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The Canadian Engineer

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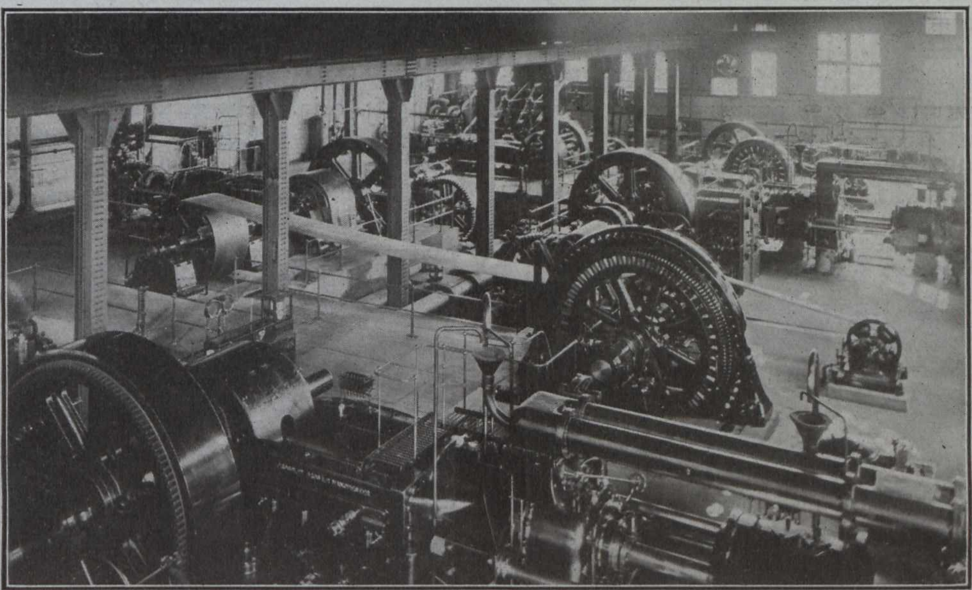
High Pressure Plant Used As Standby

Steam Standby for Motor-Driven Domestic Pressure Pumps Proved too Costly to Maintain in Condition for Quick Operation, So Two Generators Were Connected to Producer-Gas Engines at Winnipeg High Pressure Pumping Plant and Tied to Booster Pumps at Main Station

By WILFRID PROCTOR BRERETON, B.A.Sc.
City Engineer, Winnipeg, Man.

THE city of Winnipeg derives its present water supply from artesian wells, four of which (with a capacity of about 8½ million Imperial gallons) pump directly into the distribution system, the remainder (having a capacity of about 5 million Imperial gallons) pumping into reservoirs which have a total capacity of 24 million Imperial gallons. The main pumping station is utilized entirely for boosting purposes, deriving its supply from the reservoirs. In this station there are installed five 1 M.I.G. Mather & Platt pumps, one 5 M.I.G. Allan pump and one 5 M.I.G. Worthington pump. All these capacities are on basis of 24 hours' continuous service. Each pump is driven by direct-connected motor taking current at 2,200 volts.



View of Winnipeg High Pressure, Producer-gas Plant, Showing Belted Unit, Slow Speed Generator. Photo, July 23rd, 1917

In the same station there is a stand-by steam plant consisting of six 250 h.p. and five 135 h.p. Babcock & Wilcox boilers, with 135 lbs. maximum allowable steam pressure; one 500 kw. Curtis steam turbine, and one 1,000 kw. Westinghouse steam turbine.

In case of interruption to the supply of electric current to the pump motors, it is necessary to have the turbines above-mentioned operating in the shortest possible time, but to effect this desirable condition, the expense involved in keeping the requisite number of boilers under pressure, and the steam piping, auxiliaries and turbines warm at all times, runs into a large figure, especially during the long and extremely cold winters in Winnipeg. Tests were made, under special conditions, of the laying and preparation of fires under the boilers, to determine the time required to operate one turbine under working conditions, with the steam plant maintained as follows :—

One 250 h.p. boiler with 50 lbs. steam and banked fire; and one 250 h.p. boiler with fire ready to light and water at a temperature between 200 and 212° F.

Under summer conditions minimum time required was 45 minutes and in extreme winter conditions minimum time required was from 1¾ to 2 hours. This was unsatisfactory, as the city would be entirely without a water supply for altogether too long a period.

As it was considered too expensive to maintain this plant in a condition which would allow the steam turbines to be operated at a moment's notice, some other method of meeting the condition was looked for, and after thoroughly considering all phases, the following scheme was undertaken and is now completed :—

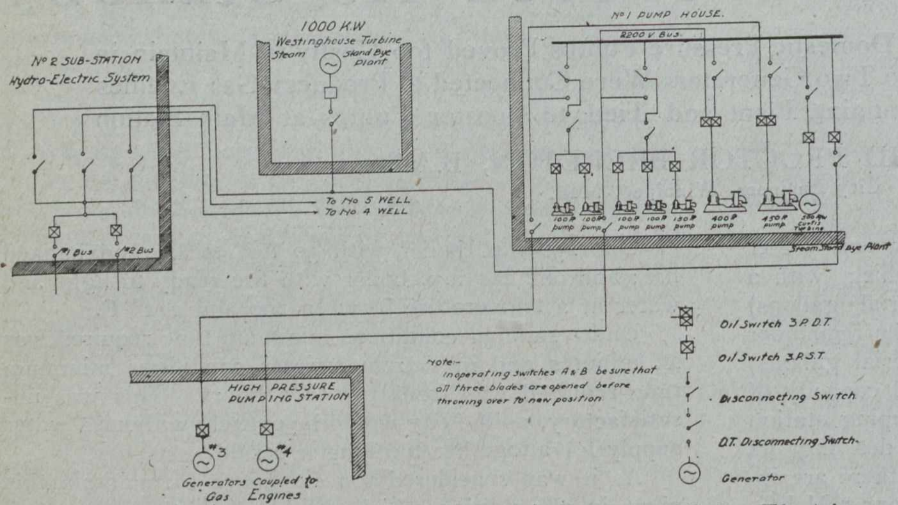
The city has in operation a special pumping plant and mains for fire protection only. The plant is constructed near the centre of the city, on the bank of the Red River, which is the source of its water supply. The pumps are driven by gas engines, the gas being supplied by pressure producers.

The plant includes four 500 h.p. and two 250 h.p. two-cylinder, tandem, single-acting Crossley engines, with speed of 120 r.p.m.

These engines are started under air pressure of 200 lbs. per sq. in. Each engine drives its pump through a Hele-Shaw friction clutch on the extension of the crank shaft. Each crank shaft had been extended in the opposite direction a distance of 22 ins. beyond the bearing, and provided with key seat, for an arrangement somewhat similar to that which has been now undertaken.

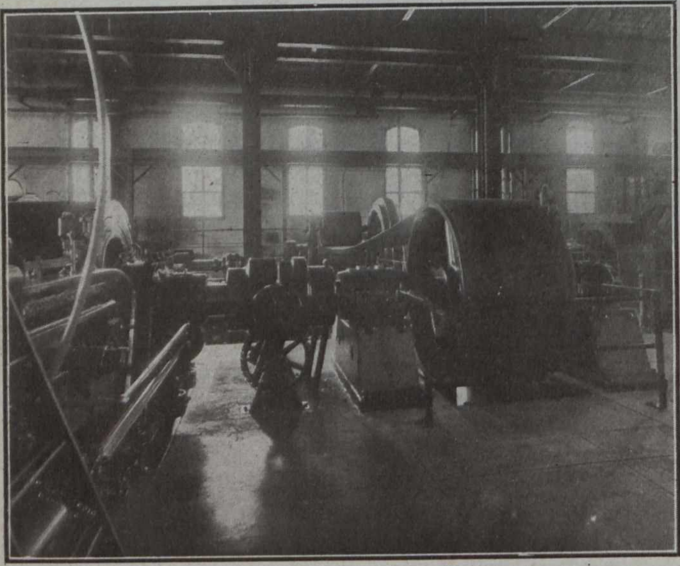
By installing a generator to each gas engine, and connecting to pumps in the booster station described above, the pumps can be operated within the length of time required to bring the gas engines up to speed. Allowing for delays in telephoning instructions, releasing the friction clutch, etc., the operation can be completed in less than five minutes.

Owing to the difficulty in trying to operate the engines in synchronism, separate wires were run from each generator to each pump or pumps.



Line Diagram for 2,200 Volt Switches for Winnipeg Hydro-Electric System, Showing How Generators at High Pressure Station are Tied to Main Pumping Station

Two of the larger units are at present electrified, giving sufficient power to operate pumps having a total capacity of 10 million Imperial gallons per 24 hours. It is considered that this will give sufficient water under the circumstances to cope with any fire which may be expected, and by the use of the fire department's pumping engines, the pressure on the mains may be lowered with a resultant increase in the water supply. There is ample power to handle this extra load on the motors.



Shaft Extension to Gas Engine, For Driving Belted Unit. Photo, July 26th, 1917

Second-hand generators were obtained, the particulars of which are as follows:—

One 350 kw., C.G.E., 2,300 volts, 88 amps., 300 r.p.m.

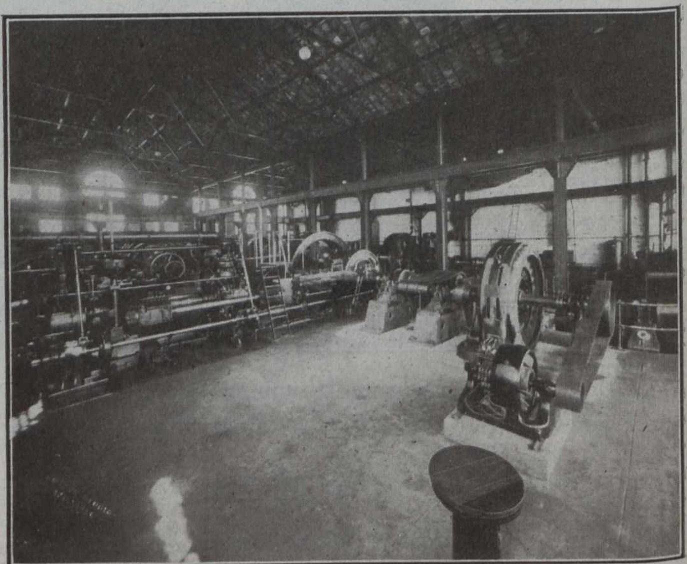
One 450 kw., Bullock, 2,400 volts, 108 amps., 150 r.p.m.

Both are 3-phase, 60 cycles.

The first is belted to the engine shaft by means of a Renold silent chain drive of three strands, each 10½ ins. wide with a circumferential pitch of 1¾ ins. The triple pinion is 12.60 ins. diameter by 34 ins. face, with 23 teeth, and the triple sprocket is 32.35 ins. diameter and 34 ins. face, with 58 teeth.

The engine shaft is extended through a cast steel jaw clutch, half of which is keyed to the 22-in. extension above referred to. The clutch is operated by hand wheel through suitable reduction. This shaft is 12½ ins. diameter by 10 ft. 1 in. long, and is provided with two outboard ring oil, brass-lined, heavy bearings, each 22 ins. long, of a pattern identically similar to the outboard bearings on the original engine shaft for the pump drive. The generator shaft is extended to a length of 8 ft. 9 ins. and has a diameter of 6 ins., with two suitable heavy ring oil, brass-lined outboard bearings, each 21 ins. long. The two shafts are on 5-ft.-6-ft. 5/16-in. centres.

The second is belted to the engine shaft by means of a two-ply leather belt, 41 ins. wide. The driving pulley is 6 ft. 6 ins. diameter by 44 ins. wide, and the driven 5 ft. 2⅜ ins. diameter by 44 ins. wide. The engine shaft is extended as in the first instance, is the same diameter, and extended a length of 13 ft. 0 in. The generator shaft is 15 ft. 8 ins. long and 12½ ins. diameter. The outboard bearings are exactly similar to those on the engine shaft. The two shafts are on 38-ft. 4½-in. centres. An idler pulley with suitable means for adjustment is also provided for adjusting the tension of the belt.



High Speed Generator Unit With Silent Chain Drive. Photo, July 26th, 1917

The arrangements of the two units in the above manner was decided upon because the 300 r.p.m. generator, the 41-in. leather belt, and the idler pulley were all on hand.

To connect the 300 r.p.m. generator by leather belt would have necessitated very expensive driving pulley. By being able to purchase the 150 r.p.m. generator to advantage, and by utilizing the leather belt, the two pulleys for the same were quite ordinary. The silent chain drive was the logical solution for driving the higher speed generator.

When found necessary the remaining gas engines may be coupled up to generators and they in turn to motor-driven pumps.

MANITOBA BRANCH EXTENDS RECEPTION TO NEW CAN.SOC.C.E. SECRETARY

(Staff Correspondence).

Winnipeg, Man., August 17th.—The visit of Fraser S. Keith, Secretary of the Canadian Society of Civil Engineers, to the Manitoba Branch was marked with great enthusiasm from the moment Mr. Keith landed in this Western Metropolis. An official luncheon was tendered Mr. Keith at one o'clock, Wednesday, August 15th. W. A. Duff, chairman of the branch, presided, and about fifty members and guests were present. The secretary conveyed the greetings of the council to the local branch, expressing the great appreciation of the hearty co-operation of the Manitoba Branch. He gave a very interesting account of matters of interest to the society, and of the work at headquarters during recent months, referring to the large amount of work done by the Montreal members of the society.

The council, Mr. Keith stated, takes great interest in the different branches. His visit was at the council's suggestion, with the idea that the secretary's visit to the various branches would give him an opportunity of meeting the branch secretaries and executives, and also many of the members, and result in closer co-operation between branches and headquarters.

Mr. Keith, in referring to the future of the society, stated that the status of the engineering profession is in a state of evolution, changing from the view held in the past to one of greater breadth and usefulness, particularly in regard to its relations to the public. The near future would see the development of a greater fraternal spirit, uniting all engineers in Canada in one great national organization, everybody working together for the welfare of the profession.

W. G. Chace, of the Greater Winnipeg Water District, spoke briefly at the luncheon about the work of the Winnipeg Technical Committee. J. G. Sullivan, of the C.P.R., also made a few interesting remarks. Mr. Keith was introduced to all members present.

Wednesday afternoon was spent seeing points of engineering interest in or near Winnipeg. The Winnipeg Electric Terminal Station, the C.P.R. shops at Weston, and the City Light and Power Terminal Station were visited, and at each place the members were the guests of the management.

A very full programme of entertainment was provided for Mr. Keith for Thursday. In the morning a representative party motored out to Transcona and visited the plant of the Lock Joint Pipe Co. to see the manufacture of 66 in. reinforced concrete pipe for the Winnipeg Aqueduct. The method of reinforcing and the entire process was explained by Mr. Chace. The party also saw the pipe being laid on the section of the big aqueduct east of the Red and Seine rivers. After that, the party visited the Manitoba Agricultural College, where all were the guests, at luncheon, of the Provincial Government, having as hosts S. C. Oxton, Deputy Minister of Public Works, and Messrs. Leamy and Bowman of the engineering department. Mr. Oxton conducted the party through the buildings, particularly the power house and other parts of special engineering interest.

The next visit was to the new Parliament buildings now under construction, also the Law Courts building and power house.

After leaving the Parliament buildings, the party motored to St. Andrews Lock and also visited the plant of the Manitoba Steel Foundries, where they were the guests of Mr. Tirbutt, the managing-director, who later entertained the party at the Motor Club at Lower Fort Garry.

To sum up, a most pleasant two days were spent by Mr. Keith in Winnipeg. He left on Thursday evening for Regina, and on Saturday, August 18th, attended the Annual Summer Meeting of the Saskatchewan Branch, at Moose Jaw, where the following programme had been arranged:—

11.45 a.m.—Rally in front of Canadian Pacific Railway Depot at Moose Jaw. Car ride through city and visit to car barns.

12.30 p.m.—Luncheon at the Royal George Hotel.

1.30 p.m.—Visit to Gordon, Ironside & Fares (packing house), Moose Jaw Brewing Co., etc.

3.00 p.m.—Inspection of Canadian Pacific Railway yards, roundhouse and various civic utilities; also Canadian Northern Railway bridge under construction.

5.00 p.m.—Meetings of various committees in engineer's office, city hall (executive nominating, paper and library).

6.30 p.m.—Dinner at the Royal George Hotel, as guests of the city of Moose Jaw.

8.00 p.m.—Regular meeting in council chamber of city hall. Paper read by W. H. Green, assistant city engineer, Moose Jaw, on "Some Public Utilities."

OWEN SOUND-HAMILTON HIGHWAY PROPOSED

Deputations from Mount Forest and Fergus, Ont., were present at a luncheon held last week by the Board of Trade Executive Committee of Guelph, Ont., to discuss the proposed county-provincial highway between Owen Sound, Ont., and Hamilton, Ont. The people of the former town are behind the project, wishing to get better connections to Guelph and Hamilton, and promote trade all the way along the line.

The scheme was fully explained by the deputation from Mount Forest, though no figures were given. The route proposed is what was formerly the old Indian trail for teaming between Owen Sound and Hamilton, when Guelph was the chief stopping place. Mount Forest, about 45 miles from Guelph and the same distance from Hamilton, is very much interested in the proposed road.

After hearing the deputation, a committee was appointed from the Guelph board to join with Durham, Arthur, Fergus and other places in holding a meeting at Mount Forest to consider the proposition and prepare facts and figures for submission to the Ontario government. The committee is as follows: G. B. Ryan, chairman; J. M. Taylor, J. W. Lyon, G. Powell Hamilton, George W. Walker, D. M. Sanson, W. M. Burgess, S. D. Parleydge and City Engineer McArthur.

DESIGN AND CONSTRUCTIONAL FEATURES OF TURBINE PUMPS*

By A. E. L. Chorlton

THE turbine has become so highly successful as a pumping engine for duties of all description, that no apology is needed for offering a few practical notes on the design and construction of its detailed parts. It will be convenient to consider the subject under the headings of the various component parts of a pump. These are:—

I.—The stator, which consists of (I. a) the casing or housing, and (I. b) the guide vanes or appliance for converting velocity energy into pressure energy.

II.—The impeller (considered separately).

III.—The balancing appliance—hydraulic or mechanical.

IV.—The rotor, considered as a whole, and including the spindle with its projecting sleeves, impellers, and in most cases the balancing appliance.

V.—The bed, and other details, bearings, stuffing boxes.

Of these components III., IV. and V., broadly speaking, are the factors governing reliability and resistance to wear, and I. b and II. are those determining the efficiency.

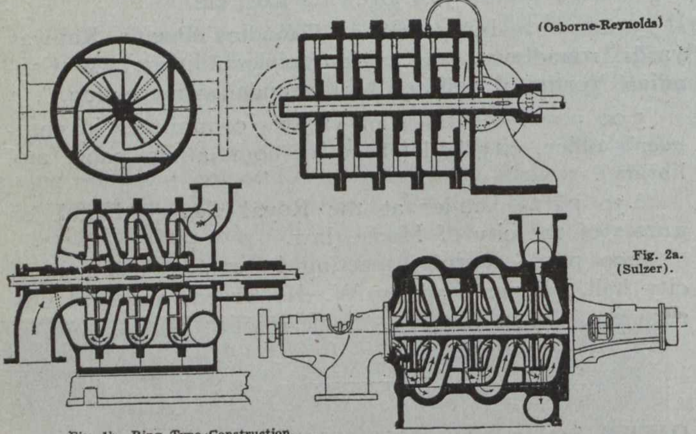

(Osborne-Reynolds)

Fig. 2a. (Sulzer).

Fig. 1b. Ring Type Construction.

Sections Showing Types of Turbine Pump Casings

It is proposed to deal at greater length with III. and IV., for the reason that they have probably been less discussed than the others, also their practical importance is of the greatest moment, but the whole subject cannot be adequately treated within the confines of a paper written during the present time. The chief points only of items I., II. and V. will be briefly reviewed:—

I.—The Casing

The individual impellers of a turbine-pump revolve in chambers or cells containing the outward flow guide-passages and the return conduits for the water; these chambers may be part of a whole in which the outer body is cast in one piece, or, an aggregation of a number of distinct cells without any outside envelope. There are, therefore, two main types:—

1. The Osborne-Reynolds or divided type, and sometimes called the "ring-type."
2. The Sulzer, integral or one-piece type, sometimes called the "cylindrical" type. Recent American practice provides a variation of this type with the housing in halves divided on the horizontal centre line.

The two main types are diagrammatically illustrated by Fig. 1 (a and b) and Fig. 2 (a and b), with variations in Figs. 3 and 4.

The Osborne-Reynolds pump and its evolution was dealt with by the writer in collaboration with Dr. E. Hopkinson, in some detail in a paper read before the Institution of Mechanical Engineers in January, 1912. This type was followed at a later date by the integral one of Sulzer, which had, for a period, a considerable vogue. An examination of the present-day practice of various makers will prove, however, that the ring-type has ultimately proved the preferred one. The Reynolds pump has always used a separate cell for each impeller, and it is therefore correct to say that the ring-type of pump owes its inception to Great Britain. The continental form of the series turbine-pump is due to Sulzer (first pump 1896); in this type a monoblock housing was used for all the chambers or cells, the guide-vanes being inserted from the end.

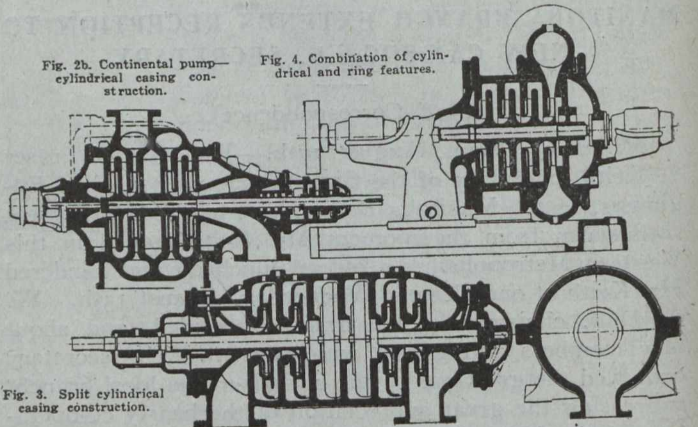


Fig. 2b. Continental pump—cylindrical casing construction.

Fig. 4. Combination of cylindrical and ring features.

Fig. 3. Split cylindrical casing construction.

Sections Showing Types of Turbine Pump Casings

Before dealing with either type or variations arising out of them, it is advantageous to consider the essential functions of the chamber or housing of a turbine-pump. Primarily, each cell consists of (1) the outward flow guide-passages in which the kinetic energy of discharge from the turbine-impeller is converted into static head, and (2) the return water-passages back to the centre for conduction to the next impeller; a complete housing is a collection of such cells.

Fig. 5. Form of Guide Passage - Throat Only.

Fig 6. "Stage" or "Cell." Flow Tangential and Radial: Return Radial.

a—Flat. b—Perspective.
Fig. 7. Flow Tangential and Spiral.

Fig. 8. Single "Cell," Single Passage Only.

Sections Showing Types of Turbine Pump Guide Vanes

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*From a paper read before the Institution of Mechanical Engineers.

Obviously, in the design, commercial considerations must have a material guidance on theoretical claims. Against the requirements for best theoretical conversion of kinetic energy must be matched the allowable limits of dimensions conformable with commercial possibilities, and, in the interests of efficiency, special attention must be paid to the arrangement and dimensions of the divergent channels or guide-passages. As is well-known, the form for guide-passages is represented diagrammatically by Fig. 5, and this passage must be disposed in some form to lie conveniently in the desired casing. The general character will be either a simple outward flow type in one plane, Fig. 6, or a mixed type outward and axial in two planes. See Fig. 7 (a and b) and Fig. 8.

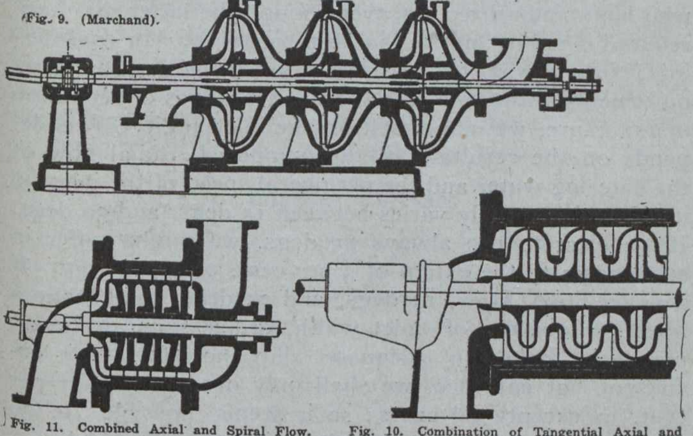


Fig. 9. (Marchand).

Fig. 11. Combined Axial and Spiral Flow.

Fig. 10. Combination of Tangential Axial and Radial Flow (Escher Wyss).

Sections of Turbine Pumps Showing Combination Passage Assemblies

The divergent angle of guide-vane, Fig. 5, for best efficiency was shown by Professor Gibson to be 10° to 11°. In many cases such a small divergent angle leads to a large overall diameter guide-vane in order to give a sufficiently reduced speed of water to permit reversing its radial direction, and the result is a very heavy casing in consequence. For this reason divergent angles of 15° are commonly found in practice. Evidently a more efficient pump will sometimes be heavier and more expensive than one less efficient, and commercial considerations must provide the final deciding factor between efficiency and weight. There is, of course, a school of design which believes in dealing with a proportion of the velocity conversion in the wheel itself, thus leaving less to be dealt with in the guide-passage; the extent, however, to which this method can be used for weight saving is very small, if any. The various assemblies of passages may clearly be grouped into:

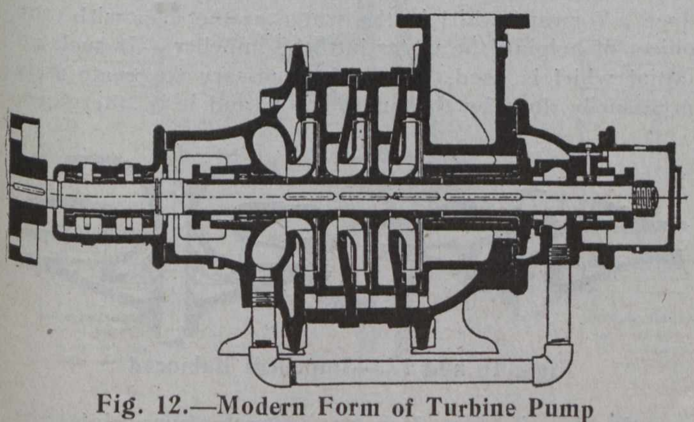


Fig. 12.—Modern Form of Turbine Pump (Mather & Platt)

A—Tangential and radial with return radial (see Fig. 6 and Fig. 1 b).

B—Tangential and spiral (see Fig. 7 (a and b) and Fig. 8).

C—Combinations (see Figs. 9, 10 and 11).

The Osborne-Reynolds pump (1887 and 1875 type) employed an early form of the B assembly, and has adhered to this type up to the present day, various improvements being embodied from time to time, in some of which the writer was concerned. On the Continent of Europe, Messrs. Sulzer introduced in 1896 design A, and the writer believes they have made little departure from the type beyond a considerable simplification of their early arrangement of passages, Fig. 2 a. Speaking generally, combination designs (C) are not so efficient as the simpler types A and B, owing probably to the hydraulic loss through changing the radial direction of the water at high speed.

From a works construction point of view, "ring casings," Fig. 1 (a and b), are the most economical, and in practice give high efficiency. In the form similar to that shown in Fig. 12, the writer some years ago was able to mould and cast ring-casings without cores, machine moulding being adopted, and the cost per chamber coming out at a very low rate.

For "cylindrical" casings, Fig. 2 (a and b), a complete pattern is required for each size and variation in number of chambers. Its accessibility, however, and ease of dismantling is sometimes considered to be greater than with the "ring" type, though this is, to a certain extent, a matter of opinion. A great drawback to casings containing separate cells is that, on account of the sliding fit between the intermediate pieces and casing, an unknown amount of leakage constantly takes place between the cells. With a "ring" type of pump, leakage is instantly detected and can be remedied. As a commercial proposition the writer unhesitatingly favors the divided or "ring" type of casing, and when properly carried out, has met no difficulty with it in practice.

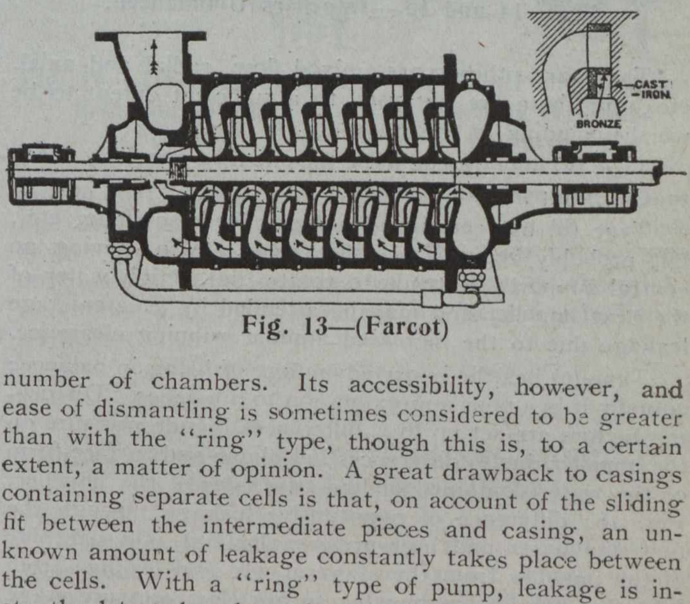


Fig. 13—(Farcot)

Finish of Guide Passage Surfaces

Before leaving this part of the subject, a word about the finish of guide-passage surfaces is necessary. For best efficiency the throat of the passage at least, if not the entire passage, should be gun-metal or bronze, as iron does not preserve a sufficiently good surface for high velocity conditions. Common practice is to provide only three sides of the guide passage in bronze, Fig. 13, but this can only be defended on grounds of cheaper first cost. For best results a bronze-plate should be provided to box in the passage, the plate being attached to the guide-vane casting or dowelled to the casing. Guide-vanes are sometimes cast completely boxed in, and this method necessitates hand finishing of the passage by file and scraper; open vanes, however, lend themselves better to cleaning out and accurately finishing either by hand or by machining. A good smooth surface is essential for the best results and will always justify the increased cost. The method adopted of securing guide-vanes from rotation and vibration must be a thoroughly sound one or trouble will result.

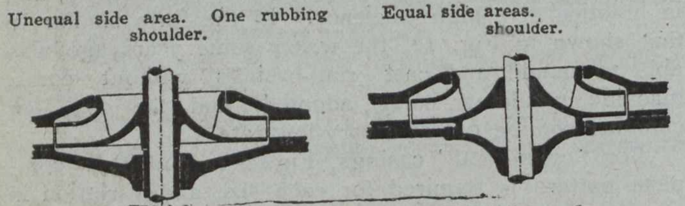
II.—Impellers

Impellers are either single entrant, or double entrant. The first is almost universally in use for multicellular pumps, and the second almost exclusively for single-chamber pumps; it is only proposed to deal with the single entrant form. Multicellular pumps use the single-eye wheel in three forms:—

(a) Unbalanced, unequal side area, one rubbing shoulder, Fig. 14.

(b) Unbalanced, equal side areas, two rubbing shoulders, Fig. 15.

(c) Balanced—on paper, Figs. 16 and 17.



Figs. 14 and 15.—Impellers Unbalanced.

There are other types, mixed flow, radial and axial, etc., but these are not used to a sufficient extent to be worth including in this paper.

Type (a) may be said to be the one now generally used; that is, the preferable design.

Type (b) has certain advantages for machining, etc., but probably requires a stiffer shaft. Also, having no central supports, it tends to rotate the suction water of the next impeller and may be attended by greater stage leakage due to the increased annular running clearance.

Type (c) has the paper advantage of being in balance; actually it is a poor approximation to a balance. Disturbing factors are set up by: differences in side pressure on the impeller due to differences in volume and surface-form of the water contained on the two sides of the impeller, Fig. 18; difference of quantitative leakage through the two shoulders; and high-pressure leakage into one side of the impeller from the stage above, and leakage from the other side of the impeller to next low pressure stage below. Therefore, in practice, it is necessary to provide an additional end balancing device of the hydraulic type, or a mechanically positioning fitting such as a thrust-collar or ball-bearing; a method, especially for mine usage, not to be recommended.

The internal design of all impellers is governed by the same controlling features:—

(1) The entrance or inlet angle of vane.

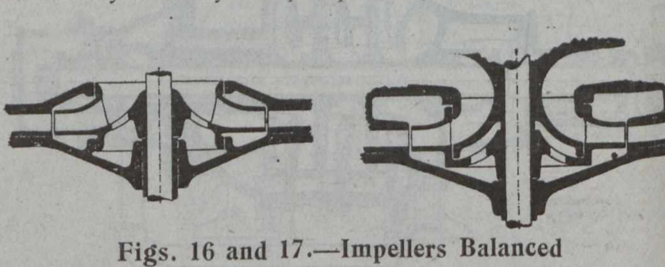
(2) The delivery or exit angle of vane.

The entire design must, while based on these considerations, consult the convenience of the workshop to the utmost degree possible without departing from required dimensional accuracy. The standing difficulty with turbine-pumps, from the manufacturing point of view, is their constant variation to meet the infinite number of conditions of varying head, speed, and quantity encountered in practice. Whatever efforts are made, it seems impossible to keep to a small number of standard impellers if the highest efficiency is to be reasonably well reached each time. Efficiency, it should be noted, is really the prime factor in design and not apparent first cost, for the pump is very often driven by an electric motor of greater value. If, therefore, by the use of a pump of higher efficiency, a reduction is effected in the necessary power and size of motor, the combination will generally come out cheaper.

The maker who elects to change his impellers and diffusers to suit the demands of the inquiries as they come in, will obtain a higher percentage of orders than one who has standardized his, even though the latter may have reduced costs by making in large quantity. In considering if in any way it is possible to meet the designer's requirements without losing all the advantages of repetition manufacture, we may first take the inlet angle. This depends on the resultant of the (supposed) radial flow of the entering water and the peripheral speed of the inlet tip itself, and it usually varies between 15 degs. and 30 degs. If we elect to use always 15 degs. we might suffer in some cases to the extent of 3 per cent. or 4 per cent. If we take two sizes, 15 degs. and 25 degs., and make a liberal provision of inlet width, or, as some designers phrase it, make an adequate allowance for "weir coefficient" at entrance, we shall only drop perhaps 1 per cent. in exceptional cases; so it seems possible to do something in the way of standardizing the inlet angle.

Current Ideas Concerning Inlet Angle

One might refer, in passing, to some of the current ideas concerning the inlet angle and the condition of the water at entry to the impeller. Some designers have maintained that very great accuracy of the inlet angle is vital to high efficiency, in spite of the fact that in the ordinary unobstructed eye it is impossible to say what the absolute velocity and direction of the incoming water is, and therefore, to estimate precisely what the correct inlet angle should be is impossible. Further, the behavior of the incoming water varies with every rate of flow, and the only way to foretell its condition would be to insert inlet guide-vanes; this, however, in such experiments as the writer is aware of, has proved an objectionable practice and only introduces further losses in the pump. Another school holds that it is an advantage purposely to introduce a forward whirl in the water at the eye with the object of helping the water into the impeller. If such an initial whirl is used, the work necessary to create it is necessarily done by the pump itself, and it is, therefore, questionable if this does not entirely overweigh any possible gain.



Figs. 16 and 17.—Impellers Balanced

The discharge angle depends on the resultant of the peripheral speed of the wheel and the radial out-flow, the variation of which is so great it seems impossible to devise any standardization. To meet quantity variation two widths of impeller may be used, and to meet required speeds of revolution it is usual to allow a small percentage variation in the impeller diameter to suit special demands; this latter, however, is conveniently done without pattern or casting alterations.

The foregoing considerations lead to the conclusion that nothing less than a special core-box will be required for each case, and it is quite usual to meet the difficulty in this way. Evidently, however, a most valuable appliance would be a special form of core-box, which in itself was more of a standard and could be adopted for manufacture in quantity; this result might be effected by fitting in vanes of a flexible nature, so that the necessary alteration and adjustment would not be great, and the whole outfit would come out cheaper than if a pattern-maker had to build a fresh box and fittings for each new demand. As the accuracy and smoothness of the impeller is of great importance, the writer has always looked to machine moulding, and to a special machine like a wheel-moulding machine, for the purpose; he has not, however, as yet, arrived at the final design for such.

Impeller Surfaces

The surfaces of the impeller, both inside and out, play an important part in the efficiency of a turbine-pump. The smoother the outside surface the less the power lost in disk friction, and the less the power wasted in revolving idle "dead-water." An interesting point to note is that the greater the speed of revolution of the "dead-water" (that is, the greater the power absorbed in this way), the less the leakage from the periphery of the impeller; but a little consideration will show that greater overall economy is gained by reducing the wasted power in idle revolution to a minimum. As regards the internal smoothness of the passages of the impeller, it is usual practice to clean up the surfaces as well as possible with file and scraper. Impellers have been built up with one loose side so as to permit of machining or more effectively cleaning the interior; and it is evident that with individual impellers producing high heads the results would well repay the extra cost. Objections to this practice are the difficulty of making attachment of the two parts and the extra weight necessary to provide attachments.

III.—Balancing Appliance

The experienced designer knows, from practical knowledge, that even if a group of impellers, or even a single impeller, is theoretically balanced by equivalent areas subject to pressure, it will not in actual practice be free from all end thrust. Apart from variable leakage at the two sides of an impeller, which, by the way, is the principal cause of end thrust, we often have variable side surface both of the impeller and the cell chamber. If the conditions of capacity or surface of the two clearance-chambers vary, the resulting pressures will vary and an axial thrust is set up. Professor Gibson has investigated the effects on efficiency (power lost) due to varying the side clearance of the impeller, and he took readings of circumferential pressures set up by revolving disks, but he apparently did not plot out the resultant effect in end-pressure. This interesting problem is discussed in a paper by F. Zur Nedden, where use is made of the results from both Professor Gibson's and Professor Unwin's revolving disk experiments. The general effect of the gyratory pressures set up is indicated in Fig. 18. It is seen that the speed of the revolving "dead" water at the two impeller sides sets up pressure in opposition to the leakage pressure from the impeller-tip, as already pointed out; the faster the water revolves the greater the resistance to leakage, and the less the resultant pressure due to that leakage. It can readily be seen, therefore, that the effect of the chamber at one side of a wheel having greater capacity than the other, or having more obstructions in the way of ribs, pockets, or exceptional roughness, etc., plays some part in the determination of end-thrust.

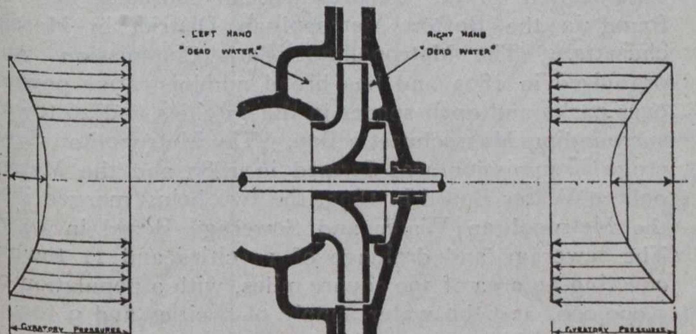


Fig. 18.—Effects of Gyratory Pressure on End Thrust

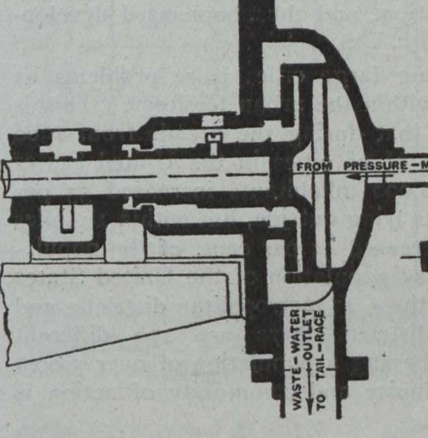


Fig. 19.—Hydraulic Axial Balancing Device (Francis)

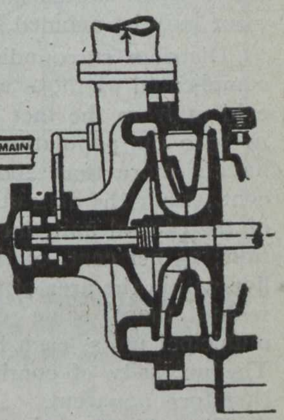


Fig. 20.—Pump (Rateau) Showing Hydraulic Compensator

(Continued in the next issue.)

CEMENT GUN REPOINTS JOINTS THREE TO THIRTY-SIX INCHES DEEP

Mortar is seldom pushed in over 6 in. in hand pointing open joints. On the Governors Island seawall in New York harbor there were many thousand feet of joints from which the mortar had come out, leaving open seams from 1 to 1½ in. wide and from 3 in. to 3 ft. deep. A cement gun outfit working from June 1 to June 29, or 25 working days, filled 22,320 ft. of this joint, or 900 ft. per working day, at a total cost of $2,913, or a little over 13 cts. per foot. This cost, owing to the isolated position of the work, is estimated by Henry N. Babcock, U. S. Assistant Engineer, in "Professional Memoirs," to have been 10 to 15 per cent. greater than it would have been at an accessible point in the city.

The cement gun outfit, besides the gun, consisted of a portable gasoline compressor, on which was also mounted a Gould pyramid pump. A compressor operator, a gunman, five to seven laborers, a horse and cart, and an overseer made up the gang.

The feature of the work was that so far as a number of tests could determine, the joints were filled to full depth with compact mortar. It is estimated that probably the average depth of joints was 12 to 15 ins.

METROPOLITAN DISTRICTS FOR PLANNING AND ADMINISTRATION*

By Morris Knowles, M.Can.Soc.C.E.

THE need of community co-operation has grown more and more urgent with greater concentration of population and with the development of conditions in the Western hemisphere similar to those which have long been prevalent in Europe. Many municipal problems are in no wise limited to artificial political boundaries, and in many such cases efficiency and economy are secured by central control. Such undertakings as water supply, drainage, sewerage, main thorofares, park developments and general planning are accomplished much better under united action, and thus haphazard development may be avoided.

Districts surrounding large cities have problems as complicated as those within the urban territory. This is evident from the fact that during the decade from 1900 to 1910 the population of 25 cities in the United States having more than 200,000 inhabitants increased 33 per cent., while the districts lying outside, but within 10 miles of the central unit, increased 43 per cent. of the population; 25 per cent. of the population of the United States live within the area of these 25 metropolitan districts, and within these same districts there are 170 different municipal units, each having a population of over 5,000. The necessity of continuity and community of action is therefore apparent.

The objection is often made that such co-operation conflicts with home rule, but the conflict is only seeming, for, as a matter of fact, home rule does not mean the right of the city to injure its neighbors by neglecting, in its development, to consider their interests. The desire for local autonomy and the frequent ambition of energetic municipal representatives should not cause us to lose sight of the sovereignty of the state and of the requirement that individual communities as well as persons must give way to the common good and the need of the many. A paragraph from a recent publication by W. Jethrow Brown, Professor of Law, in the University of Adelaide, Australia, entitled "The Underlying Principles of Modern Legislation," is pertinent in this connection:

"If, then, we take the various factors already mentioned and regard them in combination—the pressure of social and economic problems, the democratization of our political machinery, and the growth in the sense of collective responsibility—we must conclude that the supreme problem of the future will be, not how to thwart the movement towards state control, but how to direct it in such a way as to achieve legitimate ends without sacrificing the individuality of the citizen."

Many examples exist of attempts to secure the benefits of co-operation by annexation and by county control, but such methods are useful only in cases where the whole area involved is completely saturated as to population. Many cases exist where these forms of organization are wholly inapplicable, and for such instances the best type yet developed is the formation of municipalities into a metropolitan district under commission control. This preserves local autonomy, develops individual initiative, and at the same time brings about a realization of the need of serving the common good by co-operative action and by the submergence of local pride and selfishness.

It must not be supposed that there are no disadvantages; some of them are the occasional lack of complete representation, and sometimes the development of works ahead of the immediate requirements. This, however, need not be so, because true community planning will provide for construction only so fast as it is needed, although the plan should take a long look into the future. Means of meeting the expense of big public works, how this expense shall be distributed and apportioned, and what part, if any, shall be borne by territory not yet developed, but which will be brought into development by the building of such works, are all serious questions and may prove to be stumbling blocks, or even the rocks upon which the project may be wrecked.

The irrigation and levee districts of the United States and Canada, and the flood prevention districts of Ohio are all analagous to the metropolitan district in providing the benefits of co-operation under commission direction, as is also the Ontario Hydro-Electric Commission. More typical are the urban district organizations of London and Berlin and the Metropolitan Public Works combinations of Boston, New York, Winnipeg and Vancouver.

Greater London, comprising 530 square miles under the control of the Metropolitan Water Board; and containing 2 cities, 35 boroughs, 58 districts and over 35 poor law unions and parishes; and including also the Metropolitan Police District, which covers 692 square square miles with a population of over 8,000,000, is the most extensive urban metropolitan district government in the world. This form of administration was made possible by a series of acts, beginning with the Local Government Act of 1888, and culminating in the Metropolitan Water Act in 1902. The cities of Liverpool, Manchester, Birmingham and Glasgow have similar districts extended for different public works. Community of interest between the municipal area and adjacent territory is shown, however, most completely in the English Housing and Town Planning Act of 1909, which permits "a town planning scheme with reference to any land within or in the neighborhood of a given municipality."

The most important illustrations of this type of organization on the North American continent may be found in the Boston Metropolitan District in Massachusetts. The Metropolitan Park Commission was organized in 1893 and has broad administrative powers over parks and open spaces in the 13 cities and 26 towns surrounding Massachusetts Bay. The Metropolitan Sewerage Commission was formed in 1889 and the Metropolitan Water Board in 1895, the two being merged into the Metropolitan Water and Sewerage Board in 1901. The sewerage and drainage of 12 cities and 11 towns, covering an area of 190 square miles, with a population of 1,000,000, and the water supply of 9 cities and 9 towns included within an area of 175 square miles with a population of 1,250,000, are under the administration of this combined board. More recently a Metropolitan Fire Prevention Commission has been organized, having jurisdiction over 22 cities and towns and extensive powers and duties relative to fire protection and prevention and the study of fire hazards. The record of the development of legislation and of the study of the metropolitan district idea in the Boston district, contained in the report of the first Commission in 1894, the second one in 1909, a third in 1911 and a fourth in 1912, forms a most interesting review of the history of this important type of community action.

(Concluded on page 168.)

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*Abstract of an address before the Windsor, Ont., Board of Trade.

SANDS AND CONSISTENCY OF CONCRETE

By L. N. Edwards
Supervising Engineer of Bridges, Toronto

(Continued from last week's issue.)

Tests of Mortar Briquettes and Cubes.—The tests of mortar briquettes and cubes were undertaken with the primary object of securing information relative to the mortar values of the 12 test sands. The secondary object of the tests was to discover the relation, if any, existing between the results obtained from the testing of 2-in. mortar cubes and those obtained from the testing of 6 by 12-in. cylinders. The mortars were composed of 1 part cement to 3 parts sand.

Standard briquettes and 2-in. cubes were prepared in the laboratory from the "mixer produced" samples of the test sands. The methods and equipment used for this work were in accord with the standards of the Society, and the mortars were of normal consistency. The work in the laboratory was entirely performed by one operator.

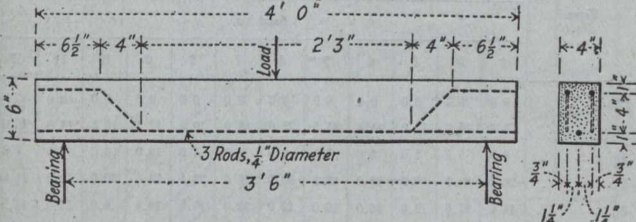

Fig. No. 7.—Details of Reinforced Concrete Beam Used in Tests

Tests of Cylinders and Beams.—The two series of tests upon concrete cylinders and beams were originally planned as follows:

For tests for grading of sand, the test specimens were cylinders, 6 ins. in diameter by 12 ins. long. Five specimens were tested at each age of 7, 30, 60, 90 days and one year.

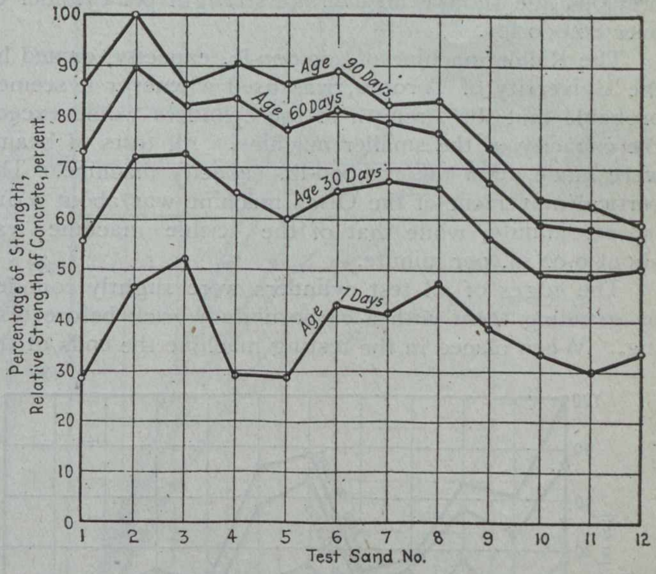

Fig. No. 9.—Relative Compressive Strengths of Test Cylinders, 1:2:4 Mix. Based on Compressive Strength of Sand No. 2 at 90 Days

For tests for consistency of mix, the test specimens were cylinders, 6 ins. in diameter by 12 ins. long, and reinforced-concrete beams, 4 by 6 ins. in cross-section by 4 ft. long, reinforced as shown in Fig. 7. Five cylinders

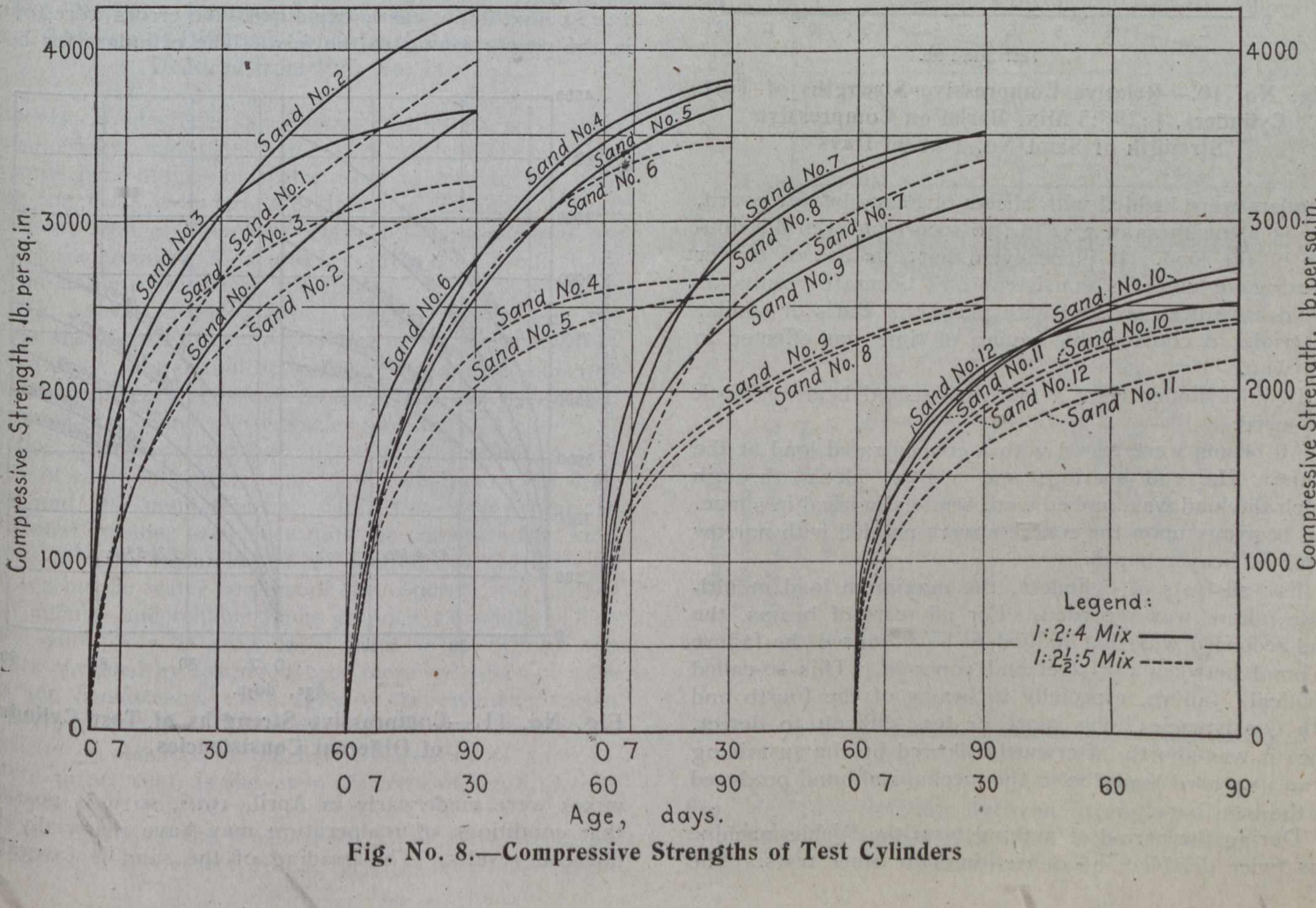

Fig. No. 8.—Compressive Strengths of Test Cylinders were tested at each age of 7, 30, 60, 90 days and 1 year, and five beams at each age of 30, 60 and 90 days.

The Olsen testing machine of 100,000 lbs. capacity, owned by the city of Toronto, was used for practically all cylinder tests, except those in which the tests of the previous age showed an average strength per cylinder of over 80,000 lbs.

The Riehle machine of 200,000-lb. capacity, owned by the University of Toronto, was used whenever it seemed probable that the strength of the cylinders would exceed the capacity of the smaller machine. All tests of beams were made upon the 100,000-lb. capacity machine. The vertical movement of the Olsen machine was about 0.016 in. per minute, while that of the Riehle machine was about 0.02 in. per minute.

The edges of all test cylinders were slightly rounded by grinding them with a carborundum brick before testing. When placed in the testing machine the ends of the cylinders were bedded with sheets of heavy beaver board, having a thickness of 7/32 in., to secure an even distribution of the load. It is believed that this use of beaver board gave quite as consistent and accurate results as would have been secured with plaster of Paris or similar material. A considerable saving of time was effected in this way.

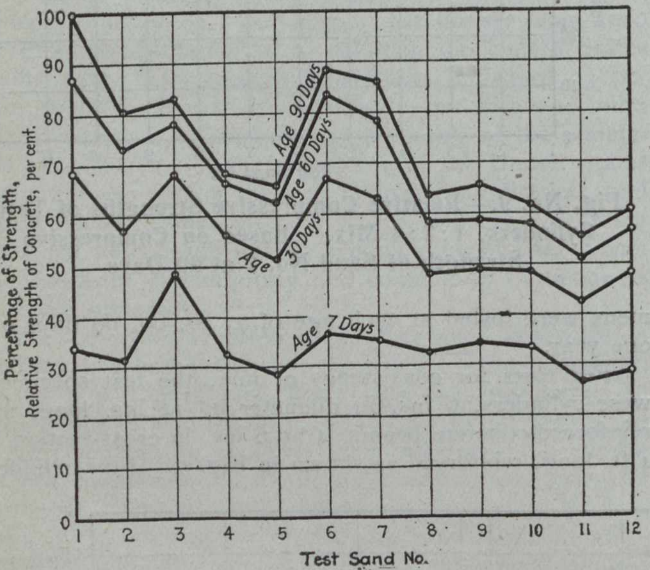

Fig. No. 10.—Relative Compressive Strengths of Test Cylinders, 1:2½:5 Mix. Based on Compressive Strength of Sand No. 1 at 90 Days

In all cylinder tests a spherical-seated bearing block was used.

All beams were tested with a concentrated load at the centre. The end bearings and centre block through which the load was applied were semi-cylindrical in shape. The bearings upon the concrete were padded with narrow strips of beaver board.

For all tests of cylinders, the maximum load at ultimate failure was recorded. For all tests of beams, the load recorded was that judged to have caused the failure of bond between the steel and concrete. This so-called "critical" failure, especially in beams of the fourth and fifth consistencies, was more or less difficult to detect, since it was shortly afterward followed by the sustaining of an increased load due to the mechanical bond produced by the bent bars.

During the period of making tests the Riehle machine was twice disabled in connection with other tests. The time involved in the securing of repair parts, together with the testing of accumulated materials mainly for war purposes, disarranged to a considerable extent the time schedule of the cylinder tests.

Results of Tests

The unavoidable "overdue" tests just referred to, rendered it advisable that the results obtained be reduced to graphical form, in order to permit of the making of direct comparisons. The results of all tests are, therefore, shown graphically rather than in tabulated form.

Tests for Grading of Sands.—Fig. 8 shows the compressive strengths obtained from the tests of the cylinders in which the specially graded sands were used. The rather inconsistent condition shown, wherein sand No. 1 gives greater strength for a 1:2½:5 mix than for a 1:2:4 mix, is not easily explained. No errors were found in the proportioning of the mix. The cylinders for both mixes were made early in April, 1916, so it is possible that conditions of temperature may have materially influenced results. The grading of the sand is favorable

TABLE III.—ACTUAL GRADINGS OF SANDS
Sample from Mixer

Sieve No.	Percentage retained on Sieve.											
	Sand No.											
	1	2	3	4	5	6	7	8	9	10	11	12
¼ in.... ...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8........	8.5	15.0	17.0	11.5	15.5	23.0	14.0	19.0	17.5	18.5	19.0	20.0
10........	8.0	5.5	8.0	6.0	3.5	6.0	4.0	3.0	10.0	6.0	6.0	4.0
20........	20.0	28.5	32.0	22.0	25.5	30.0	23.0	23.5	23.0	30.0	30.0	31.0
30........	14.0	11.5	13.0	20.0	19.0	12.0	13.0	15.0	14.5	9.0	12.0	13.0
40........	15.0	11.5	12.0	17.0	13.0	13.0	15.0	14.5	10.5	10.0	12.5	14.5
50........	14.5	12.0	10.0	6.0	4.5	3.5	15.5	13.5	18.0	11.0	10.0	12.0
80........	15.0	12.5	5.5	12.5	10.0	8.0	10.5	9.0	5.5	11.0	6.5	4.0
100........	3.0	2.0	1.5	2.5	3.0	2.5	3.0	2.0	1.0	3.0	2.0	1.0
100 (passing)...	2.0	2.0	1.0	2.0	2.0	2.0	2.0	1.5	0.5	2.0	2.0	0.5
Total........	100.0	100.5	100.0	99.5	99.5	100.0	100.0	101.0	100.5	100.5	100.0	100.0
Voids........	30.0	29.60	30.06	30.6	31.0	29.10	29.10	29.26	30.53	27.66	27.51	30.2

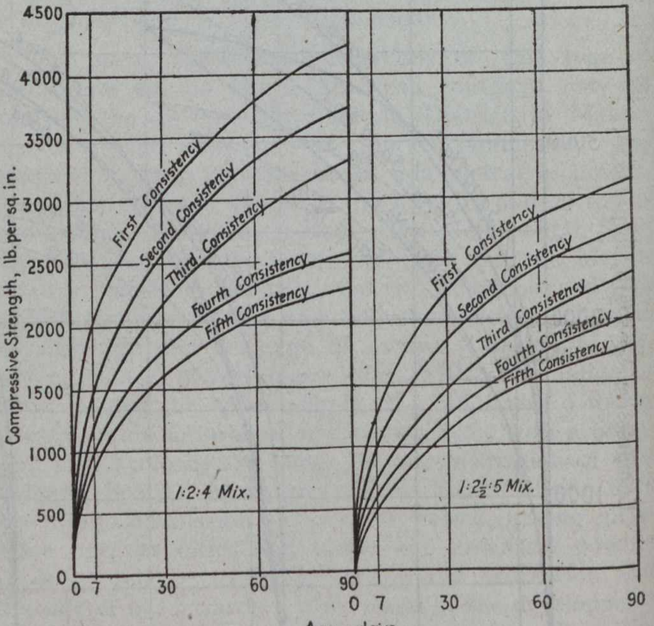

Fig. No. 11.—Compressive Strengths of Test Cylinders of Different Consistencies

to a high-strength 1 : 2½ : 5 concrete. It should be noted that the strengths given for sand No. 5, 1 : 2½ : 5 mix are slightly in error due to a mistake having been made in the composition of the sand entering into the mix. This error was discovered after the mixing of concrete had been discontinued. With this exception, Table III. gives the actual gradings for the sands of Fig. 8. Figs. 9 and 10, deduced from values taken from the curves shown in Fig. 8, show by percentages the relative strengths of the concretes.

Tests for Consistency of Mix.—Fig. 11 shows the compressive strengths obtained from the tests of the cylinders, in which the consistency of the mix was varied from a sticky, semi-plastic to a very wet condition. The different percentages of water used in mixing the concrete for these cylinders are shown in Table II. Sand and stone were of limestone origin. The proportions are by volume, reduced to a unit weight basis; 1 cu. ft. of cement assumed to weigh 100 lbs.

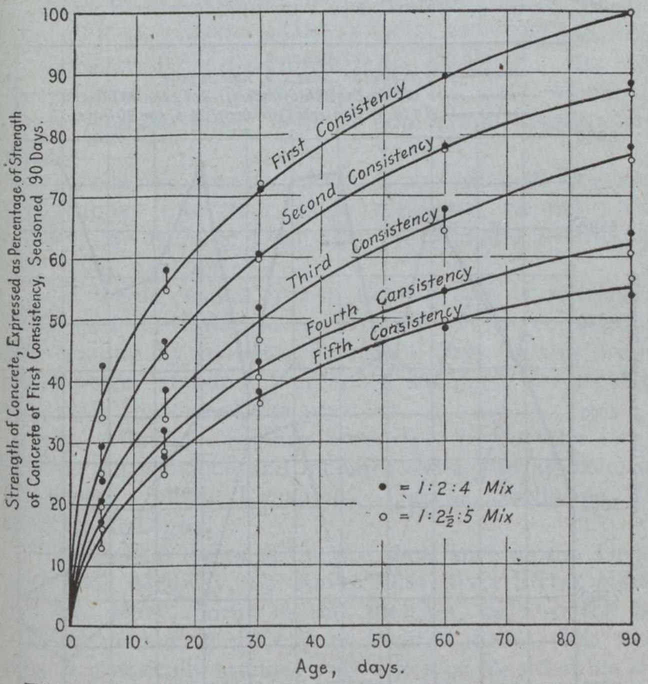

Fig. No. 12.—Relation Between the Strengths of Concrete of Different Consistencies and Ages. Deduced from Fig. No. 11

Fig. 12 was deduced from values taken from the curves shown in Fig. 11. It shows in a general way, by percentages, the relation between the strength of concrete of first consistency seasoned 90 days, and the strength of concretes of varying consistencies and ages.

Fig. 13 was prepared from the results obtained in a series of compressometer tests upon cylinders of the first, third and fifth consistencies. Since the curves apply to individual cylinder tests they must be considered as indicating only the variability of the modulus of elasticity as affected by the water content of the concrete mix, rather than definite and reliable limits of such variability. The latter could only be determined from an average of the results obtained by testing five or more cylinders of each mix and consistency. The ages of the cylinders varied from 317 to 325 days. A reduction in the modulus of elasticity of concrete of the first consistency of approximately 35 per cent. is shown in concrete of the fifth consistency.

Fig. 14 shows the tensile and compressive strengths of the steel and concrete, respectively, as determined from

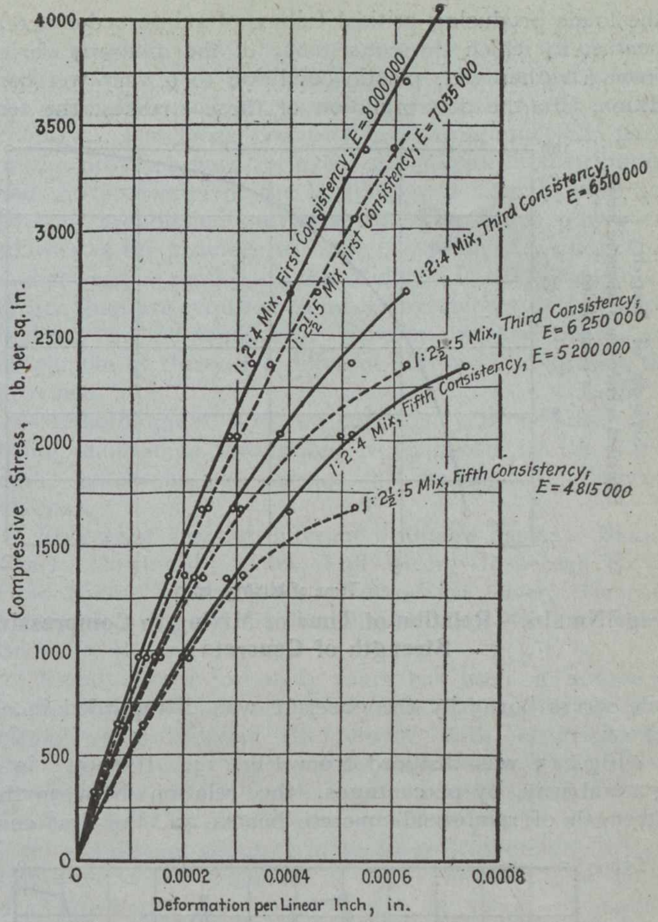

Fig. No. 13.—Compressive Tests Upon Individual Cylinders of Concrete of Varying Consistencies

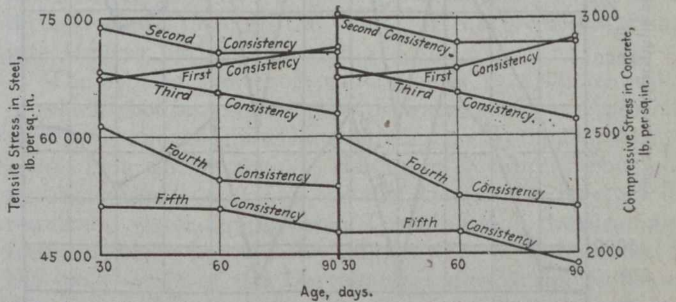

Fig. No. 14.—Stresses in Reinforced Concrete Beams at Various Ages, 1 : 2 : 4 Mix

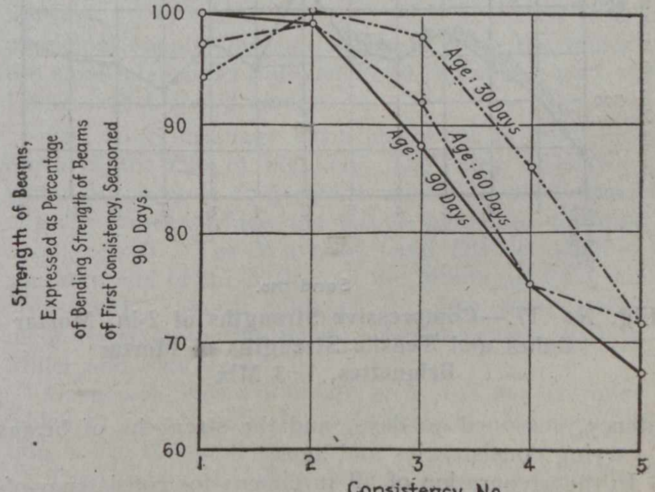

Fig. No. 15.—Relation Between Strengths of Beams of Various Consistencies and Ages. Deduced from Fig. No. 14

the loads producing critical failure of reinforced-concrete beams, in which the consistency of the mix was varied from a rather wet, plastic condition to a very wet condition. In the determination of these stresses, the tensile stress borne by the concrete was disregarded in all cases.

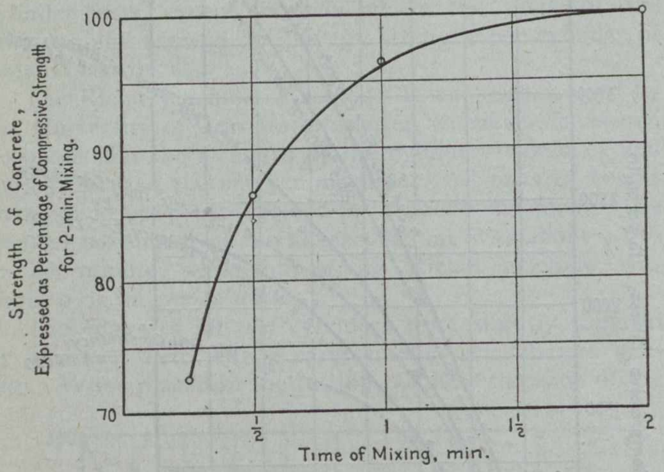

Fig. No. 16.—Relation of Time of Mixing to Compressive Strength of Concrete

Fig. 15 was deduced from Fig. 14. It shows in a general way, by percentages, the relation between the strength of reinforced-concrete beams of the first consistency, seasoned 90 days, and the strengths of beams of varying consistencies and ages.

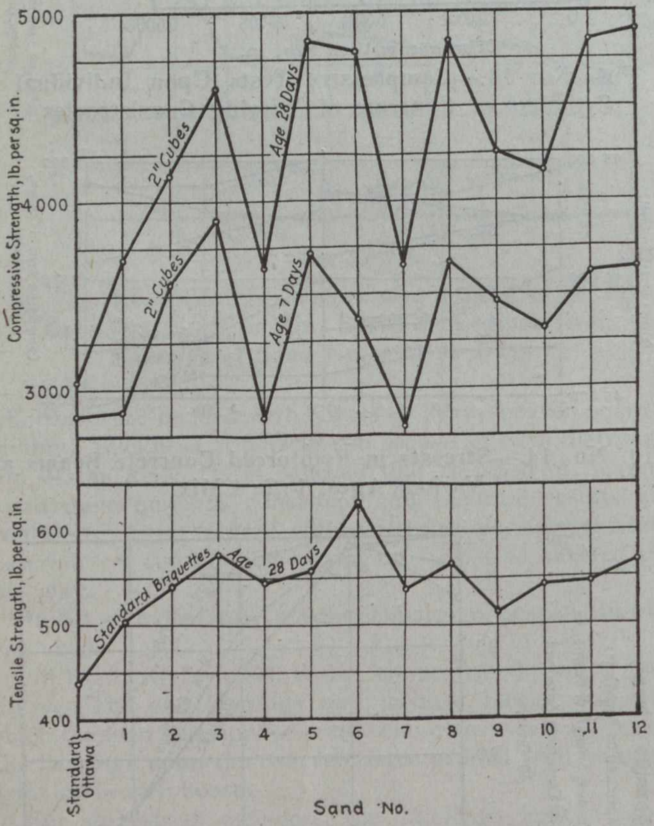

Fig. No. 17.—Compressive Strengths of 2-in. Mortar Cubes and Tensile Strengths of Mortar Briquettes, 1:3 Mix

In the preparation of all specimens for consistency-of-mix tests, specially graded sand No. 2 was used.

Time-of-Mixing Test.—The cylinders composing the four groups were tested at the age of 162 days. From the results of this test the curve shown in Fig. 16 was prepared.

The abrupt change in the direction of the curve at the location indicating the 1 to 2-minute period of mixing, together with the rapid increase of strength shown for mixing periods of less than 1 minute duration, show conclusively the advantage gained by continuing the mixing operation for a period of from 1 to 2 minutes after all the materials have been placed in the mixer.

Mortar Tests.—Fig. 17 shows the compressive strengths obtained from the tests of the 2-in. cubes and the tensile strengths of 1:3 briquettes. Each value is an average of the values of five specimens.

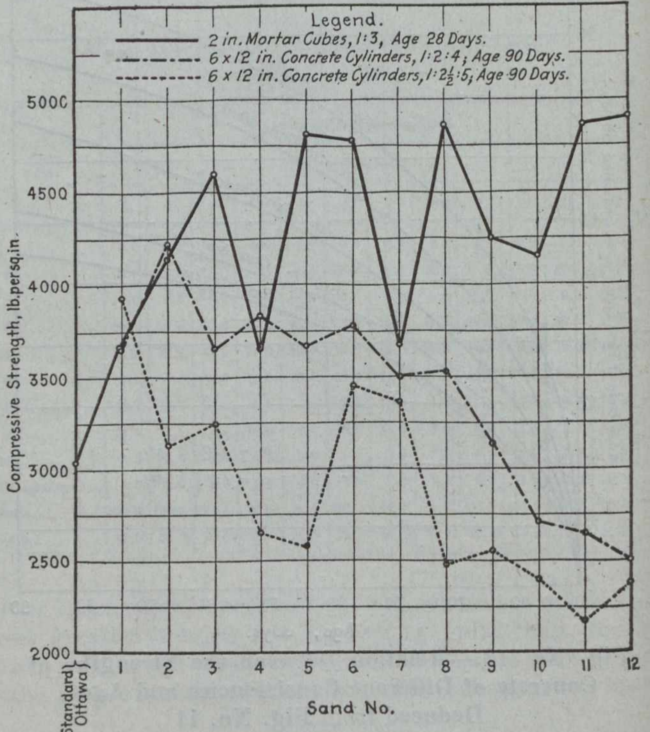

Fig. No. 18.—Relative Compressive Strengths of 2-in. Mortar Cubes, and 6 x 12-in. Concrete Cylinders

Fig. 18 shows the relative strengths of 2-in. mortar cubes, age 28 days, and 6 by 12-in. cylinders, age 90 days. The dissimilarity of the curves is of special interest.

(Continued in the next issue.)

The production of finished steel in Great Britain in 1916 is reported by the Iron and Steel Federation as follows:—Bloom, billets and rods, 1,945,000; sheet bars, 1,272,000; rails, 271,000; plates, 1,153,000; sheets, 78,000; shapes and angles, 757,000; beams and girders, 346,000; galvanized sheets, 132,000; tin plates, 577,000; total, 6,531,000 gross tons. The production of steel castings was 207,000 tons, of which 18,000 tons were made in electric furnaces. The production of wrought iron was 960,000 tons.

At Norrköping, Sweden, a new shipyard is about to be constructed where the Motala River enters Breviken. Two slips are already so far completed that the keel of the first vessel can be laid, a vessel of 725 tons deadweight. A shed will be built over the slip, so that work can proceed in all weathers. In the first instance cargo motor-boats of moderate dimensions are to be built, but the intention is to undertake heavier work by degrees; a floating dock for good-sized vessels will also be constructed. It has been decided to start a new yard also at Korsör, Denmark, specially with a view to the building of wooden vessels. Three slips will be erected, and orders have already been received.

THE WATER POWERS OF NOVA SCOTIA

By Lieut. T. W. J. Lynch
Formerly Assistant Engineer, City of Halifax.

THE Province of Nova Scotia, like its capital city Halifax, is almost entirely surrounded by water, the narrow isthmus which connects it to the mainland being only about fifteen miles at its narrowest point. The extreme eastern portion, Cape Breton Island, is separated from the other part of the province by the Strait of Canso.

Nova Scotia, including Cape Breton, is about 400 miles long with an average width of about 75 miles and lies in a northeasterly and southwesterly direction. Its total area, including a large proportion of water surface, is 21,430 square miles with a population approximately 500,000.

Nova Scotia may be classified, according to its general topography, into four main divisions, namely: Cape Breton, the Atlantic Drainage, the Midland District and the Valley District.

The whole central area of Cape Breton is occupied by the Bras D'Or Lakes at sea level, which are connected to the Atlantic by narrow channels. The streams from a water-power standpoint are only adaptable for local use at certain seasons of the year.

The Atlantic Drainage comprises by far the largest part of the province and includes the following counties: Guysboro, Halifax, Lunenburg, Queens, Shelburne, Yarmouth and Digby.

The largest rivers of the province, such as the Tusket, Liverpool, Medway, La Have, East River Street Harbor and St. Mary, occur in this division, as also the best harbors, including the city of Halifax itself. The whole area is practically studded with lakes of considerable size.

The rivers are generally large and terminate in tidal harbors of large size and moderate depth with high, rocky shores.

This drainage section referred to possesses a large amount of potential water power which can be made available by developments of a general low and medium head type.

The Midland District includes the counties of Hunts, Colchester, Cumberland, Picton and Antigonish and is distinguished from the other districts in that it contains no lakes of consequence.

There are no water-power sites of any great magnitude in this whole district though there are a number of small sites well suited for local use.

The Valley District includes only the counties of Annapolis and Kings. The prominent stream in this area is the Annapolis River, flowing through a large valley and into a tidal basin to the Bay of Fundy. The tidal range at its mouth is about 50 ft. Flowing into the Annapolis River, particularly from the south, are a number of small but extremely precipitous streams which literally tumble from a height of 500 or 600 ft. into the river. Paradise River is one of the most characteristic of this type, while the Nictaux, a somewhat larger river, flows in a narrow valley and is not so precipitous.

The Cornwallis River corresponds in all respect to the Annapolis River except it is smaller and flows in an easterly direction emptying into Minas Basin.

It is obvious that the smaller precipitous streams mentioned with lakes at their heads, present opportunities for power developments of moderate size at relatively small cost.

In general, Nova Scotia has many sites which from their location, distribution and size are well suited to meet the immediate and prospective industrial needs of the country. The large precipitation throughout all parts of the province with its even geographical distribution and the proximity of the larger power sites to deep sea harbors are distinct advantages. The water power resources of the province with the exception of Cape Breton and a certain section of the Midland District, are much larger than are required to meet any market demands yet realized or contemplated. Stream measurements are obtainable at thirty-five different stations throughout the province.

Meteorological and evaporation stations are now being maintained throughout Nova Scotia by the Canadian meteorological service at twenty-four different stations.

Following are the different drainage basins: Bloody Creek, Dartmouth Lakes, Fall River, Gasperean River, Gold River, Indian River, North-East River, Kearney Lakes, Lequille River, Paradise River, Pennant River, Sackville River.

Bloody Creek for many years has been a source of power for small saw and grist mills and has for the past eleven years supplied Bridgetown with electricity for lighting and other purposes by means of a small hydro-electric plant. This brook rises in a small lake known as Godfrey Lake at an elevation of about 700 ft. above sea level and distant about 12 miles from Bridgetown; it joins tidewater at the Annapolis River. The total area of the drainage basin is 24 square miles, of which 21 square miles is available for power purposes.

The Dartmouth Lakes drainage basin lies immediately north of the town of Dartmouth and the main outlet flows directly south through the centre of the town, emptying into Halifax harbor.

The area of the whole watershed is 13.4 square miles of which about 1.5 square miles is water surface. Approximately 6.7 square miles is made tributary to the Dartmouth Lakes by artificial means. Maximum elevation, about 300 ft. above sea level. The town of Dartmouth receives its municipal water supply from Topsail Lake, the drainage basin of which immediately adjoins that of Loon Lake at the headwaters of the Dartmouth Lakes drainage basin. The Starr Manufacturing Co. controls practically all the power possibilities of this basin. The town of Dartmouth also operates a small hydro-electric plant for street lighting. The water for this plant is drawn from the municipal supply, but is discharged from the tailrace of the small plant into Sullivan Pond, becoming part of the Dartmouth Lakes drainage.

Fall River drainage basin lies about 12 miles directly north of the city of Halifax. The area available for water purposes is 17.5 square miles, of which 2 square miles is water surface and has a maximum elevation of about 600 ft. The Waverley Gold District adjoins the southern end of the basin and the Montague gold mining areas within seven miles of it. One power development operates in this basin a Leffel turbine 40 h.p. by Miller and McPherson.

Gasperean River drainage area, 148 square miles, of which 11 square miles is water surface. Its mean elevation is 650 ft. above sea level.

The Cornwallis Valley with the towns of Kentville and Wolfville immediately adjoins the Gasperean Valley on the north. The Dominion Atlantic Railway crosses the Gasperean River near its mouth and runs approximately parallel to it for a distance of four or five miles.

Kentville is about seven miles from the outlet of Gasperean Lake. Saw mills and shingle mills are the existing developments in this basin.

Gold River drainage area is 144 square miles, of which about 5 square miles consists of lakes of considerable size. The maximum elevation is about 700 ft. above sea level.

Indian and North-East River drainage basins total an area of 105 square miles, of which surface lakes comprise about 10 square miles.

Kearney Lakes drainage area lies to the northeast of Halifax and parallel to Bedford Basin. Area, 16 square miles, of which about 1.5 square miles is water surface.

Moirs, Limited, have a box mill and chocolate grinding plant at the outlet of Kearney Brook, Millview, about seven miles from Halifax.

Lequille River drainage basin has an area of 48 square miles, of which 4 square miles is water surface. The municipal water supply for the town of Annapolis Royal is secured from this basin. This stream has peculiar interest from an historical standpoint as it is believed the first water-driven mill in America was built on it in 1607 by the early French settlers.

Paradise River drainage basin has an area of 41 square miles. General elevation, about 700 ft. above mean sea level.

Pennant River drainage area is 30 square miles of which 3 square miles is water surface.

Sackville River drainage area consists of 55 square miles. The Halifax Power Co. investigated the possibilities of this river and during the 1916 session of the Nova Scotia Legislature an act was passed incorporating the Atlantic Power and Development Co.

RESEARCH COUNCILLORS INSPECT COLLEGES

After a six weeks' tour of Western Canada, Dr. A. B. Macallum, Dr. R. F. Ruttan and Dr. F. D. Adams, of the Honorary Research Council, have returned east. At the universities visited on their trip, they investigated the methods employed and studied the capacity of each institution for carrying on research work. Various industries were visited and the problem of cheaper fuel was discussed.

A joint committee has been appointed in Dublin of the Institution of Electrical Engineers, the Institution of Civil Engineers of Ireland, and the Engineering and Scientific Association of Ireland, with the object of investigating and reporting upon the utilization of the peat deposits of Ireland.

N. Cauchon, of Ottawa, who was associated with W. F. Tye, consulting engineer, of Montreal, in the railway entrance report for the city of Hamilton, Ont., advocates the construction of a wide boulevard from the proposed new terminal station to the old city quarry at the head of Ferguson Avenue. The beauties of Hamilton, says Mr. Cauchon, can be improved by a landscape architect sufficiently to make that city a rival of the coast of Normandy and other world-famous European beauty spots.

Very good results are said to have been attained in the experimental manufacture of square and bar steel, etc., at the Kawasaki Dockyard Company's branch factory at Hyogo, where two 15-ton smelting furnaces were installed last year. Encouraged by these results, the company has decided to establish a steel works on an extensive scale for the manufacture of steel plates and rails, and a suitable site is being sought in Fukuoka Prefecture, Kyushu. When the site is fixed, a large works, with five 30-ton smelting furnaces to begin with, will be erected on a capital of 5,000,000 yen, for manufacturing steel plates, rails, square and bar steel, etc., the same as the Government Steel works at Edamitsu.

DRINKING FOUNTAINS*

By H. A. Whittaker

Director of Sanitation, Minnesota Board of Health

AN investigation was undertaken to determine the sanitary condition of the drinking fountains in use at the University of Minnesota and, if they were found to be unsatisfactory, to offer recommendations for correcting defects. The work consisted of a study of the mechanical features of each fountain, bacteriological examinations of the parts of the fountain exposed to the lips of the consumer, and bacteriological examinations of the water supplied to and discharged from the fountain.

The method of conducting this investigation was briefly as follows: Samples of water were collected from taps in the various buildings to represent the water supplying the fountains, and from the jet on each fountain to represent the water discharged from the fountain. A swab was rubbed over all parts of the fountain that might easily come in contact with the lips of the consumer, in order to determine the presence or absence of streptococci. The water samples were examined for the total number of bacteria per cubic centimeter, for B. coli in 1 and 100 cubic centimeter amounts, and for streptococci in 100 cubic centimeter amounts. The bacterial counts were made on agar after forty-eight hours' incubation at 37° C. The determinations for B. coli were made in accordance with the routine methods used by this division. The examinations for streptococci in 100 cubic centimeter samples of water were made by enriching the samples with quadruple strength dextrose broth and examining microscopically after forty-eight hours incubation at 37° C. The examinations for streptococci on the swabs were made by inoculating directly into dextrose broth and examining microscopically after forty-eight hours' incubation at 37° C. The presence of streptococci was used to indicate possible contamination from the mouth of the consumer, as these organisms are commonly found in abundance in the mouths of human beings. It must be admitted that streptococci might be contributed from other outside sources, but this is not probable under existing conditions. The presence of B. coli was used as an indication of contamination of fecal origin.

Following the collection of the specimens for bacteriological examination, a study of the mechanical features of each type of fountain was made by removing various parts so that the details of construction could be observed.

The water supply of the main campus of the University of Minnesota is obtained from the public supply of the city of Minneapolis. This water is taken from the Mississippi River and is subjected to sedimentation, coagulation, filtration, and liquid chlorine treatment before distribution for consumption. The water supply of the department of agriculture is obtained from two drilled wells located on university property.

A résumé of the results shows that 77 drinking fountains, which represented 15 different types, were examined. Sixty-five per cent. of these fountains were of the continuous-flow type and 35 per cent. of the intermittent type operated by the consumer. The nozzles on all of these fountains discharged the water vertically. The height of the water jet above parts of the fountain that could be touched by the lips of the consumer was less

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*Abstracted from 1917 Report to United States Public Health Service.

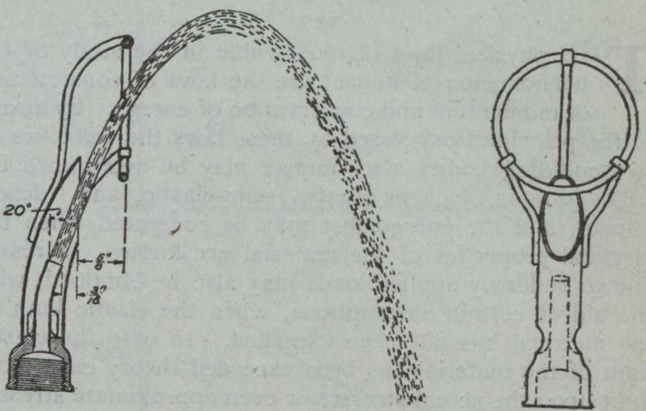
than 1 inch in 40 per cent. of the fountains. Many of the fountains are subject to contamination by the consumer, either directly by the lips or by water falling back from the lips onto the jet or the surrounding parts. Certain of these types have closed receptacles around the point of discharge, which retain a part of the water discharged from the outlet. Coloring matter added to these receptacles was not entirely removed for long periods of time.

The bacteriological examinations of the water supplied to 18 university buildings show consistently low bacterial counts, and B. coli and streptococci were not found present in 100 cubic centimeter amounts. The results on water discharged from the fountains show higher bacterial counts in a few instances, and the presence of streptococci in 11 per cent. of the fountains examined, but B. coli was not found present in 100 cubic centimeter amounts in any case. The examinations of the swabs show the presence of streptococci on the parts exposed to the lips of the consumer in 80 per cent. of the fountains. To summarize these results, they show: (*a*) That a large proportion of the fountains were infected with streptococci, which it is reasonable to assume came from the mouths of the consumers as these organisms were not found in the water supplying these fountains; (*b*) that streptococci were actually present in the water discharged from the fountains and could be transmitted to the mouth of a consumer, even though the lips were not touched to the infected parts. These facts suggest the possibility of the fountains being a factor in the transmission of certain communicable diseases, and that certain changes should be made in their construction to eliminate this danger.

The principal defect in construction was the vertical discharge of water from the fountain. This made it necessary for the consumer to place the mouth directly over the point of discharge, and the majority of persons drank with the lips touching the discharge nozzle of the fountain. This was especially true where the water jet was low, but even when it was high enough to avoid this practice the average consumer placed the mouth over the jet and then lowered the head until the lips touched the discharge nozzle or adjacent parts of the fountain.

Experiments were conducted with various types of fountains which were designed with the view of correcting the defects noted in those already in use. It was found that the most practical construction to obviate the principal defect mentioned was to discharge the water from the fountain at such an angle that the consumer could drink without approaching the point of discharge, thus eliminating the possibility of water falling back from the mouth onto parts of the fountain at or near the point of discharge. This principle was suggested previously by Pettibone, Bogart, and Clark following an investigation of drinking fountains at the University of Wisconsin.

It was found necessary in a practical design to entirely protect the point of discharge and to guard the nozzle against the approach of the consumer. The nozzle shown in the accompanying illustration fulfils these requirements, and can be substituted for the nozzle used on practically any of the common types of drinking fountains. This type of nozzle protects the point of discharge by inclosing the small discharge tube in a larger tube which is cut at an angle with its upper surface extending beyond the outer extremity of the inner tube. The wire muzzle prevents the consumer from approaching the point of discharge. This nozzle can be used on the constant or intermittent flow type. In cases where the water pressure varies to a large degree, pressure regulators should be installed. Doubtless there are many other mechanical possibilities of accomplishing the same result, but the one shown is simple and inexpensive, and it can be attached to practically any fountain.



A Protected Type of Drinking Fountain Nozzle

Summarized Results of Investigation

Number examined		77
Number of types		15
Height of water jet:		
Continuous—		
Minimum	inches	0.1
Maximum	inches	3.0
Intermittent—		
Minimum	inches	0.4
Maximum	inches	12.0
Bacteriological examination:		
Swab from fountains—		
Streptococci positive	per cent.	80
Water from fountains—		
Streptococci in 100 c.c. positive	per cent.	11
Bacteria per c.c. average		6
B. coli positive—		
1 c.c.		0
100 c.c.		0
Water from buildings—		
Streptococci in 100 c.c. positive		0
Bacteria per c.c. average		2
B. Coli positive—		
1 c.c.		0
100 c.c.		0

Results on Drinking Fountain with Improved Nozzle

Number of examinations	3
Bacteriological examination:	
Swab—Streptococci positive	0
Water from fountains—	
Streptococci in 100 c.c. positive	0
Bacteria per c.c. average	3
B. coli—	
1 c.c.	0
100 c.c.	0
Water from buildings—	
Streptococci in 100 c.c. positive	0
Bacteria per c.c. average	0
B. coli—	
1 c.c.	0
100 c.c.	0

STRESSES IN IMPACT*

By Armin Elmendorf,

Instructor in Mechanics, University of Wisconsin,
Madison, Wis.

THE physical laws of most value in the study of the phenomenon of impact are the laws of conservation of momentum and conservation of energy. By means of the principles expressed by these laws the velocities of two colliding bodies after impact may be determined for all conditions, such as elastic, semi-elastic, and "dead" impact, and the energy lost may be computed when the physical properties of the material are known. Stresses due to suddenly applied loads may also be obtained, with the aid of certain assumptions, when the elastic limit of the material has not been exceeded. In case the elastic limit of the material has been exceeded theory casts little light upon the actual stresses or even approximate stresses such as the modulus of rupture or the stress at failure, which is of so much importance in engineering construction. How do the stresses at failure of a wooden beam, for example, compare with the corresponding stresses for a beam loaded statically to rupture? Will a material absorb more or less work to the point of failure when suddenly loaded than it does for slow loading? Is the modulus of elasticity the same for the two methods of loading? Will a beam deflect farther at rupture in impact than it does in static bending? While the latter question may be readily answered by making a few simple tests, the matter of stresses is not so readily put aside and requires for its solution both the application of the laws of impact and experimental data of a somewhat unique nature. It was primarily the determination of the stresses actually set up in impact that prompted the investigations presented herewith.

Before proceeding to the tests themselves it will be necessary to analyze the phenomena of impact and to formulate the theory involved. In the study of the theory the conditions under which the tests were made will be kept in mind constantly and no assumptions will be made that cannot be amply justified by the results of the test.

For the purpose of this study we will imagine the usual wooden beam supported at the ends and struck at the centre by a falling weight or tup whose mass is at least ten times that of the beam. The beam is rectangular in section, and the nose or surface of contact of the tup is rounded so that undue crushing of the fibres on top of the beam will be avoided. The tup is allowed to fall from a height sufficiently great to break the beam with a single blow. At the instant of contact the pressure between the tup and the beam is zero. Then, as the tup proceeds in its descent, dropping through a distance ΔS, there results, first, a slight depression or indentation in the beam due to the inertia of the particles of the beam in the path of the motion; second, a displacement of the centre of gravity of the section of the beam under the tup equal to ΔY, so that the difference ΔS-ΔY represents the depth of the indentation; and, third, a wave is sent out to each side with a speed equal to that of the velocity of stress propagations in timber. Inasmuch as ΔY is small, the upward pressure of the beam due to flexure is as yet quite negligible, and the actual pressure between the beam and the tup may be considered as due entirely to the inertia of the particles in the vicinity of the centre. As the descent proceeds with ΔS still very small, the difference ΔS-ΔY becomes constant, and soon the centre of gravity of the section under the tup has the same velocity as the tup itself. This does not imply, however, that the sections to either side of the centre have attained velocities proportional to their proximity to the centre or to the deflections associated with a deflection ΔY at the centre, due to static loading. The latter state is merely the limiting or equilibrium condition that the beam assumes as the deflection proceeds. Since the velocity of stress propagation for timber is about 13,000 feet per second, and the total time for the deflection has a minimum value of 0.02 second for the tests made on 50-inch beams, it may be assumed that this condition of equilibrium has been reached a relatively long time before the maximum deflection has been attained. When this condition has been arrived at the beam has an elastic curve very nearly the same as the elastic curve in static bending, and the pressure between the beam and the tup is due solely to flexure. In the meantime, since the bending has increased, the actual pressure between the two has also materially increased, with a corresponding increase in the depression.

Having followed the changes that take place in the beam up to the instant that its inertia has been entirely overcome, we are now in a position to determine the external moments that set up the stresses producing failure.

Considering the forces acting on the tup, there is, first, the force of gravity giving it a downward acceleration g, and, second, an upward force p, the pressure of the beam imparting acceleration in the direction opposite to motion and equal to a. If s stands for the vertical displacement of the tup then $\frac{d^2s}{dt^2}$ represents the rate at which the tup is changing its velocity; that is, the acceleration of the tup, which, it has just been seen, is the resultant of a upward and g downward. Since the motion of the tup relative to the centre of the beam is extremely small, being due only to a change in the indentation, $\frac{d^2s}{dt^2}$ is also the acceleration of the centre beam. Besides these major forces, there remain, of course, friction of the tup in its guides and air resistance. Tests made to find the change in velocity due to friction showed that the velocity was not decreased more than 2 per cent., indicating that friction is quite small when compared to the force of gravity and absolutely negligible when compared with the upward force of the beam.

Put as an equation, these conditions are expressed by the relation

$$\frac{ds^2}{dt^2} = a - g$$

or

$$a = g + \frac{d^2s}{dt^2}$$

If p represents the pressure exerted by the beam upward in pounds, W_t the weight of the tup in pounds, and a and g accelerations in feet per second we have

$$p = \frac{W_t}{g}a = W_t + \frac{W_t}{g}\frac{d^2s}{dt^2} \qquad (1)$$

Proceeding now to the energy-work relations, we obtain the general energy equation:

$$\int (ds - dy)p + \int Fdy + \int \frac{W_b}{2g}u^2 + \frac{1}{2}\frac{W_t}{g}v^2 + E_e$$
$$= \int W_t\,ds + \int \delta W_b z + \frac{1}{2}\frac{W_t}{g}v_t^2 \qquad (2)$$

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*Abstract of paper in Journal of the Franklin Institute.

Work done up to any instant plus kinetic energy at that instant is equal to the initia kinetic energy plus work available.

$\int (ds - dy)p$ = work done in compressing the fibres at the point of contact of the tup, s being distance passed through by the tup, y the distance the centre of gravity of the beam passes through, and p the pressure between the tup and the beam. The difference between y and s is usually less than ½ of 1 per cent. of the total deflection, so that the work lost in denting the beam is negligibly small and will be neglected in the subsequent discussion.

$\int F dy$ = work done in deflecting the beam. The force F is practically identical with the pressure p, and would be exactly the same as p for weightless beams. F is in the determination of this force that the main problem of stresses in beams subject to impact lies. F is equivalent to the centre load in a static bending test, which, when plotted against deflections, gives a curve from which the modulus of elasticity, the modulus of rupture, and the energy of rupture may be computed.

$\int \frac{\delta W_b}{2g}\mu^2$ = kinetic energy of the beam, where W_b is the weight of the beam and μ the velocity of any element $\delta W_b{}^1$.

$\frac{1}{2}\frac{W_t}{g}v^2$ = kinetic energy of the tup at any instant under consideration after initial contact, W_t being the weight of the tup.

E_e = energy lost in vibrations. In all impact some energy is lost in vibrations, but this can be largely reduced by making the ratio of the weight of the machine frame to that of the tup relatively large. It will be omitted on this basis.

$\int W_t ds$ = work done by gravity on the tup after initial contact with the beam.

$\int \delta W_b z$ = work done by gravity on the beam after initial contact, z being the deflection of the element δW_b.

$\frac{1}{2}\frac{W_t}{g}v_t{}^2$ = kinetic energy of the tup at the instant of contact, v_t being the velocity of the tup at that instant.

While equation (2) is general and applies at any instant during the motion, the energy that exists as vibrations will be relatively large for the first part of the deflection during the time required to overcome the inertia of the beam. Consequently the subsequent discussion will concern the motion after the vibrationless condition has been more nearly reached.

Referring again to the integral $\int F dy$, it will now be observed that the work of deflection is equal to the change in kinetic energy of the tup plus the work done by gravity on the tup and beam during deflection, minus the energy lost in imparting velocity to the beam and denting it at the point of contact.

Bearing in mind that v is the velocity at the centre after the inertia of the beam has been entirely overcome, and u is the corresponding velocity of any element δW_b, away from the centre, it is a simple matter to express u in terms of v, since the elastic curve is assumed to be known. Let l be the length of the beam, y' and z', y'' and z'' be the corresponding deflections at the centre and at any section distant x from the end, respectively, and let P' and P'' be the loads at the centre corresponding to y' and y''. Since the load at the centre is directly proportional to the deflection at the centre, or at any other point with the elastic limit

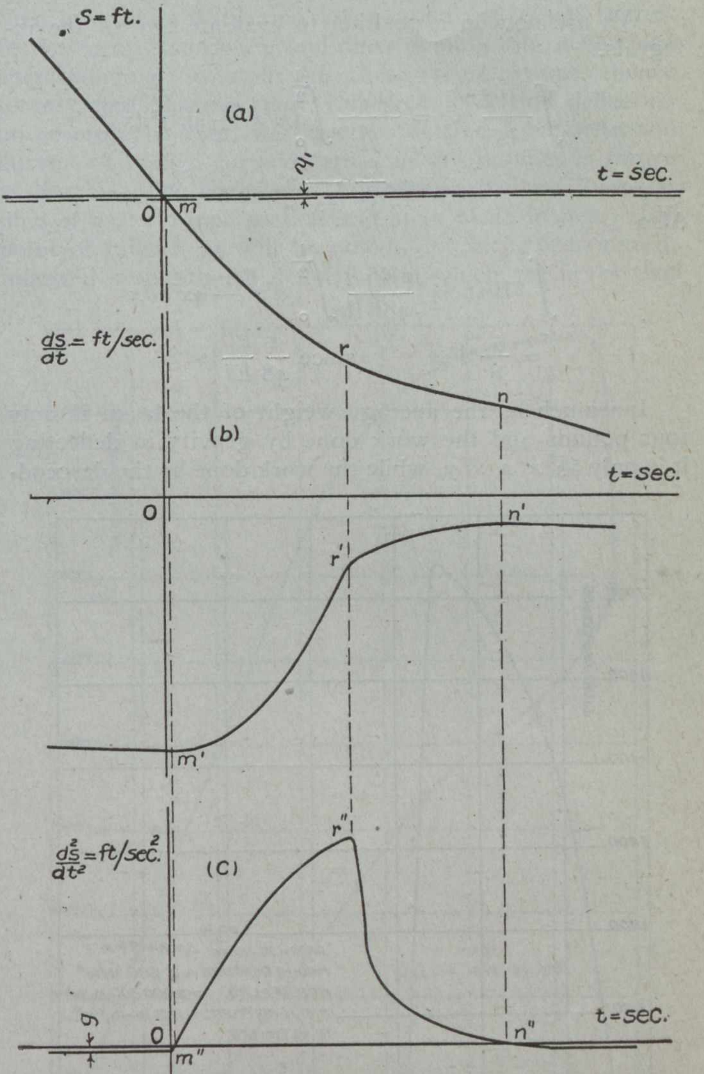

Fig. 1.—A Typical Time-Deflection Curve from Impact Test on a Timber Beam, and Its First and Second Differential Curves

$$\frac{y'}{y''} = \frac{P'}{P''} = \frac{z'}{z''}$$

$$\frac{y'' - v'}{y'} = \frac{z'' - z'}{z'}$$

But $y'' - y' = dy$, and $z'' - z' = dz$, hence

$$\frac{dv}{y'} = \frac{dz}{z'}$$

$$\frac{dy}{dt}\ \frac{1}{y'} = \frac{dz}{dt}\ \frac{1}{z'}$$

$$\text{or } \frac{v}{y'} = \frac{u}{z'} \qquad \text{and } u = v\frac{z'}{y'}$$

The deflection at any section distant x from the left end of the beam is

$$z' = \frac{P'}{48EI}(3l^2x - 4x^3)$$

The deflection at the centre for the same load P' is

$$y' = \frac{P'l^3}{48EI}$$

It follows that

$$u = v \quad \frac{(3l^2x - 4x^3)}{l^3}$$

We are now in a position to evaluate two of the integrals.

$$\int \frac{\delta W_b}{2g} u^2 = \frac{W_b v^2}{gl^7} \int_0^{\frac{1}{2}} (3l^2x - 4x^3)^2 \, dx$$

$$= \frac{17}{35} \frac{W_b}{2g} v^2$$

Also

$$\int \delta W_b z = \frac{2 W_b P}{48EIl} \int_0^{\frac{1}{2}} (3l^2x - 4x^3) \, dx$$

$$= \frac{5}{8} W_b y \qquad \text{since } \frac{1}{48} \frac{Pl^3}{EI} = y$$

Inasmuch as the average weight of the beam is only four pounds and the work done by gravity in deflecting it is only 5/8 × 4 × y, while the work done by the descending tup will average 800y, the error introduced by omitting this integral is also very small. Moreover, since one of the purposes of the discussions is to make a comparison between the energy of rupture for static and impact bending, and the former test disregards the work done by gravity on the beam, it will also be neglected here.

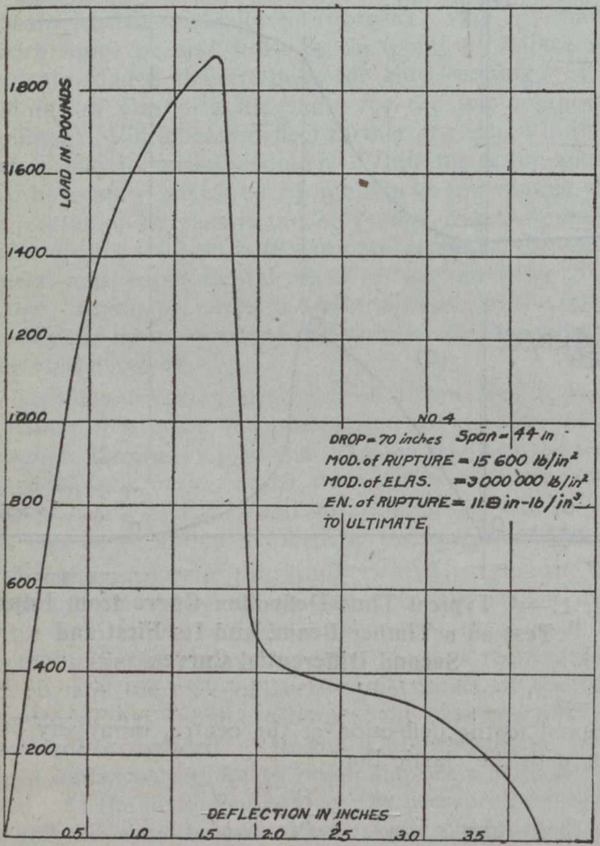

Fig. 2.—Impact Force Deflection Curve for a Long-leaf Yellow Pine Beam Completely Ruptured by a Single Blow

There results, then, upon replacing in equation (2) the integrals valuated, the new equation

$$\int F dy + \frac{17}{35} \frac{W_b}{2g} v^2 + \frac{1}{2} \frac{W_t}{g} v^2 = W_t y + \frac{1}{2} \frac{W_t}{g} v_t^2$$

For any one height of drop v_t is a constant, hence on differentiating

$$\frac{F dy}{dt} + \left(W_t + \frac{17}{35} W_b \right) \frac{v}{g} \frac{dv}{dt} = W_t \frac{dy}{dt}$$

But

$$\frac{dy}{dt} = v' \qquad \text{and } \frac{dv}{dt} = \frac{d^2y}{dt^2} = \frac{d^2s}{dt^{2\prime}} \text{ so that}$$

$$Fv + \left(W_t + \frac{17}{35} W_b \right) \frac{v}{g} \frac{d^2s}{dt} = W_t v$$

$$F = W_t - \left(W_t + \frac{17}{35} W_b \right) \frac{1}{g} \frac{d^2s}{dt^2} \tag{3}$$

From the last equation it is seen that the beam must exert a force upward that will overcome the weight of the tup and impart to a mass of $\left(W_t + \frac{17}{35} W_t \right)$ pounds an acceleration $\frac{d^2s}{dt^2}$.

The latter should be noted in particular, for it shows that the beam imparts an acceleration not only to the tup but to forces in the beam also. This is obvious when one remembers that at the instant when the inertia of the beam has been overcome, which happens very soon after initial contact, the beam has acquired a considerable velocity, and this velocity is reduced to almost zero at the time of maximum deflection. These forces proceed, of course, from the elastic deformation of the fibres.

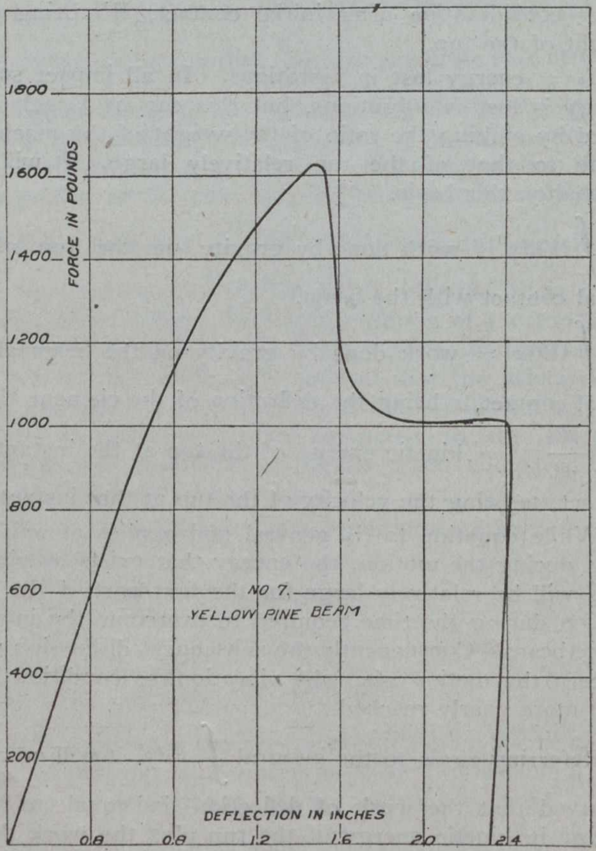

Fig. 3.—Impact Force-Deflection Curve for a Long-leaf Yellow Pine Beam Fractured but Not Entirely Ruptured

The force F being a centre force acting on a simple beam supported at the ends, the external or bending moment is obtained immediately, and equating to the internal or resisting moment there results.

$$\frac{Fl}{4} = \frac{SI}{v} \qquad \text{(Within the elastic limit)}$$

$$\text{or} \qquad S = \frac{Flv}{4I} \qquad (4)$$

Where S = fibre stress desired,

$\frac{I}{v}$ = section modulus of the beam,

l = length of the beam.

The problem has now resolved itself down to finding the value of F in equation (4), all the other terms of the equation being known. This in turn takes us back to equation (3), in which all the terms are known except the acceleration $\frac{d^2s}{dt^2}$.

A double differentiation of the deflection-time curve yields the acceleration.

The machine used for making the tests was a Hatt-Turner drop testing machine, having a maximum capacity of 72-inch drop, in use by the United States Forest Products Laboratory at Madison, Wis. It is provided with a cylinder which is rotated at a relatively high speed and has wound around its surface a metalized sheet for receiving the impression of the stylus fixed to the descending tup. A zero or base line is first drawn on the sheet, giving the position of the tup when it rests upon the beam as a static load. An electric contact releases the tup when it has been drawn up the desired height, and a tuning-fork record gives the scale of the abscissa in seconds per inch. The latter record was taken to serve as a check on the theoretical velocity attained by the tup at the instant of striking.

Deflections must be measured from a base line of no load, so that it was necessary to compute first the distance up from the line drawn with the tup resting on the beam to the position of no deflection, by the equation

$$y_1 = \frac{1}{48} \; \frac{W_t l^3}{EI}$$

A typical deflection-time curve as obtained in the tests is shown in Fig. 1 (*a*). The differential or velocity curve of (*a*) is shown as (*b*) immediately below, and the second differential or acceleration curve is shown at (*c*). The dashed horizontal line represents the base line drawn on the paper while mounted on the cylinder with the tup resting on the beam, and y_1 is the static-load deflection computed according to the method mentioned. Deflections are likewise distances of descent, s, of the tup, except at the start when the inertia of the beam has not been overcome. Up to the point where the curve crosses the time axis, the tup is falling freely under the influence of gravity, the velocity increasing in the downward direction proportional to the time, and the acceleration remaining constant, being equal to g, the acceleration of gravity. At m (neglecting inertia at the beam) the curvature changes, indicating a change in direction of the acceleration from negative to positive values. At r failure occurs and the acceleration curve shows a sudden drop. Rupture is not yet complete, but proceeds up to the point n. Here again there is a change in curvature of the space-time curve, signifying a change in the direction of the acceleration, which again becomes negative; and thereafter the body falls through the action of gravity alone.

Accelerations being the quantities desired, it is necessary to go through this process of differentiation for each curve, drawing first the velocity-time curve and then its differential by finding the slopes at a series of points on each curve, and plotting these slopes as ordinates to a new base line. This was done mechanically by means of the author's differentiating machine.

After computing the scales of each of the curves, we are in a position to draw the load or force-deflection curves for impact. By dividing the time axis into small units, finding the acceleration corresponding to each time interval, substituting in equation (3) to get the effective centre force F, and then scaling the deflections corresponding to each of these accelerations (hence forces), and plotting these values of force and deflection on co-ordinate axes, we have the desired force-deflection curve. A typical curve obtained in this manner is shown in Fig. 2. The beam was thoroughly air-dried long-leaf pine of a 2 x 2-inch section and span of 44 inches. The point of failure, as will be noted, is very pronounced, followed by continued deflection, in which the fibres that were not completely ruptured at the first failure are torn or crushed progressively.

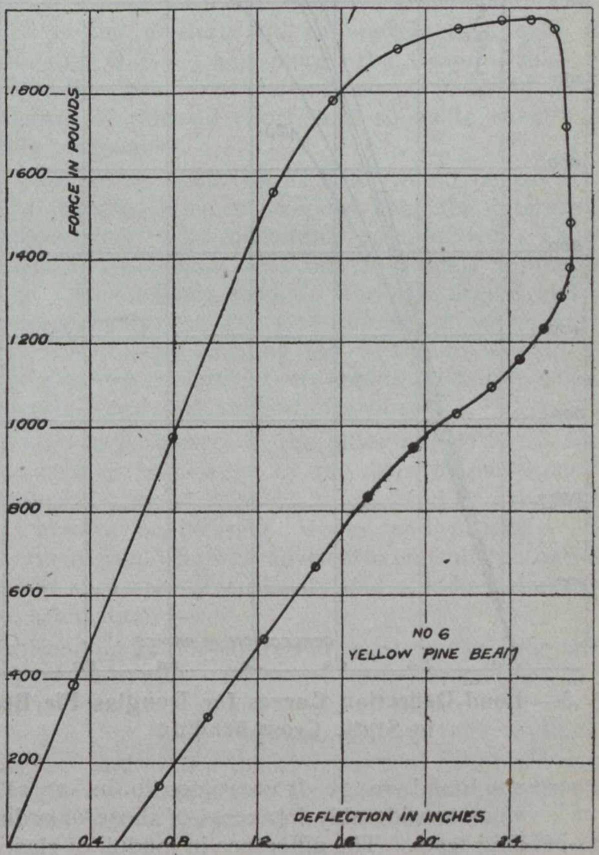

Fig. 4.—Impact Force-Deflection Curve for a Long-leaf Yellow Pine Beam Fractured but Retaining Considerable Resilience. The Circles Space Off Equal Time-intervals

Figs. 3 and 4 show the curves for two beams not completely ruptured, each retaining sufficient resiliency to send the tup back after the maximum deflection had been reached. The beam of Fig. 3 is peculiar in that initial failure was followed by an increase of deflection in which the load remained practically constant, indicating that the fibres failed at a rate just sufficient to balance the increase in force due to increase in deflection. At maximum deflection the total available energy had been consumed, and almost simultaneously there occurred a second failure. But the tup had already reversed its motion, as indicated by the returning curve. The latter phenomenon occurred more strikingly in the beam whose curve is shown in Fig. 4. The circles distributed along this curve are spaced at equal time intervals apart. Evidently, as the time increases, the stresses in the fibres tend to give away, causing the curve to bend over during the latter part of the sweep up to the ultimate. Motion is extremely rapid, the time between two successive points being only 0.00167 second. The values of stress at the ultimate, the so-called modulus of rupture, computed according to the flexure formula, the modulus of elasticity, the energy consumed up to the ultimate, and the deflection to the ultimate are all tabulated in the summary of results below.

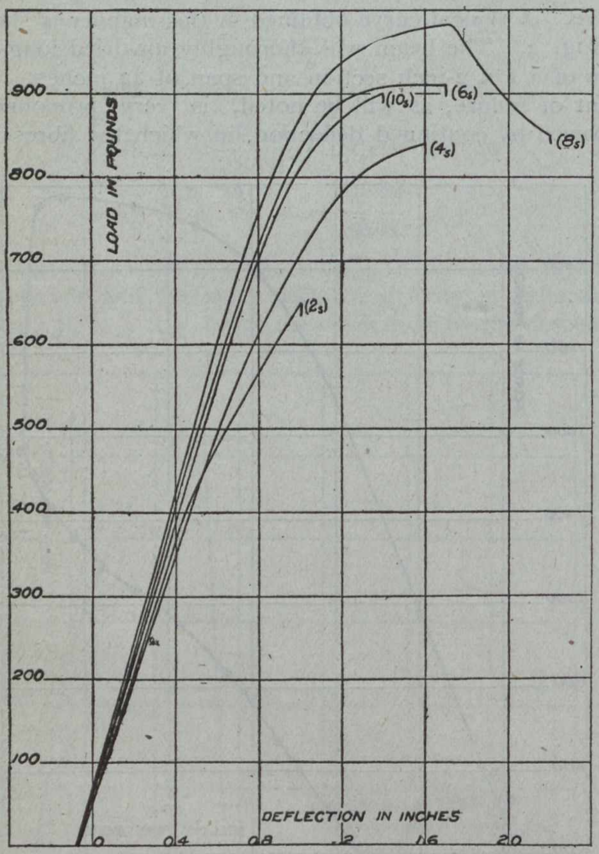

Fig. 5.—Load-Deflection Curves for Douglas Fir Beams in Static Cross-bending

The stresses found range from 10,000 lb./in.^{2} to 22,000 lb./in.^{2}, values considerably in excess of those of ordinary cross-bending tests. The difference in moduli of elasticity is not quite so pronounced. The large values for stress may be due in part to selected material, but more probably to the nature of the loading itself.

Summary

1. Fibre deformations in impact set up forces which overcome the kinetic energy of the tup and the kinetic energy acquired by the beam during the short impulse period immediately after initial contact.

2. By setting up a general energy-work equation for impact, differentiating, and dividing by the velocity, an expression for the effective force was obtained:

$$F = W_t + \left(W_t + \frac{17}{35} W_b \right) \frac{1}{g} \quad \frac{d^2 s}{dt^2}$$

3. Double differentiation of the time-deflection curve obtained autographically yielded the acceleration-time curve.

4. By substituting values of the acceleration from the acceleration-time curve in the equation for F and plotting against the corresponding deflections from the deflection-time curve, force-deflection curves for impact were obtained.

5. From a series of force-deflection curves for six beams of Douglas fir broken under a single blow and five beams broken in static cross-bending, all beams being cut from the same piece of timber, the following conclusions were drawn:

(*a*) The impact fibre stresses are almost double the slow bending stresses, at rupture.

(*b*) The energy of rupture in impact up to the ultimate load is twice that of static bending.

(*c*) The deflection at the ultimate load and the modulus of elasticity are about one-fourth higher for impact than the corresponding properties under static loading.

6. The mechanical properties of long-leaf yellow pine and spruce are higher in impact than the average values for the same properties in static bending.

7. The energy available is practically entirely consumed by the beam, supporting the contention that very little energy is lost in vibrations of the machine frame.

METROPOLITAN DISTRICTS FOR PLANNING AND ADMINISTRATION*

(*Continued from page 156.*)

Canada has not been backward in this respect. Two important districts have been formed in the Dominion, one for the purpose of a metropolitan water-supply and the other for the purpose of constructing district sewerage works. The Winnipeg Water District was formed in 1913, to bring a supply of water from Shoal Lake for Winnipeg and the surrounding territory, with an area of 92 square miles and a population of 238,000. The Greater Vancouver Sewerage District was organized in 1913 for the construction and maintenance of the necessary intercepting sewers and sewage disposal plants needed in the urban territory around Vancouver and the city itself, including 5 municipalities, covering an area of 90 square miles, with a population of over 150,000 in 1911.

Many variations have been worked out in the methods of dividing costs of such systems, but most of them may be classed either under general taxation, special assessment, or rates based upon quantity of service. It is desirable that the methods shall not be specified too definitely in the preliminary legislation, as much more satisfactory results can be worked out after the details of the project have been largely determined. The change of the methods of apportionment of the charges for the various services in the Boston Metropolitan District is an illustration of the growth of public opinion as to desirable means of payment. It is always possible in any case, however, to work out a method which will be equitable and which will give service to each community involved, at a cost far below that which could be attained by independent action.

The South African Government Railway Administration has ordered twenty superheater mountain type locomotives from the American Locomotive Company.

It is reported from France that the Société des Mines de la Loire has recently started its first of two electric furnaces for the production of iron, utilizing current from its own generating station.

Editorials

A BLANK CHEQUE

Members of the opposition have stated in parliament that the government legislation for arbitrating the value of the capital stock of the Canadian Northern Railway is tantamount to handing Messrs. Mackenzie and Mann a blank cheque. The argument is not entirely illogical. A maximum limit should certainly be placed upon the possible award by the arbitrators. Legislation giving arbitrators such unique and unlimited authority to commit the country to the expenditure of huge unknown sums of money, without any repeal or recourse by the government, establishes a dangerous precedent in Canada.

The government has just admitted the correctness of the principle of limiting the railway expenditures that can be authoritatively made without seeking further sanction of parliament. The government has agreed to a limit of $25,000,000 as the amount which may be spent for rolling stock, interest payments, improvements, etc., without going back to parliament for further approval. If the government sees the necessity of placing a maximum limit upon the purchases of rolling stock for the C.N.R., it should far more readily see the necessity of placing a maximum limit upon the purchase of the capital stock of the railroad. Whatever sum of money may be spent for rolling stock will inure to the benefit of the country. The government will have the rolling stock and the people will have the benefit of it. There will be definite value received for the expenditures; the money will be transformed into valuable assets.

OUTLINE THE TERMS OF ARBITRATION

In the issue of August 9th, we urged that the government should establish more clearly the basis upon which the arbitration should be conducted. This point has now been partially met by Sir Thomas White's announcement last week that, if the arbitrators take the physical value of the road into consideration, the determination of the value of the stock should be upon normal pre-war prices of labor, material and equipment, and not upon present abnormal prices. So far, so good; but the government should go much further. The wording of the announcement in regard to the pre-war prices intimated that if physical value be considered by the arbitrators, it should be upon the basis of reproduction cost. Why should the country pay for stock in the C.N.R. valued on a reproduction basis? The plant and equipment of the C.N.R. has been in use for many years and has created earnings in which the country has not shared. The value of the C.N.R. should be upon a basis of reproduction less depreciation, and the government should make this quite clear before the C.N.R. bill becomes law.

Hon. Mr. Bennett, of Calgary, suggests that the government introduce an amendment making it clear that the actual value of the stock itself, and not the control value of the stock, be the value to be considered by arbitration. This is a point well worth the consideration of the government. At the same time the government might make it clear that the arbitrators should not take good-will into consideration. When a firm goes into receivership, good-will usually goes into the same melting pot as the prospective earning value of its capital stock.

ENGINEERING HELP IS NEEDED

The basic idea of the government's taking over the C.N.R. is sound, provided that the government will go further in the matter, and ultimately take over the G.T.R. and G.T.P., and merge the Grand Trunk and the Canadian Northern systems, so as to avoid further duplication of railroad effort, and so as to effect many possible economies.

A plan to take over the C.N.R. would be worthy of general popular support provided that the interests of the people were to be thoroughly safeguarded. The bill now before parliament does not adequately protect the country. It is loosely drawn. There is urgent and immediate necessity that the government introduce amendments; first, clearly defining the maximum amount that may be awarded by arbitration; second, definitely defining the precise terms and method of arbitration.

Failure to be clearer in the latter regard is no doubt due to lack of knowledge by members of parliament of the technical side of railroad affairs, and of arbitrations which involve engineering works and property. The government would be well advised to consult railroad and valuation engineers of authority and standing, in regard to the arbitration.

Railroading is not entirely a legal matter, nor is the buying of railroads. These are technical matters, more within the province of the engineer than of the lawyer. It is hoped that the government will yet take cognizance of this fact and secure the assistance of capable consulting engineers to aid the goverment counsel in their arguments before the board of arbitration.

PLACE YOUR ORDERS NOW

Municipal engineers and others who are planning roads, bridges, sewage disposal plants or other construction work for next year, would do well to place their orders for machinery and materials right away.

Everyone knows how scarce labor is and how costly it is; also the difficulty which the manufacturers are having in getting delivery of raw materials, and the high prices which must be paid for them. The purchasing agent of a big concern advised us recently that there is only one safe rule for buying under present conditions, and that is to place all orders at once at current market prices, not only for present requirements, but also for future requirements so far ahead as can be foreseen.

Broadly speaking, no prices are coming down; everything is increasing, and unless unlooked-for events take place between now and next spring, the cost of machinery and all materials will be higher than now. The engineer or contractor who is farsighted will place his orders now, thus avoiding dissappointments in delivery; getting the benefit of lower prices than will obtain later on; and giving the manufacturer a chance to cover himself with purchases of the necessary raw materials at present prices, and sufficient notice to obtain those raw materials in time to manufacture the machinery required.

AN IMPERIAL DEVELOPMENT BOARD

In their final report, the Dominions Royal Commission, probably as a result of their investigation of the operations of the Canadian Commission of Conservation, recommend for the Empire an "Imperial Development Board," which is evidently designed upon the same lines as the Conservation Commission. The references to the need of a "purely advisory" body to make a "continuous survey and consideration of Empire resources," "to study the best means of co-ordinating Empire effort for the development of these resources," and that it "should not encroach upon the administrative machinery," sound like an echo of the evidence respecting the operations of the Conservation Commission given before the Dominions Commission by its deputy head, James White.

The Dominions Royal Commission say:—

"We believe that the time has come when something less occasional is needed, when a body should be created which could be referred to at any time and by any of the Governments in order to smooth the path of Imperial development. There is, in brief, both scope and need for a new Imperial Development Board, which, without displacing any existing body, would devote its energies and experience to a continuous survey and consideration of Empire resources and opportunities, and to study of the best means of co-ordinating Empire effort for the development of these resources for the extension of Imperial trade, and for the strengthening of Imperial lines of communication. It would be impossible to exaggerate the significance and influence of such a Board, composed, as it should be, of men possessing an intimate knowledge of the Empire and its resources, in constant consultation and collaboration, on the watch for every opportunity, and alive to every possibility. . . .

"To the duty of advising and guiding on these matters would, of course, be added that of collecting the necessary particulars bearing upon them. This would involve research not only into the conditions prevailing in the Empire, but into the methods of production and distribution of rival trading countries which have similar problems to face. Accurate and up-to-date knowledge of such matters will be, in our judgment, necessary, and, indeed, vital, under the keener competition and closer organization which will obtain after the war. The proposed Board should further undertake the elaboration and the critical examination of joint Imperial schemes of development. The submission of questions of joint development to an Imperial Board would save both time and money. It would save time by the curtailment of the interminable negotiations which are now required to achieve joint action between the various Governments. It would save money in the sense that the schemes submitted to it would receive thorough examination, and would pass through the fire of criticism.

"The primary condition of this new Imperial Development Board must be that it should not encroach upon the political or administrative machinery of any of the self-governing parts of the Empire.

"In other words, it should be purely advisory in its initial stage. We are not prepared to suggest that, at its inception, any specific administrative functions should be assigned to it, but equally we hesitate to restrict the future activities of a new, and, to some extent, experimental, organization. If, at some future time, the Governments of the Empire should, either through the Imperial Conference or otherwise, desire to delegate any administrative duties to it, we see no inherent difficulty in giving effect to such a wish."

PERSONALS

W. P. NEAR, city engineer of St. Catharines, Ont., has been appointed manager of the city's gas plant.

WILLIAM HUNTER, Kincardine, Ont., has been appointed overseer of good roads for the county of Bruce.

ALEXANDER GILLESPIE, for the past twelve years resident engineer at the waterworks department, Brantford, Ont., has resigned.

Sapper FRED HUDSON has been appointed by Works Commissioner R. C. Harris, of Toronto, as inspector of water main installation in York Township.

G. PALMER HOWARD, manager of the Phœnix Bridge & Iron Works, has left Montreal for Washington, having been chosen to act on the British Imperial Munitions Board.

STEEL HUNTER, for the past eight years engineer in charge of fire protection waterworks at Lucknow, Ont., has resigned in order to take a position at Calumet, Mich. He will be succeeded by JOHN NEVINS, of Brussels, Ont.

C. ROYER, for several years manager of the L'Air Liquide Society, Montreal, has severed his connection with the firm. He contemplates starting as a consulting engineer in the oxy-acetylene process of cutting and welding in general engineering practice.

W. P. HINTON has been appointed vice-president and general manager of the Grand Trunk Pacific Railway and G.T.P. Coast Steamship Company, with headquarters at Winnipeg. Mr. Hinton succeeds MORLEY DONALDSON, M.Can.Soc.C.E., who has been associated with the Grand Trunk Railway System since 1905, and has now resigned on account of ill health.

Lieut. LEWIS WYNNE-ROBERTS, R.E., formerly of Regina, Sask., has been selected for duty in Mesopotamia. He left England in March, and made the voyage down the west coast of Africa, spending a few weeks in Cape Town and other cities. Letters indicate recent arrival in Bombay, from which point he was sent to Bangalore, where he is attached to a corps of sappers and miners.

R. R. SHAFTER, manager of the crushing machinery department of the Traylor Engineering & Manufacturing Co., Allentown, Pa., has resigned his position for the duration of the war in order to become engineer-in-charge of the Traylor Shipbuilding Corporation. The latter company, which has a contract for the building of ten vessels for the United States government in connection with the Emergency Fleet Corporation's work, is a subsidiary of the Traylor Engineering & Manufacturing Co. Mr. Shafter is well known in Canada, having designed a number of the largest rock-crushing plants in the Dominion, including the big crushing plant that will soon be erected for the Hydro-Electric Power Commission at Niagara.