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The Canadian Engineer

*A weekly paper for Canadian civil engineers and contractors*

# Design of Concrete Truss Bridges

## Discussion of Theoretical and Practical Points Resulting From Designs Proposed For Bridges on the Toronto-Hamilton Highway—Method of Computing Stresses in Arched Chord—Top Lateral Struts Unnecessary — Expansion Plates — Splice of Lower and Arched Chords

By FRANK BARBER
Consulting Engineer, Toronto

UP to 1915 the concrete truss bridge was something of a novelty in Canada, hardly more than a dozen such bridges then having been built in this country. Of late, however, a wide interest is being taken in them by bridge engineers. This is doubtless due to the fact that the cost of concrete superstructures has not advanced to the same extent as steel bridges. A steel bridge which in 1915 cost erected about five cents a pound, cost in the last season from eleven to thirteen cents a pound. But concrete has advanced in cost only about 50 per cent. in the same time.

I have had several inquiries from engineers in the last year or two regarding various points of design and construction concerning concrete truss bridges and I believe that some of these matters are of some general interest to bridge engineers. Amongst these are the following:—

1—Splice of lower chord with arch chord.
2—Connection of floor beam with hanger.
3—Expansion plates required.
4—Advisability of top lateral struts.
5—Method of computing stresses in arched chord.

It happens that these matters were all discussed at a conference of bridge engineers under the following circumstances:—

The Toronto and Hamilton Highway Commission have let contracts for four concrete truss bridges of 20-ft. roadway, three of them of 120 feet clear span and one of 100 feet. The floor systems were hung from the curved top chords by hangers, no diagonals being used. They were designed by the bridge engineer to the Commission, but as the various counties in which these bridges are situated had to pay the bulk of the cost, the counties had these designs reviewed by bridge engineers retained by them.

### Results of Conference

After a discussion of the above points, amongst others, the three engineers retained by the various counties found no difficulty in arriving at conclusions as follows:—

First.—The splice of the lower chord with the arched chord is undoubtedly the most important in the bridge. The maximum stress in the lower chord is the same from end to end, the floor system with its imposed loads being suspended by hangers from parabolic upper chords in a manner similar to the floor system of a suspension bridge suspended from the cables. The function of the lower chord is to tie the opposite toes, i.e., the skewbacks, where in the ordinary arch the earth between the two abutments resists this tension. It was considered necessary for safety that the steel rods of the lower chord should pass through vertical plates at each end to nuts and washers at the back of the plates. The toes of the arch chords press against these plates, the size of which are computed for resisting the total horizontal thrust of the top chord.

Second.—Since the concrete of the lower chord is in tension the hanger rods should pass through a horizontal steel plate at the bottom of each hanger in the same way that the lower chord rods pass through the vertical plates mentioned above. The end of the floor beam then rests upon this plate, which makes a satisfactory bearing for it.

Third.—As to expansion plates, two steel bearing plates, with a brass plate between, was considered to be sufficient and the most satisfactory. The lower bed plate may rest upon a thin sheet of lead so that it shall come to an even bearing after the centres are struck. The expansion due to temperature is less than is ordinarily allowed for. Experiments on the Walnut Lane Bridge, Philadelphia, for instance, show that the concrete of these arch ribs rose in temperature almost evenly from the average temperature of January and February to the average temperature of July and August, 25 degrees C., this being less than half of the actual variation of temperature in air, which was 54 degrees C.

Fourth.—It was considered that top lateral struts were unnecessary for the following reasons:—They are not required to resist wind, since the arch ribs can easily be made to take the wind stresses, and in any event, the toes of the arch must resist nearly all the wind stress.

### Not Required to Resist Wind

In one of the designs above referred to which was reviewed, only one-fifth of the wind stress was resisted by hangers, considering the stiffness of hangers and top chords according to their moments of inertia at the bottom section of each.

The hangers were found to be stiffer than the ordinary steel outriggers dividing the top chord of a pony truss into short columns, if the number of hangers compared to the number of outriggers be considered. I quote from the report of one of the engineers above-mentioned as to top lateral struts: "The vertical hangers, along with the fixed ends, would in my opinion constitute as rigid a fixing of this chord as usually obtains in a pony truss. . . . Struts between the chords would not be of value unless along with these diagonals were used as well as portal braces."

Fifth.—There was some discussion as to the readiest method of computing the stresses in the arch chord. The moment of inertia of the lower chords was found to be nearly as great as that of the arch chord at the crown, and as one cannot be strained out of position with carrying the other with it, it was agreed that the moment of inertia of the lower chord should be given as much consideration as that of the upper chord in analyzing it by the theory of elasticity.

Some case could be made out for considering the moment of inertia of the whole floor system, but this was rejected.

Opinions differed as to whether the arch at the skewback could be considered fixed or not, and a compromise was made by taking it half way between the two-hinged chord hinged at the skewbacks and one entirely fixed.

This results in making the arch chord at the skewback **considerably thinner than if it is to be computed as having** fixed ends.

Three methods were used in checking the live load moment effects. One was to figure the arch by the theory of elasticity, augmenting the moments of inertia at each point by those of the lower chord section horizontally below it, and computing the moments by the ordinary theory of elasticity. A check was to leave the upper arch chord out of account altogether and figure the floor system as a stiffening truss according to the same theory that would be used in figuring the stiffening truss of a suspension bridge. The floor system was found to be entirely stiff enough to resist the live load moments without counting upon the arch chords at all except to bear up the floor system.

The third method was to figure it as a truss bearing up a moving load from panel to panel. As each panel is considered, an imaginary diagonal is drawn in and the tension upon it is found. The bending moment on the upper and lower chords, resulting from the removal of this imaginary diagonal, is then computed.

## Letter to the Editor

### LAND DEVELOPMENT, TRANSPORTATION AND HOUSING

Sir,—In Mr. Thomas Adams' communication to the Building Industries Conference at Ottawa, reported in your issue of December 5th, he says: "As builders you are aware of the important connection between the method of developing the land—including the method of planning and constructing the streets—and the building operations which you carry on. It is perhaps unnecessary, therefore, for me to point out how important it is that any organization which may be set up to deal with the question of housing, should also take into its purview the question of land development in relation to housing, and such problems of local transportation as have a direct bearing on housing."

#### The First Consideration

I doubt whether builders in Canada have realized the importance of this matter; but it is certainly the first question that should be considered before housing on any extensive scale is carried out under federal, provincial or municipal control. There are three standards which have been sanctioned by long custom in American and Canadian cities, but which have a deterrent effect on the economical development of land for building purposes. They are a standard width of street, a standard depth of lot and a standard street car fare.

That some width of street should be defined as the minimum width is wise and necessary; but that all streets should be made of one width, irrespective of their purpose, is foolish and wasteful. A short street serving residential property does not need to be the same width as a main thoroughfare between two cities or the principal business street of a town. It is occasionally true that in a city subdivision some streets are made wider than others; but because they do not form part of a well-considered plan, the increased width is often land wasted.

In Vancouver, for instance, Fourth Avenue was widened from 66 to 80 feet to accommodate a double car track, and also paved to form a main thoroughfare, at a cost of $132,758 for widening alone, whilst Fifth Avenue, an 80-foot street, remains unutilized. Similarly Hastings Street East was widened and improved from 66 feet to 86 feet, at a cost for widening alone of $120,350, whilst Pender Street, 244 feet to the south, remains a 99-foot street and an earth road. The capital expenditure wasted by these two examples of a defective city plan would be sufficient to build 100 homes on each street.

By saving on the width of the less important roads, greater width could be given to the main arteries, and by enforcing a building line the requisite air space between buildings could be better preserved.

Few realize that on the ordinary standard rectangular system, generally 33 per cent. and sometimes 40 per cent. of the area of the land is taken up by streets, nor is it realized how under modern planning great economy in this regard can be obtained, thus making it possible, by saving on the cost of land and land development, to spend more money on the home itself.

Take, for instance, a standard sub-division, as in Ward 8 of the city of Vancouver. Sixty per cent. is available for building, 38 per cent. is taken up by streets and lanes, and 2 per cent. utilized for school and park sites.

#### Division of Available Areas

Compare this with modern planning for industrial development. The average of seven industrial developments carried out by Mr. John Nolen, town planner, Cambridge, Mass., shows 58.5 per cent. available for building, 25.7 per cent. taken up by streets, and 15.8 per cent. in school and play sites; whilst in the Sawyer Park development at Williamsport, Pa., described as the nearest approach this country has to the best English Garden City development 63.5 per cent. is available for building, 21 per cent. is occupied by streets, and 15.5 per cent. for school and play sites. It is surely better to economize in the width of the streets, and to devote the area saved to school playgrounds and parks, rather than have unnecessarily wide streets, expensive to construct and maintain, and then expect them to serve as the children's playground.

When we come to consider the second standard named, a standard depth of lot, we find it equally illogical, extravagant and foolish. Lots, of course, vary in depth, but in a standard rectangular development are generally 100, 122, or 132 feet deep, depending partly on whether or not a lane is provided.

If 132 feet be adequate for the mansion of the rich man, it is evidently too much for the cottage of the workingman; and yet 132 feet may be quite inadequate for many public buildings or industrial workshops. When housing is considered as a national problem, it is generally industrial housing that is in mind, and it should not be overlooked, if single houses are to be erected, that a lot 33 feet by 100 feet is infinitely better to secure a sanitary and economical home than a lot 25 feet by 132 feet; and yet both take the same area of land.

It seems a strange failing of the people on this continent that they have been content to accept a method of subdividing land for town and city development, devised by our grandfathers, but proved to be quite as inadequate to meet modern conditions as would be the locomotives they built if set to haul the "Imperial Limited" train to-day.

It is time we stopped planning our cities with a ruler and a square, and laying out our streets to the points of the compass regardless of the contour of the ground. City planning is a complex problem, quite beyond the province of the real estate agent; and upon the success of a city plan depend many economic and social questions.

#### Standard Street Car Fares

The third standard, a standard street car fare, may at first sight appear to have little relation to the housing question; but a little investigation in almost any city will show that it has had a great effect on the economical development of land. The tendency of the standard street car fare has been to congest the population at the terminals, and leave an undeveloped territory in the centre; and the greater the distance travelled on one fare, the greater has usually been the effect.

The reasons for this migration are too numerous to enumerate here, but the result has been in most cities that roads, sewers, watermains and other public utilities have been extended to provide for the population so diverted, and in other cities it has meant that a large population has been placed just outside the city limits and left unprovided with the sanitary facilities and not subject to the same building restrictions, forming a very serious problem when the time comes that the district has to be absorbed in the city.

The effect on the middle zone has been to leave it only partially developed, and yet subject to high taxation caused by roads and other accommodation carried through it to serve the population on the outskirts. A car-fare more scientifically regulated would lead to a more even distribution of population, and would make possible the utilization of land closer in, thus saving in the time of transportation between the industrial centres and the homes of the workers.

It is sincerely to be hoped that Mr. Adam's advice on these matters will be taken, and that no extensive housing schemes will be carried out in a hurry on old sub-division plans, but that full advantage will be taken of the knowledge gained in modern town planning, both in this country and in Europe. By so doing money will be saved, the character of the home to be built greatly enhanced, and the success of the scheme assured.

A. G. DALZELL,
Consulting Engineer.

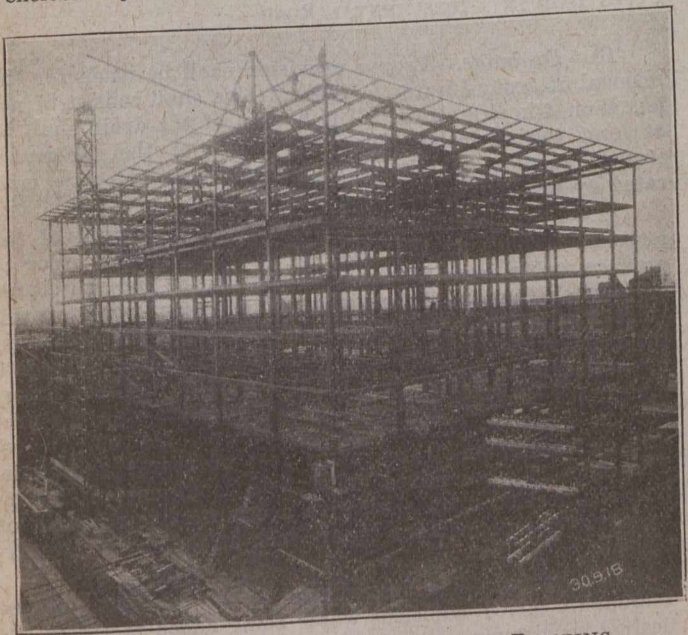
Vancouver, B.C., December 18th, 1918.

## DOMINION GOVERNMENT OFFICE BUILDING

At Ottawa the Department of Public Works has under construction a Dominion Government office building, to be known as the Hunter Building. The designs for this building were prepared by the chief architect's staff of the Department of Public Works, and the contract is being carried out by Bate, McMahon and Co., of Ottawa.

For several years the office accommodation for the several departments of the Civil Service has been altogether inadequate, and it has necessitated separating different branches of one department, and, in some cases, even having the work of one department carried on in buildings widely separated. This has caused delay, inconvenience and duplication of work in many cases. The completion of this new modern office building will permit the consolidation of work and consequently greater efficiency than is possible under present conditions.

The building will occupy the eastern portion of the block enclosed by O'Connor, Bank, Queen and Albert Streets. It



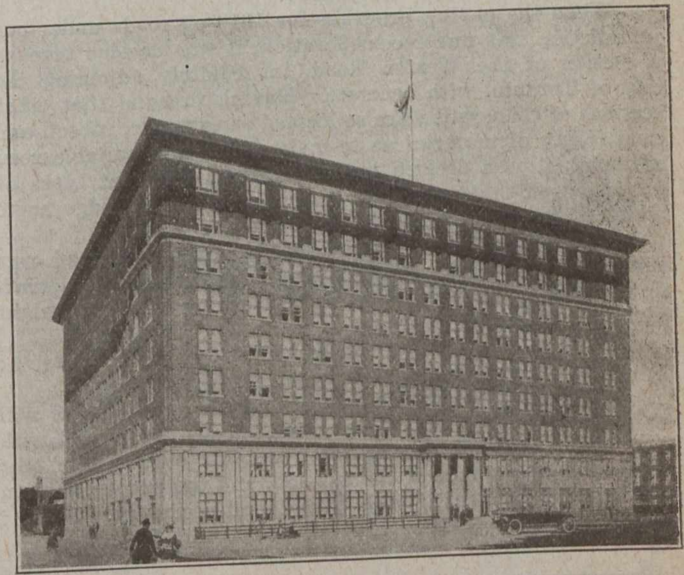
Steelwork of Government Office Building

is 200 ft. long by 150 ft. wide, with nine stories above the sidewalk. The court is 96 ft. by 48 ft., and the corridors 7 ft. 2 ins. wide.

It is not a part of what is generally known as the Parliament Buildings, but is separated from them by two blocks of commercial buildings of various styles of construction. The designs and plans of this building were formed more along the lines of an up-to-date commercial office building than for any architectural display, although it has been treated in such a way as to give a very dignified and pleasing appearance.

The building is carried upon steel columns from the surface of the rock. The steel is encased in concrete and the whole building is fireproof. The floors are of reinforced concrete with mastic finish and the partitions of terra-cotta. The roof is reinforced concrete slab, with a waterproofing felt and gravel cover.

Granite is used throughout the exterior facades to about the ground floor level. Above this there are two stories of



Dominion Government Office Building Now Under Construction at Ottawa

limestone. The remaining stories are of a light tapestry brick with stone trimmings backed with 12 in. terra-cotta blocks.

The building may be entered from three sides: O'Connor, Queen and Albert Streets. A vestibule at each entrance gives direct access to one of the three double elevator shafts. A corridor runs entirely round the building giving access to the various offices on each side of it.

The only marble finishing is found in the three entrances which have marble mosaic floors and marble dadoes. In all other halls and corridors the floors are terrazo and the dadoes of concrete 7 ft. high, with white vitralite enamel finish.

Provision has been made for very adequate fire protection, ventilation, vacuum cleaning, sanitary lavatories and heating.

## TENDERS FOR PETERBOROUGH BRIDGE

Three tenders were received by the Peterborough, Ont., City Council last Friday for the construction of the high-level concrete bridge. The tenders were: R. Sheehy, $381,474; John O'Toole, $351,710; Canadian Engineering and Contracting Co., $337,338.

As the ratepayers had voted only $245,000 for the bridge, the lowest tender was more than $92,000 in excess of the funds authorized, therefore the aldermen, whose terms expire at the end of this month, decided to leave the situation to be dealt with by the incoming council. It may be necessary to submit another by-law to the people for the extra money needed unless the Provincial Government authorizes the work to be done without that formality.

Frank Barber, consulting engineer, of Toronto, pointed out that Mr. O'Toole's tender excluded the guarantee bond, amounting to about $2,000, and that he required two years in which to complete the bridge, whereas the other two bidders agreed to build it in one year. The reason given for the increased cost of the bridge as compared with the estimate made a year ago was the added length and width and the increased cost of materials. About ten contractors had figured on the structure but only three tendered.

## WESTON ROAD CONCRETE PAVEMENT

By E. A. James
*Chief Engineer, Toronto and York Roads Commission*

In 1911 the Toronto and York Roads Commission built two miles of concrete pavement on the Lake Shore Road, but because of the necessity for a wider and a relocated pavement, it was replaced in 1917.

When the paving program for 1918 on roads under our jurisdiction was under consideration, it was decided to pave a section of the Weston Road, immediately adjoining the city of Toronto, with concrete. Having in mind that other sections of this system are so located as to traffic, subsoil and availability of material as to make concrete a suitable road material, it was decided to build sixteen different types of pavement so that we might be in a position to judge as to which, if any, would be suitable for future work.

A traffic census was taken, and the average spread over several weeks may briefly be summed as follows. The traffic census per hour from six in the morning to nine at night gives the following average:—

Bicycles, 7; horse-drawn vehicles, 34; motorcycles, 1; automobiles, 44; and motor trucks, 15.

A study of the drawings accompanying this article will indicate that the types of pavement selected were used with a view to determining the most suitable section, the best shape for the surface of the sub-soil, and the proper location of the reinforcement if such were found necessary.

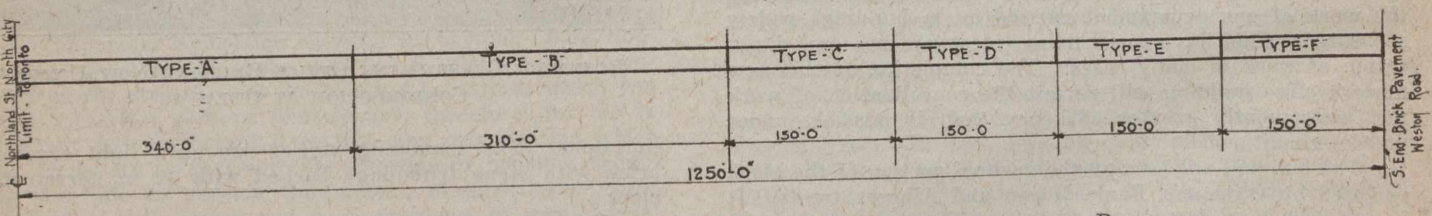
4.—*Natural Mixed Aggregates.*—Natural mixed aggregates shall not be used as they come from deposits, but shall be screened and re-mixed to agree with the proportions hereinafter specified.

5.—*Water.*—Water shall be clean, free from oil, acid, alkali, or vegetable matter.

7.—*Preparation.*—The sub-grade shall be brought to a firm and unyielding surface by rolling with a self-propelled roller weighing not less than five tons; all portions of the sub-grade inaccessible to the roller shall be thoroughly compacted by hand tamping, to the satisfaction of the engineer, and shall be puddled if the engineer considers the same necessary. All soft and spongy places shall be removed and all depressions shall be filled with gravel, broken stone, or other material approved by the engineer, and shall be thoroughly compacted in layers, each of which shall not exceed four inches in thickness. When a fill exceeding one foot in thickness is required to bring the sub-grade to the proper elevation, it shall be made in a manner satisfactory to the engineer.

8.—*Sub-base.*—Should it be necessary to build a sub-base, the same shall consist of clean hard material not exceeding four inches in the largest dimension. All materials for this purpose shall be approved by the engineer. The sub-base shall be thoroughly compacted and brought to the proper elevation as before specified.

9.—*Wetting.*—While being compacted, the material of the sub-base shall be kept moist and the surface shall be in that condition when the concrete is deposited.




Plan Showing Location of Different Types Laid in Experimental Road

The total length of the pavement is approximately 1,250 ft., and this was divided into six sections, located as shown in the accompanying plan. The width throughout was made 22 ft., and the surface was given a crown of 2 in. The grades were light, the minimum being 0.08 per cent. and the maximum, 0.38 per cent. Little trouble was experienced with drainage, as open ditches were easily located which were carried to a manhole midway in the section paved, and from there to a suitable outlet.

Expansion joints were constructed at right angles to the centre line at intervals of 25 ft. and 30 ft., depending upon whether the contractor was able to lay 50 ft. or 60 ft. in the day's run. In two sections a longitudinal expansion joint was also used.

In every case the expansion joint consisted of two thicknesses of three-ply, tarred, roofing felt, built up so as to make a joint about ¼ in. thick and extending high enough that the felt frayed out over the joint.

### Clauses From Specifications

The following clauses in the specification indicate the method of construction and the character of material used:—

1.—*Portland Cement.*—The cement must be a well-known brand of Portland Cement, and shall meet the requirement and tests of the Canadian Society of Civil Engineers.

2.—*Fine Aggregate.*—The fine aggregate shall consist of any material of soliceous, granitic or igneous origin, free from mica in excess of five per cent., and other impurities, uniformly graded, the particles ranging in size from ¼ in. down to that which will pass a No. 100 standard sieve.

3.—*Course Aggregate.*—The course aggregate shall be sound, broken trap rock, or granite having a specific gravity of not less than 2.6. It shall be free from all foreign matter, uniformly graded, and shall range in size from ¼ in. up, the largest particle not to exceed in any dimension one and a quarter inches.

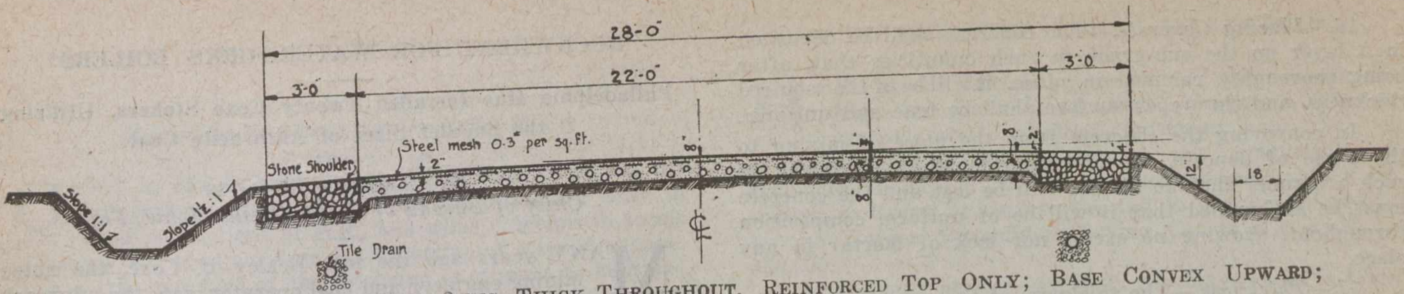
10.—*Drainage.*—Proper provision shall be made for the removal of ground water. Under drains shall consist of not less than 4-in. tile drain. The bottom of the drain shall be at least twelve inches below the crown of the sub-grade. Outlets and lateral blind drains shall be provided as indicated by the engineer.

12.—*Proportions.*—The densest possible mixture of the material making up the concrete is desirable. In order to produce such a dense mixture the voids in the fine and coarse aggregates shall be determined. The cement shall overfill voids in the fine aggregate by at least five per cent. and the mortar shall overfill the voids in the coarse aggregate by at least ten per cent. When the voids are not determined, the concrete shall be mixed no leaner than the proportion of 1 cu. ft. of Portland cement, 1½ cu. ft. of fine aggregate, and three cubic feet of coarse aggregate. The concrete when mixed under field conditions in th proportions decided upon shall give a compressive strength of at least 1,500 pounds per square inch at the end of twenty-eight days.

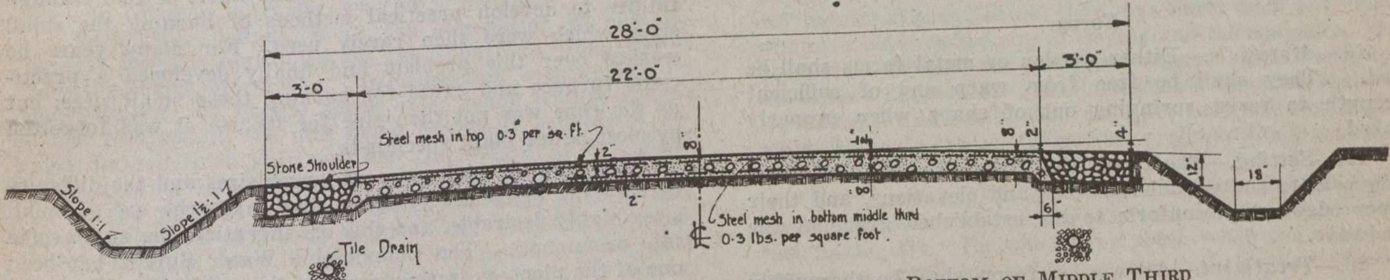
13.—*Mixing.*—The ingredients of the concrete shall be thoroughly mixed, sufficient water being added to obtain the desired consistency, and the mixing continued until the materials are uniformly coated with cement and each particle of the coarse aggregate is thoroughly coated with mortar.

Where a mechanical concrete mixer is used, the materials must be proportioned dry, then deposited in the mixer all at the same time. The mixer must produce a concrete of uniform consistency and color, with the stones thoroughly mixed with water, sand and cement.

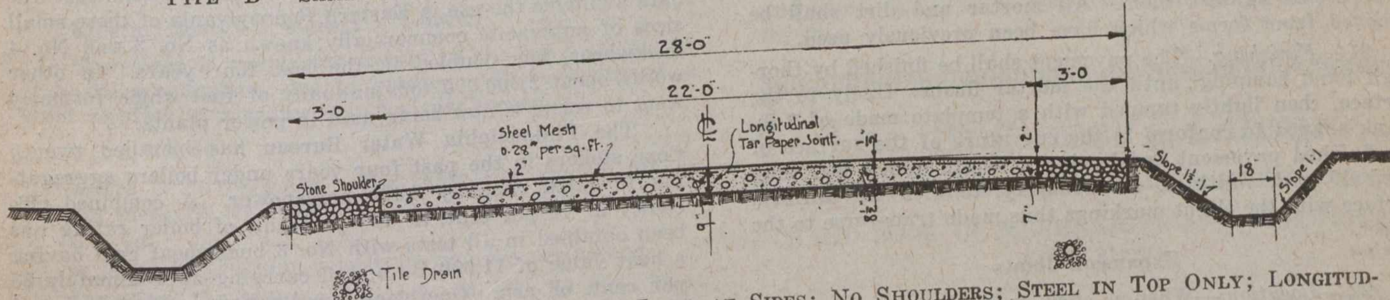
14.—*Consistency.*—The materials shall be mixed wet enough to produce a concrete of a consistency that will flush readily under light tamping, but which can be handled without causing a separation of the coarse aggregate from the mortar.



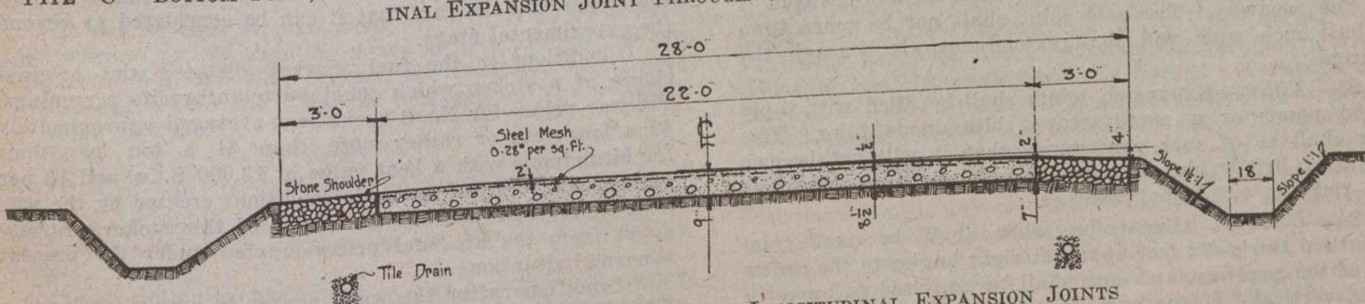

Type "A"—Section 22-ft. Wide, 8-ins. Thick Throughout, Reinforced Top Only; Base Convex Upward; Shoulders on Side of Road



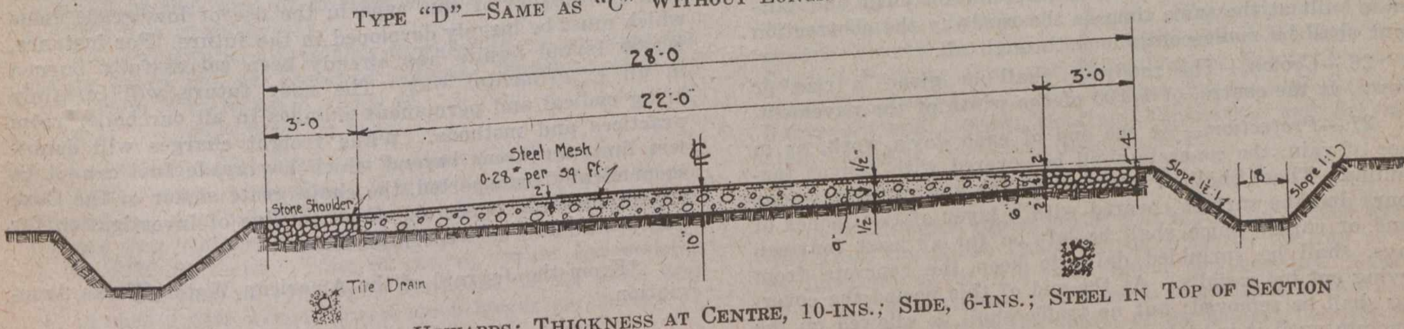

Type "B"—Same as "A" With Addition of Reinforcement in Bottom of Middle Third



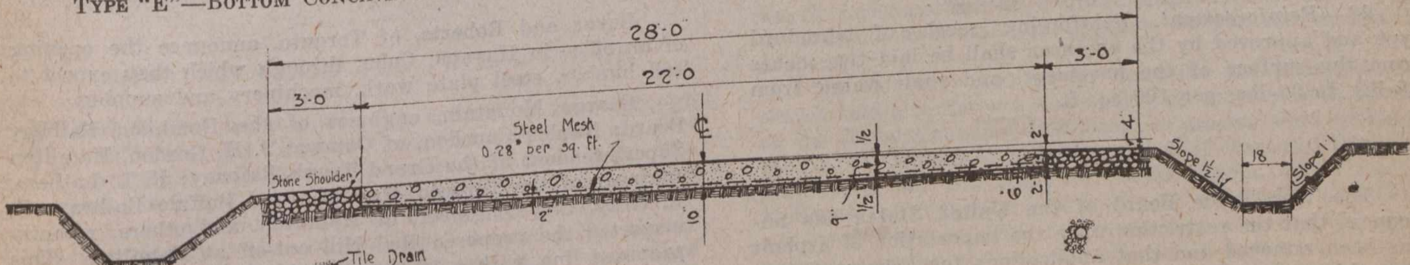

Type "C"—Bottom Flat; 9-ins. Thick at Centre, 7-ins. at Sides; No Shoulders; Steel in Top Only; Longitudinal Expansion Joint Through Centre of Pavement




Type "D"—Same as "C" Without Longitudinal Expansion Joints




Type "E"—Bottom Concave Upwards; Thickness at Centre, 10-ins.; Side, 6-ins.; Steel in Top of Section




Type "F"—Same as "E" but Steel in Bottom

16.—*Placing Concrete.*—The concrete shall be deposited in a layer on the sub-grade in such quantities that, after being thoroughly rammed in place, it will be of the required thickness, and the upper surface shall be true and uniform.

In conveying the concrete from the place of mixing to the place of deposit, the operation must be conducted in such a manner that no mortar will be lost and the concrete must be so handled that it will be of uniform composition throughout, showing no excess nor lack of mortar in any place.

17.—*Thickness.*—The thickness of the pavement shall be .... inches, with its upper surface on the finished grade.

### Forms

18.—*Materials.*—Either wooden or metal forms shall be used. They shall be free from warp and of sufficient strength to resist springing out of shape when properly staked.

19.—*Setting.*—The forms shall be well staked or otherwise held to the established lines and elevations, and their upper edges shall conform to the established grade of the roadways.

20.—*Treatment.*—All wooden forms shall be thoroughly wetted or oiled and metal forms oiled before any material is deposited against them. All mortar and dirt shall be removed from forms which have been previously used.

21.—*Finishing.*—The pavement shall be finished by thorough hand tamping, until the mortar flushes freely to the surface, then lightly tamped with a template made of 2-in. plank shaped to conform to the curvature of the surface of the finished pavement and having a length of not less than one-half with width of the roadway, to give the uniform surface with the slight markings thus made transverse to the street.

### Expansion Joints

22.—*Location.*—When a curb or combination curb and gutter is used, an expansion joint shall be left between it and the roadway. The said joint shall not be more than one-half inch wide and shall extend entirely through the concrete.

23.—*Filler.*—Expansion joints shall be filled with 3-ply tarred paper or a manufactured bituminous filler. This filler shall be of such consistency that it will not become hard and brittle and chip out in cold weather or become soft and run out in hot weather.

24.—*Location.*—Expansion joints shall be made not more than thirty-six feet apart, at right angles to the centre line of the roadway, and care shall be exercised to have the joints vertical. If the curb or combination curb and gutter is built at the same time as the roadway the contraction joint shall be made continuous through all.

26.—*Crown.*—The roadway shall be given a rise or crown, at the centre, of 1/100 of the width of the pavement.

27.—*Protection.*—At the end of each day's work, or in case of rain, the concrete shall be covered with canvas tarpaulins. These shall be removed at the end of twenty-four hours and the surface covered with a layer of two inches of sand or earth, which shall be left on for at least fourteen days, shall be sprinkled daily to keep the concrete from drying out too rapidly. At the end of this period the covering shall be removed; but no traffic shall be allowed on the concrete until it is at least sixteen days old.

28.—*Reinforcement.*—Reinforcing mesh of standard type and approved by the engineer shall be laid two inches from the surface of the pavement, and shall weigh from 25 lbs. to 30 lbs. per 100 sq. ft.

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The War Trade Board of the United States has announced that the restriction upon the importation of asphalt has been removed and that applications for licenses to import this commodity will now be considered.

## BUCKWHEAT FOR WATERWORKS BOILERS*

### Philadelphia Has Installed Twenty Coxe Stokers, Utilizing the Smaller Sizes of Anthracite Coal

By Carleton E. Davis
*Chief of Bureau of Water, Philadelphia, Pa.*

MANY years ago the late Eckley B. Coxe, the noted mining engineer and coal operator, saw the approach of much higher costs of production in the anthracite fields. He also saw the enormous waste of coal through failure to develop practical methods of burning the small sizes which were then rarely used. For many years he worked over this problem and finally developed a practicable furnace and grate for burning these small sizes, but as the time was not then ripe for its use, it was forgotten by most power plant specialists.

Recently the high price of larger sizes and the difficulty of securing deliveries of them have made the use of small sizes highly desirable, and this old invention has again come into prominence. The Philadelphia Water Bureau has been one of the pioneers in this new practice, which is of real significance as a matter of national economy. From the best data available the use in Eastern Pennsylvania of these small sizes of anthracite commercially known as No. 3 and No. 4 buckwheat, has doubled in the last four years. In other words about 2,000,000 tons annually of fuel which formerly went to waste is now being used in power plants.

The Philadelphia Water Bureau has installed twenty Coxe stokers in the past four years under boilers aggregating in rated capacity 8,400 horsepower. A combined efficiency of 70 per cent. at 125 per cent. of boiler rating has been obtained in all tests with No. 3 buckwheat coal having a heat value of 11,000 B.t.u. and carrying approximately 23 per cent. of ash. Operating results have approached test conditions in a way that demonstrates the dependability of the stoker and the fact that it can be considered as beyond the experimental stage.

Conditions in the fuel market dictated the original choice of a stoker which could burn anthracite screenings. Pre-war prices for No. 3 buckwheat averaged approximately $2 a long ton, or rather more than $1 a ton less than for bituminous with a heat value of 13,000 B.t.u. and 13 per cent. of ash. Broad economic conditions created by the war have more than justified the choice of this stoker, entirely apart from the artificial prices created under the present abnormal situation.

Conditions after the war apparently open a still wider field for stokers of this type in the use of low grade fuels which must be largely developed in the future. For instance, Rhode Island lignite has already been successfully burned in an experimental way. The near future will certainly bring radical and permanent changes in all our boiler room practices and methods. While freight charges will doubtless limit the areas beyond which low grade fuel cannot be economically transported, the chain grate stoker of the Coxe type apparently opens one practical line of investigation for many waterworks superintendents.

*From the Journal of the American Water Works Association.

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Burns and Roberts, of Toronto, announce the opening of an office in Havana, Cuba, through which they expect to sell lumber, steel plate work, machinery and supplies.

George Mountain, engineer of the Dominion Railway Board; Naulon Cauchon, of Ottawa; J. H. Gordon, Hamilton Superintendent of the Grand Trunk Railway; R. L. Latham, engineer of the Toronto, Hamilton and Buffalo Railway; E. R. Gray, City Engineer, of Hamilton, and others, recently inspected the proposed Red Hill cut-off at Hamilton. This proposed line, with a 1% grade, was designed as a common entrance to the city of Hamilton for all steam and electric railroads.

## $WR^2$—AN EXPLANATION

By John S. Carpenter
*Hydraulic Engineer, James Leffel & Co.*

QUITE a few instances there have been in which the writer has noticed that many engineers are hazy in their conceptions of $WR^2$, and what it means in terms of energy absorbed or given out by virtue of a speed change. It is a true measure of the tendency of a mass to continue rotation when forces are applied to stop it, or the tendency to resist rotation when forces are applied to set it in motion. In common language, we call it inertia.

Technically defined, it is the summation of the individual weights multiplied by the square of their radius from the centre of rotation. In connection with generators and flywheels, we usually speak of so many pounds weight at one foot radius, the unit being especially convenient because its square is still one, and the weight at any other radius varying inversely as the square of the radius.

As the question is usually stated, we want to know how many footpounds of energy is given out when the rotating body is retarded from N r.p.m. to $N_1$ r.p.m. To make this clear, we will go back to the well-known formula for kinetic energy:—

$$\text{Kinetic Energy} = \text{Mass}/2 \times \text{Velocity}^2 \qquad \text{(1)}$$

Now mass is simply the weight of the body divided by 32.2, the acceleration due to gravity. The velocity of a point rotating at a radius R in feet per second is

$$v = 2 \ RN/60$$

where N is the r.p.m. For those who prefer to use angular measure, we have

$$v = wR$$

w being the angular velocity in radians per second.

Inserting the above equivalents in (1), we now have

$$K.E. = W \ (2\pi \ RN)^2/2g60^2 \qquad \text{(2)}$$

It will be seen at once from (2) that if we reduce all the weights of the rotating mass to 1 ft. radius, we can substitute $WR^2$ for WR, because one raised to any power whatsoever is still one. We can now express (2) in terms of $WR^2$. We have

$$K.E. = WR^2 \ (2\pi \ N)^2/2g60^2 \qquad \text{(3)}$$

Reducing (3) to its lowest terms, we have

$K.E. = 0.00017 \ WR^2N^2$ as the total available energy in foot-pounds, whether used up in one second or in many hours.

When designing brakes we require to know the energy required in the form of friction to stop the rotating body and which is given by (3).

For computations involving flywheel effect, we want the energy given out or absorbed between certain speeds in r.p.m. from N to $N_1$ r.p.m. This is

$$K.E. = 0.00017 \ WR^2 \ (N-N_1)^2$$

and which varies inversely as the time element.

In the design of flywheels it is usual to put about 90 per cent. of the required $WR^2$ in the rim, and if the arms and hub are well designed there will be about 10 or 12 per cent. of the $WR^2$ in them. This, of course, would not strictly apply in the case of very light flywheels, as the arms and hub in such a case would form a much larger percentage of the total weight.

## FILTRATION PLANT FOR PETERBOROUGH

LAST Friday evening the city council at Peterborough authorized the Utilities Commission to purchase property on which to build a water filtration plant. The property purchased is near the waterworks station and was acquired for only $7,000. It was stated by a number of the aldermen that the water supply, though treated with chlorine at present, is not of the standard desired, and they realize that the installation of a filtration plant will be imperative within the next few years at least and probably sooner.

## IMPERIAL OIL'S GIFT TO SARNIA

HON. W. J. HANNA, president of the Imperial Oil, Ltd., on behalf of that company, has presented an asphaltic pavement to the city of Sarnia, Ont., where one of the company's main refineries is located. The pavement extends along Milton St. to Green St. and to the G.T.R. depot, and was laid by the Warren Bituminous Paving Co. at a cost of over $60,000.

At the presentation ceremony the mayor paid a tribute to the Imperial Oil Company, stating that during the whole twenty-one years in which that establishment has "carried on" industrially at Sarnia, there has never been any friction whatever between the city of Sarnia and the company. They had pulled together for one common good. One was ever at the other's assistance. He characterized the presentation of the pavement as one of the best gifts that any municipality could receive in the age of greater progress along good roads lines. It was an example set.

Mr. Hanna replied in a fitting manner for the donors. He told the story of the origin of the idea of the presentation to the city. He was in the south when the suggestion first came under his notice by wire. He realized Sarnia's supreme need, as is the supreme need of every other city and municipality, to be good roads, and he readily endorsed the idea.

# The Engineer's Library

### HAND BOOK OF MECHANICAL AND ELECTRICAL COST DATA

By *Halbert P. Gillette* and *Richard T. Dana*. Published by McGraw-Hill Book Co., Inc., New York. 1,750 pages, illustrated, flexible binding, 4¾" x 7". Price $6 net.

This new book fills an outstanding vacancy in the mechanical and electrical engineer's library. Authentic information on costs, applicable to all requirements, is given in full, as is evidenced by the voluminous size of the book:—

Following are the chapter headings:—General Economic Principles, with lucid explanation equating the data throughout the volume to any condition of the labor or financial markets; Depreciation; Repairs and Renewals; Buildings; Chimneys; Moving and Installation; Fuel and Coal Handling; Steam Power; Internal Combustion Engines and Gas Producers; Hydro-Electric Plants; Complete Electric Light and Power Plants; Overhead Electric Transmission; Underground Electric Transmission; Lighting and Wiring; Belts; Shafts; Pulleys; Pipe and Miscellaneous Power Transmission; Compressed Air; Gas Plants; Pumps and Pumping; Conveyors and Hoists; Heating, Ventilation and Refrigeration; Electric Railways; Miscellaneous.

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A Washington report states that a plan for a deep waterway from the Great Lakes to the Atlantic, by way of the St. Lawrence River, will soon receive new impetus. Senator Townsend, of Michigan, who intends to continue his advocacy of an investigation of the merits of the project, believes that the St. Lawrence can be canalized much more effectively than at present, and that the channels at the Soo should be deepened.

The Honorary Council for Scientific and Industrial Research held a conference last week with the Research Council of the Royal Canadian Institute. Addresses were delivered by Dr. McCallum, of the University of Toronto, President Murray, of the University of Saskatchewan, and President McKenzie, of Dalhousie University. It was stated that there are special opportunities for young men who are willing to undergo training in research work, as the supply of men who are trained to do this work is said to be limited in Canada.

## SIGNIFICANCE OF BLACK SANDS IN FILTERS*

By J. E. Welker and C. C. Young

REGULATIONS adopted by the Kansas State Board of Health under the Water and Sewage Law passed by the 1915 Legislature require weekly analysis to be made in the laboratory of the Board of waters from all surface sources and semi-annual inspections of the water works by the engineers of the division of water and sewage of the board. This relatively close contact with the filter plants has brought up many topics of filter plant operation for discussion and solution, not the least interesting of which is the darkening of the sands.

Filter plant operators noted a gradual darkening of the sands in many of the plants. At first no thought was given to the phenomenon other than the fact that the beds were not clean at the time of observation, but it was found impossible to wash the sand back to its original color. Samples were submitted to the laboratory and analyses made which showed that the dark color was due to manganese and iron. The darker the deposit, the higher the percentage of manganese.

At Osawatomie there was the most striking change in the color of the sand. In a few weeks the color changed from a natural light yellow to coal black. Careful study of the basin and influent lines showed a growth of bryozoa or pipe moss. When these organisms died, the deposit of their sheaths showed a very high percentage of manganese. An analogy was drawn between this phenomenon and the fact that the muck lands of Florida, Hawaii and other places carry an extremely high percentage of manganese and it seemed perfectly plausible that the same principles of decomposition and deposition would be maintained in a filter bed that was allowed to become foul.

**Table 1.**

*Results of analyses of filter sands: grams in 10-gram samples*

| | Rate of Water *inches* | $Mn_3O_4$ | Years in Bed | $Fe_2O_3$ | $Mn_3O_4$ and $Fe_2O_3$ | Oxides and Clay | Difference, Clay |
|---|---|---|---|---|---|---|---|
| *Neosho River* | | | | | | | |
| Burlington .......... | 12 | 0.0030 | 4 | 0.0035 | 0.0065 | 0.0771 | 0.0706 |
| Chanute ............ | 15 | 0.0076 | 4 | 0.0142 | 0.0218 | 0.3908 | 0.3690 |
| Humboldt ........... | 15 | 0.0129 | 2 | 0.0214 | 0.0343 | 0.4594 | 0.4251 |
| Council Grove ....... | | 0.0683 | 3½ | 0.0071 | 0.0754 | 0.3470 | 0.2716 |
| *Verdigris River* | | | | | | | |
| Independence | | | | | | | |
| Original .......... | | 0.0007 | 4 | 0.0093 | 0.0100 | 0.0583 | 0.0483 |
| Used ............. | | 0.0070 | | 0.0214 | 0.0284 | 0.2915 | 0.2631 |
| Coffeyville .......... | 15.0 | 0.0172 | 4½ | 0.0092 | 0.0404 | 0.3169 | 0.2765 |
| Cherryvale .......... | 12.0 | 0.0312 | 6 | 0.0214 | 0.0526 | 0.9930 | 0.9404 |
| *Walnut River* | | | | | | | |
| Douglas ............ | 12.0 | 0.0061 | 3½ | 0.0017 | 0.0078 | 0.1206 | 0.1128 |
| Winfield ............ | 7.5 | 0.0634 | 8 | 0.0214 | 0.0848 | 0.6042 | 0.5194 |
| Augusta ............ | 9.0 | 0.2037 | 6 | 0.0178 | 0.2215 | 0.9459 | 0.7244 |
| *Marais des Cygnes* | | | | | | | |
| Osawatomie ......... | | 0.0298 | 2½ | 0.0172 | 0.0470 | 0.2876 | 0.2406 |
| *Mill Creek* | | | | | | | |
| Washington ......... | 12.0 | 0.0580 | 3½ | 0.0071 | 0.0651 | 0.2550 | 0.1899 |
| *Impounding Reservoir* | | | | | | | |
| Garnett ............ | 18.0 | 0.0240 | 3 | 0.0214 | 0.0454 | 0.3507 | 0.3053 |
| Olathe ............. | 14.7 | 0.0141 | 3½ | 0.0050 | 0.0191 | 0.1084 | 0.0893 |
| Shreveport, La. ..... | | 0.0095 | | 0.0214 | 0.0309 | 0.2642 | 0.2333 |

In most communities plants are built to supply much more water than is actually needed. Consequently, they are intermittently operated. The filters will be run for a few hours and be allowed to stand six or eight or even twenty-four hours without filtering again and without washing. This procedure is continued until such a loss of head results that no more water can be put through the filter. The filter is then washed. In every filter plant mentioned in this paper, there have probably been many periods of stagnation varying from eight to twenty-four hours.

In Meade County, Kansas, and elsewhere there have been found small beds of almost pure quartz sand, coated with a deposit similar to those that develop in intermittently operated filter plants. No one can say just how and where these beds were laid down but it is fair to suppose that the conditions were somewhat similar to that existing in a foul filter bed.

In making analyses, the sodium bismuthate method was used to make the determination of manganese and the iron was determined colorimetrically. The clay reported in the table was accreted with the deposit of manganese and iron oxides. It is fortunate that the laboratory saved samples of the original sands that were introduced into the filter plants at the time of their construction. All of the sands returned negative results for manganese with the exception of the sample from Independence, which gave 10 milligrams of the combined oxides.

Table 1 gives the results of analyses and a short description of each plant is appended.

*Burlington.*—Installation test made May, 1914. New York Continental Jewell standard filter equipment; combined air and water wash. Wash water from distribution system at pressure of 50 pounds per square inch. Wash water valve opened to give rate of 12 inches vertical rise per minute. Considerable difficulty has been experienced with microscopic growth in basins and filters. General operation of plant good. Sand removed March, 1917, following trouble with filter bed. One manifold pipe found broken.

*Chanute.*—Installation test made May, 1914. Pittsburg Filter Company Standard equipment. Washed with water alone, furnished by centrifugal pump, giving a rate 15 inches vertical rise per minute. Plant operation fair.

*Humboldt.*—Installation test made May, 1916. Pittsburg Filter Company standard equipment. Filters washed with water alone. Wash water supplied from distribution system and valve opened to give wash water rate of 15 inches vertical rise per minute. Plant operation fair.

*Council Grove.*—Installation made September, 1914. New York Continental Jewell Filter Company standard wooden tub filter construction. Filters washed with mechanical agitation. Wash water supplied from distribution system pressure No reducing valve used on the wash water line and as a result excessive rates have been used, resulting in the displacement of the sand and gravel. In 1916 the filter beds were dug up and the gravel was found to be very much displaced and mixed with the sand, and many of the strainers clogged. February, 1918, the beds were again dug up and approximately 50 per cent. of the strainers were found to be clogged. Plant operation good.

*Independence.*—Installation test made May, 1914. Concrete filter construction, with ridged bottom under-drains using wire screen between gravel and sand. Wash water supplied from wash water tank, having a pressure of approximately 22 pounds per square inch at the inlet. Plant operation fair.

*Coffeyville.*—Installation test December, 1913. New York Continental Jewell Filtration Company standard equipment. Combined air and water wash. Wash water supplied by centrifugal pump, giving a wash velocity of approximately 15 inches vertical rise per minute. Plant operation good.

*Cherryvale.*—Installation test June, 1912. New York Continental Jewell Filtration Company standard equipment. Filter washed with combined air and water wash. Wash water supplied by centrifugal pump, giving a wash water velocity of approximately 12 inches vertical rise per minute. Plant operation good.

*Douglas.*—Installation test made September, 1914. New York Continental Jewell Filtration Company standard equipment. Filter washed with combined air and water wash. Water supplied from distribution system at a pressure of

(Continued on page 561)

*From paper read before the American Water Works Association.

## THE GROWTH OF ELECTRIC SYSTEMS

By Julian C. Smith
*Chief Engineer, Shawinigan Water & Power Co., Montreal*

*(Continued from last week's issue)*

ALL that I have stated hitherto shows the growth of electric systems. The reason for the growth is, of course, because electric systems have supplied the demand. They have not only supplied this demand, but to a certain extent they have created the demand also. The figures showing use of electrical energy per capita per year in the United States show this growth as follows:

K.W.H. per capita:—1902, 31.5; 1907, 67.0; 1913, 121.5; 1917, 265.0.

This means that each year the amount of power used directly or indirectly by all users has increased rapidly, not only in such evident uses as light, trolley rides, etc., but as the wealth of the country is increased, in more clothes, food, automobiles, phonographs and a host of other things which are constantly being purchased by the general public.

You can generally analyze any manufactured product into raw materials, labor, skilled and unskilled, and energy. Not that the energy always remains in whole or in part, but it has been used, changed in form, and the result in the shape of work remains.

### The Energy Component

This energy component, so to speak, of the cost of the finished article, varies in amount from 3% of the cost of fine cotton goods, to over 50% of the cost of some electrically refined metals.

The distribution of energy is by no means uniform. In cities where a great number of industries are in operation, the average K.W.H. per year varies from about 400 in Baltimore to 700 in Montreal. The figure for the entire United States is 265.

In those centres where electric energy is cheap, such as Niagara or Shawinigan Falls, we find a very different condition. The kilowatt hours per capita per year at Niagara is 33,000, Shawinigan Falls 41,000, and in some of the towns in Norway, where huge amounts of power are used in making nitric acid, the kilowatt hours per capita per year are even higher than these figures.

Transmission lines have grown around water-powers for an obvious reason. To use the water-power it must reach the market. As in most cases the user could not build his works near the power, transmission lines were necessary. So transmission lines and water-power developments have grown up together. So, too, the steam engineer who sees no good in the water-powers has until recently condemned the transmission line as well. But the march of events has compelled the steam-power plant engineer to alter his views, and we are just at the opening of a new chapter in the development of electric systems, and this development involves the construction of huge steam plants at favorable locations, where coal and water are cheaply obtainable, and starting from these stations there will radiate a network of transmission lines. The energy will be sent over the wires as electricity instead of shipped as chemical energy, as coal in railway cars.

### Where Power is Cheapest

Such systems are already in existence. The first extension naturally took place by supplying territory adjacent to the large city plants such as the Chicago Edison and the Detroit Edison, but new plants have recently been built in Pennsylvania and elsewhere, based on the same theory as water-power developments; that is, the establishment of a plant where the power is cheapest and the transmission of the power from that point to the consumer.

There has been a great deal of talk and much written of the water-powers of the United States. Very exaggerated estimates appear constantly in the public press as to the amount and value of these water-powers. Up to the present time not 25% of the electrical energy used in the United States has come from water-powers.

The cost of a transmission system in cases of small developments may equal the cost of the water-power development itself. So the development of water-powers, with a few important exceptions, has followed and fluctuated with the development of steam engineering. The steam engineers have held the trench; only here and there have the water-power engineers succeeded in capturing a section.

The war has made a great change which undoubtedly will have lasting effects. Service is difficult to express in terms of money. The value of electric service was only appreciated when the customer saw a chance of being deprived of this power. Now a steam station depends on many complicated performances for its success. On coal; on labor to get coal; on transportation, which involves weather, labor, and the effect of Government control of rates.

### Water Powers Have Scored

Water-powers after they are built depend on the sun and rain, and curiously enough, the results of the last year have impressed men's minds deeply with the fact that, proverbially uncertain as the weather is, the elements involved in a steam plant are still more uncertain. So, generally speaking, the water-power has scored.

Then, too, the price of labor has gone up enormously. The effect on the cost of power from existing steam plants, as compared with existing water-powers, has been to practically double the cost of power from steam plants, and to only slightly change the cost of power from the water-power plant previously built.

But as new plants are built under the present conditions, the advantage may not rest with the water-powers. Its capital cost is twice that of a steam plant, and is permanently fixed. If this cost is high because of high labor costs, then the plant is handicapped forever. I have gone into this phase of the subject because I think it is important, at a time when most public men are talking a great deal about water-powers, to emphasize the fact that the day of the huge steam plants is just beginning instead of having passed, as some folks would like to have us believe. For very many years to come I believe the steam plants will be of primary importance, and water-powers of secondary importance.

This does not mean that water-powers are of little importance,—far from it. In exceptional cases water-power developments, even including long transmission lines, can compete successfully with steam, particularly where coal is expensive, and if Government consent could be obtained for large developments on such rivers as the Niagara or St. Lawrence, enormous benefits would result and the truest kind of conservation would be accomplished.

### Will Build Large Steam Plants

Then, too, for special uses such as electro-chemical works, water-powers are superior—for in these cases the continuous use of power really adds little or nothing to the expense; so as the revenue is proportional to the energy derived it is evident that for high-load factor loads, good water-powers are much more economical than steam. There is more demand than the water-powers can supply, so the natural result would seem to be to supplement the steam-driven generating station with the water-power, so far as it will go, keeping in mind that unless new and radical improvements in heat engines are made, the slow increase in cost of steam power will result in the construction of water-power plants now deemed of no immediate value.

So we may look forward to the building of large steam plants to which will be connected the water-power plants in the vicinity. These steam plants will be spaced perhaps 100 miles apart, depending on the density of the population and the natural conditions. One system, a uniform voltage, a standard frequency, will enable these future systems to deliver service at minimum rates.

In England a special commission has reported to Parliament, recommending the division of England into sixteen zones, with a power plant in each zone. The plants would be interconnected by transmission lines, and when complete this system would supersede more than 600 existing central stations and save some 50,000,000 tons of coal per year, or about 50% of the amount now used in this service.

With every such development of a branch of human activity there result changes and additions in other branches. For example, take our language. As a result of the growth of electric systems many hundreds of words have been added. Some of these words are now in common use. Such expressions as "peak of the load" have become so common as to be applied, not only in the original sense, but now applied with a wider meaning. Such words as phases, voltage, potential, power, kilowatt hour, energy, all have become more or less common, and the ideas represented by these words have made a deep impression on our language.

### Legal and Governmental Phases

Another result of the growth we have been considering has been the development of the legal and governmental phases. A vast legal literature has developed, including the jurisprudence and Government acts affecting the industry. And not only has this development of electric systems resulted in this legal development, it has caused some fundamental changes in view-point which are reflected in so-called "Public Utility Commissions" acts, etc. The tendency of the development has been to weld the community together, to lessen individualism, and this tendency has resulted in a changed and changing idea of what the Government's duties are or ought to be.

The development of electric systems started in a complicated, chaotic manner, with all kinds of different standards, and with each system bearing the individual stamp of the engineer who designed it. Generally this stage has passed. Many standards have been adopted. The engineering practice on most points is uniform throughout the whole country. The heart of these systems, that is, the generating stations, have undergone great changes. The old steam plants were crowded, dirty, noisy, and wasteful. The modern plants are spacious, clean, silent, and efficient.

In your life-time you will probably see every household in thickly-settled communities supplied with electric power. You will see the energy used per capita perhaps multiplied by ten. You will see the elimination of smoke from our cities, the electrification of the important railroads where traffic is dense.

The figures I have given will look pitifully small twenty-five years from now, when systems using one thousand million kilowatt hours per year will be so common as to cause no surprise instead of being the object of wonder they are to-day.

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Reconstruction problems were discussed at the annual meeting and dinner held last week by the Winnipeg Builders' Exchange.

Thomas O'Sullivan is suing the city of Montreal for $87,027. Mr. O'Sullivan, who was the first contractor for the LaSalle bridge, claims $11,570 for work done, $22,000 return of deposit with interest, $21,436 value of machinery taken over by the city, $2,020 damages to equipment, and $30,000 damages alleged to be suffered through the city's proceedings. Mr. O'Sullivan's contract called for the construction of the bridge with head gates within 200 days, but he claims that this time was governed by a condition "that he could obtain the reinforcing steel specified in the agreement." Furthermore he claims that he was to be allowed such extension of time as would compensate him for delays caused by other city contractors. He says that he was not able to procure the kind of steel the city demanded, on account of war conditions, and that owing to the flooding of the works by one of the other contractors on the aqueduct, he was delayed, and that he notified the city of these delays, but that the city did not accord him the extensions to which he claims he was entitled.

## PACIFIC GREAT EASTERN RAILWAY*

### Reconnaissance Along the Route Between Squamish and Lillooet—Possible Water Power Development

By C. Camsell

THE Pacific Great Eastern railway was designed to follow a route almost due north from Vancouver through the middle of the province of British Columbia and to give rail connection between that city and the Grand Trunk Pacific at Prince George. At present the only portion of the line completed is that between Squamish, on Howe sound, and Clinton, a length of 167 miles, and this has been in operation since the autumn of 1915. The portion between Squamish and North Vancouver along the shore of Howe sound is still unfinished, and north of Clinton the grade has been built to Prince George, but no steel laid.

From Howe sound to Fraser river at Lillooet the railway traverses the Coast mountains, following a series of transverse valleys across the ranges. At Fraser river it enters the Interior Plateau region, through which it will run when completed, until it reaches the Grand Trunk Pacific at Prince George.

### General Character of the District

The Coast mountains of British Columbia form a broad belt 60 to 80 miles in width extending northward from Fraser river into Alaska and separating the Interior Plateau portion of the province from the Pacific coast. On the west the summits rise abruptly from the sea to heights of 4,000 to 6,000 feet, increase in elevation towards the axis of the mountains to a maximum of about 9,000 feet, and decline gradually on the east to the plateau region with which they appear to merge without any sharp break.

The general trend of the whole system is north-northwesterly, but since it is built up very largely of massive granitic rocks, it has not such a well-defined system of ranges separated by longitudinal and transverse valleys as, for instance, has the Rocky mountains. Such a system is, however, rudely developed, one series of valleys trending northeasterly across the axes of the ranges and the other north-northwesterly. The principal longitudinal valley along the line of the Pacific Great Eastern railway is that occupied by Lillooet river and where the river is crossed by the railway the valley is deep, flat-bottomed, and about 2 miles wide. In crossing the Coast mountains the railway follows the transverse valleys of Cheakamus river, Green river, Birkenhead river, Gates river, and Anderson and Seton lakes.

The longitudinal valleys are broad and fairly direct. The transverse valleys are narrower and more irregular in shape and trend, a result of the alternation of rocks of varying hardness.

The slopes of the valleys are steep, frequently broken by bare rock cliffs, and rise upwards to massive dome-shaped or sharply terminated peaks which are frequently flanked by snow fields or mountain glaciers. A heavy growth of coniferous forest clothes all the slopes up to a line about 6,500 feet above sea-level, but within a zone bordering the Pacific coast where the winter snowfall is very heavy and the slopes very rugged, forest growth ceases 1,000 feet or more below that level.

### Development of Water Power

A few small snow fields and mountain glaciers are visible from the railway track on its southeast side, but larger glaciers and snow fields occupy the heads of many of the tributary valleys on both sides, particularly in the mountains west of Lillooet river. East of Lillooet river, although the summits are as high and sometimes higher, glaciers are not as common because of the relatively lighter snowfall in this half of the Coast mountains.

An effect of valley glaciation which will have an influence on the commercial development of the district is the over-deepening of the master valleys compared to the tribu-

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*From report to the Geological Survey of the Department of Mines, Canada.

tary valleys and the development of "hanging valleys" in the latter, where water-powers can be developed. Many of the side streams entering both Lillooet valley and the various valleys occupied by the railway, plunge over falls or through narrow rocky canyons for a depth of sometimes several hundred feet, providing in many cases good sites on which to develop electrical power at comparatively low cost. When mining development is carried to the point of actual production of metals, some of these sites will no doubt be used. The following data, compiled largely from the reports of the Water Powers branch of the Department of the Interior, give the principal localities at which power could be developed:—

### Volume and Fall

*Brandywine Falls.*—On Brandywine river, 40 sec. ft. minimum volume, 200 ft. direct fall, 600 h.p.

*Cheakamus Canyon.*—On Cheakamus river, 400 sec. ft. minimum volume, 400 to 500 ft. fall in three miles.

*Nairn Falls.*—On Green river, 230 sec. ft. minimum volume, 170 ft. fall in 400 yards.

*McGillivray Falls.*—On McGillivray creek, small minimum volume, 60 ft. direct fall.

*Roaring Creek.*—On Roaring creek, small minimum volume, several hundred feet of fall per mile.

*Mission Mountain.*—On Bridge river, 500 sec. ft. minimum volume, 1,200 ft. direct fall by tunnel through Mission mountain, 100,000 h.p.

*Three Miles above Mouth.*—On Cayuse Creek, 150 sec. ft. minimum volume, 90 ft. direct fall.

*Half Mile from Mouth.*—On Portage creek, small minimum volume, two direct falls of 200 ft.

Because of the ruggedness of the topography, the scenery along the line of railway through the Coast mountains is particularly wild and impressive and from the point of view of the tourist will stand comparison with many of the other widely advertised railway routes in the mountains of the west. This is particularly true at the deep, narrow, granite gorge of Cheakamus river below Watson and at Anderson and Seton lakes, along the shores of which the railway runs for many miles.

### A Mountainous Route

On leaving tidewater at Squamish, the railway follows the valley of Squamish river and that of its tributary, the Cheakamus. The divide between Squamish and Lillooet rivers is crossed at Mons at an elevation of 2,000 feet above the sea, after which the railway descends Green river valley to Pemberton and crosses Lillooet valley at an elevation of 700 feet. East of this it ascends Birkenhead river and at Birken station, 1,650 feet above the sea, crosses the divide between Lillooet and Fraser rivers. Beyond this it descends the valley of Gates river to Anderson lake and for 30 miles follows the high, precipitous shores of this and Seton lakes before entering Fraser valley at Lillooet through a deep narrow notch cut into mountains which rise 6,000 feet or more on either side.

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The Montreal Branch of the Engineering Institute of Canada this evening will continue the discussion on proposed legislation. An interesting feature of the meeting will be the welcome to some members who have returned from overseas, and especially to Lieut.-Col. A. E. Dubuc, D.S.O., Officer of the Legion of Honor, commanding officer of the 22nd Battalion.

Justice Maclennan at Montreal last week reserved judgment in the case of Bank of Hochelaga vs. Canadian Inspection and Testing Laboratories, Ltd. The bank sued the company for $46,647, money advanced to Damien Lalonde, Ltd., on what purported to be vouchers issued by Damien Lalonde, Ltd., for alleged delivery of munition boxes to the Imperial Munitions Board. The board refuses to reimburse the bank on the ground that the boxes were not delivered. The bank's suit against the inspection company is based upon the delivery vouchers which they claim were presented by Damien Lalonde, Ltd., as collateral security.

## THRUST BEARINGS

### Their Development for Hydraulic Turbines—Description of the New Gibbs Bearing for Vertical or Horizontal Shafts

By Eugene U. Gibbs
*of S. Morgan Smith Co., York, Pa.*

WITH the advent of the hydraulic turbine, the displacement of the old overshot and breast wheels was very quickly made, when the advantages of the turbine became apparent and accepted. The Fourneyron turbine, of French origin, was first installed on a vertical shaft and supported by a thrust bearing or step, which was copied by the first turbine builders on this continent.

This step, or thrust bearing, was first made of hard wood (maple or oak) on which fitted a concave step shoe. In some cases this shoe was made of cast iron as a separate casting and in others the shaft swelled on the end and the concave was turned in the end of the shaft. The thrust step in all cases, being under the wheel and in the tail water, was lubricated by the water.

In the early development of the turbine on this continent, all the builders adopted this type of thrust step or bearing; and as the power and speed of these early turbines were very low as compared with those of to-day, the thrust to be taken care of was comparatively small and there was no difficulty with these bearings unless the water in which they operated contained a considerable amount of sand or grit.

The advent of lignum-vitæ was also found to be an improvement over the native hard woods and has been universally used for this work. In a few isolated places, manufacturers endeavored to use metallic thrust bearings and were partially successful, but these were plain ring types and had to be very carefully made; for this reason, they did not come into general use. One engineer made a thrust bearing in which he made the supporting ring of glass, but it was found that at varying temperatures the glass faces did not expand and contract evenly, and this bearing had to be abandoned on this account.

With the advent of the horizontal shaft turbine in the seventies, lignum-vitæ thrust steps were used to a great extent; but in a few years, owing to the possibility of using the marine type, or collar, thrust bearing, the lignum-vitæ thrust bearing for horizontal shaft turbines was soon replaced by the marine type, which was generally a part of one of the bearings supporting the shaft.

### Collar Bearings

Sometimes these collar bearings had four collars, one on each end of the bearing and two between, and sometimes they only had two collars, one on each end of the bearing. They were lubricated by means of oil-rings as in the ordinary ring-oiling bearing. These bearings operated very well on a horizontal shaft when there were two turbines on the shaft so placed that the thrust was practically balanced and the thrust bearing had very little work to do.

When single-runner units were used, the collar thrust bearing had to be very carefully made, with various refinements as to oil feeding and adjustments, so that until within the last ten years it was impossible to sell them, owing to their high cost. However, the purchasing public had learned that the thrust bearing was as important as the turbine itself, and consequently saw the responsibilities of the thrust bearing and were willing to pay for a reliable device to take care of the end thrust.

The development of the hydraulic turbine in this country in the last ten years has been phenomenal. The tendency has been toward increased power and speed with increased efficiency. These have all been brought about by careful study of the application of scientific principles to the design and construction of these machines; and in the development, it was demonstrated that the single runner, vertical shaft turbine offered the best solution for high efficiency when installed in a setting properly designed and constructed.

The main difficulty to overcome was the thrust, especially when the turbine was to be direct connected to an electrical generator. As the capacity of the units was increased, the initial cost of the development per horse power decreased; consequently it soon became apparent to engineers that when conditions would allow, it would be the most economical to install the largest units possible. Under low heads this meant the absolute use of a single runner. This type of setting, with direct connected turbine, was recommended several years before it was adopted. The reason for the delay was the thrust bearing. Ball thrust bearings were tried as well as roller thrust bearings, but were not satisfactory.

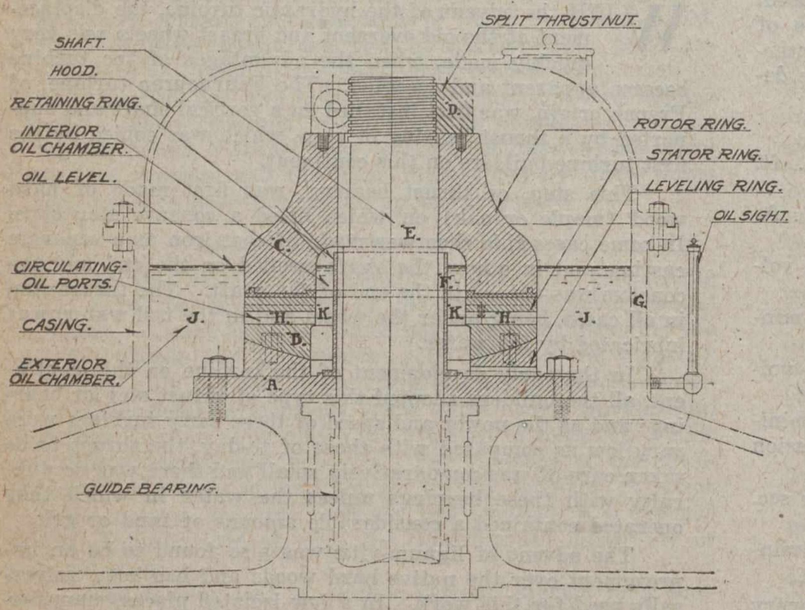


FIG. 1— SECTION THROUGH VERTICAL THRUST BEARING

The oil pressure thrust bearing now made its appearance, and consisted of a stationary and a revolving ring, the revolving ring being above the stationary one. Oil was pumped between the rings under pressure and so separated them that when the turbine operated, it was supported on a film of high pressure oil.

But should the pressure fail in the oil supply, the rings would come together and the bearing would immediately be out of service, thereby making it necessary to replace the rings, which was an expensive operation.

### New Bearing Needed

It was very evident that a new bearing would have to be developed which would operate without external high pressure,—one practically placed in an oil bath. After several years of experimenting along these lines, the "Gibbs Thrust Bearing" was developed in 1911 and has given results beyond the most sanguine expectations. It consists of three principal elements; namely, a rotor ring, a stator ring and a levelling ring, enclosed in a casing and submerged in oil. It operates on the principle of the wedge, in the following manner:—

The stationary ring or stator has (depending on the size of the ring) four or more radial grooves across the bearing surface dividing it into a corresponding number of segmental sectors. Each sector face has a definite portion flat, and the remaining part of the sector has a gradual taper or bevel to the radial groove. The circumferential width of the face and the depth of the taper face depends on the unit pressure on the bearing face and the speed of the rotor.

The stator ring, for low and medium pressures up to 300 pounds per square inch, is made of close grain cast iron, and is generally made in one piece, except in some cases where it is necessary to make it in halves so that it can be removed without disturbing the shaft or other parts attached to the shaft.

The bottom face of this ring is made spherical to fit the spherical seat of the levelling ring, and is connected to the the levelling ring by means of a dowel pin, so as to allow the stator ring to have a limited amount of adjustment.

The revolving ring, or rotor, is made of cast iron, on to which is placed a soft metal face (babbitt), and is perfectly flat. When the rings are placed in normal position (the rotor ring on the stator ring) there will be a series of flat faces, with alternating wedge surfaces, which, when the bearing is at rest, are filled with oil.

When the rotor ring is rotated, it pulls in the oil, by adhesion, from the radial groove, up the wedge surface. It also carries the oil across the flat surface of the stator ring. The rotor ring in drawing the oil up the wedge surface, develops automatically a pressure between the rotor and stator rings that equals the total load on the bearing.

### No Critical Speed

The levelling ring has its upper face spherical, to fit the spherical face of the stator ring, in order to allow for a small amount of alignment, so that the rotor ring will rest properly on the stator ring. The levelling ring is also securely fastened to the casing in which the bearing is placed.

The casing is made of cast iron, of such design and capacity that for low unit pressures, or not exceeding 150 pounds per square inch, auxiliary devices for cooling the oil are not required; but when unit pressures are higher than this, cooling coils are placed in the casing, or the oil circulated through an external cooling system by means of a small pump.

Owing to the fixed oil film, these bearings have no critical speed at which point the babbitt will wipe off. They can be run slowly as desired without wiping the babbitt. Peripheral speeds up to 5,000 feet per minute have been obtained without any detrimental effect whatever on the bearing. For the most efficient service, an average unit pressure of 150 to 300 pounds per square inch can be used without deteriorating the oil.

The principal advantages of the "Gibbs Thrust Bearing" are simplicity, minimum number of parts, fixed oil film and absolute distribution of the load over the bearing surfaces.

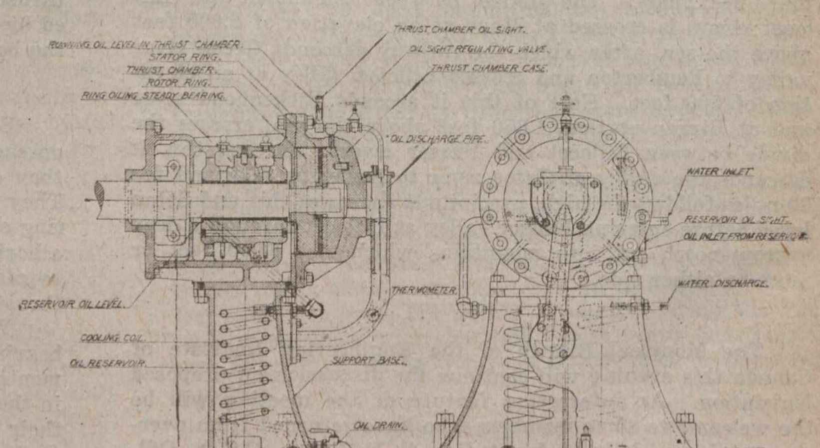


FIG. 2—GIBBS BEARING ON HORIZONTAL SHAFT

### Vertical Shaft Bearing

The accompanying illustration (Fig. 1) shows a bearing for a vertical shaft. Similar construction is used for horizontal shaft installations. "A" is a levelling ring bolted to the base of casing "G". The top face of the levelling ring is spherical, to fit the spherical face on the bottom of the stator ring "B". The top face of the stator ring in this particular bearing has six radial grooves and six wedge faces. The ports "H" in this ring allow the oil from the outer chamber "T" to pass into the inner chamber "K" formed by the retaining ring "F" and the inside of the stator and rotor rings "B" and "C".

The circulation of the oil is toward the shaft "E" from the outside chamber "J" to the chamber "K", and then outward through the radial grooves in the top face of the stator ring "B".

The rotor ring or step "C" has a sliding fit on the shaft "E" and is held by a feather key. The bottom face of the rotor ring "C" is of genuine babbitt metal and runs on the top face of the stator ring "B". The nut "D" is used for adjusting the shaft to take up any deflection that may arise in the support or foundation of the machine.

When the average pressure per square inch exceeds 200 pounds, the oil in chamber "J" is circulated through outside cooling coils by means of a low pressure pump. With average pressure below 200 pounds per square inch, cooling coils can be placed in chamber "J" and no exterior circulation of the oil is required; the circulation of the oil within the bearing itself being sufficient.

### Horizontal Shaft Bearing

The horizontal shaft bearing consists of two separate bearings, namely, a journal bearing and a thrust bearing.

The journal bearing is used as a steady bearing to support the shaft and maintain its proper alignment. It is of the standard ring oiling type with removable shells in an outer casing. The casing is supported by a hollow base which is filled with oil. Coils, through which water circulates, are placed in the hollow base for cooling the oil after it passes through the thrust bearing.

The thrust bearing proper consists of two principal elements, namely, a rotor ring and a stator ring. The rotor is a cast iron ring keyed to the shaft, and rests against a shoulder on the shaft so that it cannot move endwise along the shaft. It has a babbitt metal face.

The stator is a cast iron ring, and the wearing surface consists of four to twelve sectors, depending on the diameter of the ring, produced by as many radial grooves across the bearing face.

Each segmental face is part flat and part tapered or inclined like a wedge, so that when the rotor is revolving on the stator, in oil, it draws or forces the oil across the inclined surface and consequently builds up a pressure between the rotor and stator; this pressure being in equilibrium with the load on the rotor. The back face of the stator is spherical and fits into the spherical seat of the case head. This allows for a small alignment with the rotor. The stator is prevented from rotating by means of a dowel pin in the case head.

### Lubricated Automatically

The thrust bearing is lubricated automatically by the rotor, which is partly submerged in oil, as the oil is a little below the bottom of the shaft.

The rotor and stator rings are enclosed in a casing or thrust chamber which is connected by proper opening to the oil chamber under the journal or steady bearing, to which the oil passes from the reservoir or the tank beneath.

When the rotor revolves, owing to its being partly submerged, it carries up oil with it and fills the thrust chamber surrounding the thrust rings. The only exit for the oil to escape is through the radial grooves in the stator to the centre of the stator, where it discharges into the discharge pipe which carries it back to the oil tank below, completing the circulation. The oil, in passing through the radial grooves in the stator, passes across the bearing faces, consequently the bearing is continually flooded with oil. There is also tapped into the top of the thrust chamber a small pipe in which is placed an oil sight gauge and a small discharge pipe. This enables one to see when the bearing is properly supplied with oil, and the small discharge pipe is used to carry off the excess oil so that it will not flow or spill out of the top of the oil sight. This connection varies in design, depending upon conditions.

There are over one hundred "Gibbs Thrust Bearings" in operation on horizontal and vertical shafts, operating under most trying conditions. They are installed on centrifugal pumps, hydraulic turbines, electric generators, bevel mortise gears, and even Ford automobiles. Propositions are now under consideration to install them on steam turbines and steamships. On account of the simplicity of the bearing its cost is moderate.

This bearing can be used where there is a thrust on a revolving shaft, no matter what the load or speed. Horizontal bearings carrying loads as high as 100,000 pounds, and vertical bearings carrying loads as high as 220,000 pounds, have been in continuous operation for more than two years.

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## MASTER BRICKLAYERS PLAN TO ELIMINATE "RUINOUS" COMPETITION

HARRY HAYMAN, of London, Ont., presided at the convention of master bricklayers held this month at St. Louis, Mo. Walter W. Wise, of Indianapolis, succeeds Mr. Hayman as president of the International Boss Masons' Association, which organization represents 500 master bricklayers in Canada and the United States.

The chief topic at the St. Louis meeting was the elimination of ruinous competition. A committee of four was appointed to arrange for systematic co-operation in bidding, instead of the "destructive competition" which, according to R. M. Gillespie, of St. Louis, has become "economically impossible with labor united and organized for collective bargaining."

"Collective bargaining must work both ways," declared Mr. Gillespie. "Our bricklayers and hod-carriers are thoroughly organized, and in order to cope with the situation we must get together ourselves and eliminate cut-throat competition.

"One of the first things we are going to do away with is the famous old slogan, 'Estimates cheerfully given gratis'. In the future the master bricklayers will charge for furnishing estimates. Our overhead expense has become too large to continue this practice.

"Big business is getting together all along the line and the master bricklayers recognize that in union there is strength. Ours will be co-operative effort for the introduction of systematic and uniform methods of doing business. You might call it a trust, but it will be a good trust—one that will profit the public."

Among the Canadians present were H. Elgie, of Toronto; H. Hayman, of London; and J. Nuttein, of London.

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The Civil Service Commissioners of Canada will receive applications for position of hydrometric engineer in the Irrigation Branch at Calgary, salary, $1,500; as engineer on the staff of the Manitoba Hydrometric Survey, salary, $1,500; as agricultural engineer for Irrigation Branch, Calgary, salary, $1,600 (two appointments to be made). Further information can be obtained from William Foran, Secretary, Ottawa. Applications for the first-mentioned position will be received to January 10th and for the other positions not later than January 4th.

No less than 8,370 men are required to-day by the railways of Canada, according to a statement issued by the Repatriation and Employment Committee at Ottawa. This is not counting the 15,200 railroaders who enlisted and who will be replaced in their former positions when discharged from the army. Furthermore it is stated that next spring the C.P.R. will require 10,000 to 15,000 men, the Grand Trunk 3,000 and the Canadian Northern 5,000, and that the Canadian Government Railways will also require 11,500 men for railway extension work.

## VELOCITY FORMULAS

### Their History and Investigation of Their Relative Accuracy—Report Prepared for the Miami Conservancy District

By Ivan E. Houk

As an element in estimating the discharge of a stream, the velocity of the water was first introduced by Castelli in 1628. In 1643 Torricelli discovered that the velocity of water flowing freely from a small orifice, is equal to the velocity of a body falling in a vacuum a distance equal to the depth of the orifice below the water surface.

Guglielmini, whose works appeared near the end of the 17th century, adopted the theories of Torricelli and proposed the celebrated parabolic theory of river velocity which may be briefly stated as follows: Any particle $x$ feet below the surface of a stream will tend to move at the same velocity that it would if issuing from an orifice $x$ feet below the surface of a reservoir. Although this theory would indicate that the velocity at the surface of a stream is zero, and that the maximum velocity occurs at the bottom, it was adopted by many eminent scientists and was not disproven until Pitot published the results of his experiments in 1730-1738, his experiments consisting of measurements of velocities at different depths by the aid of the tube which bears his name.

#### Chezy the Real Beginner

In 1738 Daniel Bernoulli published his noted works on hydraulics in which he proposed the well-known Bernoulli theorem. In 1753 Brahms observed that the velocity does not accelerate in accordance with the law of gravity, but that it tends to assume a constant value. He pointed out the friction of the water against the bed and sides of the channel as the force opposing the acceleration and assumed that the resistance is proportional to the hydraulic radius. In 1775 Chezy put the theories of Brahms into algebraic form, introducing the well-known Chezy formula. Although Varignon, in 1725, reduced the theories of Guglielmini to algebraic equations, the work of Chezy marks the real beginning of velocity formula studies.

Dubuat, whose work was published in 1786, started with the law that when water flows uniformly the forces which keep it in motion are equal to the sum of all resistances. He reasoned that the best method to deduce a formula is to find by experiment algebraic expressions for these two opposing forces and then equate them. Following these ideas he made a number of experiments upon pipes and small channels and from them deduced a formula for velocity. He established the principles that the motive force of the water is due entirely to the surface slope, that the resistances are due to viscosity and friction on the sides and bed of the channel, and that the resistance is independent of the weight or pressure of the water.

Coulomb published a paper in 1800 in which he discussed the laws of friction between fluids and solids. He showed that the resistances may be represented by a function consisting of two terms, one containing the first power of the velocity and the other, the second. Girard, in 1803, applied this theory of Coulomb's to the flow of water in open channels and deduced a formula which was more simple than Dubuat's.

#### De Prony's Contribution

In 1804, de Prony, by a discussion of experiments, corroborated the general conclusion of Coulomb's regarding the resistances, but showed that the two terms should be modified by independent co-efficients instead of by a common one as had been proposed by both Coulomb and Girard. He discussed the measurements of Dubuat and others, and from them deduced values of the coefficients for pipes and canals.

In 1814 Eytelwein, from a study of 91 observations on rivers and canals covering a wide range of conditions, proposed new values for the coefficients in de Prony's formula. De Prony's formula with Eytelwein's coefficients was used extensively for several years.

Additional formulas were proposed by Young in 1808, by Berlanger in 1828, by Lombardini in 1844, by Taylor in 1851, by Ellet in 1851, and by Stevenson in 1858.

In 1851, de Saint Venant proposed the first of the formulas which have been termed exponential formulas; that is, he proposed a formula based on the assumption that the velocity does not vary as the square root of the slope times the hydraulic radius as was assumed by Brahms, Chezy and others, but that it varies according to some fractional power of the slope times some other fractional power of the hydraulic radius, both terms being multiplied by a coefficient, as in the Chezy formula.

Formulas of similar nature were proposed by Lampe, Flamant and Hagen. The last, however, concluded that the exponents of the slope and the hydraulic radius are not constants except for given classes of pipes or channels.

During the latter half of the 19th century, numerous formulas have been proposed. A few of these, such as Kutter's and Bazin's, have been based on long and careful studies by able investigators. Others have been based on but poor foundations.

#### German Formulas Lack Merit

The studies and comparisons of the various German velocity formulas, which have been developed on the assumption that a roughness coefficient is not necessary, show that no one of them possesses sufficient merit to warrant its use. In fact, no one of them could be considered to be definitely better than the others. Although the results determined by the Hessle equation show up fairly well in certain instances, they are among the worst in others. The velocities calculated by the Siedek equation are apparently the most erratic and discrepant of all, being as much as 100 per cent. in error in certain cases. The final comparison of the formulas shows conclusively that in any general formula for computing velocities in open channels, a roughness coefficient is necessary.

The exponential formulas thus far proposed do not possess any important advantages. The equation recently proposed by Barnes is not as accurate as his comparisons indicate. In fact, the type of formula that he assumes—namely, one in which $C'$ (the coefficient of roughness in exponential formulas), is a constant for a given class of roughness, does not appear to be feasible. If any exponential equation were to be recommended for general use it would be one similar to that proposed by Williams.

The claim that $C'$ is less variable than $C$ (the coefficient of roughness in Chezy's formula), does not seem to be correct for natural river channels. In fact, for such conditions the reverse appears to be true. Whatever constancy is gained by the higher exponent of $R$ (the hydraulic radius of the cross-section of channel), is evidently more than offset by some other factor or factors in favor of the Chezy equation. This shows that no saving in the amount of engineering judgment required would result from the adoption of an exponential formula.

#### Biel Inferior to Bazin

The Biel velocity formula, which has the distinction of containing a temperature correction, is inferior to Bazin's formula. In several series of experiments in which the roughness conditions were constant, the roughness factor in the Biel formula was found to vary more than the corresponding coefficient in the Bazin equation. For open channels the temperature term is negligible in all but very extreme cases. Even in those instances in which it is appreciable, it is, of course, a question as to whether it should be considered. There is no data at hand to show that the effect assumed by Biel is correct. The publication in which Biel proposed his formula is not available. It is said, however, that he recommended his formula for the computation of velocities of gases and liquids in general, instead of for water only. In view of this fact it seems probable that he introduced the temperature term on account of the effect of temperature on the flow of gases and such liquids as oils rather than on account of its effect on the flow of water.

Manning's formula, in its original form, is practically as good as Kutter's for channels of small or ordinary dimensions. Although his roughness coefficient is slightly more variable than Kutter's $n$ in cases where the roughness conditions are constant, this disadvantage is more than offset by the greater simplicity of the equation. However, for unusual conditions such as the Mississippi River, Kutter's formula possesses the advantage. The average error of the results calculated by the Manning formula for the gaugings of Humphreys and Abbot was 19.8 per cent., while the average error of those calculated by the Kutter formula for the same gaugings was only 4 per cent. For general applicability the Kutter equation undoubtedly possesses an advantage. The form of Manning's equation given by Parker probably would prove satisfactory for a limited range of conditions. For general use, however, it could hardly be recommended.

### Kutter Includes Slope Correction

The only essential difference between the Bazin and Kutter formulas is that the latter includes a slope correction, while the former does not. Both investigators started with the same fundamental form. In fact, for certain values of $m$ (coefficient of roughness in Bazin's formula), $n$ and $S$ (friction slope; or, if the velocity is constant, the surface slope), the two formulas are identical. For each value of $m$ greater than 0.36 there is a set of values of $n$ and $S$ for which the Kutter formula will give results identical with those given by the Bazin formula, for all values of $R$. For values of $m$ less than 0.36, $S$ would have to be negative in order for the two formulas to be the same.

Kutter complicated his equation by introducing the slope in such a way as to cause $C$ to increase with an increase in $S$ when $R$ is less than one meter, to be independent of $S$ when $R$ equals one meter, and to increase as $S$ decreases when $R$ is greater than one meter. In all cases, the effect of a change in $S$ is greatest for flat slopes, decreases as $S$ increases, and becomes negligible when $S$ is about 0.001. Kutter's determination to introduce the slope in this manner was based primarily on a study of Humphreys' and Abbot's gaugings on the Mississippi River and on the measurements made by Bazin in a small experimental channel.

Bazin concluded that the slope effect shown by the Mississippi River gaugings was due to errors in measurement rather than to any general law applying to the flow of water. Although he recognized the effect of $S$ on $C$ in certain series of his own experiments, he did not consider it to be of sufficient importance to warrant its introduction into a general formula.

Many engineers have criticized the Kutter formula on account of its containing the slope term. Some have expressed the opinion that $C$ always increases as $S$ increases, while others have claimed that $C$ is entirely independent of $S$. Practically all of them have admitted the accuracy of Bazin's work and have questioned the accuracy of the Mississippi River gaugings. Bazin's experiments were made in an artificial channel about 6 feet wide and about 3 feet deep, while Humphreys' and Abbot's gaugings were made in a river channel about a mile wide and sometimes as much as 135 feet deep. Such inaccuracies as do occur in the latter are due to the unfavorable circumstances under which the measurements were made, rather than to any lack of care on the part of the observers.

### Velocities Too Large

A careful study of the gaugings made by Humphreys and Abbot, which were used by Kutter in determining his slope term, has been made. This study included a comparison of their results with the later and more accurate work of the Mississippi River Commission, as well as a comparison of vertical velocity curves obtained by double floats with those obtained by current meters. It was found that the velocities as given by Humphreys and Abbot are probably from 6 to 10 per cent. too large; that the cross sectional dimensions are probably accurate within allowable limits; and that the values of $S$ may possibly be in error as much as 55 per cent. at Columbus, from 7 to 21 per cent. at Vicksburg, about 27 per cent. in the case of the two gaugings at Carrollton having the steeper slopes, and over 100 per cent. in the case of the other two gaugings at Carrollton.

### Should Not be Rejected

On first thought it might seem that the magnitude of these possible errors is great enough to discredit Humphreys' and Abbot's work. However, if consideration is given to the unfavorable conditions under which the measurements were made, as well as to the amount of knowledge and experience available at that time regarding the gauging of such streams, it seems remarkable that the results are as good as they are. The results obtained from the measurements at Columbus, and those obtained from the two gaugings at Carrollton where the slopes were least, are the only ones that should be rejected. Although the other gaugings offer but a poor basis for a general formula, they do merit consideration, especially since errors of a given amount in $S$ cause errors of only about half as much in $C$. Of course, none of the measurements should be rejected on account of the errors in velocity, since allowance can readily be made for such inaccuracies.

While the various engineers who have criticized the Kutter formula on account of its containing a slope correction, have differed somewhat in their opinions as to the effect of $S$ on $C$ in small channels, they have unanimously claimed that $C$ does not decrease as $S$ increases under any conditions. However, no one of them has ever submitted data in support of his statements. A study of the question seems to show that in the case of large channels having flat slopes, $C$ does decrease as $S$ increases.

For small channels the evidence is not so consistent. Practically the only data at hand suitable for investigating this effect in small channels is that taken by Bazin. Studies based on such of his data as might properly be used for this purpose, did not show any definite effect. Out of five comparisons only one indicated an increase in $C$ with an increase in $S$. The other four did not show any appreciable effect of $S$ on $C$. Bazin's conclusion was apparently justified in the case of small channels.

It is not unlikely that for open channels $C$ always decreases with an increase in $S$, but that this effect becomes appreciable only in instances where the slopes are unusually flat. It is not possible to say at present whether or not the magnitude of the effect is dependent on the size of the stream, since no data is available for small channels with flat slopes.

### No Detailed Comparison

Although a great many engineers have discussed the relative merits of the Kutter and Bazin formulas, no one of them has ever made a detailed comparison of the two equations. The nearest approach to a satisfactory comparison that has ever been published is the one given by Bazin when he proposed his new formula. A cursory examination of this might lead to the conclusion that Bazin's formula is the better of the two. However, a careful study of Bazin's work shows that he was somewhat partial to his own equation. In certain instances his classification of experiments seems questionable. In others, as for instance, the Irrawaddy measurements, he hid the agreement of the Kutter formula by platting only average values. While he did not fail to point out the advantages of his own equation, he neglected to call attention to those of the Kutter formula.

Several engineers have said that in series of experiments where the roughness conditions were plainly constant, Bazin's $m$ is less variable than Kutter's $n$. However, as in the case of the criticisms of the slope effect, no one of them submitted evidence to prove his statements. Studies made on the basis of 24 series of experiments, covering a wide range in conditions, showed that the average variation of $m$ exceeded that of $n$ in 23 instances out of the total of 24, and that in the 24th series the variation in $m$ was as great as the variation in $n$. The mean of the average variations of $m$ for all of the series was 9.67 per cent., while the corresponding value for $n$ was only 3.58, about one-third as great. Out of the total of 24 comparisons, 16 were based on Bazin's own measurements.

There is no question but that Kutter's formula is the best equation for open channels at the present time. Although his slope term should undoubtedly be changed somewhat, the data available at present seems to indicate that such a correction should be included in some form. The rather clumsy coefficients appearing in the formula for the English system of units doubtless could be replaced by round numbers. However, it does not seem advisable to attempt any modification at present. Algebraic complications are of no particular importance, inasmuch as numerous tables and diagrams are available for use in determining *C*. Although the slope term should be modified, it would be better to wait until more data is at hand before attempting such an improvement.

### Contracted Opening Estimates

When the drop in the water surface at a contracted opening amounts to one foot or more, and the length of the contracted section is so short that the friction head is either negligible or only a small part of the total head, the conditions afford a fairly reliable means of calculating the discharge.

The estimates are made by a simple application of the well-known Bernoulli theorem, that the sum of the pressure head, friction head, and velocity head is a constant. Briefly stated, the method consists in determining the velocity at the place of maximum contraction by adding the head due to the velocity of approach to the drop in the water surface at the opening, deducting the friction loss through the contracted section, and calculating the velocity corresponding to the remaining head by the well-known formula:—

$$V = \sqrt{2gh}.$$

This method has the advantage that it is not necessary to estimate a roughness factor. Under favorable conditions, about the only uncertain element connected with the computations is the determination of the friction head; and, in cases where the contraction is narrow and unobstructed and the surface drop amounts to a foot or more, this factor has a relatively small influence on the calculations.

Of course, if sharp edges or square corners exist at the entrance to the contraction, it will be necessary to apply a contraction coefficient; but the value of this factor will not, in general, be less than 90 or 95 per cent. Furthermore, this manner of calculating discharges has the advantage that the upper limit of possible error is always definitely known. It is certain that the velocity through the contraction cannot exceed the velocity corresponding to the total head at the opening.

This method was found to be especially valuable in determining the maximum rates of flow of the 1913 flood. Accurate estimates of the discharge were obtained by the aid of measurements at contracted openings, at places where results calculated by velocity formulas alone would have been very questionable. Even where the flood channels were remarkably well adapted to calculations by velocity formulas, measurements at contracted openings furnished excellent checks on the results.

### No Satisfactory Experimental Test

It has not been possible, up to the present time, to secure a satisfactory experimental test of this method of measuring the flow of water. Only one experiment has been secured thus far. It was made at a contracted opening where the conditions were not suitable for an accurate estimate of discharge, the friction head amounting to about 67 per cent. of the total head.

However, the results obtained under these unfavorable conditions are not without value. The discharge calculated from the drop at the opening only differed from the value obtained from the current meter gauging by about 16 per cent.

This may be considered as a very satisfactory check on the accuracy of the 1913 flood estimates, since for those measurements the friction head, on the average, was only about 26 per cent. of the total head. The results of the experiment also show the feasibility of securing fairly reliable estimates of discharge by this method even under unfavorable conditions.

## THE RELATION BETWEEN CIVIL AND MILITARY ENGINEERING*

By Major-General Wm. M. Black
*Chief of Engineers, U.S. Engineer Department*

It would be interesting to know which is the older, military or civil engineering. Were the first attempts at construction made for shelter or were they for protection against human or animal foes? Certainly both branches of the profession developed one with the other, and they do so to-day. The fundamental principles of both are the same. The same mental training is required for both. Of the two, military engineering is the more comprehensive, for there is not a branch of civil engineering which is not applied to military work, while to civil engineers in general the art and science of war is a closed book. The military engineers of to-day have organizations for the construction of ports; of port and interior terminals; for the construction and operation of railways, both broad and narrow gauge, both in the territory far from the enemy's fire and directly in the field of bursting shells; for the erection and repair of locomotives and cars; for highway construction; for quarrying; for mining; for general construction of buildings of all kinds; for water supply and sanitary works; for chemical and physical research; for electric power and lighting; for surveying and mapping; for camouflage work; for gas and flame warfare; for the production of lumber from the forests; and in addition in each division there is an engineer regiment for military work at the front and in each corps are bridge and searchlight trains. I am speaking now of the Engineer organizations serving with the army in France, and being prepared for that service. To obtain the personnel for all of this would have been impossible had not the members of the engineering profession of the nation responded most nobly to their country's call. But further, there is not one of these Engineer Reserve Corps men who does not now know that he could serve his country to better advantage had he had, beforehand, military training—training much beyond that possible in a three months' camp.

### Fundamentals are the Same

The fundamentals of the course of study required for a civil engineer of all branches of the profession are the same as those for the military engineer. The foundation of all is the general education which gives thorough command of our own language, both for speaking and for writing. An engineer not only must have ideas, but also must be able to express these ideas clearly to others. I have yet to discover any engineering project which cannot be described as to be clearly understood by a non-technical man. Then, a knowledge of general history and of law is most valuable. Passing to the more technical studies, mathematics to and through the calculus, descriptive geometry, physics and mechanics, electrics, the principles of chemistry, some mineralogy and geology, and the qualities and nature of the materials of construction should be mastered before the special studies of any particular branch of the profession are entered upon.

In the examinations which have been held for some years of candidates for the position of Second Lieutenant in the Corps of Engineers of the Army, some interesting facts have developed. All candidates must be graduates from some approved technical school, and the questions to be answered in the written examination are such as should be answered by any man who has mastered his course. Yet the proportion passing these examinations is woefully small. At the last examination held, out of 190 candidates, the papers of only 36 could be accepted as up to or approaching the required standard. The failures were not in the most difficult studies only—topographical surveying frequently was a stumbling block. Descriptive geometry was so generally unknown that the impression was created that the value of this subject was underestimated by the schools themselves. Yet what study does so much in teaching the mind to make a mental picture

*From "Professional Memoirs."

of the problem to be solved, and what quality is more valuable to any construction engineer than the ability to visualize a contemplated piece of work? Topographical surveying was found in cases to be not thoroughly understood, yet in what branch of the profession is ability to interpret topographical maps not necessary? It has seemed at times as if the whole scheme of the education had been at fault, that the scholars had never been compelled to tackle the tasks set and do the allotted work as a duty, whether congenial or not, and further, that the foundation of all, the general knowledge that every man who wants to attain success must have, was lacking. I wish you would think of these things. Is it not better to have the mind so trained that it can grapple unafraid with any problem, than to start life with only a smattering knowledge of certain applications of partially understood laws? The courses of study at the schools are for two distinct purposes, one to train the mind and the will for work, and the other to furnish the useful tools for doing the work. The memorizing of certain facts is of little value. The ability to do certain things in a certain way without knowing clearly why that way is best, or even if it be the best, is poor preparation for an engineer. The study of accomplished engineering work has the same value as the study of history; it is experience acquired at second hand, but to be most valuable, failures should be studied along with successes. The development of mankind as portrayed in general history is a picture of a struggle upward with many slips and falls, but nevertheless with a continued advance.

### Same Strategy, Different Tactics

It is a saying well known to students of military affairs that strategy is always the same but tactics vary. In other words, the fundamental principles of the science of war always remain the same, but the methods of applying these principles vary through the ages in measure as the advancing knowledge of nature's laws forges new tools for the soldier's use. The better knowledge of chemistry and of metallurgy are the main causes which make the fighting methods of this war different from those of earlier wars. Have you ever thought of a ship as a truss, which must have a certain limitation of depth on account of the natural limitations of our harbor entrances but whose length (and consequently the cross section of the ship) is limited by the qualities of the materials which are available? So with our guns. Increased chemical knowledge gives new and more powerful explosives. Advances in metallurgy make it possible for these explosives to be utilized to the greatest advantage. Improvements in the vehicles of transportation, in the paths in which they travel and in the means for the transmission of orders, make possible the handling of men in larger bodies and on larger battle fronts. In all lines of endeavor required by war, the influence of the advancement of human knowledge makes itself felt, and those charged with the responsibility of defending the nation's life must be constantly alert to take advantage to the fullest extent of the advancements in human knowledge. In military engineering, the officer entrusted with certain work must obtain beforehand all the information he can. He must study the surroundings, take into full account the character of the tools and supplies available, and must know the number of men whom he has to carry out the work, as well as their individual abilities. He must then lay out the plan he hopes to follow, estimate probable difficulties to be met, and be ready to change this plan at short notice and adapt it to unexpected happenings. All this means that he must be thoroughly trained in the art and craft of his profession, so that when trouble occurs his mind will work in part intuitively and he can see quickly the best course to take and will be prepared to follow it and carry it through. All this involves a long and special training and a quickness of view and decision which are vital to the success of his work, especially in war.

The same principle holds good in civil engineering, in which the general principles of mechanics and construction remain unchanged, but the processes must vary with the character of work to be done, with the condition of the labor market, with advances in machinery and methods of doing work, etc. This is exemplified particularly in those works in which the great forces of nature must be opposed, or made obedient servants for the accomplishment of a desired result, as in river and harbor improvements. The chief enemies are the weather, storms and floods, and often an uncertain supply of labor and a long distance from a base of supplies. While the civil engineer does not often have to make the instant decisions of the military engineer engaged in actual war, he must, nevertheless, follow the same path in carefully planning his work ahead, must see that one part in the programme will not delay or overlap another, and must have behind him a general knowledge of construction and an experience in the special work he has in view which will enable him to meet and decide the unexpected and drive the work ahead. In both cases—the civil and the military—the chief requisite to success is the careful study and choice of a suitable plan of work and the ability to meet the changes in conditions which always come.

### Many Problems the Same

Again, the problems connected with the organization, care, training and use of large bodies of men are similar in both military and civil engineering work. The greater the hazard, the greater the need for discipline. The larger the force, the more elaborate must be its organization. The more active the opposing forces, the greater the need for the training which makes the doing of the necessary thing intuitive. Discipline is probably the most essential factor for efficiency where large bodies of men must act in co-ordination in a hazardous work. The will of each man must be subordinate to that of his commander. What may be the right thing to do from the viewpoint of the subordinate might be disastrous from the broader vision possible to the commander. This subordination of will must be sharply distinguished from the blind doing of what is directed. Intelligent initiative must always be cultivated, for each man is allotted a definite field of responsibility, and within that field he must be prepared to act promptly and intelligently.

Before a man can consider himself a real soldier he must have acquired a self-mastery which will make him intuitively ready to obey loyally and at the same time to command effectively. This comes only after long and hard training. Donning a uniform, with or without shoulder straps, and knowing something of military drill does not make a soldier. Soldierly qualities may be cultivated in ordinary school life—with or without strictly military drills.

Through the ages there has developed in all nations a system of training and of customs designed to aid in the installation and cultivation of discipline. The courtesies demanded between soldiers is one of these aids. Military courtesies in final analysis prove to be the same as those that should prevail in civil life between the young and the old, between the young man starting in life and the man who has already achieved distinction in his fulfilment of life's duties. In civil life, unfortunately these courtesies are too frequently neglected. In military life they are enforced. In the army, rank is assumed to be the mark of distinction, and the junior pays deference to the rank of the senior. The obligation of courtesy is the same for each, but the salute must be made first by the junior. Mistaken views of democracy have led at times to attempts to do away with this observance of the difference of rank and of the deference due to rank. It was tried at the beginning of the French Revolution. Necessity soon caused the revival of the law. It is being tried now in Russia. What has been the effect on her armies?

### Largest Force to Accomplish Single Purpose

An army constitutes the largest force assembled by man for the accomplishment of a single purpose, and the accomplishment of that purpose involves hazards greater than those of any other human endeavor. Hence, in an army, discipline, organization and training must be carried to the highest degree. With the great number of men gathered together for a single work, come increased problems of supply and care. The sanitation must be supplied as needed and in sufficient quantity. To supplies of this character must be added supplies in enormous quantity of all the kinds and varieties required for the comfort and protection of the men and for the needs of offensive and defensive operations. This supply of an army requires great system in the methods of obtaining, using and replacement. John Smith, private, is but one of a number in his company. But John Smith is an individual for whom the United States is responsible. His status must at all times be known. He must be fed, clothed, properly housed and paid. If wounded or sick he must be cared for. If killed his family and friends must be notified, and his body be given decent burial. If he survives, at the end of the war he must be discharged. All of this requires that his status must be of record daily and that all he needs must be procured and furnished. This necessitates an amount of paper work, alongside of which the most elaborate system of civil cost-keeping sinks into insignificance. The papers are made as simple and fool-proof as possible, but the mastery of the subject requires hard study and work of a kind little removed from drudgery.

### Technical Details Easy

This subject is too much neglected by men who aspire to commissions in the army. A large part of the suffering among newly organized troops is due to the ignorance of their officers of the methods of supply; another large part to a lack of discipline. So I say to those of you who desire to enter the service as officers of any branch, learn discipline first and the care of men next. The technical details of work are easy to learn. In a lesser degree the same advice is good for those of you who expect to practice your profession in civil life only.

The construction methods used in works of military engineering and in works of civil engineering are much the same. In the military work at the front any materials at hand must be utilized.

Economy must be disregarded. Economy in time is the essential. Initiative and fertility in resource in the engineer in charge and discipline and training in the men are the elements of success. Tools are provided in the engineer train. Materials in general must be found. In river crossings, the bridge trains are used, first for ferrying, then in a bridge. Immediately, however, a fixed bridge must be started with the best materials which can be found and of the type best suited to the conditions at the site. Here, again, the engineer in command must be able to form instantly an accurate judgment, and must be able to make his plans for the work without any office assistance and generally without even drawings. His bridge must have stability and sufficient strength to carry the heaviest loads which the material of the army demands, including armored tanks and ten-inch guns.

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The union labor interests have issued a statement in which they estimate that there are 35,000 unemployed skilled and unskilled laborers in Toronto and surrounding district.

An order-in-council has been signed to authorize the use of the name "Canadian National Railways," the new title to include those used formerly for the lines comprised in the Canadian Northern Railway System and Canadian Government Railways, the Intercolonial and National Transcontinental.

"In Canada's 3,730,000 square miles there is room for the entire world's population, allowing nearly 1½ acres for each person. If Canada were only as thickly populated as the British Isles, it could accommodate 1,356,000,000, roughly, four out of five persons living on the earth to-day. At present its population is only 7,250,000, or less than two persons to each square mile."—The Toronto World.

Members of the Engineering Institute of Canada at Sault Ste. Marie, Ont., held a meeting at the Y.M.C.A. last Thursday evening and decided to apply to the Council of the Institute for permission to form a Sault Ste. Marie branch. A meeting of the branch will be held January 9th, at which a paper of engineering interest will be read. The temporary executive committee is as follows: J. W. LeB. Ross (chairman), B. E. Barnhill, C. H. E. Rownthwaite, J. H. Ryckman, N. L. Somers and L. R. Brown (secretary).

## THE QUEBEC BRIDGE

### Why "K" System of Bracing Was Adopted—Statement by St. Lawrence Bridge Co. Officials Regarding Cause of Failure of the Phœnix Company's Structure

WITH the compliments of the St. Lawrence Bridge Co., a handsome booklet is being distributed descriptive of the Quebec Bridge. The booklet is printed in two colors on coated paper and contains 104 pages, 9 in. x 12 in., and embossed cover A large number of full-page illustrations are included, which add a great deal to the interest and value of the book. These illustrations are from photographs by E. M. Finn, staff photographer of the St. Lawrence Bridge Co., and are excellently selected to show the progress of the work. A number of pages are devoted to the history of the bridge, its design and erection, tables of weights, summary of progress dates, description of the hoisting of the central span, etc.

### Why Bridge is Notable

"The bridge is notable," says the booklet, "not only as having the longest and by far the heaviest single span yet built, but for the use, the first time in an important structure, of what has become known as the 'K' system of web bracing, which is believed to have important advantages over the Pratt or the Warren web system generally used in cantilevers.

"It is statically determinate as regards stresses. The deflection is uniform, without local irregularities, and secondary strains are negligible. Each web member carries only about one-half of the total shear. Diagonal web members have economical inclination.

"Main panels are short, resulting in more numerous and smaller increments of chord stress than in trusses with long panels. All web members of the trusses transmit live as well as dead load stresses. The support for an intermediate floor beam in each main panel is readily provided without injurious bending of any main member.

"The truss members at their connections meet at favorable angles and simple and satisfactory connecting details are easily arranged. The assembly in erection is the adding of simple unsubdivided triangles one to another, each self-supporting as completed and requiring but a minimum of temporary supporting members.

"The use of the 'K' web system was conceived and proposed by Phelps Johnson. The design was developed by G. Herrick Duggan. The detailing and erection was under the direction of George F. Porter.

### Why First Bridge Fell

"Before the final decision to adopt the 'K' system of bracing was reached, practically all other web systems were studied. The decision to use the 'K' bracing was largely influenced by considerations connected with the erection of the structure and, particularly by the conclusion that there would be no necessity for leaving any compression joints partly open and unriveted, until the deformation of the truss, due to the addition of dead load as the erection progressed, was sufficient to close the joints.

"This conclusion was found to be fully warranted and in erection the abutting faced ends of all compression joints were easily brought to a full bearing and riveted before succeeding material was placed.

"The engineers of the company had long been convinced that the initial cause of failure of the Phœnix Company's bridge was the high intensity of pressure and consequent distortion and displacement of material at the bearing edges of the lower chord sections of the anchor arm. These chords had been assembled with partly open joints, which were expected to gradually close as the cantilever arm and the suspended span were built out, and the consequent increased stresses and changes in the lengths of the truss members brought the chord sections to full bearing. Before the closing of the joints was complete the cords must have been subject to practically the full stress intended to be borne by their full section, resulting in a very great intensity of pressure upon the limited areas actually in contact."

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HEAD OFFICE: 62 CHURCH STREET, TORONTO, ONT
Telephone, Main 7404. Cable Address "Engineer, Toronto."
Western Canada Office: 1208 McArthur Bldg., Winnipeg. G. W. GOODALL, Mgr.


## PRINCIPAL CONTENTS



## LOCAL BUILDERS' EXCHANGES BECOME BRANCHES OF BIG NATIONAL ASSOCIATION

BUILDERS' exchanges throughout Canada should be merged with the newly-formed Association of Canadian Building and Construction Industries. In unity there is strength. United the exchanges will grow strong; divided they will fail.

The exchanges in Montreal and Toronto have set the example. At a meeting held December 17th in Montreal, the members of the exchange in that city decided unanimously to wind up the affairs of that exchange as such at the next annual meeting, and to reorganize as the Montreal Branch of the Association of Canadian Building and Construction Industries.

W. E. Dillon, president of the Toronto Builders' Exchange, gave a dinner at Foresters' Hall, Toronto, last Thursday evening, to which he invited all of the members of his exchange. About 125 men, including nearly 95 per cent. of the membership of the exchange, were present.

After dinner, J. P. Anglin, who is president of the Montreal Builders' Exchange, and also president of the Canadian Association of Building and Construction Industries, explained the action taken by the Montreal builders and contractors. Following a lengthy and thorough discussion, it was decided almost unanimously that a recommendation be made to the executive of the exchange that a merger be effected with the Association of Building and Construction Industries at the annual meeting of the Toronto exchange in January.

A very few of the oldest members of the Toronto Builders' Exchange were reluctant to give up the name "Builders' Exchange," their reasons being largely sentimental. Many of these were won over by the strong arguments presented by the members who had attended the Ottawa conference and who are enthusiastic about the new association; and even those who were not completely won over, remained silent when the vote was taken. Only one member of the exchange afterwards expressed himself as dissatisfied with the step taken.

In urging the exchanges throughout the country to become members of the new association, there is no thought of belittling the work of the exchanges. The Montreal exchange has been a corporate body for twenty-one years. There were men present at Mr. Dillon's dinner who have been members of the Toronto exchange for half a century. These and the other exchanges throughout the country have in past years, at least, been highly respected by their communities and looked up to as truly representative of the building and contracting trades.

But changed conditions arose about ten years ago through the introduction into Canada of the general contractor or contracting engineer. This development was a natural result of modern business conditions, but it mitigated against the success of isolated builders' exchanges. The new association, with its three sections comprising the best thought from all branches of the industry and from all parts of the country, fills a national need that is not filled by isolated exchanges.

In organizing the new sections of the Association of Canadian Building and Construction Industries, Toronto and Montreal will take in general contractors, trade contractors and supply men whose headquarters are anywhere within a large district surrounding those two cities. It is hoped that the other exchanges who may desire to form branches of the Association will follow suit and get as many as possible of the contractors and supply men from surrounding municipalities into their exchanges, or branches, so as to organize the whole industry throughout the entire country.

There is no room for sentiment regarding the name "Builders' Exchange." If a change of name will give new birth to the exchanges, by all means change the name. As Mr. Phinnemore, of Toronto, said at Mr. Dillon's dinner, the time has come when "the contractors must take part in the reconstruction of the country, socially and economically. The salvation of the building industries in Canada is in co-operation by all along national lines. We must adopt the principles of the Allies,—co-operation all the way 'round, and advance efficiently along the lines of other institutions so as to gain national recognition."

## SIGNIFICANCE OF BLACK SANDS IN FILTERS

*(Continued from page 550.)*

approximately 50 pounds per square inch. Variable rate of wash water. Operation of plant good.

*Winfield.*—Plant installed 1910. Modified Greer filter construction, using combined air and water wash. Wash water supplied by separate wash water pump, giving a wash water velocity of 7½ inches vertical rise per minute. Plant operation variable.

*Augusta.*—Installation test July, 1912. American Water Softening Company standard filter equipment. Air and water wash. Wash water originally furnished from distribution system; now furnished by separate wash water pump, which gives a wash water velocity of 9 inches vertical rise per minute. In 1916 the beds washed unevenly and mud balls were in evidence. Plant operation inconstant.

*Oswatomie.*—Installation test December, 1915. New York Continental Jewell Filtration Company standard equipment. Combined air and water wash. Wash water secured from distribution system at 60 to 80 pounds pressure per square inch. On different occasions the wash water valve has been opened so that the wash water rate was excessive and the sand and gravel became mixed. The plant has had considerable operating trouble from microscopic growth in basins and filters. Plant operation variable.

*Washington.*—Installation test October, 1914. New York Continental Jewell Filtration Company standard equipment. Filter washed with combined air and water.

Wash water supplied by separate wash water pump, giving a wash water velocity of 12 to 13 inches vertical rise per minute. Plant operation variable.

*Garnett.*—Plant installed 1908. New York Continental Jewell Filtration Company standard equipment. Filters washed with water only. Water supplied directly from distribution system, at a pressure of approximately 60 pounds per square inch at the manifold, giving a wash water velocity of approximately 18 inches vertical rise per minute. Sand replaced in 1915; in a very dirty condition in 1917. Plant operation poor.

*Olathe.*—Installation test August, 1914. Pittsburg Filter Company's equipment. Air and water wash. Wash water velocity 14.7 inches vertical rise per minute. In January, 1918, the filters washed unevenly and several of the strainers were clogged. Operation good.

This investigation has not been carried to a point where it can be definitely stated that the darkening of the sand has any effect upon the efficiency of the filter, but there is a feature well worth investigation along this line because it seems that penetration of the bed is followed by this coloration. At the present time the only definite discovery is an ocular index of improper operation. This is something the small plant filter operator can be warned to look out for. If he finds that his sand is becoming dark, he should change his time or method of washing so that he will have no fouling or penetration of the bed.

## PERSONALS

COL. G. G. NASMITH, director of the bacteriological department of the City of Toronto, slipped on the steps of the City Hall recently and broke his leg, necessitating his removal to a hospital.

A. T. FRASER, of the Canadian National Railways, has been appointed chief engineer of the western lines. Mr. Fraser was with the C.N.R. at Edmonton for several years. His headquarters will be at Winnipeg.

ARTHUR MOSS, chief engineer of the Hydraulic Service, Quebec, and a member of the Quebec Streams Commission, has been added to the Dominion Power Board as a representative in the interests of the Province of Quebec.

E. R. GRAY, city engineer of Hamilton, has been appointed a member of the Natural Gas Advisory Board of the Ontario Government. This Board will co-operate with the department of Lands, Forests and Mines in connection with the gas problems of the province.

SIR CLIFFORD SIFTON has resigned as chairman of the Commission of Conservation. The work is being carried on by James White, assistant to the chairman and deputy head of the commission, pending a new appointment by the government. No reason for the resignation was given by Sir Clifford, who is now in England.

G. M. GEST, of Montreal, is managing-director of the Sino-North American Company, Ltd., which has been organized to promote Canadian export trade. Mr. Gest is well known as a conduit contractor. His new company has opened offices in Pekin, Hong Kong, Shanghai and Vladivostok, and the company expects to open an office in India. The company represents the Dominion Textile Co., the Ogilvie Flour Mills, Steel Company of Canada, Canada Carbide Co., Warden King & Co., Brandram-Henderson, Dominion Bridge Co., Thos. Davidson & Co., Empire Typewriter Co., and Waterous Engine Works. Among those connected with the company are Sir Herbert Holt, of Montreal, and A. E. Aldred, president of the Shawinigan Water & Power Co.

MAJOR F. L. C. BOND has been appointed chief engineer of the Grand Trunk Railway, with headquarters at Montreal. Major Bond, who succeeds Mr. H. R. Safford, recently appointed engineering assistant to the Regional Director of the Central Western District, United States Railroad Administration, has just returned from overseas after two years' service with the 10th Battalion Canadian Railway Troops. He was born in 1877 at Montreal, and graduated from McGill University in 1898. He later entered the services of the Grand Trunk as assistant resident engineer of the Eastern Division, and in 1901 was appointed engineer in charge of double track construction. In 1902 he was night superintendent on the construction of the Park Avenue tunnel of the New York subway, but returned to the Grand Trunk as resident engineer, Eastern Division, a position which he held until 1913. From that time until 1916, when he went overseas, Major Bond was division engineer, Eastern Lines.

## OBITUARIES

L. O. CLARKE, of Toronto, died recently in his 38th year. Mr. Clarke was a surveyor, and had the distinction of surveying the townsite of Cobalt. He recently had been engaged in work for the C.P.R. on the Lake Superior division.

LIEUT. JOHN R. KIRBY, B.A.Sc., Toronto University, was killed December 15th as a result of an aeroplane accident in England. Lieut. Kirby, who was in his 28th year, was born and educated in Toronto, winning honors in 1916 in the Faculty of Applied Science.

WALTER KENDALL GREENWOOD, B.A.Sc., engineer of the Orillia Water, Light & Power Commission, died last Friday at Orillia, aged 37, after a brief illness, from pneumonia. Mr. Greenwood was a graduate of the Faculty of Applied Science, University of Toronto. He was the eldest son of Russell Greenwood, of Toronto.

WM. J. GALBRAITH, a graduate of McGill University, 1909, died recently from pneumonia. He was born at Lachine 32 years ago. Mr. Galbraith was engaged in the construction of a ship canal and shipyard at New Orleans, La., which was designed to be, in time, the largest plant of its kind on the North American Continent.

CLIFFORD E. ROGERS, a graduate of the School of Practical Science, University of Toronto, who enlisted as a private in the Canadian Corps, Cyclist Battalion, died of wounds November 7th, in France. Prior to enlistment, Pte. Rogers was an inspector in the Department of Works, Water Supply Section, Filtration Plant, Toronto.

L. A. DAREY, of Sherbrooke, P.Q., died suddenly on Nov. 29th at the age of 53. He was born in Montreal and spent a number of years in South America in railroad construction work. Of late years he had been engaged on the C.N.R., G. T.P., and the Transcontinental Railways. For the last four years Mr. Darey had been a prominent worker in the good roads movement.

LOGAN WALLER PAGE, director of the United States Office of Public Roads and Rural Engineering, who was well known to many Canadian highway engineers and contractors, died suddenly in Chicago, December 9th, while in attendance at the annual meeting of the American Association of State Highway Officials. He was born in Richmond, Va., in 1870, and was a student in engineering at Virginia Polytechnic Institute for two years and at Harvard University for six years. Later, at Harvard, he was in charge of tests of all materials used by the Massachusetts Highway Commission and some for other states and Canada. In 1899 he made an extended study of road building in Europe. A year later, he became chief of the road material laboratory, United States Government, afterwards re-organized as the Division of Tests. In 1904 he became Director of the Office of Public Roads, which combined the Division of Tests and the Office of Public Roads Inquiry, in the Department of Agriculture.



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