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MISSING

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

Direct Design of Curvature of Arches

A Short and Accurate Analytical Method of Finding the Ordinates of the Curve for Concrete and Masonry Arches, With An Example

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It has long been known that the Transformed Catenary is the curve of equilibrium for a linear arch under a vertical load-area of uniform weight per unit area. This may be shown as follows:—

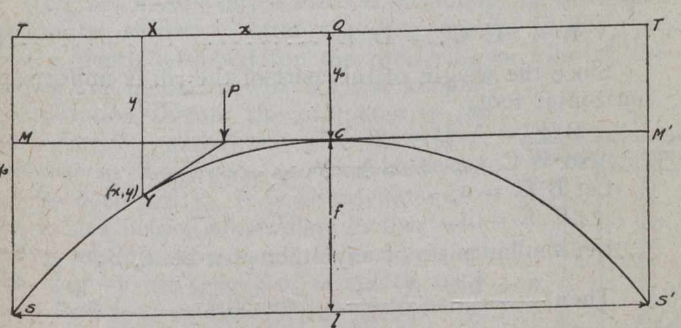


Fig. 1—Curve of Equilibrium for Homogeneous Loading

Let the linear arch S C S′ be in equilibrium under the load-area above it T T′ S′ C S.

Take O T axis of x.
  O C axis of y.
Let A = area O C X Y
  ω = weight per unit area of load-area.
  H = constant horizontal thrust.
  P = weight of load under O X.
Take a, so that $H = \omega a^2$ ....I.
Then $P = \omega A$.

and $\frac{A}{a^2} = \frac{P}{H} = \frac{dy}{dx}$ ....II.

and $A = \int_{x = o}^{x = x} y \, dx$ ....III.

$\therefore \frac{d^2 A}{dx^2} = \frac{dy}{dx} = \frac{A}{a^2}$

Integrating

$$A = V e^{\frac{x}{a}} - W e^{-\frac{x}{a}}$$

Where V and W are constants to be determined:

When $x = o$, $A = o$, and $e^{\frac{x}{a}} = e^{-\frac{x}{a}} = 1$.
and the above equation can be put in the form

$$A = V\left(e^{\frac{x}{a}} - e^{-\frac{x}{a}}\right),$$

$$\therefore \frac{dA}{dx} = \frac{V}{a}\left(e^{\frac{x}{a}} + e^{-\frac{x}{a}}\right) = y \text{ from III.}$$

When $x = o$, $y = y_o$.

$$\therefore y_o = \frac{2V}{a}$$

and the above equation becomes:

$$\frac{y}{y_o} = \frac{e^{\frac{x}{a}} + e^{-\frac{x}{a}}}{2} \qquad \text{..........................IV.}$$

which is the equation to the curve.

This curve was made the basis of a direct method of design for masonry arches, where no tension in any part of the arch ring was desired, by Alexander and Thomson* whereby the line of resultant pressure for dead and live loads may be kept within the middle third of the ring. Otherwise small mention has been made of it in late works on arches.

In important arches it has often been considered worth while to fit the line of resultant pressure for the dead load by graphical methods to coincide with the middle line of the arch ring, so that under the dead load there shall be no bending moment at any section of the arch ring. This curve is chosen in order to be economical of material, for the principal stresses from other than the dead load are reversible moment stresses of about equal amounts, positive and negative. It is not, however, the arch of exactly minimum material where the dead loads alone are taken for the equilibrium curve, as there are exceptions to the above statement as to reversible stresses of equal amounts which may be taken account of. But any part of the distributed live load may be taken along with the dead load in forming the equilibrium curve just as easily as the dead load alone. It is therefore unnecessary for the purpose of this article to discuss further the arch of minimum material.

The curve of the middle line of the arch may be found so that it coincides with the equilibrium curve by the following analytical method. This applies to open spandrel arches where the weight of the floor system (as distinct from the spandrel vertical supports and the arch ring) is uniform per lineal foot and to earth-filled arches if the pressure of the filling is assumed to be vertical.

In these cases part of the dead weight is uniform per horizontal foot, the weight of the floor system and part of the arch ring, and that part of the spandrel supports

*"On Two-nosed Catenaries and their Application to the Design of Segmental Arches." Transactions of the Royal Irish Academy, Vol. XXIX., part III., 1888.

(as these are ordinarily designed), if any, which lies above the level of the crown—in fact to all of the arch system at the crown. The rest of the arch dead load varies from zero at the crown, C, to a definite amount at the skewbacks, S, S′. Let us call these parts I. and II. Let the area M M′ T T′ represent I, and the area S C S′ M M′ represent II. The weight of the spandrel supports (or that part of them in II) will vary sensibly as the ordinates between M M and the curve. We must assume that the spandrel supports are of uniform section and spaced equally, and that the floor system is of uniform weight per horizontal foot, in accordance with usual practice. Let us further assume for the present that that part of the ring which varies from zero at C to any amount we wish at S varies according to the same law. Here f represents the actual rise of the linear arch, but y_o is, of course, not the actual height of the floor system. Its meaning is not of practical interest. It is the height to which the part of the arch in I would rise if it weighed the same per cubic foot as the part in II, the latter supposed to be distributed uniformly over M M′ S C S′.

We may suppose the dead weight to be thus distributed, in which case let it weigh ω lbs. per cubic foot.

Assume that the linear arch S C S′ is the equilibrium curve and also the middle line of the arch ring. Then we find as follows:—

The last term of IV is an hyperbolic function, cosh $\frac{x}{a}$ Tables of these functions were prepared by the Smithsonian Institution and published in 1909.* We shall have recourse to them in what follows.

The equation of the curve then becomes—

$$\frac{y}{y_o} = \cosh\frac{x}{a} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{V.}$$

We have—

$\omega\, y_s$ = weight per lin. ft. of whole arch system at S = S (say) which must be computed,....VI.

$\omega\, y_o$ = weight per lin. ft. of arch system at C = C (say) which must be computed ......VII.

When $x = \frac{1}{2}$, $y = y_s$.

$$\therefore \frac{y_s}{y_o} = \cosh\frac{1}{2a} = \frac{S}{C}\text{(from VI. and VII.)}.$$

whence a is found from the tables.

Also—

$$\frac{S}{C} = \frac{y_s}{y_o} = \frac{f}{y_o} + 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{VIII.}$$

whence y_o from VIII, ω from VII and H from I.

We are now ready to tabulate the values of x for as many points on the curve as is required, say the points at the feet of the spandrel posts, or 8 or 10 points for the half arch. Then tabulate $\frac{x}{a}$, $\cosh\frac{x}{a}$ and $y_o \cosh\frac{x}{a}$ which gives the values of y. It will now be convenient to subtract y_o from each value of y giving the ordinates $y - y_o$. We then have the abscissae and ordinates of the curve conveniently on a horizontal line through the crown of the linear arch and perpendicular to it.

Let us now examine the assumptions made above as to distribution of weight. In Fig. 2 the central part of the ring is that part which is of uniform weight per horizontal foot, part 1. The shaded portions are part 2 of the ring, varying from zero at C to anything required at S. Also any one spandrel post is shown, the shaded part being part 2 of it. The shaded parts of the rib have been assumed to vary in weight per horizontal foot from C to S according to the ordinates $y - y_o$. Suppose the rib to have been designed as to intermediate depths between C and S in this way, then we prove as follows:—

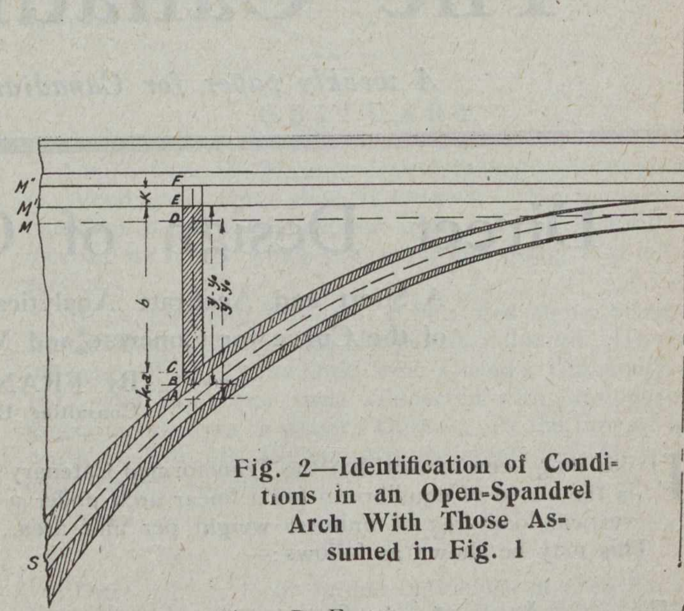


Fig. 2—Identification of Conditions in an Open-Spandrel Arch With Those Assumed in Fig. 1

A B = C C′, = D E ....(a)

Since the weight of this part of the rib is uniform per horizontal foot.

$\therefore$ B E = A D = $y - y_o$ ....(b)

Also B C varies as $y - y_o$ ....(c)

Let B C = a,

C E = b.

Let similar parts of any other post be a′, b′.

$$\text{Then } \frac{a+b}{a'+b'} = \frac{y - y_o}{y' - y_o} = \text{from (b)},$$
$$= k, \text{ say.}$$

$$\text{Also } \frac{a}{a'} = k \text{ from (c).}$$

$$\therefore \frac{a'k + b}{a' + b'} = k$$

$$\text{whence } \frac{b}{b'} = k$$

or C E varies as $y - y_o$.

Now C E is all that part of the post in division II, as the part (if any) above it is the part above the extrados of the ring and is of uniform weight per horizontal foot if the spandrel posts are equally spaced and of uniform section.

We have now shown that all that part of the bridge which is not of uniform weight per horizontal foot varies from zero at the crown to any required weight at the skewback, directly as the ordinates $y - y_o$, as required by the theory, but we must design the intermediate depths of the arch ring accordingly, although we may choose any depth at the crown and any other at the skewback. When the depths of the latter sections are so chosen as to make the same maximum stresses at both crown and skewback then the ring with intermediate depths chosen as above is almost ideally correct for arches with fixed ends, judging by various arches analyzed by the writer, but is slightly in excess of the requirements along the middle haunch where temperature moment stresses are small. But if the arch of ideal depth at all points is sought and found by repeated trials it will not differ at all from the one here assumed at the crown or skewback, and only so slightly along the haunches as to make no

*Smithsonian Mathematical Tables. Hyperbolic Functions. Published by the Smithsonian Institution, Washington.

appreciable difference in the line of resultant pressure for the dead load of the arch system.

It is desired to apply this method of design to an arch which does not fulfil the conditions required, as for instance, where by reason of the ring touching the floor slab at the crown (as in some flat arches) the floor system is not of uniform weight throughout, the limits of probable error may be indicated in this way.

Compute the weight of the arch and then compare it with the weight of the assumed arch W (say) which is—

$$W = \omega \int_{x=-\frac{l}{2}}^{x=-\frac{l}{2}} y\,dx$$

$$\text{or } W = 2\,a\,\omega\,y_o \operatorname{Sinh} \frac{l}{2a}$$

But in arches which fulfill the conditions the above expression gives the readiest method of getting the total weight, and without computation except for the weight per lineal foot at two points, the crown and the skewback.

Some of the advantages of this method of designing the arch curve may be mentioned.

It gives a very direct method of finding the dead load horizontal thrust. After the floor system is designed and a depth assumed for the arch ring or ribs at the crown and at the skewback a few minutes computation (before the ordinates to the curve are computed) will give the correct stresses at the crown and skewback due to the dead loads. It is an advantage to know this before proceeding further with these computations and the analysis of the ring by the theory of elasticity, as it may lead to a revision of the arch depths without waste of labor, especially in great arches where the dead load stresses are the main stresses.

It allows a check on not only the final work here shown for finding the curvature, but on almost the final work in analyzing the arch by the theory of elasticity. If when the final coefficients in the latter analysis are found the dead load moments are sought at any one point, as for instance the crown, and found to be zero, then the correctness of the curvature as well as of the coefficients themselves are verified.

An Example Worked Out

$l = 139$ ft.
$f = 36.96$ ft.
S = weight per lin. ft. of bridge at skewback for a longitudinal strip one foot wide = 890.6 lbs.
C = weight per lin. ft. of bridge at crown for a strip one ft. wide = 361.7 lbs.

$$\operatorname{Cosh} \frac{l}{2a} = \frac{\omega\,y_s}{\omega\,y_o} = \frac{S}{C} = \frac{f}{y_o} + 1 = \frac{890.6}{361.7} = 2.4623.$$

From tables $\frac{l}{2a} = 1.5502.$

Whence $a = 44.834$

also $\frac{f}{y_o} = 2.4623 - 1.$

Whence $y_o = 25.276,$
and $\omega\,y_o = C = 361.7.$
Whence $\omega = 143.10,$
and $H = \omega\,a^2 = 28{,}764$ lbs.

Now proceed to find as many points on the curve as necessary. Here we divide the span 139 ft. into 15 equal divisions of 9.75 ft., a spandrel post being at each division point, the crown being midway in the central division. The first value of x will be one-half of this division, 4.875 ft., the second 9.75 ft. more, and so on, as in Column I. The other columns are then easily computed.

I.		II.	III.	IV.	V.
x		$\frac{x}{a}$	$\log\cosh\frac{x}{a} + \log y_o$	y	$y - y_o$
Ft.			—log y		Ft.
4.875	....	.10873	1.40527	25.462	.150
14.625	....	.32620	1.42542	26.633	1.357
24.375	....	.54368	1.46397	29.105	3.827
34.125	....	.76115	1.51796	32.958	7.682
43.875	....	.97862	1.58407	38.377	13.101
53.625	....	1.19610	1.65914	45.618	20.342
63.375	....	1.41350	1.74053	55.021	29.745
69.500	....	1.55020	1.79405	62.237	36.961
308.375	....	6.8780		315.375	113.167
			$8\,y_o =$	202.208	
				113.167	check.

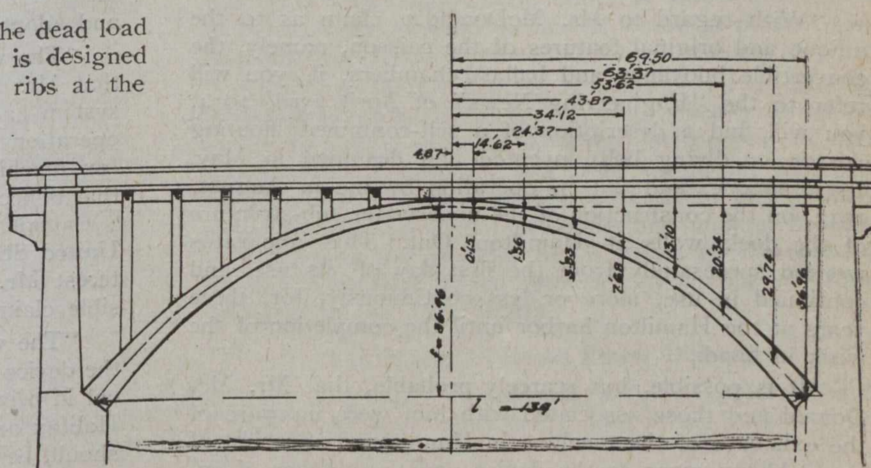


Fig. 3—Typical Open-Spandrel Arch as Example

$$\log \Sigma\,x = 2.4890791$$
$$\log\ a = 1.6516033$$

$$\log \Sigma \frac{x}{a} = .8374758$$

$$\Sigma \frac{x}{a} = 6.87810 \quad \text{check.}$$

The abscissae and ordinates to the curve are given in columns I. and V. along a horizontal line through the crown and perpendicular to it.

About 4,500 horse-power of Trent Falls electrical energy is released for the use of Eastern Ontario municipalities through the destruction of the munitions plant at Trenton.

The government will soon be complete owner of the Canadian Northern Railway stock. The minority stock is being purchased, and all but seven thousand shares held in England has been turned over to the government at the same price as was paid to Mackenzie and Mann for their shares. This stock is on the way to Canada. The Dominion will then own all but five shares. The one minority holder is a San Francisco man, who owned five shares of income convertible stock and insisted on his rights to transfer to common stock. He refuses to sell out, so that the Canadian Northern Railway will be owned by the Dominion of Canada and a San Francisco citizen.

CLAIMS INVENTION OF DIVING BELL

In a letter addressed to the secretary of the Engineering Institute of Canada, John Taylor, of McAllister & Taylor, engineers and contractors, of Hamilton, Ont., protests against certain statements made by J. J. McDonald in the paper which the latter read at the recent Halifax professional meeting of the Institute. Mr. McDonald's paper described the diving bell used in the harbor work at Halifax, and contained intimations regarding the originality or novelty of the apparatus. Following are extracts from Mr. Taylor's letter to the Institute:—

"Mr. McDonald calls his device a Floating Caisson, or Diving Bell, and lays claim to being the originator of this type of apparatus. It is necessary for me to contradict this statement. I have watched with interest the use of this particular machine, and have awaited the publication of an official detailed description of it, which, I felt, would, sooner or later, be made public. I have also been aware of the claims made in connection with the device, and have had to allow these claims to pass unchallenged for want of official detailed information. It is impossible for an outsider to get such information unless voluntarily given.

"With regard to Mr. McDonald's claim as to the unique and original features of the caisson, namely, the convertible buoyancy and ballast chambers, if you will refer to the "Engineering News" of April 23rd, 1914, you will find a description of a self-contained floating caisson or diving bell, invented and designed in May, 1913, by me, and put in operation by me in August, 1913, on the construction of the underwater sub-structure of the dock walls at Hamilton, Ont. This apparatus worked successfully from the first day of its use, and continued in use, more or less continuously, for three years at the Hamilton harbor until the completion of the work in hand.

"It is possible, but scarcely probable, that Mr. McDonald and those associated with him were unaware of the existence of the machine in Hamilton on account of the publicity given to the device and the number of engineers in the construction departments of the Dominion Government, to whose attention the apparatus was brought.

"The apparatus in Hamilton consisted of a working chamber, with buoyancy chambers convertible into water ballast chambers attached to the sides of the chamber, and with an air lock on top. It also carried additional water ballast tanks on top for use when required for additional submersion. The machine depended partly on its own dead weight and partly on the water ballast contained in the buoyancy or ballast chambers to give the necessary load to resist the upward thrust of the air compressed in the working chamber. The particular device was perfectly stable under all conditions for which it was intended, the metacentre being well below the centre of gravity under all conditions, whether floating light or submerged in operation. The machine in use required very light draft in order to clear the submerged structure, which was built in sections, and this result was obtained by placing the main buoyancy chambers alongside of the working chamber.

"The device was equipped with spuds to serve as anchorages for work near the surface, but were not required to ensure stability. Air was supplied to the working chamber, air tools, etc., from a compressor mounted on a separate scow alongside the outfit. It was not necessary on this work to have a long air shaft from the lock to the working chamber, but the device in principle only required this change and other structural adaptations for deep-water work.

"The Halifax machine, when in actual operation, does not float, the buoyancy chambers merely serving the purpose of facilitating its transportation from one part of the work to another. The one used at Hamilton actually floated at all times.

"The writer has arranged with Messrs. James Stewart & Co., of New York, for the use of his patent and design on the construction of about four miles of sub-structure of the breakwater wall to be built by the company at Toronto harbor, between the western entrance and the mouth of the Humber. This apparatus, as designed, will weigh about four hundred tons, and have a working chamber 24 feet wide, 100 feet long and 7 feet high.

"The design for this outfit has been completed in all its details, and the construction of it is only held up on account of this work having been closed down by the Dominion Government on account of the war as being not (strictly speaking) essential construction. This arrangement was made two years ago, after considerable investigation by Messrs. Stewart, and the general principle of this device is the same as that used at Halifax, except that the design of the structure has been modified and adapted to shallow water conditions.

"The writer is disposed to be charitable, and assume that Mr. McDonald was unaware that the principle and system had been anticipated, and had been in successful operation for three years before his design for the Halifax machine was prepared. In further proof of this, if that is necessary, the writer may say that he was granted a Canadian patent early in 1914 on the device and a United States patent at a later date. This fact may interest Mr. McDonald and his company in view of possible claims for patent infringement.

"The writer does not wish to unduly criticize, but as the device is hailed as something entirely novel and radical in principle by some of the engineers at the ports of Halifax and St. John, he feels it only just that the facts should be made known to the engineers of Canada as a whole, and fully expects this to be done."

PAVING NEEDED IN HALIFAX

City Engineer Doane, of Halifax, N.S., recently submitted to his Board of Control a report on street paving, from which the following are extracts: For many years there seems to have been a tendency to allow the total cost of any proposed improvements to loom so large that any benefits to be obtained were hidden. In consequence, Halifax has delayed permanent improvements which should have been made years ago.

There are two difficulties which prevent Halifax from overtaking the street repairs in a satisfactory manner with the appropriation provided by the city council this year.

The first is the scarcity of labor, which prompts the competing employers of labor to bid higher than the city can afford to bid. The second is the difficulty in obtaining the broken stone and other material which is necessary for street repairs fast enough to overtake the work within the working season. There are two reasons for this latter difficulty,—first, the trouble which employers have in obtaining labor, and second, transportation problems.

Water Powers of the Empire

Aggregate Fifty to Seventy Million Horsepower, Says Preliminary Report of the Water Power Committee Appointed by the Conjoint Board of Scientific Societies of Great Britain—Principal Powers Must Be Developed To Help Lift Financial Burden Imposed by War

ACTIVE development of the principal water powers of the Empire is recommended in the preliminary report just issued by the Water Power Committee of the Conjoint Board of Scientific Societies of Great Britain. The chairman of this committee is Sir Dugald Clerk, and the secretary is Prof. A. H. Gibson. The other members are:—

John Ashford, C.E.; Sir John Benton, K.C.I.E.; Prof. E. David, C.M.G.; H. Wilson Fox, M.P.; W. Vaux Graham, C.E.; H. E. M. Kensit; A. E. Kitson; Lord Lamington; Sir Murdoch Macdonald, C.E.; Sir Douglas Mawson, D.Sc.; Prof. J. C. McLennan; Dr. H. R. Mill; A. Newlands, C.E.; Sir John Snell, C.E.; A. A. Campbell Swinton, F.R.S.; Lord Sydenham; Sir Joseph J. Thomson, Pres. R.S.; Prof. W. C. Unwin; and Prof. W. W. Watts.

The following is the complete text of the committee's preliminary report:—

This committee was appointed "to report on what is at present being done to ascertain the amount and distribution of water-power in the British Empire."

With this in view the committee has endeavored to collect all available relevant information.

The results have been both encouraging and disappointing. Encouraging because, in spite of the meagreness of the information regarding vast stretches of the Empire, sufficient data are available to show that its water-power resources are in the aggregate enormous; disappointing because, with the exception of Canada and New Zealand, Tasmania, New South Wales, and possibly South Africa, practically nothing has been or is being done on any systematic basis, to ascertain its true possibilities.

In this preliminary report the committee has thought it desirable to exceed somewhat its terms of reference, and, in view of the great importance of the matter, to devote some little space to the general question of water-power and its utilization.

Needs of the Empire

To enable the Empire to recover, with any degree of rapidity, from the financial burden imposed by the war, it will be necessary to develop, in a much greater degree than heretofore, its latent resources. The wealth embodied in its mineral resources, its wheat areas, its forests, and the hundred products of its tropical dependencies is almost incalculably great. But it must be realized that without an ample supply of cheap energy much of this wealth must always remain latent.

Energy is required to enable the mineral ores to be won and refined. It is required for the adequate fertilization of the land, as well as for the harvesting and transportation of its crops and products; and any scheme for the extensive development of the Empire's resources as a whole, must depend upon the preliminary development of its energy supplies.

The available sources of energy are, for practical purposes, few in number. They comprise our fossil fuels, our oil-fields and oil shale deposits, and our water-powers.

In considering the relative value and importance of these sources of energy, it is to be remembered that while the solid and liquid fuels are convenient to handle; can be easily and cheaply transported to any convenient locality, and in many cases form, at present, the most convenient and cheap source of power; yet their supplies are strictly limited, and their ultimate depletion is assured. Fortunately public opinion is now awakening in some degree to the necessity for their conservation. Still, long before the supplies are actually exhausted, increasing scarcity is bound to put up their cost to a level much higher than that now obtaining.

In view of this, the utilization, to the utmost possible degree, of the water-powers of the Empire, becomes of paramount importance. Excepting the comparatively small and inconvenient supply of energy obtainable from vegetable growth, either by direct combustion or through the medium of alcohol, these at present provide our only practical perennial source of energy.

The economic development of many of our tropical dependencies, whose latent wealth is practically untapped, is directly inter-connected with the development of their water-power resources. Not only would an abundant supply of cheap power enable railroads to be operated, irrigation schemes to be developed, and mineral deposits to be tapped and worked, but it would go far to solve the labor problem which promises to be one of some difficulty in the near future.

The World's Present Power Demand

It is impossible to estimate with any pretentions to accuracy, the power now being used in the various countries of the world.

Independent estimates,* based on such data as are available, tend, however, to show that it is of the order of 120 million h.p. made up approximately as follows:—

World's factories, including electric lighting and street railways	75 million h.p.
World's railways	21 " "
World's shipping	24 " "
Total	120 " "

This includes all steam, gas, and water-power.

Of the 75 million h.p. used for factories and general industrial and municipal activities, a rough approximation of the most probable distribution would appear to be—

——	United Kingdom.	Continental Europe.	United States.	British Dominions and Dependencies.	Asia and S. America.
Millions of h.p. ..	13	24	29	6	3

An estimate by the Dominion Water-Power Branch of the Canadian Department of the Interior, outlines the hydraulic situation of the various countries, as follows:—

*"The World's Supplies of Fuel and Motive Power." Hawksley Lecture. Inst. Mech. Engineers, 1915. Sir Dugald Clerk.

"Natural Sources of Energy." A. H. Gibson. Cambridge University Press, 1914.

Country.	Area (Square Miles).	Population (Latest available figures).	B. Horse-power available (1915 estimate).	B. Horse-power developed (1915 estimate).	Per cent. utilized.	Horse-power per sq. mile of Area. Available.	Horse-power per sq. mile of Area. Developed.
United States ..	3,026,600*	92,019,900†	28,100,000	7,000,000	24.9	9.3	2.31
Canada (A)	2,000,000	8,033,500	18,803,000	1.735,560	9.2	9.40	0.86
Canada (B)	927,800	8,000,000	8,094,000	1,725,000	21.0	8.74	1.83
Austria-Hungary...	241,330	49,418,600	6,460,000	566,000	8.8	26.8	2.34
France	207,100	39,601,500	5,587,000	650,000	11.6	27.0	3.14
Norway	124,130	2,302,700	5,500,000	1,120,000	20.4	44.3	9.02
Spain	194,700	18,618,100	5,000,000	440,000	8.8	25.7	2.27
Sweden	172,900	5,521,900	4,500,000	704,500	15.6	26.0	4.08
Italy	91,280	28,601,600	4,000,000	976,300	24.4	43.8	10.7
Switzerland	15,976	3,742,000	2,000,000	511,000	25.5	125.2	32.0
Germany	208,800	64,903,400	1,425,000	618,100	43.4	6.8	2.96
Great Britain ..	88,980	40,831,400	963,000‡	80,000	8.3	10.9	0.91
Russian Empire§,	8,647,657	182,182,600	20,000,000	1,000,000	5.0	2.3	0.12

Canada "B" refers to the presently most thickly populated portion of the Dominion.

Canada "A": 2,000,000 sq. miles taken as the area treated in the Conservation Commission's estimate of available water-power, and the area which we may expect to see fairly thickly settled during the next few decades. This includes the area indicated by "B" and includes the 8,000,000 population of "B." The area of the whole Dominion is 3,729,750 sq. miles. The powers given are a 1917 estimate.

*Excluding Alaska (area about half million sq. miles).

†1911 Census + 12 per cent.

‡The estimate for Great Britain is almost certainly much too high.

§A recent estimate by the Ministry of Ways of Communication ("Electrical Review," February 22nd, 1918).

From this it appears that between 15 and 16 millions of the world's industrial horse-power is at present developed from hydraulic resources. The following table shows approximately the hydraulic power developed in the various regions, and also the ratio of this to the total industrial horse-power, excluding railways.

	United Kingdom.	Continental Europe.	United States.	Colonies.
Millions of h.p. ..	.08	6.5	7.0	2.0
Percentage of total industrial h.p.	0.6	27.0	24.0	33.0

Perhaps the most interesting feature of these tables is the extremely small proportion of available hydraulic power developed in the United Kingdom. It is the most backward in this respect of all the countries listed, except Russia, and its 8.3 per cent. compares very unfavorably with the 43.4 per cent. of Germany.

The Empire's Water-power Possibilities

The question as to the amount of potential water-power in the Dominions and Dependencies of the Empire is dealt with in more detail in the following pages.* So great is the lack of reliable data, however, in reference to all but one or two of the colonies, that any estimate of the total power must be looked upon as highly speculative. The main powers are to be looked for in Canada, India, New Guinea and New Zealand, and it is fairly certain that in these countries alone there is a potential water horse-power of the order of 40 millions. When to this are added the resources of East, South, and Central Africa, Egypt, Ceylon, Tasmania, Australia, British Guiana, Burma, the Malay States, and our own islands, it appears that in the aggregate the hydraulic resources of the Empire are extremely large, and that they are as yet barely tapped.

Reason for Neglect in the Past

There have been many good reasons for their comparative neglect in the past. The general abundance of coal in proximity to centres of industry; the necessity for a heavy initial outlay to bring most of the larger powers into bearing; the lack of co-ordination between possible producers, users, and financiers of power; the lack of markets for the energy which would be made available; and the remoteness of most of the powers from present centres of activity have all contributed. Moreover, the highly efficient combination of the hydraulic turbine and the electric generator, capable of handling large powers, is of comparatively recent development.

*Wherever hereafter in this report the term horse-power is used, it is to be taken as meaning continuous 24-hour power unless otherwise stated.

Recent Development

The developments in engineering science in the past decade, and more particularly the developments in electro-chemical, electro-physical, and electro-metallurgical processes, and in the possibility of high-voltage electrical transmission have removed some of these reasons. Transmission lines exceeding 200 miles in length are in existence to-day, and only financial considerations now set a limit to their possible length. Any distance is feasible electrically and mechanically.

Electro-metallurgy and electro-chemistry have rendered it possible to handle materials not workable by any other means; have made available new materials; and have greatly cheapened the production of many important materials of wide use. Aluminium, calcium carbide, chromium, cyanide, silicon, carborundum, are products rendered commercially possible only by electrical processes, while alkalis, hypochlorite, phosphorus, magnesium, and sodium nitrate are produced most economically by such processes. Great developments have recently taken place in the production of electrolytic copper and zinc and in processes of the electric smelting and refining of metallic ores.

All these processes demand relatively large amounts of energy. The world's production of calcium carbide, for example, was 340,000 tons in 1913, requiring 400,000 continuous e.h.p. for its production, while the energy used at the end of 1915 for electric furnaces in the United States alone was approximately 300,000 e.h.p.

Nitrogen Fixation

In the utilization of atmospheric nitrogen for the production of nitric acid and the manufacture of nitrates, great developments have taken place during the last decade, and in Norway alone over 400,000 e.h.p. is now absorbed in its production. The world's annual consumption of nitrogen in its various combinations is about 750,000 tons, representing a value of about £50,000,000, and this demand is increasing yearly. Four-fifths of this supply has been produced hitherto from natural nitrate deposits, but in view of the rapid depletion of these deposits, and of the diminution in the fertility of most of the great wheat and cotton-growing areas of the world, the production of artificial fertilizers by one or other system of nitrogen fixation must, in the near future, become a question of national importance.

At the present time the world's consumption of fertilizers amounts to close upon 6,000,000 tons per annum, and this will probably be doubled within the next 20 years. To-day, the efficiency of the electrical production is low, amounting in the case of calcium nitrate to about three-quarters of a ton per e.h.p. year. By adopting the cyanamide process the consumption of energy may be cut down to about one-fourth, but even in this case the production of the equivalent of 12,000,000 tons of fertilizers per annum would require 4,000,000 continuous e.h.p.

It is estimated that the 200,000,000 acres of arable land in Canada alone may ultimately require some 10,000,000 tons of nitrates per annum to maintain their fertility, and this in itself would necessitate the absorption of an appreciable portion of the whole hydraulic energy of the Dominion.

When to these demands are added those of India, Australia and Africa, it is evident that the fertilizer demand of the Empire will in itself call for an enormous supply of energy.

Apart from these requirements, which are admittedly for the future, electric power has a wide and practically unlimited field as a motive power conveniently and economically adaptable to any class of service. In the heating and welding of metals as a part of the process of manufacture, electricity by its control, speed, and concentration or distribution, has many advantages over coal or gas.

Electric Railroads

Electric railroads have not as yet attained more than inter-urban and terminal use. The electrification of trunk lines, which demands the supply of cheap electric power at frequent intervals along the route, and involves a very large capital outlay, has not as yet become commercially attractive, but the future possibilities in this respect are enormous.

Necessity for State Control

The considerations already outlined would indicate that the conservation and utilization of the water-power resources of the Empire is likely to be one of the most important problems in our political economy.

The solution of this problem involves many complex questions of law, of administration, and of engineering and economic investigation, if the public interest is to be best served by the development.

In view of the immensity of the interests involved, it is urged that nothing short of statutory control of these developments is desirable. The exact method of control is not for the committee to suggest. So far as is possible private enterprise should be encouraged, but under conditions which would prevent the perpetual rights being lost to the community.

In this connection it is worthy of note that Canada and New Zealand have state control over the majority of their water-powers, and that in all provinces in India there are Canal Acts which expressly lay down that government is entitled to use and control for public purposes the water of all rivers and streams flowing in natural channels. In the case of Australia, each state has enacted lengthy legislation in relation to water conservation, but no special clauses appear in respect of developable water-power. It is also suggestive that the Administration in Washington is at present taking steps to control the development of water-powers on all public lands and navigable streams in the United States; that, in spite of the revolution in Russia, the Provisional Government has recently appointed a water-power committee, with absolute control over the development of all water-power schemes in the Empire exceeding 300 h.p.; and that the Austrian Government has, during the past session, introduced a bill for the promotion of hydro-electrical development, giving the state the right to acquire any undertaking after the expiration of 25 years, and at the end of any subsequent period of five years.

It should be recognized, however, that while it is essential that the State should have the right of ultimate purchase, the period of such purchase should not be unduly short or the terms too onerous. It will be remembered that such legislation had the effect of severely handicapping the electric power and lighting industry in the early days of its development.

Cost of Hydraulic Power

It must be realized that the cheapness or dearness of energy is purely relative, and hydraulic powers which are not at present able to compete economically with steam, may in the not distant future be able to do so.

Even now in favorable localities, the cost of electric power generated from hydraulic installations compares favorably with that of steam or oil power.

The cost of such power is made up mainly of charges against capital, interest, depreciation, sinking fund charges, taxes and insurance, which are usually much greater than water charges and costs of operation, maintenance and supplies. These capital charges vary widely with the local circumstances and physical characteristics of the site. Where the available head is great and the storage reservoir is provided by some natural lake, they may be comparatively small. Where, on the other hand, extensive works are required to bring the water to the power house, and where the transmission line is long, the overall cost of power may be largely in excess of that generated by a steam plant.

An examination of some 120 European installations shows that for large installations of upwards of 10,000 e.h.p., the minimum cost of the hydraulic works is £8.4 per h.p. installed, and the maximum, £79.6 per h.p. For the majority of the installations the cost lies between £25 and £45. The cost of the electrical generators, switch boards, etc., and transmission lines, also varies greatly, ranging from £1.25 to £28.4 per h.p., while the cost of the turbines ranges from £4 to £8 per h.p. The working costs vary between £1.3 and £6.8 per e.h.p. year, with an average value of £3. From these figures it appears that on the average, making an allowance of 15 per cent. for interest and depreciation, the cost per e.h.p. per annum is in the neighborhood of £10.5.

In many installations, however, the cost is very much less than this. The Ontario Power Company, for example, is able to supply power to the Hydro-Electric Commission of Ontario at £1.8 per e.h.p. per annum. It is estimated that many of the large powers in Canada can be developed at a total cost, including all generating machinery and transmission lines, ranging from £12 to £20 per e.h.p., in which case the cost per h.p. per annum should not exceed £2 to £3.

Necessity for Preliminary Investigations

In spite of the great importance of water-powers, many of the potential powers in existence must of necessity prove economically useless, either on account of their great distance from centres of industry, the lack of transport facilities, or from the fact that the storage necessary to give a continuous or fairly continuous supply would be too costly. Of many potential powers it can be said without further investigation that for the present this is, and for a long period to come will be, the case. Of others the reverse is true, and it is evident that the scheme will amply repay development. But in the majority of cases the extent to which a scheme is capable of economic development can only be determined after a careful examination of the catchment area and of the site of the proposed works; after a careful and prolonged investigation of the rainfall and run-off records; and, especially in an undeveloped country, after an investigation of the mineral and forestal or agricultural possibilities of the surrounding region.

It has usually been understood that the usefulness of a water supply depends on the possibility of maintaining its uniformity over the whole period of the year, and that the maximum useful power is strictly limited by the minimum power which, by the aid of any suggested storage system, will be available towards the end of the longest probable period of drought.

Where the power is utilized for the supply of some industrial centre this is undoubtedly true, but if the idea were to be generally adopted, it would cut out an enormous aggregate of potential power, more particularly in tropical and semi-tropical countries. The possibility of utilizing flood supplies for seasonal operations in connection with mining, agriculture, and forestry, or for the production of nitrates in such cases, would appear to be worthy of close consideration.

In any case, the possibilities of a given scheme can only be determined after a prolonged hydrographical and meteorological investigation of the site and surroundings. To be of real value such an investigation should extend over a long series of years. Rainfall records, though forming the basis of any such investigation, are only of partial assistance in dealing with water-power questions. The actual run-off from the catchment area is the all important factor, and the ratio of run-off to rainfall varies with the physical characteristics of the area, the vegetation, and the climate, so that rainfall gaugings cannot be substituted for the more laborious and costly collection of continuous records of river levels, combined with frequent gaugings of flow. It must be emphasized that each scheme of development requires independent investigations to determine completely the local conditions governing the flow from the area intended to be utilized.

Much can be done to ascertain the approximate possibilities of a potential scheme before deciding to incur the heavy cost of a detailed survey by—

(1) Installation and continuous recording of river gauges on all likely channels.

(2) Installation and recording of rainfall gauges at suitable places.

(3) Observation of river discharges for a series of gauge readings.

If a reasonably long record of rainfall exists, the determination of the run-off for a few years will serve to give a relation between precipitation and run-off which can be carried back as far as the rainfall records go. The initiation of operations (1)—(3) costs little, and no time is lost in collecting the more important data.

While this is true, it should be borne in mind—

(1) That to be of reliable value from a commercial point of view the hydrometric studies must give a continuous record for a number of years, and show not only the minimum low water flow, but also the maximum flood conditions that have to be met in designing the head works.

(2) That the investigation of suitable rivers should include contour plans of the sites, profiles along the entire power reach of the river, and along the banks; also studies of lakes or lochs for storage, where they exist, and of the possibility of inter-connecting two or more such lakes to feed one large project. These studies should be in sufficient detail to allow of preparing preliminary plans and estimating capital and operating costs, in order to demonstrate the capacity available and the commercial feasibility of development.

(3) That to develop the most obvious power site on a river without full investigation of the whole power reach of the river may not secure, and may make it impossible to secure, the maximum advantageous use of the river by the development of two or more sites.

(4) That to secure the maximum possible use of a river the investigations should therefore be made by the government rather than by private interests.

(5) Especially is this the case where storage may be developed, in order that the maximum possible storage may be secured, and that the water may be equitably distributed to, and the cost of the works equally borne by, the various interests benefited. Proper storage may greatly improve flood conditions and enhance the value of land as well as increase the power available.

(6) That, without complete surveys the capacity of a river cannot be accurately judged. The pondage created by the dam will in many cases more than take care of the daily peak load, thus increasing the power available beyond that due to the minimum low water flow, and this may be still further increased by storage at the head waters. The power capacity of a river may sometimes be increased by such means by 100 or 150 per cent. or more.

State of Investigation Throughout the Empire

At the present time the only parts of the Empire in which any systematic attempt has been made to collect and tabulate the necessary data are Canada and New Zealand, and to a smaller extent Tasmania, New South Wales and South Africa. In Canada a large amount of excellent work has been done, during the past decade, by the Dominion Water-Power Branch of the Department of the Interior. By detailed surveys of the more important and accessible rivers, and by an extended series of river gaugings and of rainfall records, extending in most cases over a number of years, the Department has obtained information regarding a large proportion of the powers which are promising for development in the near future, and its methods might well be adopted as a model for the rest of the Empire. In New Zealand also considerable information is available, and in South Africa, New South Wales and Tasmania a beginning has been made on a comparatively small scale. But for the remainder of the Empire there is an entire lack of data on which to form a reliable estimate of the hydraulic resources.

It is a matter of urgent importance that the preparation of the necessary hydrographic and meteorological data should be undertaken at the earliest possible date in the remaining Dominions and Dependencies of the Empire.

In this connection an adequate rainfall map is of great value and importance, and where, as is the case, for example, for the greater part of the British Isles, data for such a map are available, its preparation would appear to be most advisable.

The following pages indicate very generally the water-power possibilities of the Empire, as presented by the information so far available to the committee.

Great Britain and Ireland

Much information relative to the water-powers of the British Isles is given in a paper read before the Society of Arts in January, 1918, by Mr. Alexander Newlands, M.Inst.C.E., a member of the committee.

Scotland, and especially the Scottish Highlands, offer greater water-power possibilities than any other part of Great Britain. Over a considerable extent of its area the rainfall exceeds 60 ins. per annum, and this area is studded with natural lochs, which form excellent storage reservoirs at considerable elevation. Moreover, no part of this area, which is some 12,000 square miles in extent, is more than 20 miles from some arm of the sea or from the Caledonian Canal.

Mr. Newlands, assuming that 28 ins. of the total rainfall is available for power, calculates from an examination of the various powers having natural loch storage, that a total of some 235,000 continuous h.p. is available. He claims, however, that this is a very conservative estimate, and says that each drainage area is a problem in itself and must be investigated as such. Mr. W. Vaux

(Continued on page 391.)

PROGRESS REPORT OF COMMITTEE ON MECHANICAL ANALYSIS OF SANDS*

THE Committee on Mechanical Analysis of Sand has up to this time delayed the preparation of a report principally because of the fact that it is thought to be one of the principal duties of this committee to submit a proposed standard method of conducting such analyses and because during the past two years, especially, the United States Bureau of Standards at Washington, D.C., has been active in securing co-operation and joint action of parties interested in the selection and adoption of standard screens. It is recognized that standard screens are required not only for the mechanical analyses of sands but also in many other industries, yet it is believed that it is to the best interests of all having to do with such sand analyses that the one standard be used for all. There are obvious advantages in having the one standard screen scale available for all purposes and there is no apparent advantage in having a separate or distinct set of standard screens for testing sand.

Early action of the Bureau of Standards in the matter of standardizing sieves resulted in the adoption of certain specifications standardizing 200 and 100-mesh sieves used primarily for testing cement. Subsequently, early in 1917, responding to the demands of industry, the Bureau of Standards called a conference at Washington including representatives of practically all national engineering and technical organizations and others interested in the adoption of standard sieves. The conference, after considering various screen scales, adopted a standard screen scale, and recommended that it be adopted generally by scientific, technical and engineering societies and committees as part of their specifications for materials and methods of tests; also that it be used by private firms who have need of standard sieves. The committee recommends the adoption of the standard screen scale for sieves used in the mechanical analysis of sands.

The screen scale is essentially metric. The sieve having an opening of 1.0 mm. is the basic one and the sieves above and below this in the series are related to it by using in general the square root of 2, or 1.4142, or the fourth root of 2, or 1.1892, as the ratio of the width of one opening to the next smaller opening. The first ratio, that is, 1.4142, is used for openings between 1.0 mm. and 8.0 mm., while the second ratio is used for openings below 1.0 mm. to give more sieves as required in that part of the scale.

Because of the possible wide range of openings in sieves now manufactured with a given number of meshes of wire per unit length, due to the use of wires of different diameters, and because of the consequent confusion and uncertainty which arise in designating sieves by the number of meshes per unit length, the sieves of this series are designated by the width of the opening in millimeters, as, for example, a 1.41 mm. sieve, or a 0.36 mm. sieve. The committee recommends that this method of designating sieves be adopted instead of the customary method of designating the number of meshes per inch.

To meet the need for sieves of this series at the present time the committee has included a temporary provision in the specifications for the acceptance of sieves of slightly different mesh and wire diameter than that called for in the screen scale, provided the resultant opening is the same as the nominal opening within a small range. This will make possible the use of a number of sieves now on the market in which the ratios of wire diameter to opening are only slightly different from those of the screen scale.

Specifications for Standard Sieves.

Sieves shall be of brass constructed in diameters of 20 cm. (7.87 inches) or 15 cm. (5.91 inches). These are the outside diameters of the bottom of the sieves or the inside diameters of the top of the sieves.

Wire cloth for standard sieves shall be woven (not twilled, except that the cloth of 0.062-mm. sieves may be twilled until further notice) from brass, bronze, or other suitable wire and mounted on the frames without distortion. To prevent the material being sieved from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder, or so made that the material will not catch.

The number of wires per centimeter of the cloth of any given sieve shall be that shown in the accompanying Table 1, in the second column, headed "Mesh," and the number of wires in any whole centimeter shall not differ from this amount by more than the tolerance given in the 5th column, that headed "Mesh" under the heading "Tolerances." No opening between adjacent parallel wires shall be greater than the nominal width of opening for that sieve by more than the following amounts:

Table I.—Standard Screens for Mechanical Analyses of Sand.

	Width of Openings.	Mesh.	Wire Diam.	Ratio Wire Diam. to Opening.	Tolerances. Mesh.	Tolerances. Diam.
Metric	8.00	1.00	2.00	0.25	0.01	0.008
Customary	0.315	2.54	0.079	0.25	0.03	0.003
Manufactured	8.05	2.5	0.083	0.26		
Metric	5.66	1.4	1.48	0.26	0.01	0.08
Customary	0.223	3.56	0.056	0.26	0.03	0.003
Manufactured	5.66	3.5	0.063	0.28		
Metric	4.00	2.0	1.00	0.25	0.02	0.05
Customary	0.157	5.1	0.039	0.25	0.05	0.002
Manufactured	4.04	5.0	0.041	0.26		
Metric	2.83	2.75	0.81	0.29	0.02	0.05
Customary	0.111	7.0	0.032	0.29	0.05	0.002
Manufactured	2.82	7.0	0.032	0.29		
Metric	2.00	3.9	0.56	0.28	0.04	0.05
Customary	0.079	9.9	0.022	0.28	0.1	0.002
Manufactured	2.03	10.0	0.020	0.25		
Metric	1.41	5.0	0.59	0.42	0.08	0.025
Customary	0.0555	12.7	0.0232	0.42	0.2	0.001
Manufactured	1.42	12.0	0.027	0.69		
Metric	1.00	7.0	0.43	0.43	0.15	0.020
Customary	0.394	17.8	0.0169	0.43	0.4	0.0008
Manufactured	1.01	18.0	0.016	0.41		
Metric	0.71	9.0	0.40	0.56	0.3	0.012
Customary	0.0280	22.9	0.0157	0.56	0.75	0.0005
Manufactured	0.72	22.0	0.017	0.60		
Metric	0.50	12.0	0.33	0.66	0.4	0.012
Customary	0.0197	30.5	0.0130	0.66	1.0	0.0005
Manufactured	0.50	3.0	0.0135	0.68		
Metric	0.36	16.0	0.26	0.72	0.6	0.010
Customary	0.0142	40.6	0.0102	0.72	1.5	0.0004
Manufactured	0.36	40.0	0.011	0.79		
Metric	0.25	23.0	0.185	0.74	1	0.008
Customary	0.0098	58.4	0.0073	0.74	3	0.0003
Manufactured	0.25	60.0	0.007	0.72		
Metric	0.17	31.0	0.15	0.88	1	0.008
Customary	0.0067	78.7	0.0059	0.88	3	0.0003
Manufactured	0.17	80.0	0.00575	0.85		
Metric	0.125	47.0	0.089	0.71	1.5	0.008
Customary	0.0049	119.4	0.0035	0.71	4	0.0003
Manufactured	0.119	120.0	0.0036	0.77		
Metric	0.088	67.0	0.061	0.69	2.5	0.005
Customary	0.0035	170.2	0.0024	0.69	6	0.0002
Manufactured	0.089	170.0	0.0024	0.69		
Metric	0.062	98.0	0.040	0.65	3.5	0.005
Customary	0.0024	248.9	0.0016	0.65	9	0.0002
Manufactured	0.061	250.0	0.0016	0.67		

*Abstracted from Report of Committee appointed by American Water Works Association.

Five per cent. of the nominal width of opening for the 8-mm. to 1-mm. sieve inclusive.

Ten per cent. of the nominal width of opening for the 0.71-mm. to the 0.36-mm. sieve, inclusive.

Twenty per cent. of the nominal width of opening for the 0.25-mm. to the 0.125-mm. sieve, inclusive.

Thirty per cent. of the nominal width of opening for the 0.088-mm. and the 0.62-mm. sieve, inclusive.

The diameters of the wires of the cloth of any given sieve shall be that shown in the third column of Table 1 headed "Wire Diameter," and the average diameter of the wires in either direction shall not differ from the specified diameter by more than the tolerance given in the last column of Table 1, that under "Tolerances" headed "Diameter."

Sieves shall be rejected for obvious imperfections in the sieve cloth or its mounting, as, for example, punctured, loose or wavy cloth, imperfections in soldering, etc.

Until further notice, to permit the use of sieves now on the market which have slightly different mesh and wire diameters from that specified above, sieves will be satisfactory if the measurements of mesh and wire diameters show the resulting average width of opening to be within 4 per cent. of the nominal opening of a given sieve, and the ratio of wire diameter to opening of the sieve in question is within 0.03 of that given in Table 1, in the column headed "Ratio Wire Dameter to Opening" for the 8-mm. to the 2-mm. sieves, inclusive, and within 0.06 of the ratio given for sieves of smaller openings than 2 mm.

The Bureau of Standards has announced that it will test sieves of the standard screen scale to determine whether they conform to the specifications which follow. This test will consist of an examination of the mesh of both the warp and shoot wires of the cloth to ascertain whether it comes within the tolerances allowed; also measurements of the diameter of wires in each direction to determine the average diameter; also a measurement of any large openings to determine whether they exceed the limits given in these specifications; also, an examination of the sieves to discover any imperfection of the sieve which may seriously affect its sieving value. Sieves which pass the specifications will be stamped with the seal of the Bureau and will be given an identification number and a certificate will be furnished for each sieve that passes the requirements.

For sieves which fail to meet the specifications reports will be rendered showing wherein the sieve was not up to the standard.

In the accompanying Table 1 the committee has shown the specifications for standard screens which it recommends for adoption by the Society. The first 7 sieves listed, that is, from the 8-mm. to the 1.0-mm. sieve, include the first 7 sieves of the entire screen scale. For the sieves smaller than the 1.0 mm. sieve, only the alternate sieves of the screen scale are included.

In the table are shown the meshes per inch and diameters of wire, together with their tolerances, all expressed in millimeters and inches. Widths of openings are expressed also in millimeters and inches. There is also shown for each standard screen specifications for that sieve now manufactured which most nearly approaches the suggested standard screen, as regards width of opening and ratio of wire diameter to opening.

The committee wishes to call attention to the importance of the latter factor or ratio. Referring to the table, it will be observed that the ratio of wire diameter to opening varies from 0.25 to 0.88, generally increasing with the finer cloth. In practice it is found that the diameter of wire used should be as small as will withstand the service required, because material will not pass cloth composed of coarse wire so freely as it will pass cloth woven of fine wire. This fact undoubtedly is the principal reason why confusion has arisen in the past when it has been attempted to establish a relation between the diameter of opening and the size of the particle passing the opening, that is the separation of the sieve. For instance, in the case of two sieves having the same width of opening, that in which the wire has the larger diameter will pass the larger particle, and vice versa.

Another feature of the manufacture of wire cloth which has considerable importance in affecting the separation of a screen, is the weave. The finer screens are frequently made of twilled cloth, that is, each wire crosses above and below each adjacent two wires, while in the plain woven cloth, each wire crosses above and below each adjacent wire. The plain woven cloth is always used for the coarser sieves. Experience shows that larger particles will pass through twilled cloth than through plain woven cloth of the same width of opening.

The committee recommends that the cloth in all of the standard sieves be plain woven and not twilled, although for the present it may be necessary to use twilled cloth for the 0.062 mm. sieve.

Methods of Making Mechanical Analysis.

A mechanical analysis of sand is generally accomplished in the following manner: The selected sieves are nested with the coarsest at the top varying to the finest at the bottom. For the 8 inch diameter sieves 300 grams and for the 6-inch sieves 100 grams of the sand to be analyzed are dried and placed in the top sieve, the nest of sieves is shaken in a mechanical shaker practically to refusal of any further separation, the sieves separated, and beginning with the finest sieve the sand remaining on each sieve is weighed accumulatively. The results are then plotted to a suitable scale.

There are six factors which control the results of a mechanical analysis, as follows: The selection of a representative sample; the quantity of material taken for analysis; the number and rapidity of the shakes; the accuracy of the weights of the separated portions; the rating of the sieves to determine their separations; and finally, the interpretation of results. Each of the above features has an important bearing on the accuracy and reliability of a mechanical analysis and should be given proper consideration.

The material to be analyzed should preferably be in its natural moist condition when sampled as otherwise it tends to separate. When dry it should be handled with a scoop and thoroughly mixed. In sampling a pile of moist sand a large sample should first be taken of several portions from different parts of the material, these portions mixed, the resultant sample quartered and the process continued until finally there is secured a sample of the required size.

The amount of sand used should be as large as practicable. For the 8-inch sieves 300 grains of graded sand and for the 6-inch sieves 100 grrams may well be used. More than these quantities tend to stretch and clog the cloth and are not readily separated by shaking.

A mechanical shaker is required, especially where a large number of analyses are to be made. Several satisfactory machines are on the market. The essential feature of such a machine is that its speed shall be properly controlled. Experience will readily indicate the period of shaking required in the machine which should be operated by trial, using the required amount of sand until there is practically no further passage of sand grains through the screens.

In the case where a mechanical shaker is not available, as in field work, hand shaking when carefully executed will give results commensurate with a mechanical shaker. Experience indicates that when using the portions of sand indicated above, hand shaking for about 200 double horizontal shakes will give a satisfactory separation.

The accuracy of the weighing depends upon the precision of the balance used. Weights should be taken to 0.1 gram, with the understanding that the weights may be slightly in error when the total weight is greater than 100 frame.

The interpretation of a mechanical analysis depends primarily upon two features, the size of separation as determined for each sieve and the method of plotting and recording results.

At least two methods are available to determine directly the separation of a sieve, either to measure the three principal diameters of representative sand grains and to compute their average diameter or to count and weigh the grains and to compute the volume of the average particle obtained by dividing the weight of the average grain by its specific gravity. There is thus obtained the mean volume of the average grain which is considered to be a sphere and its diameter computed and taken as the separation of the sieve. The former procedure is recommended as giving the best results for large gravel; also for the extremely small grains of sand such as will pass a sieve of 200 meshes to the inch. A pair of calipers may be used to measure the diameters of the larger particles and a microscope to measure the smaller particles. The second procedure is the one commonly used for sieves ranging from 4 to 140 meshes per inch and requires the accurate separation of the sample, the counting and weighing of the grains and the determination of the specific gravity of the grains. It will be observed that the rating of a nest of sieves in this manner is at best a tedious and difficult procedure.

Whatever the method used in determining the sizes of the grains the securing of an accurate sample is of first importance. The procedure is as follows: a sample of sand is put through the sieve in exactly the same manner as in making a mechanical analysis. Each sieve is then shaken a little by hand and the last particles going through are shaken over the next finer sieve. The last material remaining on the next finer sieve is considered the separation of the sieve.

Experience indicates that the results of the determinations of the sizes of separation are dependent almost entirely upon the selection of proper samples, because two determinations of the separation of a sieve using portions of the same sample should give the same results to the required accuracy when reasonable care is used. Owing to characteristic variation in the sizes and shapes of the grains it is desirable to use several kinds of sand from different locations or sources in order to determine the average separation. Where sieves are required largely for the mechanical analysis of a particular sand the procedure may properly be limited to determinations of the sizes of separation with this material only.

A comparative method of rating sieves also suggests itself in the event that there is available a nest of sieves already rated. A representative sample of sand may then be analyzed in the usual manner by the rated sieves and again may be separated into weighed portions by the unknown sieves. By plotting the percentages of the total weight on the curve of the analysis as determined by the first set sieves, the separations of the unknown sieves may be read directly. The comparative method has obvious advantages and in general is one of the methods now used by the Bureau of Standards to test 100 and 200 mesh cement sieves.

Because the method of rating a nest of sieves by counting and weighing the grains is a very tedious and expensive procedure, investigations have been made from time to time to determine whether or not there is any definite relation or relations between the width of opening of a screen and the size of separation. In view of the fact that in the past screens have been made with little if any attention to definite specifications or tolerances of mesh and diameters of wire, it is not surprising that these investigations were not satisfactory and did not indicate whether or not such a relation exists. Part of the difficulty undoubtedly was attributable to the personal factor and also to the use of grains of sand of different degrees of sharpness.

In Table 2 are shown the openings of the standard screens and the probable sizes of separation that may be obtained with sieves built under the accompanying specifications, especially in regard to tolerances of mesh and

Table II.—Relation Between Sizes of Opening and Sizes of Separation of Sieves.

Sieve Opening, mm.	Mesh. inches.	Ratio wire Diameter to Opening.	Ratio Size of Separation to Opening.	Corresp'd'g Size of Separation. mm.
8.00	2.54	0.25	1.09	8.72
5.66	3.56	0.26	1.09	6.17
4.00	5.1	0.25	1.09	4.36
2.83	7.0	0.29	1.09	3.08
2.00	9.9	0.28	1.09	2.18
1.41	12.7	0.42	1.10	1.55
1.00	17.8	0.43	1.10	1.10
0.71	22.9	0.56	1.10	0.78
0.50	30.5	0.66	1.10	0.55
0.36	40.6	0.72	1.11	0.40
0.25	58.4	0.74	1.11	0.28
0.17	78.7	0.88	1.11	0.19
0.125	119.4	0.71	1.11	0.14
0.088	170.2	0.69	1.11	0.10
0.062	248.9	0.65	1.20*	0.07

*Ratio assumed for twilled cloth. For plain woven cloth ratio is 1.11 and separation is 0.068 mm.

diameter of wire. Experience indicates that many sieves used for the mechanical analyses of sand would not come within these specifications especially because the spacing of the wires in one direction is not correct and within these specifications. Moreover, it is not uncommon to find the wires used in the cloth to be of larger diameter and unsatisfactory on this account.

The committee is not in accord as to the value of factors to be applied to determine the separation of a sieve with relation to its average width of opening. It is obvious, however, that the use of the accompanying specifications should result in a material improvement in the manufacture of testing screens; also that the use of such factors would be of great assistance in many cases in determining the relation between analyses made by different investigators and expressed by either one of the two standards of measurement. Moreover, it is apparent that the use of the standard screens in specifications of material required has obvious advantages as compared with the use of such terms as will define the sizes of the particles, or of selected arbitrary percentages by weight of the particles.

Furthermore, the committee is not in accord as to the standard of measurement which can best be adopted for rating sieves required for the mechanical analysis of sand. It is, of course, true that the principal use of such analyses, so far as this Association is concerned, is for the determination of the characteristics of sand required or used for filtration purposes. Moreover, up to the present time, the standard of measurement has been the size of separation of a sieve and not the width of opening. The screen scale now recommended by the Bureau of Standards for adoption is based upon the width of opening and not upon the size of separation. The committee is not yet prepared to report upon the adoption or uses of either standard of measurement because further investigation is required to reach a conclusion in this matter.

GREAT MINERALIZED BELT OF DOMINION

Canada possesses a mineral belt, roughly two hundred miles wide, that stretches from Newfoundland to Vancouver Island. It is the greatest mineral belt in the world. Practically all the known minerals are found in it. The deposits of important metals are abundant. Considering this list:—Gold, silver, nickel, iron, coal, copper, cobalt, mica, asbestos, molybdenum zinc and tungsten. Geologists predict that within a few years Canada's mineral belt will be the envy and one of the wonders of the world.

BOSTON CREEK CAMP IS FORGING AHEAD

The sensational developments at the Miller-Independence, and the subsequent rich gold discoveries on a number of other nearby properties, including the Cullen-Renaud, Cotter and Campbell group, all tends to point toward a busy winter for the growing camp. The indications appear to be that a number of mining plants in addition to those already in may be installed and working before the winter passes.

The auriferous zone of Boston Creek borders on the Temiskaming and Northern Ontario Railway. The hydro-electric transmission line of the Northern Ontario Light & Power Company passes right through the heart of the camp, on its way to Kirkland Lake. These two factors solve the vital problems of transportation and motive power, thus leaving but one other requisite—the deposition of precious metal in economic quantities. This latter condition is already proven, and it now only remains to be seen just how big the camp will ultimately be.

Progress has been made in the research conducted by Dr. R. D. MacLaurin, Professor of Chemistry in the University of Saskatchewan, which has as its object the utilization of the waste straw in Western Canada by converting it into gas by the process of carbonization. Dr. MacLaurin has been investigating this project with a view to making the process practicable so that the individual farmer could use his own straw fuel in the form of gas for heating, lighting and power. An experiment was conducted recently by Prof. MacLaurin which proved that it was possible to use the straw gas as motor fuel. A bag containing 300 cubic feet of gas produced from straw was fastened to the top of the car, and this was produced from 50 pounds of straw. This fuel was equivalent to one gallon of gasoline. A ton of straw is capable of producing about 11,000 feet of gas, and is equivalent in power to 35 or 40 gallons of gasoline.

CONFERENCE OF CANADIAN BUILDING INDUSTRIES

On September 4th of this year a group of Canadian contractors met in conference in Toronto under the chairmanship of J. P. Anglin, of Montreal, at which time it was decided to organize a Dominion-wide convention, to be held at Ottawa at a future date. This meeting was fully reported in *The Canadian Engineer* for September 5th, 1918.

Growing out of the gathering, a convention has been called for November 26th, 27th and 28th, 1918, at the Chateau Laurier, Montreal, under the auspices of the new association, to be called the "Canadian Association of Building Industries."

Following the appointment of temporary officers and the election of convention officers, the following matters will be brought before the conference:—

Appointment of Publicity Committee—Four members. Daily Reports, Trade Papers, Building Statistics.

Appointment of Committee on Permanent Organizations—Ten members. Future of Builders' Exchanges, Our Relations to Board of Trade and Manufacturers' Associations, etc.

Appointment of Committee on Resolutions and Order of Business—Six members.

Appointment of Committee on Attendance or Membership—Five members.

Appointment of Arrangements Committee — Five members.

Appointment of Building Situation Committee—Twenty members, plus:—

(*a*) Public Works, Good Roads, Railroad and Corporation Work.

(*b*) Industrial Housing.

(*c*) Agricultural Development.

(*d*) Building Materials: Resources, economy, adjustment, standardization; builders' plants, yards, etc.

Appointment of Business Relations Committee—Twenty members, plus:—

(*a*) Percentage: Cost, plus fixed sum—Owners.

(*b*) Method of calling and opening tenders: Engineers, architects, sub-contractors, powers of inspector or superintendent, arbitration.

(*c*) Foreign Competition and Designing.

Appointment of Committee on Labor Conditions (present and future)—Ten members, plus:—

(*a*) Labor and Trade Parliaments.

(*b*) Employers and Apprenticeship—Technical and Vocational Training.

Appointment of Legal Affairs Committee—Ten members, plus:—

(*a*) Building By-laws, Lien Laws and Privileges.

(*b*) Guarantees: Bid bonds vs. big cheques, contract bonds, standard agreements, unit prices.

Appointment of Code of Ethics Committee—Ten members, plus: Receiving bids, awarding sub-contract work, supply houses, payments, bonds, bonus and penalties, zones of operation.

Messrs. Jones & Attwood, of Stourbridge, England, has just received an order for equipment of an activated sludge plant for the American Red Cross Hospital at Salisbury Green, near Southampton, England. The plant is to be completed one month after the placing of the order, and Jones and Attwood's design throughout was adopted. The same firm has also secured an order from the Admiralty for a complete plant for the Moreton Royal Naval Airship Station. Laurie & Lamb, Montreal, represent Jones & Attwood in Canada.

WATER POWERS OF CANADA

(Continued from page 386.)

Graham, M.Inst.C.E., has made such an independent investigation of a number of the schemes and has arrived at much larger figures.

Mr. Graham has investigated 60 possible schemes in the Highlands, basing his calculations upon rainfall figures supplied by Dr. H. R. Mill, and arrives at the conclusion that an aggregate of upwards of 400,000 continuous h.p. is available, divided as follows:—

10 Schemes above 10,000 continuous h.p.
20 Schemes between 5,000 and 10,000 continuous h.p.
20 Schemes between 2,000 and 5,000 continuous h.p.
10 Schemes below 2,000 continuous h.p.
—
Total. 60 Schemes.
—

The works necessary to develop these powers have been laid down on the one-inch Ordnance Survey and their particulars tabulated for reference. It is not, of course, suggested that all these schemes are commercially possible at the present time, but many of them are sufficiently promising to justify closer investigation.

The largest installation as yet developed in the United Kingdom is the Kinlochleven Works of the British Aluminium Co. Although the drainage area is only 55 square miles, the high rainfall amounting to 70 inches per annum and the large fall of 920 feet, are sufficient to give an output of about 30,000 e.h.p. continuously. These works are now being increased by the addition of the power to be obtained from Loch Eilde Mor.

The same company has also 7,000 e.h.p. installed at Foyers on Loch Ness.

England

While in England there are larger rivers than in Scotland, there are fewer natural lakes. The possibility of water-power development is restricted, too, by the general lack of elevation.

Such powers, therefore, as are possible would of necessity be in comparatively small units, and must be developed without storage by utilizing the natural river flow, as has been done, for example, on the Dee at Chester.

Ireland

Like England, Ireland's possibilities of power appear to lie in her great rivers. A large part of the interior of the country forms a flat plateau at no great height above sea-level. On this plateau flow large, sluggish rivers, the Erne, Corrib, Shannon, Bann, Lee, Inny, etc., most of which have a steep fall to the sea for the last few miles of their length. This feature of the rivers makes them valuable for power production. The best of the lochs lie in agricultural country, and the raising of their levels would flood much valuable arable and pasture lands. The amount of power available is probably considerable, but without much closer investigation than has as yet been made even an approximate estimate cannot be given.

Wales

In the mountainous area of N. Wales where the rainfall is high two power installations have already been established, developing some 12,000 e.h.p. There are possibilities of further development in this region which are well worth investigation. Several promising schemes have been investigated by Mr. Vaux Graham in the same way as those in the Highlands of Scotland.

General

While the possible water-powers of the United Kingdom are comparatively small, yet, occurring as they do at no great distance from industrial regions, they are relatively valuable, and every effort should be made, by close investigation, to ascertain their commercial value at an early date.

India

Very little definite information is as yet available regarding the hydraulic resources of India. The power problem in India is in general complicated by the urgent necessity for conserving as much water as possible for irrigation purposes. There are numerous great perennial canals with drop falls at fairly short intervals; there are also numerous large reservoirs. At first sight it might seem that these sources of power should be utilized. When carefully examined most of these are, however, found to be useless for power purposes, owing to the paramount necessity for operating the works with reference to irrigation requirements. Periodical closures are necessary for the execution of repairs; the canal branches are operated in rotation so as to lessen loss by absorption; and in times of heavy rainfall it may be necessary to close the canal completely. All these methods of working are directly opposed to power requirements.

Over the greater part of the country there are few perennial streams, and storage reservoirs for conserving the high rainfall of the monsoon season would be necessary. In Bombay, on the eastern side of the crest of the Western Ghats, the mean rainfall is approximately 150 ins. per annum, the whole of this rainfall occurring within four months. Many of the elevated valleys of the Ghats lend themselves to the construction of storage reservoirs, and, owing to the geological conditions, a very large proportion (up to 90 per cent.) of the rainfall may be collected and stored.

The Tata Hydro-Electric Undertaking receives its water supply from three such valleys. The total catchment area is only 22 square miles, but this is sufficient to give 100,000 e.h.p. for 3,600 hours per annum.

Other projects of a similar type are under investigation in the Western Ghats. It is estimated that a continuous 300,000 e.h.p. may be obtained from the Koyna River alone; that approximately 100,000 e.h.p. may be obtained from each of the rivers Vaiturna and Kali Nadi, and about the same amount from the Andrha Valley. It is estimated that a continuous 20,000 e.h.p. is available at the Kali Nadi, Gersappa and Lushington Falls, and that, by a combined system of storage reservoirs, suitable also for irrigation purposes, a continuous 50,000 e.h.p. might be developed from this system.

The north-west corner of the United Provinces would also appear to be a promising locality for early development. There are promising sites on the Ganges, Tons, Jumna, Paisani, and Kosi Rivers, and at present the erection of a generating station on the Jumna is under consideration. It is estimated that from 40,000 to 50,000 h.p. can be easily and economically developed on the rivers Jumna and Tons, and as this region is thickly populated, there would be immediate markets for energy for the operation of cotton, rice, sugar, flour, oil, and saw-mills, and for other industrial undertakings.

There are also known to be many promising sites in the Central Provinces, and the aggregate of power should be large; but little detailed information is available.

In Mysore there is the very successful government undertaking on the Cauvery River. As now extended the power-house has a capacity of over 22,000 e.h.p. The power is transmitted some 90 miles to the Kolar goldfields and to Bangalore and Mysore, respectively 57 and 37 miles distant.

The provinces of Bengal and Madras do not appear to show any great possibilities in the matter of hydraulic power. The question of utilizing the lake at Periyar for power purposes is, however, now being investigated.

In the Native State of Kashmir an installation on the Jhelum River at Mohora is designed to develop 20,000 h.p., and transmits its power to Baramula and Srinagar.

In general the hydraulic possibilities of India appear to be very great. The country possesses in abundance the minerals necessary for metallurgical development, the climate and land for the cultivation of cotton, flax, jute, and many other commodities, and an enormous population which, if trained, would provide abundant skilled labor. It is certain, too, that once it is determined by experimental trial for what crops and soils nitrogenous fertilizers can be used with profit to the cultivators, the demand for these, provided they can be produced at sufficiently low rates, will be enormous.

The possibilities are so great and the available information so meagre that the question of the thorough investigation of the possible sources of water-power in the Indian Empire would appear to warrant immediate attention.

Ceylon

In Ceylon, the amount of power should be considerable, but as yet the committee has been able to obtain little definite information as to its probable magnitude. Mr. H. T. S. Ward, M.Inst.C.E., estimates that at least 68,000 continuous h.p. is available even in the dry season at the falls of the Mahaweliganga and about one-half as much from the River Walawe Ganga. These are said to be very conservative estimates. The water rights belong to the Ceylon government. There are a number of raingauge stations on the 712 square miles of catchment area feeding the Mahaweliganga. Rainfall records for these are available from periods varying from 5 to 45 years. The mean rainfall is 115 inches per annum.

Burma

A fair amount of information is available as to the great rivers of Burma, the Irrawaddy, and its tributary, the Chindwin. Their sources are situated in the mountainous country south of Thibet. The catchment basin has an area of about 160,000 square miles, over which the mean annual rainfall is at least 100 ins. Owing to the flat gradients, averaging about 0.4 feet per mile, the Irrawaddy offers no possibilities within about 1,000 miles of its estuary. Between Bhamo and its source gradients are much more rapid, and the same applies to the Upper Chindwin.

The catchment area drained by the upper reaches of the rivers is about 80,000 sq. miles, and assuming it possible to utilize one-fifth of the discharge over a head of 500 feet, this would give a potential 7,000,000 h.p. There are also some promising sites on the Salween River.

It is a matter of pure speculation as to how much of this power might be capable of commercial exploitation. The future increase of population is, however, likely to be considerable in the northern hilly tracts, and the influence of cheap power on the development of the mineral and forestal resources of the country would be very great.

British Guiana

While the water-power resources of this colony are comparatively large, no definite information is yet available. The falls of Kaieteur are said to form perhaps the finest untouched water-power in the Empire.

British Honduras

Here also, while the water-power possibilities are known to be large, no definite information is available.

Canada

During recent years, the Canadian government, through the Dominion Water-Power Branch of the Department of the Interior, has devoted much attention to the systematic examination and development of the hydraulic resources of the Dominion, and the data, as regards the largest, most readily available, and most promising water-powers are sufficiently complete to permit a reasonably close idea of their possibilities to be obtained. These data are published in a series of some 24 reports issued by the Dominion Water-Power Branch. This department has instituted a comprehensive system of mapping, indexing and filing all available information concerning every important water-power throughout the populated portion of the Dominion. This system has been developed in collaboration with all the provincial authorities, and is intended to form a clearing house from which all available information regarding the water-power and allied resources of any given district can be immediately supplied. Much information is also contained in the reports of the Commission of Conservation, and in the annual reports of the Hydro-Electric Power Commission of Ontario.

The Canadian Government, by an Order-in-Council dated April 25th, 1918, has established a body to be known as the "Dominion Power Board." This board, under the chairmanship of the Minister of the Interior, consists of nine engineer officials selected from the permanent staff of the different departments of the Dominion Government. Its function is to make a systematic study of the fuel-power situation throughout Canada with a view to encourage the substitution of water-power for fuel-power wherever practicable, and so to co-ordinate the use of water and fuel resources that fuel, and in particular coal, may in future be reserved for purposes such as heating, for which it is at present indispensable. It is felt that the rail and water transportation facilities will thereby be relieved of an unnecessary burden, the Nation's balance of trade will be favorably affected since a large part of the coal supply is now imported, fuel resources will be conserved, and the substituted agency, water power, can never be depleted through use.

(Concluded in the next issue.)

On the recommendation of Hon. C. C. Ballantyne, Minister of Marine and Fisheries, a contract has been entered into by the government with the Victoria Machinery Depot, of Victoria, B.C., for the construction of two ships of 8,200 tons. This brings the number of ships the construction of which has been authorized by order-in-council up to 25, and some additional contracts will be closed within a few days. Of the 25 ships built, in the course of construction, or contracted for, ten are of 8,100 tons capacity, six of 5,100 tons, three of 3,400 tons, four of 3,750 tons and two of 3,400 tons. Canadian Vickers, Limited, of Montreal, heads the list with eight contracts and the remaining contracts are divided between the Collingwood Shipbuilding four, the Tidewater Shipbuilders four, Halifax Shipyards, Limited, two, the Davie Shipbuilding Company two, Victoria Machinery Depot two, Wallace Shipyards, Limited one, the Port Arthur Building Company two.

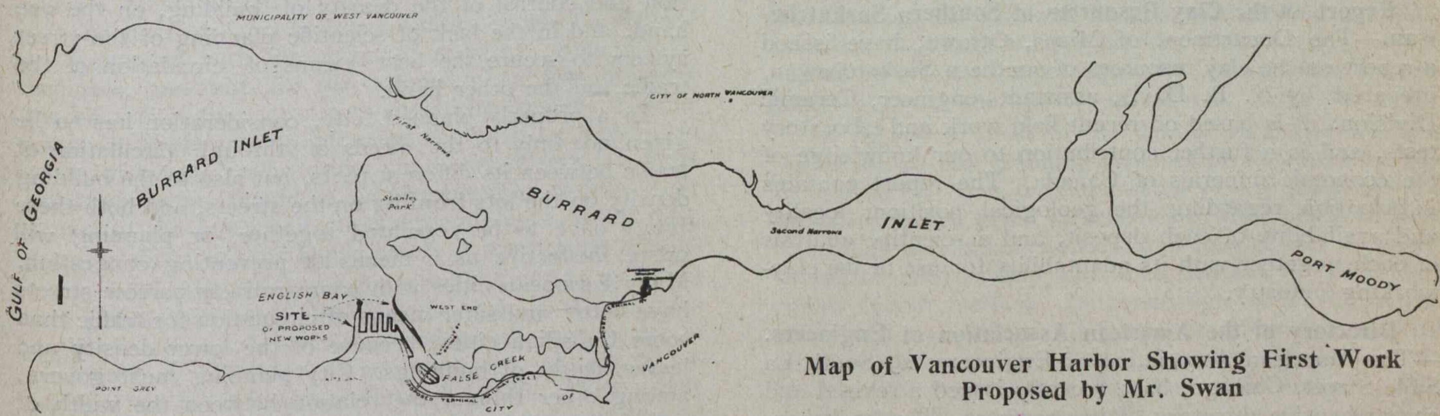
Will Plan Development of Vancouver Harbor

Government Asks Consulting Engineer To Lay Out Work Proposed To Be Done During Next Twenty Years

As a result of an interview with Hon. C. C. Ballantyne, Minister of Marine, it has been announced by H. H. Stevens, M.P., that the minister has selected Andrew Don Swan, consulting engineer, of Montreal, to make a report to the government regarding the proposed development of Vancouver Harbor. Mr. Swan's report will be very comprehensive, covering all development work proposed to be done during the next twenty years.

It is said to be the intention of the government to commence the improvement of this harbor at the earliest possible date. The first work to be done, as proposed by Mr. Swan, is indicated on the accompanying map.

Conferences are now being held by Mr. Ballantyne with several steel ship builders regarding work on the Pacific coast, and it is expected that further announcements will be made of new shipbuilding contracts for Vancouver.



Map of Vancouver Harbor Showing First Work Proposed by Mr. Swan

Mr. Stevens has been in Ottawa for more than a week and has held a number of conferences with Sir Robert Borden and Mr. Ballantyne, and has announced that the difficulties hitherto existing in regard to additional shipbuilding contracts for Vancouver have now been removed.

PUBLICATIONS RECEIVED

The Diesel Engine.—By Herbert Haas. Bulletin No. 156 issued by the Bureau of Mines, Department of the Interior, Washington, D.C.

For Private Estates.—Booklet distributed by the Barrett Co., New York, Montreal, Toronto, etc. Printed on coated paper, 6 in. x 9 in., printed in two colors. 32 pages. Consists mostly of full-page illustrations of driveways on private estates.

Tarvia Meter.—Issued with the compliments of the Barrett Co., New York, Montreal, Toronto, etc. A circular slide rule showing the quantity of Tarvia required per mile at various applications, and distances covered by various tank capacities at specified quantities per square yard.

Jeffrey Belt Conveyers.—Catalogue No. 175 has just been issued. It contains a great deal of practical information for all who are interested in the handling of material. It is fully illustrated and carefully cross-indexed. The catalogue is being sent out from the Canadian office of the Jeffrey Manufacturing Co., Power Building, Montreal.

Turbine Water Wheels.—Bulletin 54, issued by the William Hamilton Co., Ltd., of Peterborough, Ont., Canadian manufacturers of Leffel turbine water wheels. 6″ x 9″, printed on coated paper, 32 pages and cover, numerous illustrations in several colors showing cross-sections of typical installations and numerous tables giving statistics of turbines of various characteristics.

Analysis of Canadian Fuels.—Bulletin No. 22, issued by the Department of Mines, Canada, is compiled by Edgar Stansfield, M.Sc., and J. H. H. Nicolls, M.Sc. The field will be covered in five parts. Bulletin No. 22 comprises Part 1, which deals only with the Maritime Provinces. The positions and relative values of the various fuel areas are indicated and their composition given in tabular form.

The Annual Report of the Department of Public Highways, Ontario, for 1917, has recently been published. It has special reference to work carried on by the counties of Ontario under the Act to Aid in the Improvement of Public Highways. A series of appendices accompany the report, dealing with the various phases of road and street construction and maintenance, traffic conditions, etc.

Condensers, Pumps, Cooling Towers, etc.—Bulletin 112-A, issued by the Wheeler Condenser and Engineering Co., Carteret, New Jersey, discusses the two general classes of condensers, surface and jet, besides describing and illustrating vacuum pumps and cooling towers of various types. It indicates ways of installing vacuum and condensing equipment, and gives information regarding methods, results and costs in a variety of plants.

Tests to Determine the Rigidity of Riveted Joints of Steel Structures.—The University of Illinois, Urbana, has recently issued Bulletin No. 104, compiled by Wilbur M. Wilson and Herbert H. Moore, of the Engineering Experiment Station. It describes a series of tests, with apparatus and methods of testing, followed by a discussion of the results obtained. The booklet is interspersed with illustrations, and concludes with a comparison of results of tests of different test pieces.

Efficiency in the Use of Oil Fuel.—A handbook for boiler plant and locomotive engineers. By J. M. Wadsworth, of the Bureau of Mines, Department of the Interior. The pamphlet is a handbook of information on oil fuel, giving the results of investigations made by the department in co-operation with the United States Fuel Administration. It is shown how fuel consumption may be reduced in the operation of plants. Tables and formulae are presented, and the method of developing these can be obtained by consulting the authority quoted.

Report on the Clay Resources of Southern Saskatchewan.—The Department of Mines, Ottawa, have issued a report on the clay resources of southern Saskatchewan, prepared by N. B. Davis, assistant engineer, Ceramic Division. It is based on recent field work and laboratory tests, and is a further contribution to our knowledge of the economic minerals of Canada. The report contains information regarding the geological position, locality and availability of each deposit, and a scientific analysis of each, together with its adaptability for use in the clay-working industry.

Directory of the American Association of Engineers.—The American Association of Engineers, 29 South La Salle Street, Chicago, have recently issued a revised and comprehensive directory of its members. The book contains 190 pages, and in alphabetical order gives the address and a brief synopsis of the experience of each member. The constitution and by-laws of the organization are embodied in the publication, and a resumè is included of the objects and scope of the association.

British Engineers' Association Official Directory.—This association is composed of manufacturing engineers, the object of which is to provide a central national organization in the engineering industry for the promotion of the interests of British manufacturing engineers and British engineers generally. This directory of 420 pages contains a list of members, arranged alphabetically, and also as to their product. It is printed in three languages, English, French and Russian, and will be found exceedingly useful to those in Canada who may desire to purchase British engineering plant or machinery, or who are interested in British connections generally.

METHODS OF MEASURING TEMPERATURE

Reviewed by Prof. G. A. Guess

By *Ezer Griffiths*. Chas. Griffin & Co., publishers. 8/6 net, 176 pages, illustrated, 81 figures from photographs and drawings.

This volume is a complete treatise, a monograph on temperature measurement. It deals with the subject thoroughly. The book is written rather for the physicist than for the engineer, and presumes a previous knowledge of the subject. The engineer interested in temperature measurement will find the principles underlying the various types of pyrometers discussed and methods given for calibration. If he is interested in extreme accuracy in temperature measurement he will find this book particularly useful.

The very complete bibliography at the end of each chapter is a valuable addition to the book.

TOWN PLANNING IN RELATION TO PUBLIC SAFETY*

By Thomas Adams

DANGER to human life in city streets is not caused by the growth of the cities, but by the haphazard and unregulated manner in which that growth takes place. Canadian cities are not congested, as a whole, but have badly congested spots; their streets are more than adequate in their total capacity for traffic circulation, but they are not of adequate width in the right place. The fault lies in the lack of proper distribution and control of the density of building, on the one hand, and in the lack of scientific planning of the street system to secure the best means of circulation of the traffic, on the other hand.

In a properly planned city, consideration has to be given not only to the needs of through circulation of traffic between its different parts, but also to the building density on the lots fronting on the streets, and both these things have to be regulated together, or planning will prove ineffective as a means of preventing congestion. Many European cities with comparatively narrow streets have better and safer means of circulation for traffic than some Canadian cities, because of the lower density and lesser height of buildings. City planning must govern, among other things, the relation between the width of street and the height of buildings thereon, and the ideal to aim at, however difficult of attainment it may appear to be, is that the height of a building should correspond to the width between its front wall and the front wall of the building facing it. Until we can reach that seemingly difficult standard we shall not be able to obtain the space in our streets necessary to overcome congestion of traffic and its consequent dangers to life and loss of valuable time to its citizens.

Three Problems of City Planning

Three distinct but related problems, each having a bearing on public safety, have to be dealt with in our city planning schemes. There are:—

1. Regional Planning.—The problem of regulating new development in open or partially built-upon lands within and surrounding the city, including the control of all new forms of growth and the planning of a comprehensive arterial highway system for the purpose of securing adequate means of access and egress for traffic to and from the city and the surrounding country.

2. City Re-planning.—The problem of re-planning areas already built upon within the city, where changes in the character of buildings or in the use to which they are put, are taking, or are likely to take, place, including adjustment, as far as practicable, of this change of character to the existing street system.

3. Reconstruction.—The problem of remodelling the street system to suit the existing building densities and traffic where these have already become congested and where buildings are permanent in character or unlikely to be reconstructed in the near future.

Some of the Objects to be Sought in Schemes

In planning, re-planning and re-constructing cities an effort should be made, as far as practicable, to carry out the following, among other, objects in regard to streets, buildings and open spaces for recreation:—

Streets.—Heavy-traffic streets should be wide, and those which carry street railways should not be less than

*Abstracted from article in "Conservation of Life."

100 feet in width. Directness of route should be sought for main highways, free from the right-angled turnings, abrupt endings, irregular crossings and collision points caused by rectangular planning. On hilly sites reasonable curves, with a clear vision of a hundred yards at all points, should be substituted for straight, steep grades. Sharp curves should be avoided, and those existing should be abolished. Bad grades should be avoided, particularly at intersections. More than four streets should not be made to converge at one point unless large traffic space is provided at the point of convergence. Frequently the rounding of sharp angular corners at street junctions will do more to relieve congestion than widening of the interior of the street.

The street railway systems of cities should be planned or re-planned with the object of securing general convenience, and not for the interest of a few property owners. New by-pass streets should be created, in many cases, in preference to widening the existing streets, so as to distribute traffic rather than concentrate it. Main radiating routes should be supplemented by wide circular routes at the inner and outer circumference of the city, so as to distribute the traffic before it reaches the centre.

In residential areas, narrow streets should be designed and restrictions made, limiting the height of the residences to two or three storeys and preventing change in character of buildings. Narrow streets should be so planned as to discourage through traffic. The whole street system should be planned of various widths in relation to building use and density and prospective traffic requirements. Intersections should be planned to secure that all traffic may move either at right angles or in a gyratory form in a circle of ample radius (not less than 100 feet).

Building set-back lines should be fixed on all streets, especially where streets of comparatively narrow width cross, so as to permit of a better view of the intersection and of all approaching vehicles.

Streets up to 50 feet in width should be constructed at the expense of the owners of the frontage land on the following principles: When any land is sub-divided for building purposes the owners at the time of sub-division should be made to construct the street and sewer, as well as to grade the street, up to certain minimum standards but not to include a finished surface. This is customary in many American cities, and is the British practice in all cites. It secures good access to all buldings when erected, prevents the scattered development and long mileage of vacant lots to be seen in many suburbs, which is a source of great expense to the city, and obviates the dangerous and unhealthy mud-ways that constitute a great part of our suburban thoroughfares. In proportion as we improve the construction of our secondary streets we shall lessen the concentration of traffic on the main thoroughfares. The foundation and a partial surface construction of the street having been made prior to, or simultaneously with, building, a finished surface should be provided by the city when a half or two-thirds of the street frontage is built upon, and this should be assessed against the lot-owners. When, for purposes of general traffic, streets have to be wider than 50 feet, the extra cost should be met by the city and be a charge on the inhabitants at large.

Buildings.—The ideal to be aimed at in regard to height of buildings should be to limit the height to the width of the street in the front and to the width of the space between the rear walls of buildings. Only thus can we give effect to our measures to prevent congestion and secure the benefit of street improvements. The amount of superficial area of a lot to be built upon should not exceed 75 per cent. in business areas and 50 per cent. in residential areas, except on corner lots.

These standards may seem to be so much in advance of present-day practices as not likely to receive the sanction of public opinion, but the time is approaching when they will be adopted and enforced. Cities should be zoned for purposes of limiting heights and densities in different districts and prescribing manufacturing, business, residential and other uses of property—the street system having been simultaneously planned to suit these different uses. This has been done in New York and other cities, but the standards so far attainable are not yet adequate to reduce possible congestion. The spreading out of cities on a more even basis, less congested in some parts and less blighted or scattered in other parts, is not only essential to relieve congestion and secure safety, but is needed to secure a more equitable distribution of property values in the interest of owners.

In regard to most of the details regarding building regulation by city planning schemes no definite rules can be laid down. It is of the essence of city planning that consideration be given in schemes to the variety of local conditions and circumstances, and that expert judgment should be used to deal with these instead of the present rule-of-thumb method. In connection with regulations to secure better safeguards for public safety, we have still much to learn, and more encouragement should be given to scientific investigation into the whole subject. Past experience will not necessarily guide us as to what we should do in the future. City planning has to deal with growth, and growth means change. Our schemes will only be successful if they are sufficiently elastic to permit adjustment to new conditions as these occur. Thus every city should have a permanent organization to give undivided attention to the development of its plan as a means of securing, among other things, the safety of its citizens. Such an organization exists in several cities in the United States.

Open Spaces.—Canadian cities are, generally speaking, adequately provided with open spaces for recreation, but in those rare instances where such spaces are in the right place and are properly distributed to be accessible to the population, it has been the result of accident and not of design. The reduction of street space in residential areas and the lessening of building density on lots should be made more practicable and beneficial if it is accompanied by the provision of playgrounds in every district. Such provision is necessary to lessen the usage of the street for purposes of play. Large parks are of great value to a city, but they do not lessen the need for recreation spaces in close proximity to the homes of the people.

Building permits of some of the western cities for the month of September show a great improvement. In Winnipeg the total is $144,850, against $94,800 in the same month last year. The total permits for the nine months this year are less than that of the corresponding period last year, but in the latter case there was included $475,000 for the parliament buildings, which would more than account for the difference. In Regina the figures for the month of September, 1917, are almost trebled. In Calgary the permits for the nine months of this year have crossed the million mark for the first time since 1914.

The Belgian government already has taken steps to compute the enormous total of the damage done to property in Belgium by the Germans during their occupation of the country, said a cablegram received on the 20th inst., by the Belgian Legation. The Council of Ministers met at Havre and adopted measures for verifying claims for damages to civilian and public property. These will be employed as a means for determining the total compensation to be demanded.

HIGHWAY COST-KEEPING*

CHIEF among problems in developing a cost system for highway work is that of devising a general classification of expenditures that will conform to accounts appearing upon the ledger of the organization. Highway work is obviously a public improvement, paid for entirely from funds derived from the public revenue. Ultimately, then, the taxpayer pays for all this improvement, and is entitled to a full and detailed account of how this money was expended. The objects of a cost-keeping system are two. First, to show the efficiency of performance and facilitate the reduction of costs; secondly, to supply data which may be used for the intelligent estimating of future improvements, and to furnish material for published reports. Records of this kind are all that remain to be used for the comparing of the efficiency of one administration with that of another.

Cost Elements

The term "cost," as generally interpreted, may be defined as the summation of expenditures, expressed in terms of money involved, to acquire or produce a utility, or perform a service, and the cost of every unit of product is composed of four basic elements of expense, viz.: (1) labor, (2) materials, (3) plant and equipment, (4) overhead charges.

Labor.—The costs of labor are divided into two classes, direct and indirect, the former being all labor chargeable against the product which can be designated as directly expended on it, such as the cost of men using picks and shovels, while the latter is all labor not directly expended, such as the cost of superintendence, and the services of watchmen, timekeepers and others, whose wages are only chargeable, pro rata, against the production of all the work units they cover.

Materials.—The costs of materials are divided into two similar classes, direct and indirect. All materials entering into the product as an integral part of its composition, such as cement, stone, sand, mixed together to form concrete, are direct materials, the oil used for lubricating and the gasoline for operating the mixer being indirect materials.

Operating Charges

Plant and Equipment.—"Plant" includes such physical property used on the work as structures, machinery, live stock, and tools of a more permanent character than those referred to as materials. "Equipment" is a less inclusive term, and is interpreted generally to mean the smaller, and especially the movable, plant units. The cost can be charged most readily in the form of a daily rental against the work upon which it is used, and consists of "operating charges," which are (*a*) the expense of operation, (*b*) the average cost of repairs, (*c*) charges for the time spent in idleness, and "fixed charges," which are (*d*) charges for depreciation, (*e*) interest (*f*) taxes, (*g*) insurance.

Overhead Charges.—This includes all charges that cannot be connected directly with the cost of labor, material and plant. For convenience in accounting, and for the purpose of securing a desirable division of road cost, this may be considered as divided into two classes, "engineering and supervision" and "administration expenses." To engineering and supervision shall be charged all expenditures for surveys, plans, specifications, estimates, tests, and all engineering inspection and supervision in the nature of oversight required to secure the proper execution of the work. Administration expenses include such expenditures as salaries and expenses of the executive officers, legal services, maintenance of office, departmental engineering, investigations, experiments, clerical staff, fiscal operations and miscellaneous fixed charges.

Analysis

The accompanying analytical chart forms a summary of the foregoing discussion of cost elements applied to road work, and shows the relation between the cost elements and the final cost of the project as expressed in totals and by units:—

Highway Costs

Elements of cost.	Classes of cost.	Application of cost.	Product of cost.	Summary of cost.
Labor cost...	Direct.....	Wages of laborers, mechanics, teamsters, etc.	Construction, maintenance, or reconstruction of road parts, right of way, grade and roadside, roadway, ditches, drains, bridges, and culverts, and supplementary parts.	By units, direct, as performed.
	Indirect...	Wages and expenses of superintendents, foremen, timekeepers, guards, watchmen, water boys, etc., lost labor days, labor expense.		
Material cost...	Direct.....	Materials entering into product as integral parts.		
	Indirect...	Supplies, used but not as a part of product.		
Plant and equipment service cost.	Operating.	Operation. Repairs. Idleness.		
	Fixed.....	Depreciation. Interest. Taxes. Insurance.		
General expense cost.	Project: Engineering and supervision.	Salaries and expenses of engineers, field parties, draftsmen, inspectors, and clerks; office expenses, tests, and miscellaneous expenses for individual projects.	Plans, specifications, estimates, surveys, inspection, and direct supervision of work.	By project; upon completion may be apportioned to units.
	General: Administration.	Salaries and expenses of executive, engineering, legal, and clerical staffs; expense of office maintenance, experiments, investigations, and fiscal operations; miscellaneous fixed charges.	General direction, policy, oversight, planning, control, legal, and financial provisions.	On all operations over a period of time and apportioned to projects.

General Remarks

In order to make any cost system successful certain fundamental principles must be followed. The data collected must be reliable, and the methods adopted, in the way of storing these data up for future use must be simple, but at the same time effective. If the data collected are not reliable, all records based upon them, of course, will be misleading and the results dangerous. If simplicity be not maintained, the purpose of the system will be defeated. Involved and complex forms are confusing to the recording officials, difficult to compile for study and analysis, and apt to be inaccurate, and a useless expense. The cost of determining cost must itself be reduced to a minimum. If the expense of obtaining cost records to point out the way to efficiency is not much below the saving effected, they have no just claim to a place in any plan of management.

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*Compiled from "Highway Cost-Keeping," by James J. Tobin and A. R. Losh, U.S. Engineer Economists.

A total of $53,600 out of appropriation of $132,000 was spent by the department of public works of St. John, N.B., during the past summer on actual paving and sidewalk operations, according to figures given out by the department. Exclusive of salaries, interest and sinking fund, etc., the appropriation for actual operations was only $60,300, and on account of the heavy cost of snow removal and other unusual expenditures, the appropriations were pooled to take care of unforeseen demands. An overdraft of $11,000 was necessary to care for snow removal, in addition to money taken from appropriation for new asphaltic pavements.

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Principal Contents of this Issue

INTERNATIONAL JOINT COMMISSION

DAILY newspaper despatches from Ottawa state that "F. J. Bisaillon, K.C., a prominent Montreal lawyer, has been named by the government to succeed P. B. Mignault, the new judge of the Supreme Court, as a member of the International Joint Commission. The actual appointment has to be made by the British authorities, but his name has been recommended by the Cabinet."

It is to be greatly regretted that the Cabinet has not recommended an engineer for this position instead of a lawyer, and we hope that it is not too late for a change to be made in the recommendation either by the Dominion Cabinet or by the British Government. Nearly all of the questions that must be decided by the International Joint Commission are engineering questions. Law and legal procedure have entered but little into the discussions and decisions of the commission.

It does not require a lawyer to decide how much water can be diverted from a stream for power purposes without interfering with navigation. The "K.C." hardly qualifies a man to decide the extent to which boundary streams can be polluted with sewage without endangering the health of communities which use those streams as water supply. Acquaintance with judicial procedure is no recommendation of one's ability in deciding the value of a lake as a storage pond for water power development. Blackstone is not the reference to whom one would turn in deciding the effect upon the great lakes of the water diversion through the Chicago Drainage Canal, or the effect upon the St. Lawrence River level of the construction of a submerged weir or of a dam.

Practically without exception every problem that has come before the International Joint Commission, or which is at all likely to come before it, is of an engineering nature and can best be determined by engineers. It is high time that the authorities at Ottawa should recognize that there are some other professions besides that of the law which are capable of useful public service.

WATER POWERS OF THE EMPIRE

FOLLOWING are the conclusions arrived at by the water-power committee of the Conjoint Board of Scientific Societies, whose preliminary report has just been issued:—

(1)—That the potential water-power of the empire amounts in the aggregate to at least 50 to 70 million horse-power.

(2)—That much of this is capable of immediate economic development.

(3)—That except in Canada and New Zealand, and to a less extent in New South Wales and Tasmania, no systematic attempt has as yet been made by any government department to ascertain the true possibilities of the hydraulic resources of its territories or to collect the relevant data.

(4)—That the development of the empire's natural resources is inseparably connected with that of its water-powers.

(5)—That the development of such enormous possibilities should not be left to chance, but should be carried out under the guidance of some competent authority.

The Conjoint Board, composed of members selected from the various scientific societies in Great Britain, was appointed to advise the government on various technical and scientific problems, the solution of which is essential to the welfare of the empire. A strong committee of this board, under the chairmanship of Sir Dugald Clerk, was appointed "to report on what is at present being done to ascertain the amount and distribution of water-power in the British Empire."

Their report states that "to enable the empire to recover, with any degree of rapidity, from the financial burden imposed by the war, it will be necessary to develop, in a much greater degree than heretofore, its latent resources," and adds that "it must be realized that without an ample supply of cheap energy, much of this wealth must always remain latent."

The committee, recognizing that private capital may not be largely available after the war for the mobilization of the empire's latent stores of energy, recommends that the question of state-aid, where necessary, be seriously considered.

The report concludes with a number of constructive recommendations urging the government to appoint an Imperial Commission of Conservation or an Imperial Water Power Board which shall include a representative from each of the overseas dominions and dependencies. This body would co-operate with the various governments of the empire in investigating and developing hydraulic energy, chiefly in an advisory capacity.

It must be recognized that this report is merely a preliminary report. No doubt much more work will be done before the final report is issued by the committee, and many of the weak and vague parts of the report as it now stands will unquestionably be strengthened by consultation with a greater number of authorities throughout the empire.

It is to be hoped that the committee's final report will include much more accurate and detailed statistical information than is now presented for many parts of the empire. The subject is of the very greatest importance. Sufficient information has been given by the committee to whet the appetite for much more. Plentiful funds should be placed at the disposal of the committee so that its work can be continued in the more exhaustive manner, which must characterize all reports on post-bellum problems if we expect to hold our own with Germany in the war after the war.

Organizations such as the Conjoint Board should make every effort to obtain information from all possible authoritative sources throughout the entire world before attempting to present summaries for public attention. Popular views having been formed on insufficient data, naturally it would be difficult to obtain proper acceptance for subsequent fuller statements based upon more comprehensive studies.

PRECAUTIONS FOR REDUCING ACCIDENTS ON CONSTRUCTION WORK*

By W. J. Lynch
Assistant to Vice-President, Thompson-Starrett Co.

USE only substantial machinery and equipment adapted for the work on which it is used. Machinery and equipment when returned to the contractor's yard from a job should be given a thorough inspection and overhauling, so that it will be in first-class condition when delivered to a new operation.

Under no circumstances should equipment be overloaded; take no unnecessary chances where human life is in danger.

Where wooden derricks, travelers or timber rigging is used, see that all timbers are in good condition and are erected plumb and square, and that all chains and fittings are securely tied or bolted.

Where stiff-leg derricks are used, see that they are properly weighted. On industrial work, where the derrick is to remain in one location for a considerable time unloading materials, small concrete foundations are sometimes provided—bolts set in the concrete being used to hold the derrick.

In very cold weather, unusual care should be exercised not to overload derricks, on account of the action of the cold on the metal parts.

Frequent cleaning of boilers and mechanical equipment serves economy in operation as well as being an important element in accident prevention.

To protect operators from falling materials, provide housing where hoisting engines or motors are exposed.

Crank shafts, gears, and all revolving projections should be encased or other effective protection provided.

Horizontal shafting and hoisting cables should be rail guarded or some danger mark appear in the area in which the shafting or cables are located, to indicate danger to the workmen.

Vertical shafting or cables should be placed in unexposed shafts where possible, but when running through exposed areas should have temporary enclosure for 7 ft. in height, or be rail guarded.

The space adjacent to moving cables, engines, etc., should be kept clear of piles of used lumber, rope, rubbish, etc.

Moving cables should be free from chafing against concrete, tile, steel, or other hard material, producing wear.

Where guy cables turn over edge of steel plates or sharp corners, provide wood or other protection against cutting.

The loads should not be thrown too quickly on the motors of electric hoists. This brings severe strain on the hoisting mechanism and may result in burned-out coils.

Cleaning or repairing should not be done while machinery is in motion.

Blocks and sheaves should be selected for the cables used, to prevent undue wear on the cable.

Steam shovels should be kept on as nearly a level bed as possible, to prevent overturning. Special care should be exercised in lifting loads with locomotive cranes when on inclined tracks or curves.

Steam shovels and locomotive cranes should be kept orderly, and miscellaneous parts kept in their places, to eliminate stumbling or tripping hazard.

Only those actually required should be allowed on steam shovels or cranes, and wherever possible workmen should be kept out of the way of the swing of the loads, the operators being instructed to insist upon this precaution.

See that all chains and cables, including rings and hooks in same, are amply strong, the use of steel cable being recommended. Keep machine fittings and cable well oiled and greased. See that all guy cables are securely fastened by substantial clamps. Plates, shackles, chains, hooks, etc., that show any sign of fracture or are badly bent should receive immediate attention, and if liable to be subjected to heavy strains or heavy loads, should be replaced.

Hooks lifting very heavy loads should have either a safety clamp or be securely lashed, to prevent spreading and dropping of load. When lifting heavy loads, avoid sharp bends on the cable slings, and when lifting steel use wood blocking to prevent slipping and to prevent abrasion of the cable.

See that the shafts of hoisting engines are true, and clutches, brakes and gears engage properly and work freely.

Riding derrick loads or material hoists should, of course, be prohibited.

Material hoists should be guarded with wire or other enclosure on three sides and wood bar at front opening.

Passenger hoists should be provided for workmen, enclosed on three sides and top, with gate enclosure at the opening.

All power saws, planers and jointers should have enclosing guards.

Unless absolutely necessary, workmen should not be permitted to ride on automobile trucks. Many accidents have occurred through falls from overcrowding, hitching on and jumping off trucks in motion.

Men using acetylene torches should use goggles and gloves.

Many accidents occur from the use of defective and worn hand tools. Cracked or insecure handles should be replaced; saws, chisels, etc., should be kept sharp, and hammers and sledges with mashed or fractured heads should be dressed or replaced.

In cutting concrete, wire or other holders should be used to hold the handle of the cold chisel in order to avoid injury when the blow on the head of the cold chisel is misdirected. Tools should not be left lying around to be tripped over or knocked on workmen below.

*From a paper read before the Construction Section of the seventh Annual Meeting of the National Safety Congress.