them, as well as checked a growing exportation of some articles, which would probably, in time, have been of very great consequence to our commerce."

The window-tax was abolished in 1851, and house duty substituted for it. The tax no doubt affected glass production generally, but, in any case, it is quite time that we made an endeavour to supply our own requirements, and every effort should be made to assist our manufacturers to attain that object.

HIGH-TEMPERATURE APPLIANCES.

DURING the war period, when industries are being conducted on more scientific lines, when in every detail of operation the utmost care must be exercised, the exact control of temperature becomes imperative in processes of such paramount importance as metal pouring, annealing, hardening, etc. Within recent years the methods of pyrometry have reached a high order of accuracy. Many pyrometers, too, combine with moderate accuracy a simplicity and a robustness of construction which eminently adapt them for works' use, and their rapidly extending application is as important a feature of modern progress as the attainment of the highest accuracy in a limited number of instruments. In a works recently instanced no fewer than 50,000 high-temperature determinations are made weekly with electrical and optical pyrometers, this work fully engaging the attention of sixty assistants.

Progress of this nature can scarcely be adequately reflected in an exhibition such as that arranged by the British Science Guild at King's College, and the pyrometer exhibits cannot be said to be fully representative of modern work. The enormous demand for such instruments no doubt precludes their availability for exhibition purposes. In every case their installation results in a marked improvement in the quality and uniformity of products, and economies thus effected soon cover the cost of installation.

Among the exhibits relating to the control of temperature, one of some interest is an electrical thermostat developed at the National Physical Laboratory by Messrs. Haughton and Hanson. In this apparatus an accurately controlled temperature may be maintained over prolonged periods, as is often required in metallurgical research. Thus 1000° C. is maintained to within 1° C.

Many industrial operations exceed temperatures at which thermo-electric and resistance pyrometers are available. Radiation and optical pyrometers are then in demand. For works' purposes direct readings are desirable, and this condition is easily attained. The wedge pyrometer exhibited by the Optical Pyrometer Syndicate is of a simple type, capable of being placed with safety in the hands of an intelligent workman. By means of a small telescope the image of the hot body emitting visible rays is focussed through a wedge-shaped prism of dark glass, the prism being adjusted until the image just disappears. The instrument is calibrated so that the position of the prism indicates the temperature under observation. Ordinarily arranged to cover a temperature difference of 400° C., a wider range of 800° C. is possible, and thus a pair of instruments with ranges of 550°–1300° C. and 1250°–2100° C. respectively, safely cover the temperatures of a wide range of operations.

A gratifying feature of the pyrometers now in use is the large proportion of British manufacture. This achievement is due to the close co-operation of those familiar with high-temperature research, thoroughly acquainted with the essentials of design and the limitations of the various types of instruments, with the manufacturers who are responsible for the accurate reproduction of the designs of the experts. The time is surely not far distant when the few special forms of instrument emanating from Germany will have been entirely replaced by improved forms of British manufacture.

Turning now to the range of furnaces in which many types of operation essential to technical work are carried out, the extensive use of gas heating is well known. For fuel economy, clean and perfect combustion, and exact control of temperature, gas-heated furnaces present many advantages for both melting and tool-makers' purposes. The latter furnaces are frequently of the twin muffle type. One example is shown by the Monometer Manufacturing Co., and is designed for hardening high-speed steel. A feature of the furnace is the patent automatic heat regulator to give close and continuous control of the temperature in both chambers. The furnace consumes town gas with air at 2-lb. to 4-lb. pressure. The same firm also shows a ladle furnace and a die-casting machine, each fitted with a self-acting heat regulator, by which the desired temperature can be controlled. Fuel economy is thus effected, and the prevention of overheating—and with it the many errors consequent thereon—is ensured. The Davis Furnace Co. has on exhibit a portable tool-makers' outfit, which includes an oven capable of attaining a temperature of 1350° C.

The requirements of modern thermal operations are opening up the possibilities of electrically heated furnaces. These carry the advantages of compactness, simplicity of design, and the great ease with which exact temperature control can be effected. An example is seen in the Wild-Barfield muffle furnace manufactured by Messrs. the Automatic and Electric Furnaces, Ltd., and used for hardening and similar operations. Furnaces of the salt-bath type are also in use, and are fitted with pyroscopic detectors, compensators, and galvanometers.

Among other exhibits of thermal interest may be noted amorphous carbon electrodes of large diameter and more than 6 ft. in length, with screwed ends which admit of a continuous feed. Electrodes of this type are extensively used in electro-metallurgical operations such as the manufacture of calcium carbide and ferro-alloys. Messrs. Hadfields, Ltd., exhibit a large temperature chart indicating many of the important metallurgical temperatures based on the latest available data.

WATER-POWER AND ITS UTILISATION.[1]

THE World's Present Power Demand.—It is impossible to estimate, with any pretensions to accuracy, the power now being used in the various countries of the world.

Independent estimates,[2] 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.

[1] Abridged from the Preliminary Report of the Committee of the Conjoint Board of Scientific Societies appointed "to report on what is at present being done to ascertain the amount and distribution of water-power in the British Empire."

[2] "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.

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 :—

Country	Area (square miles)	Population (Latest available figures)	B.-horse-power available (1915 estimate)	B.-horse-power developed (1915 estimate)	Per cent. utilised	Horse-power per sq. mile of area	
						Available	Developed
United States ...	3,026,600[1]	92,019,900[2]	28,100,000	7,000,000	24·9	9·3	2·31
Canada "A"[3] ...	2,000,000	8,033,500	18,803,000	1,735,560	9·2	9·40	0·86
Canada "B"[4] ...	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[5]	80,000	8·3	10·9	0·91
Russian Empire[6]	8,647,657	182,182,600	20,000,000	1,000,000	5·0	2·3	0·12

[1] Excluding Alaska (area about half million sq. miles).
[2] 1911 census + 12 per cent.
[3] 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 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.
[4] Canada "B" refers to the presently most thickly populated portion of the Dominion.
[5] The estimate for Great Britain is almost certainly much too high.
[6] A recent estimate by the Ministry of Ways of Communication (*Electrical Review*, February 22, 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. ...	0·08	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 unfavourably with the 43·4 per cent. of Germany.

Nitrogen Fixation.—In the utilisation 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 more than 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*l.*, 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 fertilisers 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 fertilisers amounts to close upon 6,000,000 tons per annum, and this will probably be doubled within the next twenty 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 fertilisers 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.

Cost of Hydraulic Power.—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*l.* per h.p. installed, and the maximum 79·6*l.* per h.p. For the majority of the installations the cost lies between 25*l.* and 45*l.* The cost of the electrical generators, switchboards, etc., and transmission lines also varies greatly, ranging from 1·25*l.* to 28·4*l.* per h.p., while the cost of the turbines ranges from 4*l.* to 8*l.* per h.p. The working costs vary between 1·3*l.* and 6·8*l.* per e.h.p.-year, with an average value of 3*l.* 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 neighbourhood of 10·5*l.*

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*l.* 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*l.* to 20*l.* per e.h.p., in which case the cost per h.p. per annum should not exceed 2*l.* to 3*l.*

Resources of Canada.—Canada is exceptionally fortunate in the extent and distribution of its water-powers. Extending over a belt of several thousand miles in length, from Alaska to Labrador, and over a width of several hundred miles, there is an almost continuous network of lakes and rivers.

The following table shows how general is the distribution of water-power throughout the Dominion:—

Province	B.-horse-power		Per cent.
	Available	Developed	
Nova Scotia	100,000	21,412	21·4
New Brunswick ..	300,000	13,390	4·5
Prince Edward Island ...	3,000	500	16·7
Quebec	6,000 000	520 000	8·7
Ontario	5,800,000	789,466	13·6
Manitoba	3,500,000	76,250	3·1
Saskatchewan		100	
Alberta		32,860	
British Columbia ...	3,000,000	269,620	9·0
N.W. Territories, Yukon	100,000	12,000	12·0
	18,803,000	1,735,598	9·2

Resources of Australia.—Though comparable in area with the United States, there has yet been no notable hydro-electric development in Australia. Except on the east coast, the topography is too flat or the rainfall too low to provide the necessary conditions. Some of the large irrigation schemes are capable of being utilised for power production, but the aggregate of such possible power is small.

The only possibilities of considerable powers are to be found in the rivers draining the Great Dividing Chain of the east coast.

The aggregate power suggested as being capable of economic development in the Great Dividing Chain is as follows:—

Australian Alps	300,000 to 500,000	h.p.
Blue Mountains	25,000 to 50,000	,,
New England Range ...	200,000 to 500,000	,,
Cairns district	100,000 to 250,000	,,
Total	625,000 1,300,000	

Conclusions.

The main conclusions to be drawn from the evidence available to the committee are:—

(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.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE Institution of Naval Architects' Scholarship for 1918 has been awarded by the Council to Mr. H. W. Nicholls, of Chatham Dockyard. The scholarship is of the value of 100*l.* per annum, and is tenable for three years.

A COPY of the calendar for the session 1918–19 of the McGill University, Montreal, has been received. Its 377 pages give very full details of the varied courses of instruction provided, not only for graduation in the more ordinary university faculties, but also for non-graduate students desiring to study other branches of learning. It is possible here to refer only to a few of the expedients adopted to assist needy students of ability. Particulars are given of loan funds which have been established for the purpose of aiding students who, upon the completion of their second or later year's work, require assistance to enable them to finish their course of study. Satisfactory arrangements are made to secure the eventual repayment of the loans. The provision of scholarships, exhibitions, and prizes is on a generous scale, and the needs of every class of student seem to have been thought of, and means taken to give due recognition to excellence in whatever line of work has been followed.

THE prospectus of the University courses in the Municipal College of Technology, Manchester, for the forthcoming session describes fully the facilities which the college offers for systematic training in the principles of science and art as applied to mechanical, electrical, municipal, and sanitary engineering, as well as to architecture, the building trades, the chemical and textile industries, and to photography and the printing crafts. Not only does the college provide the necessary courses for students who desire to graduate in the faculty of technology, but it caters liberally for more advanced study and research. A new degree of Doctor of Philosophy has been instituted with the object of encouraging research among suitable graduates from approved universities. It is interesting to note in this connection that the governing body of the college is prepared to award a limited number of research scholarships in technology, each of a value not exceeding 100*l.* The prospectus gives full particulars also with regard to the entrance scholarships available at the college.

A NEW departure is announced by the Royal School of Mines, which is now a constituent part of the Imperial College of Science and Technology, in the institution of a new associateship of the school in mining geology. The curriculum has been designed under the guidance of a number of the leaders of the mining world in England, who constitute the advisory committee of the school, and also in consultation with many successful mining geologists and mining engineers. The students receive, in the subjects essential to them, the same training as the regular mining students of the school, comprising, for example, surveying, principles of mining exploitation of mines, and mine sampling and valuation, but in addition they spend practically an entire year on the branches of geology and mineralogy specially applicable to mining, concerning which much knowledge has been acquired and published in recent years. In addition to a grounding in the necessary parts of mineralogy and petrology, special attention is devoted to structural, stratigraphical, engineering, and mining geology. The course is an eminently practical one, and comprises work in the laboratory and in the field, the latter including not only instruction and practice in geological surveying, but also a series of visits