large, of irregular shape, and, therefore, difficult to store, and besides, the place where the samples have been taken is a rough hole, inconvenient to repair.

It is important to take as small a sample through the bed as conditions warrant, and not destroy or fracture the surrounding pavement, as well as to produce this sample quickly with a minimum of failure and without using a large amount of labor; also to leave a hole that can be easily repaired. These samples should also be of a standard size, easily preserved and tagged for reference.

The core drill will do this work rapidly, and meet all requirements. By using a 5½-in. shot bit, it will cut a hole not exceeding 5¾ in. diameter and produce a core 4½ in. diameter in all material, such as concrete, tar macadam or similar substances. In loose material without binder, cores cannot be extracted, but generally the sides of the hole can be examined.

The power-driven (gasoline or electric) core drill has proved most satisfactory for this class of work. The hand-operated drill can be used, but four men are required as compared to two men with the power-operated drill. The machine should be mounted on wheels for the purpose of moving to different locations. On city work, connection can be made with the water mains; in the country, a hand-pump is carried. In no case should the motor be of less than 5 h.p.

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PRINCIPAL CONTENTS

CANADA GETS NEXT CONVENTION OF THE AMERICAN WATER WORKS ASSOCIATION

MONTREAL has been chosen as the city in which will be held the fortieth annual convention of the American Water Works Association. At the thirty-ninth convention, held last week in Buffalo, N.Y., Montreal secured 62 votes on the first ballot, while eight United States cities divided the remaining 59 votes, Detroit being the "runner-up," with 29 supporters.

By the time the convention will be held in Montreal—about June, 1920—it will have been thirteen years since this association last visited Canada, as its last annual convention on Canadian soil was in 1907 in Toronto. As pointed out in the June 5th issue of *The Canadian Engineer*, Canadians form one-thirteenth of the association's membership, and Canada should, therefore, be entitled to at least one out of every thirteen conventions. The reasonableness of this contention appealed to the majority of the delegates at the Buffalo convention, and Montreal just managed to secure the necessary majority of votes cast.

The Canadian Engineer believes that it can speak for all civil engineers in Canada in heartily thanking the water works engineers and officials who voted for Montreal. Canada appreciates the honor, and Canadian engineers will undoubtedly plan ahead and co-operate in making the Montreal convention a memorable one.

The convention will probably attract to Montreal about a thousand of the brightest minds in water works engineering and contracting from all parts of the United States and Canada. It will induce important United States manufacturers who have never been in Canada to visit this country, and it will enable others who already know Canada to a certain extent, to become better acquainted with our ideals and institutions. It will help materially in cementing the friendship and mutual respect that already exists to so large a degree among the sanitary engineers of these two great and neighborly countries.

WELCOME TO GENERAL MITCHELL

ONE of the most distinguished members of the Canadian engineering fraternity is Brig.-Gen. Charles Hamilton Mitchell, C.B., C.M.G., D.S.O., Great Britain; Officer de la Légion d'Honneur, France; Croix de Guerre, and Officer of the Order of Leopold, Belgium; and Croci di Guerre and Officer of the Crown of Italy, Italy. Gen. Mitchell went overseas with the first Canadian Expeditionary Force as Major in the Intelligence Department, but was soon transferred to the Imperial Army and placed on the general staff in charge of all intelligence work for the 2nd British Army, later occupying a similar post with the British Expeditionary Force in Italy.

As a mark of respect for his services during the war, and in honor of his appointment as Dean of the Faculty of Applied Science of the University of Toronto, a dinner was tendered to Gen. Mitchell last Friday by Montreal engineers upon his arrival in that city, and a similar function was held Tuesday of this week at the Engineers' Club, Toronto, after his safe return home. Over one hundred engineers attended the banquet in the ballroom of the Ritz-Carlton at Montreal, and nearly that number were at the Engineers' Club, Toronto, to welcome the man who, like many others, so ably upheld Canada's honor and reputation during the titanic struggle which we all so fervently trust is now definitely ended.

In his new and very responsible position at the University of Toronto, Gen. Mitchell will, he declared, bend all his energies toward broadening the educational facilities for students in engineering courses, and toward stimulating scientific research. Hon. Dr. Cody, Minister of Education of the Province of Ontario, in speaking at the Toronto banquet, promised that the purse-strings of his department would be opened to any demands that Gen. Mitchell may make in the up-building of the engineering courses at the University of Toronto.

COST-PLUS FORM OF CONTRACT SAVES MONEY FOR ESSEX BORDER CITIES

TENDERS for the construction of certain sections of an intercepting sewer were received in July, 1918, by the Essex Border Utilities Commission. The figures were considered too high and the work was re-advertised on a cost-plus basis. Three bids were received upon the lump-sum basis, but ten contractors submitted figures upon the cost-plus basis. The lowest lump-sum figure quoted was $163,600 and the highest was $172,400. The estimated costs submitted by bidders, August 22nd, 1918, after the second advertisement had appeared, ranged from $120,600 to $181.200. These figures included the contractor's profit of about $12,000. The work has now been completed at a cost of about $124,200, indicating a saving of about $41,400 as compared with the lowest lump-sum bid. The contractors for the work were Merlo, Merlo & Ray, Ltd., of Walkerville, Ont., and the work was done under the direction of Morris Knowles, Ltd., consulting engineers for the Essex Border Utilities Commission.

The Toronto Hydro-Electric System has distributed its annual report for the year ending December 31st, 1918. The net income from operations was $21,667, and the balance carried forward to 1919 is $63,970. The report of the general manager, H. H. Couzens, states that in spite of the discontinuance of the demand for munitions and war supplies, which brought the load on the Toronto System up to approximately 50,000 h.p., the present peak demand is within 3,000 or 4,000 kw. of the demand at the corresponding period a year ago.

Letter to the Editor

"MACADAM-VICTORY ROADS"

Sir,—I was much interested in reading the article headed "Macadam Roads," by A. E. Sandles, and noted that "Macadam roads are 'Victory Roads,'" and that they "Sent Wilhelm into Holland," etc.

While I would be the last to wish to detract from any praise given to John Loudon Macadam, the father and founder of the macadam roads, my three years' experience at the front, building and maintaining war roads, first for a period of nine months with the Canadian corps and later for 2½ years as A. D. Roads for the British Fifth Army, has taught me that while we were able to "carry on" and keep the traffic moving with macadam, in many cases it would have been true economy if a more permanent wearing surface could have been put on the main thoroughfares early in the war.

I have in mind now the main road forward to Ypres through Popperinghe. That road for 2½ years had a big gang, sometimes three of them, resurfacing it all the time, because the traffic was so great that a macadam surface would not stand for more than a few weeks and the road was therefore continually blocked by these resurfacing gangs occupying half of the road in sections all the time.

It would have paid the armies ten times over to have put on a permanent surface that would have lasted for the duration of the war, using the macadam for a foundation. Of course we were not always able to get the best materials for resurfacing macadam, because the largest quarry which was left in the hands of the British was at Marquise and the quality of the stone ran from marble to a medium quality of limestone.

I have known traffic on the Dickebush-Ypres Road to wear out a 4-in. resurfacing of this material in a few months, as it was carrying possibly heavier traffic than the world has ever seen on roads before. The army at that time occupying that area consisted of 764,000 troops and 129,000 horses.

We also found in building new roads that the Telford method of building them was not suitable for Belgian soil, but by laying the Telford stone on its flattest side instead of up on edge, and then putting broken stone on top, we were able with a total thickness of 9 ins. to carry all the lorries guns and traffic that the army found it necessary to put on them.

We also found that the flat stone in spring and fall gave a bearing where the ordinary broken stone would mush up and become impassible when the frost was coming out of the ground.

The chief lesson I learned at the front was that for motor traffic in spring and fall, when the Belgian and French ground was water-soaked, it was necessary to use flat stone under the crushed stone to carry the traffic.

Going over some Massachusetts and Ontario roads this spring, I found exactly the same need there that we had found in France.

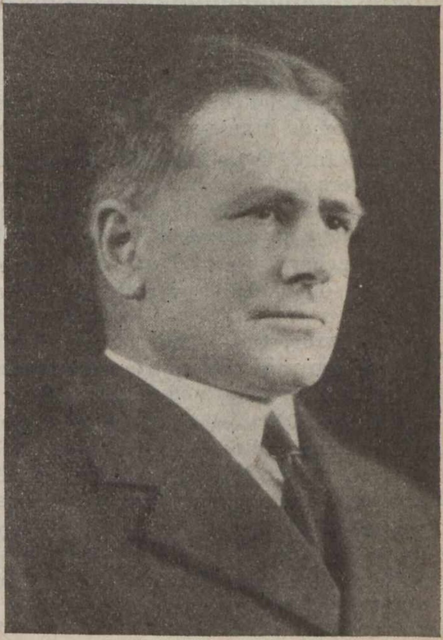
I hope these few remarks will not make any reader think that I do not appreciate what John Loudon Macadam has done for the good roads question throughout the world, because my experience leads me to believe that we can now improve on what Macadam did, and were he here he would be the first to see that we took advantage of more modern methods by placing a more permanent wearing surface on top of the macadam where traffic conditions are heavy enough to make it the economical method, as it was on many of the main roads in France and Flanders.

LT.-COL. W. G. MACKENDRICK,
President, The Warren Bituminous
Paving Co. of Ontario, Ltd.

Toronto, Ont., June 14th, 1919.

PERSONALS

CARLETON E. DAVIS, the new president of the American Water Works Association, is chief of the Bureau of Water, Philadelphia. He graduated from Massachusetts Institute of Technology in 1893. Following his graduation, Mr. Davis was assistant town engineer of Manchester, N.H. Then followed four years as assistant engineer on the construction of the new Bedford water works under the well-known engineer, R. C. P. Coggeshall. Subsequently he was in charge of water works and sewers for the Isthmian Canal Commission. Prior to assuming his present position with the Philadelphia Bureau of Water in 1912, Mr. Davis was associated with J. Waldo Smith on the Catskill aqueduct for seven years. Mr. Davis possesses an attractive personality, is diplomatic and has excellent judgment. A review of the experience which Mr. Davis has had in the realm of water works engineering, indicates the caliber of the man under whom the destinies of the American Water Works Association will rest for the next twelve months. He will preside next year at the convention in Montreal.



R. J. SANDOVER-SLY, has resigned his position as town engineer of Campbellton, N.B.

LIEUT. J. E. PRINGLE, of Hamilton, Ont., a graduate in civil engineering of the University of Toronto, has returned from Palestine, where he served with No. 10 Field Company, Queen Victoria's Own Sappers and Miners, of the Indian Army.

ROBERT G. WEDDELL and R. S. SAUNDERS have formed a partnership as Weddell & Saunders, with offices in the McKinnon Bldg., Toronto. Mr. Weddell is head of the Weddell Bridge & Iron Works, Trenton, Ont., and of the Weddell Dredging & Constracting Co. He was previously connected with R. Weddell & Co., who carried on a considerable amount of harbor, railway and bridge work. Mr. Saunders recently returned from overseas, where he was staff captain, 2nd Brigade, Canadian Engineers. He was previously a member of the firm of Wilson, Townsend & Saunders, contractors, Toronto.

CAPTAIN R. H. MURRAY, engineer to the Bureau of Public Health, Government of Saskatchewan, has returned to Regina after an absence of four years with the overseas military forces. Captain Murray was gazetted with the Canadian Forces early in 1915. At the request of the Imperial authorities he was transferred to the 2nd London Sanitary Company for special duty. He served for two years as sanitary officer with the Egyptian Expeditionary Force, proceeding later to France as sanitary officer to the 52nd Division. Captain Murray subsequently commanded the 1st and 2nd London Sanitary Companies. Following the armistice, he was appointed technical adviser to the war office on water supply, sewage disposal, incineration and other engineering questions affecting the health of the troops.

The town of Melville, Sask., is inviting applications for the position of superintendent of the electric light and power department.

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.

BRIDGES, ROADS AND STREETS

Bowmanville, Ont.—Contract for bridge has been awarded to Thomas Manley and Sons, Belleville, Ont.

Brantford, Ont.—Contract for concrete pavements, curbs and gutters has been awarded to R. Sheehy and Sons, Peterborough, and for 11,500 square yards of resurfacing to McCrae, Campaign and Cook, Niagara Falls.

Bridgeburg, Ont.—The town council contemplates construction of asphalt pavements. Town engineer, Carlton Miller.

Brockville, Ont.—The Godson Contracting Co., Toronto, has been awarded the contract for macadam roadways, curbs and gutters on Buell and Bethune Sts.

Carman, Man.—Contract for reinforced concrete bridge has been awarded to P. O. Petersen, 196 Johnson Ave., Winnipeg, at $17,289.62. Seven tenders in all were received and, with one exception, were very close to contract price.

Crowland, Ont.—Tenders for the construction of a concrete pavement, on South Main St., and Ontario Road, will be received until June 24th, by H. L. Pratt, township clerk. Plans and specifications can be seen at the clerk's office, in police station.

Daly, Man.—Tenders will be received until noon, June 28th, by John A. Dyer, secretary-treasurer Daly municipality, Wheatland, Man., for two reinforced concrete bridges and one concrete culvert. Plans, specifications, tender forms and other information may be obtained at the office of the Highway Commissioner Parliament Buildings, Winnipeg, or from the secretary-treasurer of the municipality.

Ellice Tp., Ont.—The following tenders were received for the construction of a steel bridge on concession road 6 and 7, opposite lot 33: Ontario Bridge Co., Toronto, for steel work only, $2,300; Stratford Bridge and Iron Works Co., complete, $3,495; Gaffney, Township Logan, $3,512; James Hill, Mitchell, Bridge Works, complete for $3,466 and from Alex. Hill, Mount Forest, for steel work only, $1,998. Contract has been awarded to James Hill.

Ford City, Ont.—Contract for sidewalks has been awarded to Charles Desjardin, Ford City, at 14c. per sq. ft. for walks, 18c. per sq. ft. for crossings, and 65c. per sq. yd. for excavation.

Frampton, Dorchester, Que.—No contract will be awarded for building about seven miles of road between Frampton and St. Malachie. The municipal council has decided to do the work by day labor. F. B. Boutin, secretary-treasurer.

Gananoque, Ont.—According to a statement made recently by W. A. McLean, Deputy Minister of Highways, most of the construction work on the provincial highway this year will be carried out by day labor.

Galt, Ont.—The suburban road commission will expend $8,000 for repairs to roadways. It is the intention to construct improvements on the north concession near the city limits.

Gilbert Plains, Man.—Contract for reinforced concrete bridge over Wilson River has been awarded to Ernest Pilgrim, Dauphin, Man. Tender price, $4,630.

Hading, Man.—Tenders will be received until June 20th, by W. V. Stevenson, secretary-treasurer, municipality of Woodworth, Hading, for reinforced concrete culverts.

Halifax, N.S.—Tenders are in for widening, grading and paving with macadam portions of the highway between Fairview and Bedford. Provincial Highways Board, 199 Hollis St., Halifax, N.S.

Hawkesbury, Ont.—By-law has been passed authorizing an expenditure of $75,000 for asphalt pavements.

Ingersoll, Ont.—Contract for pavements has been awarded to the Frid Construction Co., Hamilton, at the following prices: Reinforced concrete pavement, at $2.15 per sq. yd.; integral curbs, at 30c. per lineal foot; 8-inch storm sewer, at $1 per lineal foot; 4-inch tile, 18 inches under pavement, at 16c. per lineal foot; excavation for pavement at $1 per cu. yd.; catch basins, at $30 each; tarvia "B" shoulders, at 70c. per sq. yd.

Kincardine, Ont.—A communication has been received from the Department of Highways saying that the road through Chesley and along the county boundary between Bruce and Grey, would be designated a provincial county highway. This gives Bruce County its full share of highways and will make a difference in the cost of building the county highway system.

Kingston, Ont.—Tenders will be received by R. C. Desrochers, secretary, Department of Public Works, Ottawa, until noon, June 25th, for the placing of stone rip-rap along the south walls of Lasalle Highway at Kingston, County of Frontenac, Ont. Plans and forms of contract can be seen and specifications and forms of tender obtained at the Department of Public Works, and at the Post Office, Kingston, Ont.

Lennoxville, Que.—Tenders will be received until noon, June 21st, by Wm. W. Baker, secretary-treasurer, Lennoxville, for gravelling that part of the Sherbrooke-Beauceville Rd., in the Township of Ascot, from the junction of the Spring Rd. to the town line of Eaton, a distance of about three miles, and generally known as the Eaton Rd.

Lindsay, Ont.—The county council plans to build two miles of paved roadway out of the city limits.

Lotbiniere, Que.—Contract for bridge has been awarded to H. E. Pari, Fortierville, Que.

Marquis, Sask.—Tenders will be received by F. E. Hurd, secretary-treasurer of the council of the rural municipality until 6 p.m., June 24th, for all or parts of the following works, situated exclusively in rural municipality No. 191, and consisting of approximately 30,000 cubic yards grading, 20 miles of turnpiking, 60 miles regrading and hauling, and placing of about 1,000 lineal feet of vitrified clay pipe. Parsons Engineering Co., Engineers, Marquis, Sask.

Milverton, Ont.—Tenders will be received until noon, June 20th, by John Roger, county engineer, Mitchell, Ont., for construction of pavements.

Moncton, N.B.—William Durost has been given the contract for construction of 5,810 lineal feet, five feet wide, of concrete sidewalks. Tender price, 21 cents per sq. ft.

Montreal, Que.—Granite blocks will be used for repairing Craig St. from Delorimer Ave. to Papineau Ave.

Montreal, Que.—Construction of sidewalks will soon be commenced on Pine Ave., from Bleury to Peel, and on Colbourne from Smith to Wellington Sts.

Moose Jaw, Sask.—An expenditure of $22,000 is contemplated by the city council for construction of cement sidewalks.

Moose Jaw, Sask.—The city council contemplates an expenditure of $16,000 for reconstruction of Fourth Ave. bridge.

Mt. Lehman, B.C.—The Matsqui municipal council contemplates road improvements.

North Bay, Ont.—By-law has been passed providing for the paving of Main St. Mayor, J. Ferguson.

North Bay, Ont.—Contract for sidewalks has been awarded to W. H. Milne. Tender price, $7,276.50.

North Bay, Ont.—The construction of a motor road from this point to Temiskaming is under consideration.