Commission of Conservation
CANADA

COMMITTEE ON WATER AND WATER-POWERS

Water-Power and Fuel Problems

BY
ARTHUR V. WHITE
Consulting Engineer
Commission of Conservation

Reprinted from the Tenth Annual Report of the
Commission of Conservation

OTTAWA—1919

Commission of Conservation
CANADA

COMMITTEE ON WATER AND WATER-POWERS

Water-Power and Fuel Problems

BY
ARTHUR V. WHITE
Consulting Engineer
Commission of Conservation

Reprinted from the Tenth Annual Report of the
Commission of Conservation

OTTAWA—1919

Water-Power and Fuel Problems

BY

ARTHUR V. WHITE

Consulting Engineer, Commission of Conservation

IT has become clearly recognized that cheap power is one of the basic factors enabling manufacturing countries successfully to complete in the world's markets.

Before taking up this special phase of our discussion, I shall briefly refer to a few subjects in which, during the past year, this Commission has been specially interested. These are: The applications involving the use of additional water for power purposes from the St. Lawrence river; the completion of the Calumet-Sag portion of the Chicago Drainage canal; the increased development of power at Niagara Falls; the complete apportionment of the total allotment of water at Niagara under the Boundary Waters Treaty; the increasing erosion of the Horseshoe fall; anticipated new developments and market for electric power; detailed water-power investigations in the province of New Brunswick and other cognate matters.

ST. LAWRENCE RIVER APPLICATIONS AND DEVELOPMENT

Since its organization the Commission of Conservation, as its publications clearly show, has been actively interested in having the integrity of the Great Lakes system preserved, and, in this connection, has consistently striven to have development of these waters made according to a unit scheme and in such a manner as will result in their efficient utilization by all interests concerned on both sides of the boundary.

During the past year two important applications, involving increased use of the waters of the St. Lawrence river, were heard by the International Joint Commission. One application was by the St. Lawrence River Power Co., a subsidiary organization of the Aluminum Company of America. Without having previously brought the matter officially to the attention of the Government of Canada, the St. Lawrence River Power Co., under permit from the United States War Department, constructed extensive works in the bed of the St. Lawrence river, and then, subsequently, applied to the International Joint Commission for authority to erect, in the South Sault channel, a submerged weir or dam, which constituted the completing feature of their project, as commenced a year before.

The company contented that this structure was absolutely necessary as a "war measure." The Dominion Government, represented by the Solicitor-General* and counsel, Canadian shipping interests, the Commission of Conservation, and other organizations, urged most strongly that any granting of privileges under the application should only be upon such terms and conditions as would leave the Governments of both countries, and not a private corporation, in control of the situation, including control of any structures, which, as a strictly "war measure," might be authorized. The Commission of Conservation has been, and is, absolutely opposed to the granting of control of the St. Lawrence river to private interests. The International Joint Commission eventually gave decision granting the company the right, for the duration of the war, or for a period of five years, whichever term should be longer, to erect and maintain the structure for which the petition was made.

The other St. Lawrence River application is by the New York and Ontario Power Co., for the erection of a dam in the Little river, a channel between Ogden island and the United States main shore. The proposed structure is to replace, or to be in lieu of, a dilapidated dam now existing in this channel, under rights which, the applicant claims, have been existent for over 100 years, and which rights, the applicant also claims, are still of force. This application is still pending.

During the past year consideration has been given by United States federal authorities to proposed legislation relating to the development of water-powers according to some national policy. When legislation releases water-powers on the navigable rivers of the United States—the development of which has been tied up for years—fresh impetus will be given to this development. In this connection, especial interest is already being manifested in both Canada and the United States respecting joint development of navigation and water-power in international waters, chiefly the St. Lawrence river. Any national boundary water policy of Canada, involving the St. Lawrence river, is of vital relationship to every citizen of the Dominion.

Such rights as were conferred in the case of the St. Lawrence River Power Co's application are, when once granted, difficult to

*For Statement of Hon. Hugh Guthrie, Solicitor-General, setting forth the position which the Government of Canada takes in regard to the application of the St. Lawrence River Power Co., consult, *Tenth Annual Report*, Commission of Conservation, appendix III, pp. 77-86 *ante*; also *Hearings in the Matter of the Application of the St. Lawrence River Power Company*, 305 pp., 8vo., Ottawa, 1919. pp. 39-41; and for his *Argument*, pp. 126-135.

See, also, *Tenth Annual Report*, Commission of Conservation, Appendix II, pp. 71-76, and appendices IV and V, pp. 87-94.

control. An excellent illustration is found in the illegal diversion of water from the Great Lakes system through the canal of the Sanitary District of Chicago. During the past year, the Calumet-Sag portion of that canal system, providing for a still further increased diversion of water, was completed. The Sanitary District's works take water in excess of its permit, and it has not been prevented from so doing. At Niagara Falls, the diversion of water is limited by treaty, and government officials entrusted with jurisdiction in this matter have seen that diversions are not in excess of authorized quantities.

Niagara River Power Situation

Hydro-Electric Commission Chippawa Project

During 1918, notable changes have taken place in the power situation at Niagara Falls. The Chippawa-Queenston project of the Hydro-Electric Power Commission of Ontario is being rapidly advanced. The development is to consist of six units of 50,000 h.p. each, giving a total of 300,000 h.p. The total head from lake Erie to lake Ontario is about 330 feet, of which the new plant has a gross head of 316 feet and utilizes a net effective head of 305 feet. The plant will utilize 10,000 cubic feet per second, conveyed through 12¾ miles of canal, of which 4¼ miles is canalized river section and 8½ miles is excavated canal. The earth excavation is 11,000,000 cubic yards, and the rock excavation 4,000,000 cubic yards. The deepest cut is 145 feet. The excavated portion has a width of 48 feet in the rock section; in the earth section it has a width of 162 feet at the top, and about 84 feet at the mean water line. The gradient is 1 foot per mile, and the velocity in the rock section will be about 6 feet per second when the plant is under maximum load. Survey were commenced in 1914, construction in 1917, and it is hoped that the work will be completed in 1921; estimated cost, about $25,000,000. It is expected that the operating hydraulic efficiency of the turbines will be about 93 per cent, and 30 to 31 horse-power per cubic foot of water will be obtained. The over-all efficiency of the plant, it is hoped, will exceed 90 per cent. This is a great undertaking, and no effort is being spared to include in it the latest and best in development.*

The new 14-foot pipe line of the Ontario Power Co. is nearly completed. While the power-house of the new units to utilize the water from this conduit cannot be available for several months, it

*For description of Chippawa-Queenston power development, consult "Chippawa-Queenston Power Development," in *Canadian Engineer*, Toronto, June 20, 1918; also "Canada Rushing Huge Niagara Development as War Conservation Measure," in *Engineering News-Record*, New York, Oct. 31, 1918.

is expected that the supply of water through the conduit will be utilized to alleviate conditions in the main power-house.†

Hydro-Electric Commission Audit

The work of the Hydro-Electric Power Commission of Ontario, since its inception, has been an especial object of attack by some opposed to public ownership. During the past year, the Provincial Government completed a special audit of the financial operations of the Commission. With respect to this audit—which was made partly as a result of adverse criticism—the *Toronto Daily Star* editorially stated as follows:

"In view of the persistent suggestion made in print and out of it—but especially out of it—and in conversation here and there, that the Hydro-Electric was not on a sound footing, and was not paying its way, the Government appointed Mr. E. R. C. Clarkson to audit its books. Mr. Clarkson reports that the Hydro does much better than pay its way, and has a substantial surplus on hand.

"There are some people who like to knock the Hydro—never believed in it, and never intend to. They predicted that it would fail, that it would be mismanaged, and even the wonderful success it has attained has not convinced them. They do not want, and do not intend, to believe that public ownership can be a success, except, of course, in connection with a waterworks system and service—although wherein water differs from light and power and transportation in the streets, and telephonic and telegraphic communication and other things, no fellow can find out. The report of the audit made by Mr. Clarkson, however, will quite satisfy most people that the Hydro-Electric is a successful and profitable enterprise, and with excellent prospects ahead."

Niagara Falls Power Co., New York

On the United States side of the river the Hydraulic Power and Manufacturing Co., the Niagara Falls Power Co. and the Cliff Distributing Co. have been consolidated. The dominating interests are those formerly controlling the Hydraulic Power Co., although the name selected for the new company is the Niagara Falls Power Co. The consolidation also includes the Canadian Niagara Power Co. on the Canadian side. The new company has an installed capacity of about 370,000 h.p., and is installing an additional 100,000 h.p., consisting of three units, delivering, under conditions of maximum efficiency, 33,000 h. p. each. This plant is expected to be ready for operation in 1919, and will, it is hoped, have an operating hydraulic efficiency of about 93 per cent. It may be commented that the greatest localized waste which now exists in connection with high-class hydro-electric plants is from the turbine runner to tail-water and may be said to amount to from

†Consult "Extension to the Ontario Power Co's Plant," by Thomas H. Hogg, *Canadian Engineer*, Jan. 16, 1919.

3 to 5 per cent. Special refinements in design and construction are being introduced to regain part of this loss.

With respect to the new plant, it is hoped that the increase of hydraulic efficiency to 93 per cent may be secured by regaining 2 or 3 per cent of the power from the water in passage through the draught tube. The new 100,000 h.p. plant occupies about one-third of the space formerly required by equipment of similar general type and capacity. The Hydraulic Power Co. had previously made special efforts to advance hydro-electric development and to utilize the water of the Niagara river allotted to the company under conditions of best efficiency. Its present large power-house uses the water *per se* more efficiently than any other power plant now existent at Niagara on either side of the river. A clear distinction should, of course, be made between the efficiency of a hydro-electric development and the efficiency of the utilization of the water *per se* by the plant. A number of power installations, for example, may have an efficiency approximating each other to within, say, 10 per cent, but with respect to the efficient utilization of water there may be differences of almost anything. The Niagara Falls Power Co., in its new plant at Niagara Falls, will utilize approximately 70 per cent of the fall between lake Erie and lake Ontario, and claims an efficiency of at least 20 horse-power for every cubic foot of water.

In connection with this new plant a collecting basin is being constructed from which the discharge water may be drawn off by a tunnel, which it is proposed to cut through the angle formed by the lower Niagara river, and to terminate on lake Ontario in a power-house for developing power from water now flowing down the lower river. The company claims that this two-stage development gives proper consideration to investment in its existing newer plant; constitutes a truly economical treatment of the allotted water in its total fall from lake to lake, and in fact is, practically, the equivalent of a development of the full head at a single site. When the company actually constructs this plant for utilizing the remaining head of the lower river, it will move out of the class of Niagara developments that have simply "skimmed the cream" by making the easy and cheaper developments at the falls. The company plans ultimately to install at the falls seven additional units, each of the 33,000-h.p. type, to supersede the regular use of the less efficient portions of plants acquired under the consolidation.

Proposals for Increased Diversion

The water of the Niagara river allotted under the Boundary Waters Treaty—56,000 cubic feet per second—has all been apportioned to developing

interests. It has been stated that efforts are to be made to change the terms of the present treaty. One recent proposal is that, under a new treaty, each country shall be permitted to divert 60,000 cubic feet of water per second—which corresponds to approximately 1,800,000 electrical horse-power—assuming 30 horse-power per cubic foot of water.

In connection with proposals for incrased diversion attention has frequently been drawn to marked physical changes taking place at the Horseshoe fall. The water has been receding from the heels and concentrating in an accentuated V-shaped channel at the toe of the horseshoe. Suggestions have been made that action should be taken to preserve the scenic beauty of the falls, especially of the Horseshoe fall, because, if the breaking down of the crest line of the falls continues after the fashion prevailing for the last few years, the impairment of the scenic grandeur of the falls will be very serious. One suggestion is the placing in the river of submerged diversion weirs or vanes, by which the water will again be distributed over the whole crest of the falls.

Erosion of Horseshoe Fall

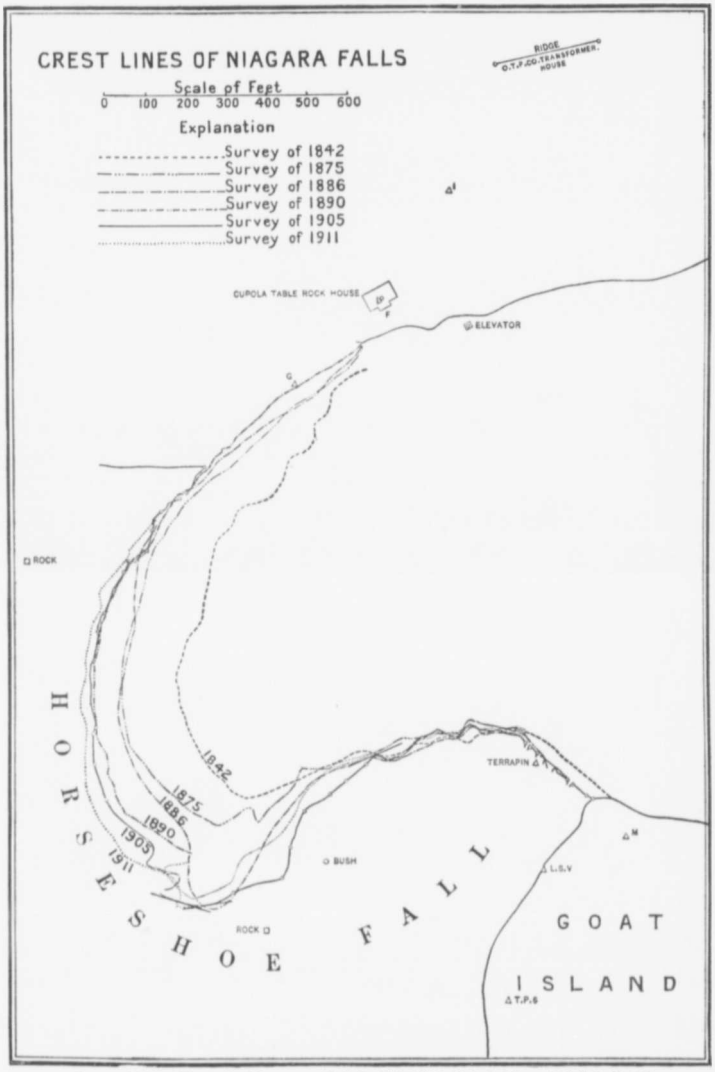
Mr. John L. Harper, chief engineer of the Niagara Falls Power Co., in an interesting and succinct manner, draws attention to this subject in a recent pamphlet, *The Suicide of the Horseshoe Fall*. Mr. Harper states:

"The 'American,' or lesser fall, carries only slightly more than five per cent of the total discharge of the Niagara river, and yet it forms at least twenty-five per cent of the total scenic spectacle.

"In these days, when engineers do not shrink from undertaking what has seemed in the past to be impossible, it should be the policy of those controlling the falls at Niagara to have constructed in the bed of the river, above the Horseshoe fall, invisible current deflectors, which would make impossible the gathering of the whole river into a deep, narrow gorge, and would again deflect its water over the sides and heels of a re-established horseshoe, not only improving the present spectacle, but causing the whole contour of the fall to wear uniformly, so that coming generations, in viewing its beauty, may also have before their eyes the emblem of good luck. .

"From actual observations, made during the past ten years, it is known that the crest is receding at the point of greatest erosion at the rate of approximately eight feet per year, while, on the sides and heels, almost no recession is noted. . . .

"The American fall, with its outflow of five per cent of the volume of the river and one thousand feet of crest, can be maintained exactly as it is now. Thirty-five per cent of the outflow of the river can be properly distributed over the three thousand feet of crest of the Horseshoe fall, covering it with a cascade more than twice as deep as that of the present American fall, and, with the much smaller



Surveys of 1842 to 1905 reproduced from map published by United States Geological Survey in Bulletin No. 306.

amount of water, produce a scenic effect equal in grandeur and greater in extent than the present one. This would, at the same time, arrest the destruction of the beauty of the horseshoe shape, which is now daily disappearing under the eroding forces of the misdirected torrents, and the loving and courageous hand of direction would replace the wastefulness and destruction which must follow negligence and inaction."

If the preservation of the scenic grandeur of the falls is really desired, certainly it is not being attained if the Horseshoe fall continues to erode as at present.

Anticipated Water-Power Developments and Market for Electric Power

Hope is expressed by many that, during the next few years, there will be throughout Canada an almost unprecedented activity in water-power development. In this development all the provinces, according to the measure of their respective possibilities, will participate. In view of the large amount of electric power absorbed by manufacturers of munitions of war, it has been concluded by some that after the war there would necessarily be a large unused surplus of power, and that this condition would maintain for a considerable period. This conclusion, however, appears to be unwarranted.

Respecting the power used by munition plants, one is apt to overlook the very important fact that a considerable block of this power was only made available by taking away a percentage of the power being used by municipalities and by manufacturers not engaged upon strictly war work, and also, by checking such growth of power consumption as normally takes place. To make electric energy available for munition work, municipalities in the Niagara district of the Hydro-Electric Power Commission were required to reduce their consumption from 15 per cent to 30 per cent below their respective maximum demands of December, 1917. Toronto was thus reduced by 7,000 h.p., Hamilton 2,000 h.p., London, 1,500 h.p., and other municipalities by amounts totalling 7,000 h.p. Thus municipalities were curtailed to the extent of some 17,500 h.p. from their load maximum demand of about two years ago, and, in addition, consumers were not permitted to take advantage of such increased growth of consumption as would naturally have occurred during the same period.

In addition to this curtailment of natural growth, new enterprises were unable to contract for power, and some companies, such, for

example, as the Beaver Wood-Fibre Co., of Thorold, which had a new contract for an extra 5,000 h.p., were unable to secure same. This company is now pressing for delivery of this 5,000 h.p. The National Abrasive Co., of Niagara Falls, has contracted for 2,500 h.p. which they have not yet received. Several industries in the Essex-Kent peninsula are ready to take some 4,000 to 6,000 h.p. additional power. A number of smaller municipalities have also been waiting to take on new loads, which would result in immediate permanent business for the Commission of at least 4,000 h.p.

Again, there may be some adjustment respecting temporary contracts, such as those with the Toronto Power Co., whereby the Hydro-Electric Power Commission may be deprived of some of the power it has been using.

Another aspect of the situation is that a number of the largest consumers of power, such as the American Cyanamid Co., of Niagara Falls, Ont., which has a firm contract for 26,000 h.p., and, during the war, has been making chemicals for the United States, will resume its production of fertilizers and other chemicals. The Electro-Metals Co. will continue to use its present 11,000 h.p., and possibly, 30,000 h.p. The Union Carbide Co., with its firm contract for 16,000 h.p., will probably resume its pre-war activities, when, at times, off-peak power was used up to 40,000 h.p. The Ontario Paper Co., of Thorold, which has a peak contract for 3,500 and an off-peak contract for 11,000 h.p., desires additional power.

Having in mind the facts just mentioned, and excluding the large Niagara Falls companies to which reference has just been made, it may be summarized that, the Hydro-Electric Power Commission, on account of the cessation of the production of war munitions, will now lose loads probably totalling some 35,000 to 40,000 h.p.—really corresponding only to a loss on peak load of about 25,000 h.p. On the other hand, it is clear that whatever power is now being released, and which is resulting in relieving the almost intolerable peak load conditions which have lately maintained, will readily be absorbed in overtaking the curtailments of usage and growth in power consumption which were placed on municipalities and others.

It is further believed that a portion of the 50,000 h.p. additional which is being made available by the Ontario Power Co.'s third pipe-line will be required to meet early demands of such consumers as above referred to; in short, that the past experiences with respect to power demands will be repeated in the future.

Proposed New Legislation Respecting Water-power

There is under consideration much new legislation and regulation respecting the development of water-powers. In the United States, there are several bills before Congress suggesting means for the better utilization of existing electrical and mechanical power and for the development of new sources of such power; also for the acquisition by expropriation of property and rights necessary for the improvement and increase of facilities for the development, transmission, distribution, and supplying of electrical energy; also for the control and regulation of the use of boundary waters of the United States for power and other purposes. Such activities demonstrate a recognition of the great importance which attaches to hydro-electric power.

In Canada, the Dominion Water-power Board, created—by order in council of April 25, 1918, under the chairmanship of Hon. Arthur Meighen, Minister of the Interior—for the purpose of assisting the Government to take prompt and constructive action to provide for the future fuel and power needs of the country, and to assist also in co-ordinating governmental activities relating thereto, had under consideration at its first general meeting the problem of co-ordinating certain legislation and regulations relating to water-power development in the various provinces.

The Sub-committee on Water-power Development of the Chamber of Commerce of the United States, in 1918, published its report, in which it draws attention to a number of special engineering and economic aspects of power development.

Certain recommendations regarding the fundamental points in connection with a federal policy designed to accomplish what the committee regards to be highly beneficial results in the public interest, are as follows:

I.—As to all developments, whether within or outside the public domain, a separate Act of Congress should not as at present be required for each development; but the authority to issue permits should be vested in some department or commission designated for that purpose and under conditions protective of the interest of the public and of the investor.

II.—Permits should be issued for a period of at least 50 years, unless at the option of the applicant a shorter period is agreed upon, and should be irrevocable except for cause.

III.—A toll should be imposed by the Government only on power developments on the public domain or benefited by headwater improvements maintained by the government. Such tolls should be based upon the horse-power actually developed, used and sold. The

tolls should be reasonable, and proportionate to the benefits actually derived.

IV.—If public lands form only a small and incidental part of the entire development, the licensee should be entitled to acquire the right to use such lands, paying the government fair and just compensation for such use.

V.—At the expiration of the license period, the government should have the right to recapture the property for itself or for a new licensee upon the payment of fair and just compensation for the property and for all dependent property, if taken; and if the dependent property is not taken, then fair and just compensation should be paid for all severance damages.

Provision should be made that, all things being equal, the original licensee have priority over any new licensee.

VI.—At the expiration of the license period, the government should (1) agree with the licensee as to the terms of a new license, (2) recapture for itself or for a new licensee, or (3) continue the license under the original terms.

VII.—Rates and service should be regulated by state commissions, where the service is intra-state; and only by federal authority where the service is inter-state and the commissions of the states which are directly concerned do not agree or there is no state commission.

The exercise of any federal jurisdiction over the issuance of securities would be unnecessary and unwise.

VIII.—No preference should be allowed as between applicants, whether a municipality or otherwise, which amounts to the granting at the expense of the government of a subsidy creating unequal competition in the same market.

Water-power Investigation in New Brunswick

During the past year, the Commission was again consulted by public organizations in the province of New Brunswick respecting the utilization of water-powers within a radius of certain centres requiring additional power As Consulting Engineer, I visited the province and, in brief, advised that the work of stream investigation, etc., being undertaken by the new Water-powers Commission of New Brunswick, was along satisfactory lines, and should result in placing the authorities in possession of such information as would, at an early date, enable them to appraise upon an economic basis the possibilities of water-power development in various localities.

National Saving of Fuel and Power

The European war has resulted in impressing upon us the vital importance of coal. Practically all industry is dependent upon coal. The United States, producing practically half the present world coal consumption, has, through its Fuel Administration, been com-

pelled to curtail coal consumption by cutting off unnecessary or wasteful uses, and by requiring, wherever possible, consumption only under conditions making for increased efficiency.

Enormous Coal Production

In endeavouring to convey an idea of the enormous quantity of coal produced annually by the United States, the Fuel Administration, in 1918, stated:

"Every year the miners go into the ground and dig out coal, and the railroad ships it for hundreds of miles, dragging back the empty cars, until the amount mined is $2\frac{1}{4}$ times the earth and rock removed in digging the Panama canal. It took sixteen years to dig the Panama canal. The miners will dig $2\frac{1}{4}$ Panama canals this year."

During the battle of Verdun, the French fired 60,000,000 shells, containing nearly 1,800,000 tons of steel, the production of which consumed nearly 9,000,000 tons of coal, equal to 25 per cent of Canada's annual consumption. Throughout the war, the coal situation has been *the* factor governing the production of manufactured articles. Every large coal-producing country, except the United States, found it impossible to maintain the pre-war production of coal.

Canada, like the United States, has striven to reduce her fuel consumption, but, being still dependent upon the latter for 22,500,000 net tons—including over 5,000,000 tons of anthracite—out of a total yearly consumption of 34,800,000 net tons of coal, it is clearly incumbent upon Canada to apply every means within her power to utilize coal in the best and most efficient manner. This, besides being an evidence of common-sense, will also result in the saving of a large amount of money now lost in coal wastefully used.

Fuel Restrictions and Economies

"Heatless days;" the times when gasolene could not be used; the denial of fuel for certain luxuries, as use on private yachts; the curtailment of fuel for the manufacture of such apparatus as musical instruments, talking machines, etc.; the allotment to florists for greenhouse purposes of only 50 per cent of the fuel they were accustomed to receive; the compelled use in certain districts of wood for fuel; the restrictions upon the use of natural gas; the prohibited use in many cases of anthracite coal and the substitution therefor of bituminous coal; the day-light saving legislation on both sides of the Atlantic; the cutting down of illuminated advertising and the enforced "lightless nights;" these and many other facts must be held in mind as indicating how widespread and absolutely necessary have been the efforts for economy with respect to fuel.

Although the efforts of the fuel administration, the termination of hostilities and a providentially mild winter, have reduced the great stress in the fuel situation, nevertheless in the period of reconstruction

and afterwards, the demand for fuel will doubtless be such that many of the restrictions placed upon its use and conservation during the war period will, in one form or another, find permanent expression; and hence are here to stay.

In Europe, the great lesson of how to use coal economically has been learned. As a leading United States journal recently stated:

"They have learned how to use coal economically in Europe through having to pay all the way from $20 to $90 a ton for it. The man who is paying that does not need any fuel administration to urge him, on patriotic grounds, to stop wasting coal. He develops the keenest interest in that subject without prompting and he saves the coal."

The writer declares that the United States Government does not propose to dispense with its regulation of the coal industry, and adds:

"The Government will not take its hand off; it wants poor people to have a chance of fuel too. It gives the people the benefit of an inexorbitant price. They ought to show their appreciation by using the coal just as carefully as though they were paying the European price."

Canada has by no means wrestled as she should and must with the solution of her national fuel and power problem. Peat-producing equipment is being constructed, and the building of a lignite briquetting plant is under consideration.* These efforts, which are in the right direction, should be given the best possible support, but they should have been undertaken and consummated years ago. While waiting for lignite production, etc., for relief, Canada, by properly applying the lessons of the past fuel shortage, may effect economies in the use of fuel which will result in saving much greater quantities of coal than will be produced by such peat and lignite plants as may be in operation within the next few years.

We desire, therefore, to emphasize the need for making every reasonable improvement which will result in the saving of fuel. The best possible efforts, under government and other expert engineering guidance, should be made to make permanent such economies as have been demonstrated through the efforts of fuel-controlling and other organizations in European countries, in the United States, in Canada and elsewhere. Let us consider some of the chief means by which these economies have been and may be effected:

*Consult *Carbonizing and Briquetting of Lignites*, by W. J. Dick, Commission of Conservation, Ottawa, 1917; also, by same author, "Canada's Own Coal and the Fuel Problem," in *Industrial Canada*, April, 1918; also *The Briquetting of Lignites*, by R. A. Ross, Honorary Advisory Council for Scientific and Industrial Research, Ottawa, 1918; also, *Fuels of Western Canada and their Efficient Utilization* (revised edition), by James White, Commission of Conservation, Ottawa, 1918.

Saving of Power and Light in Factories

Efforts were made by the United States Fuel Administration to induce several coal-using factories to effect economies in light and power by the utilization of more efficient lamps; the cleaning of dirty windows; the rearrangement of machines and shafting and the proper alignment of shafting; changes in elevator service; insulation of steam piping and cutting out unnecessary steam lines; grouping of machines in a manner to flatten as much as possible the load curve; testing of power circuits for relationship of capacity with a view to their better inter-connection; stopping of motors when the attached machinery is idle; correction of motors and other apparatus out of adjustment; installing of proper protection about doors, windows, elevator-shafts and stair areas, etc. Such efforts have resulted in effecting a coal saving in factories of from 11 to 34 per cent.

Elimination of Uneconomical Plants and Processes

In the United States there were found in factories, office buildings, hotels, apartments, institutions hospitals, etc., about 30,000 local electric-generating plants. Many were readily supplied from some adjacent large central station. Where changes were made a general fuel saving of from 20 to 60 per cent resulted. Effort is made to treat each case on its individual merits. By way of illustration, in Chicago the Power and Light Committee induced the Chicago and Western Indiana railway to close its pumping plant and substitute electric power. The Sanitary District Power Co. was induced to enter into an agreement with the Commonwealth Edison Co. Chicago now uses the Sanitary District water-power at its largest pumping station. By these three changes an estimated annual coal saving of 73,550 tons will be effected. A corresponding consolidation supplied with power from the Keokuk plant effected a yearly saving of about 110,000 tons.

Direct Heating for Industries

Fuel is being saved in industrial furnaces where used for direct heating, such as is necessary in the clay products industries. The United States Fuel Administration estimates a probable annual coal saving of 3,000,000 tons.

Refrigeration

Fuel economies can be effected in the ice-manufacturing and refrigerating industry, where, by way of illustration, it takes less power to produce opaque than clear ice, the former being quite satisfactory for many purposes.

Steam Turbines

The efficiency of a modern steam turbine approaches 80 per cent, although the terminal efficiency—that is to say, the ratio of the heat units equivalent to one kilowatt-hour at the generator terminals divided by the heat units in

the fuel consumed to produce one kilowatt-hour—is, in actual practice, rarely higher than 20 per cent. Research is devoting special effort to improvement in this field, and some look to the vaporization of a combination of fluids instead of simply water.

Standardization

Effort is being made to standardize, within reasonably flexible limits, such apparatus or portions of apparatus as do not require to possess such variations as have hitherto existed. Take, for example, the standardizing of frequency for electric systems. We may expect that, profiting from the lessons of the past, where new lines of industrial activity are opened up, there will be an increased effort to conform to certain basic standards, thereby avoiding complexity and inefficiency such, for illustration, as are found in portions of the electric systems referred to below as existing in Greater London.

Action to Conserve and Efficiently Utilize Coal in United Kingdom by means of Central Stations

In the Unitd Kingdom, the methods of mining and using coal have been the subject of an important and comprehensive investigation by the Coal Conservation Committee of the Ministry of Reconstruction. Its final report was issued in 1918.

The present coal consumption, *for power purposes*, in the United Kingdom is at least 80,000,000 tons. By proper co-ordinated and centralized systems of power production and distribution for the whole country, it is estimated that 55,000,000 tons of coal per annum might be saved and, in addition, the following important advantages would result:

A reduction in the cost of transport in carrying coal.

A possible saving in coal consumption for domestic purposes (the consumption for which purpose is now probably 35,000,000 tons per annum).

The reduction in the cost of coal handling involved in house-to house delivery and general coal distribution.

The great advantages and economies which would result from the more extended use of electricity in the household for heating, cooking, and cleaning purposes, in the way of labour-saving devices, reduction of smoke, increased cleanliness, etc.

The possibillty of utilizing the coal at present left in the pits or otherwise wasted.

The possibillty of extracting by-products, etc., before consuming the coal for power purposes.

The increase in railway electrification, with its attendant advantages, which a comprehensive electric power supply system would render commercially possible and profitable.

*See *Final Report*, Coal Conservation Committee of Ministry of Reconstruction, London, Eng., 1918.

All these savings and advantages, taken together, show a total possible national advantage which can hardly be put at less than £100,000,000 per annum, apart from the manufacturing and industrial advantages of a cheap and efficient electric power supply. The Reconstruction Committee lays special emphasis upon the part which power will play in the cost of manufacture and in the matter of international industrial competition, to which all countries are devoting such great attention. The economies resulting from the supplying of power to industry through the agency of the electric motor are everywhere recognized. In the munition factories erected during the war 95 per cent of the machinery was electrically driven. The Committee therefore points out that the problem is not so much how to apply power to tool or process as the case may be, but how best tc generate and distribute the electric power required.

As some indication of the technical difficulties to be overcome in Great Britain, in Greater London alone there are 70 different authorities, 70 generating stations, with 49 systems of generation, 10 different frequencies, 24 different distribution voltages, and 70 methods of charging and prices. It is not surprising to learn that, under such conditions, the average size of unit is under 700 k.w., and the average size of station less than 6,000 k.w. In addition, there are 9 traction stations, used chiefly for supplying power to the rapid transport systems.

The Committee recommends that, instead of over 600 districts, as at present, Great Britain should be divided into some 16 districts, in each of which there should be one authority dealing with all the generation and the main distribution. For each district, there would be a standard frequency and voltage for the trunk mains, into which power stations situated at the most advantageous sites would feed, and into which could be fed also power derived from surplus gas or waste heat. Especial attention would be given to the development of power at the pit mouth, where coal, which it does not pay at present to bring to the surface, might economically be utillzed. The main steam-power stations would be very large, probably 150,000 h.p. or over, with units of from 20,000 h.p. to 50,000 h.p. They would be constructed preferably outside the centres of population, in situations where ample area could be obtained to permit the erection of by-product recovery plants, and, in some cases, the establishment of electro-chemical industries.

A bill to give effect to many of the recommendations of this, committee is at present being considered by the British Government.

United States Taking Action Respecting Central Steam Plants

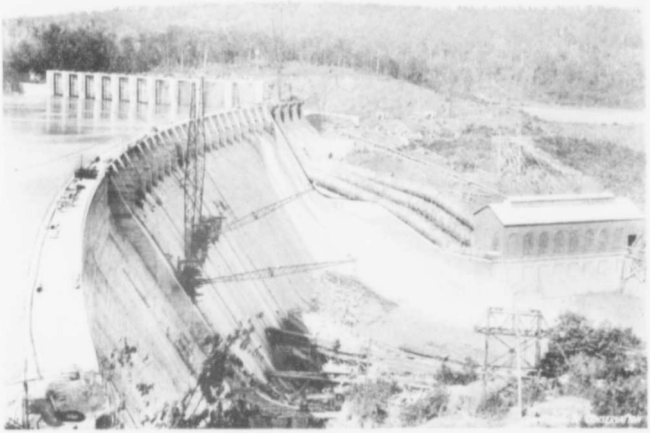
Regarding the centralization of plants at or near the coal mines, L. H. Rittenhouse, chief of the Power Section, Production Bureau of the United States Fuel Administration, states:

"There are a number of large modern central station electric power plants installed in the various coal regions of this country. The purpose for which these were built was that of supplying electric energy to the coal mines for the purpose of operating their machinery in the production of coal. Among some of the more important of these plants may be mentioned: The Virginian Power Co., Charleston, West Virginia; The Logan County Light and Power Co., Logan, West Virginia; The Appalachian Power Co., Bluefield, West Virginia; The West Penn Power Co., Pittsburg, Pa.; and others.

"These companies have large turbo-generators, some up to 20,000-k.w. capacity, and, of course, are more economical than the many isolated plants at the various collieries which have been supplanted by these modern stations. As an investment proposition, they apparently pay the owners a good return, and most of those mentioned, as well as others, were in operation before the war. The Government encouraged the operation of, and additions to, these central power plants during the war through the activity of the Power Section of the Production Bureau. Not only was the conservation in coal recognized as a necessary and worth-while result, but the saving in labour and in iron and steel that was brought about by the operation of large units was recognized and full advantage taken in the planning of new and additional power facilities in the respective coal-fields. In other words, it was impossible for an individual coal operator to install a small or medium-size power plant if central station service was available. This policy was maintained through our co-operation with the Electrical and Power Equipment Section of the War Industries Board, which section had complete jurisdiction over all power-house apparatus."

Respecting the still broader question of conservation through the elimination of a great deal of the coal distribution by construction of power plants in the coal districts, the electric energy being transmitted to the various industrial centres of the country over high tension transmission lines, Mr. Rittenhouse continues:

"To a certain extent, this result is accomplished by the power stations referred to above, as they transmit at voltages up to 60,000 and over distances reaching 100 miles in some cases. However, these plants are primarily intended to supply the energy required in the coal mines themselves, and most of them are at too great a distance and of insufficient capacity to economically distribute power to large industrial centres along the eastern seaboard. It will only be a question of time, however, before large super-stations will be



NARROWS DAM, YADKIN RIVER, BADIN, NORTH CAROLINA

With the exception of the Cheoah dam, this is the highest overflow dam in the world. Tallassee Power Co., a subsidiary of the Aluminum Co. of America. Maximum height, 216 feet; total length, 1,875 feet; length of spillway, 644 feet, maximum discharge of spillway, 160,000 second-feet; maximum discharge of bypass, 160,000 second feet; total discharge capacity 260000, sec. ft.

CHEOAH DAM, LITTLE TENNESSEE RIVER, NORTH CAROLINA—THE HIGHEST OVERFLOW DAM IN THE WORLD

Tallassee Power Co., a subsidiary of the Aluminum Co. of America. Maximum height, 225 feet; total length, 740 feet; length of spillway, 626 feet; maximum discharge, 160,000 second feet; closure tunnel 20 x 20 feet; emergency tunnel, 30 x 30 feet, for passing floods.

constructed in some of the coal-fields, particularly those near the congested industrial sections in the east, and full advantage taken of the opportunity to burn culm or refuse coal, together with the advantage of distribution at high voltage to industrial centres. The Government has fully recognized the desirability of the adoption of the above plan, in that there will be a saving in coal consumption, man-power, transportation, etc. Indeed, this very problem had been approached just previous to the signing of the armistice."*

Smoke Nuisance

While discussing the direct saving of coal, we should not overlook the important cognate subject of smoke nuisance. The Commission of Conservation has, at various times, drawn attention to the fact that smoke prevention ordinances should be strictly enforced. The present is an opportune time again to draw special attention to this subject.†

Due to the widespread employment of hydro-electric power in our factories, and to the very extensive use of anthracite coal for domestic purposes, the smoke problem has not previously been forced upon the attention of the Canadian public at large to the same extent as during this winter. The required substitution of much soft coal for anthracite, and the incomplete combustion due to apparatus and chimney flues not being best adapted for the consumption of soft coal, have resulted, at times, in charging city and town atmospheres with an amount of smoke not before observed in this country. In view of the fact that, in future, soft coal may have to be used to a greater extent, increased attention should be given to the installation and operation of efficient smoke-consuming devices. Steam locomotives contribute a great deal of smoke, which the use of electric locomotives within city boundaries would greatly lessen.

Before directing attention to the great savings in power and light which may be effected by the co-ordination and inter-connection of power plants and systems, we shall very briefly enumerate certain other efforts made to effect economies in other fields of power consumption.

Railway Electrification

The near future promises increasingly great development of hydro-electric power for use in the electrification of railways now using steam motive power. The Director-General of Railroads of the United States has stated that, if the Government were to continue the administration of the railways for any prolonged period, he would be in favour of resorting to the use of electricity just as far as it could practically be employed.

*Letter from U.S. Fuel Administration to A. V. White, December 30, 1918.
†See *Fourth Annual Report*, Commission of Conservation, Ottawa, pp. 189-205.

He stated that, probably, electrification would actually be undertaken while the Government controlled the railways and that the problem would be attacked at favourable points where water-power possibilities were most advantageous and where the cost of making the change from steam to electricity would be comparatively slight. The saving in cost of subsequent operation, he said, would be such a convincing demonstration, that electrification as a general policy would be demanded by public opinion.

In Canada there is much agitation for the creation of suburban electric lines and for the electrification of steam railways. The general railway situation, however, is in a transitional state, and it is not possible to predicate just where and what developments in electrification may take place in the near future.

Regain of Electricity

In connection with main-line electrification, there is the saving of power effected by the employment of re-generative control, *i.e.*, utilizing the weight of trains running down grade to generate electricity which is returned to the system.

The Skip-Stop System

In lieu of the old plan of having electric tram-cars stop on signal on any street corner, thus making from 12 to 14 stops per mile, railway companies have been induced to reduce the stops to not more than eight per mile in business districts, six per mile in residence districts, or four per mile in open country. By these means a saving of from 10 to 15 per cent in fuel has been effected, while, in addition, the time per trip of the cars is reduced without increase in speed. By way of illustration, the Connecticut Company has reported a saving of fuel of 10 per cent for its New Haven lines; other reports indicate saving at rates varying from 3,600 tons per year in Columbus, Ohio, to 21,000 tons per year in Detroit, Mich.

Staggered Hours of Closing

As a means of smoothing out the load curve, staggered hours for closing appear to offer great promise. A recent investigation made in Boston showed that at least 15,000 k.w. in generating capacity would be saved on the system of the Edison Electrical Illuminating Company if 30 industrial establishments would change their working hours by 30 minutes. Fifteen thousand kilowatts represents about one-sixth of the total estimated peak load of the Boston system for this winter. The comparatively small change in closing hours required to effect such a large increase in available capacity is very striking.*

*This statement was made at a recent meeting of the Boston section of the A.I.E.E., by Mr. L. L. Elden, electrical superintendent of the company. See *Electrical News* (Canada), January 1, 1919.

Restricted Possibilities of Electric Heating

For years past I have been emphasizing the comparatively limited use which can be made of electric energy as a wholesale substitute for coal for heating, including the heating of buildings. The sooner it is realized in Canada that hydro-electric energy, as a heating agent, can never be an adequate substitute for coal in Canada, the sooner will action be concentrated upon sources from which real relief may be derived. It is useless to entertain hope respecting a source whence no sufficient relief can be obtained. At our Annual Meeting in November, 1917, I stated that "The extent to which electric energy will be available for heating has been much overrated and, realizing the underlying physical limitations, one cannot be enthusiastic respecting the extent to which it may be utilized."

During the past year, increased attention has been given to this subject, and the press, both technical and public, has referred to the matter in a manner which clearly shows that, at last, it is dawning upon the public mind that electric energy as a wholesome substitute for coal is a forlorn hope.† If it is to be used wholesale, then electrical

*Consult "Electricity Will not Replace Coal," by Arthur V. White, in *Industrial Canada*, Toronto, April, 1918; also by same author, "Coal Problem of Canada Demands National Action—A Solution of a Vital National and International Question" in the *Monetary Times*, 4th Jan., 1918, pp. 25 *et seq.* See *Monetary Times*, 1st March, p. 18, also "Possibilities Ahead of the Gas Industry as Revealed by a Digest of Reports from Various Sources," by G. W. Allen in *Proceedings of 11th Annual Meeting of the Canadian Gas Association, 1918.*

The underlying principles governing in this electrical heating proposition are simple and may readily be understood by the general reader.

In order to determine what is technically termed the *mechanical equivalent of heat*, J. P. Joule, an Englishman, about 1850—and subsequently a number of other experimenters—ascertained the number of foot-pounds of energy required to raise one pound of water one degree Fahrenheit. In their simplest form, the experiments consist of confining a known quantity of water in an insulated vessel and transmitting to the water by means of agitated vanes—like a churn—the energy developed by a known weight falling through a given distance. Taking into consideration the result of various experiments, this equivalent may be taken at 778 foot-pounds. It may be stated, for example, that 778 pounds falling through one foot will develop energy sufficient to raise one pound of water one degree Fahrenheit. This heat unit is termed a British thermal unit, or B. T. U.

Now, by definition, a horsepower, is 33,000 foot-pounds per minute, or 33,000 x 60 foot-pounds per hour. If, therefore, we divide 33,000 x 60 by 778, we obtain 2,545 as the heat units derivable from one horse-power-hour of energy. Correspondingly, the heat units derivable from one kilowatt-hour are 3,412.

It makes no difference, of course, what prime agency has resulted in the development of the power. Consequently, it may be stated that *one horse-power hour of electrical energy only yields approximately 2,545 heat units. One pound of anthracite coal contains about 14,000 heat units.*

†The Hydro-Electric Power Commission of Ontario recently issued two valuable papers by A. S. L. Barnes, namely *Report of the Rate of Coal Consumption in Various Electric-Generating Stations and Industrial Establishments in Canada and the United States;* also, *Report on the Heating of Houses—Coal and Electricity Compared.* (The same discussion is published by the Honorary Advisory Council for Scientific and Industrial Research as *Bulletin No. 6.*) Consult also valuable article "Heating Our Homes with Electricity," in the *Electrical News*, Toronto, Feb. 1, 1919.

energy is more efficiently employed for power than for heating purposes. For many manufacturing processes requiring heat, and as an auxiliary heating agent for buildings, etc., electricity has a wide field of usefulness. Great economies in coal will be effected by a proper co-ordination of electricity, coal and gas, according to their respective spheres of greatest efficiency.

Growth of Co-ordination of Power Production

Greatly increased attention is being given to the subject of the inter-connection of various electric plants—whether steam-electric or hydro-electric, or combination of both—with the object of securing greater efficiency in the supply of power and light to districts respectively served. The editor of the *Electrical World*, referring to this subject recently, stated that "Economic co-operation is going to be one of the key-notes of the reconstruction period, and, whether an engineer believes that interconnection will pay or not in a given case, he will do well to analyze its prospects."*

In the United States, the Fuel Administration commenced investigations in different sections of the country to ascertain the operating status of various power-producing companies, in order to determine how best to co-ordinate their activities to the end that coal might be conserved. Commenting in general terms upon these efforts, Mr. L. R. Clapp, chief of the States Conservation Bureau of the Federal Administration, writes:

"The inter-connection of power systems, both steam and hydro-electric, offers an opportunity for real fuel economy and has received the active attention of this bureau. In many parts of the country duplicate transmission systems exist, serving practically the same territory. One or more of such lines may derive all or nearly all of its power from water, while other companies use coal. No company operates with a continuous one hundred per cent load factor, and almost always the peaks are different for different companies. Therefore inter-connections permit the use of the maximum water-power, and also allow an increase in the average load factor. In its hydro-electric work the bureau has had the assistance of the Geological Survey, and much work of permanent value to the country has been effected along these lines. Another similar activity is the possibility of closing down an uneconomical central station where, in the same territory, a more efficient power plant is able to give the same service. It is estimated that there are, throughout the country, nearly 500 instances of such duplication, and several consolidations have been effected. The savings which have resulted from this work have been estimated to be some 540,000 tons of coal in the calendar year

Electrical World, New York, Dec. 21, 1918.

1918. In general, we feel that this has not been a particularly profitable field for emergency conservation work, the projects involved requiring far too much time for their consummation for immediate benefit. Over a ten-year period, perhaps, important coal economies could be effected by this means."*

Heretofore, efforts have been concentrated in securing the efficiency of the unit apparatus of power-generating stations, such as turbines, generators, transformers, etc., but, now, efforts are being directed to increasing the efficiency, not only of units as such, but of the systens of which the units are an integral part. In this connection such questions as the load factors of generators and of systems, the diversity factor, etc., are being subjected to scientific analysis. The creation of super-power stations, suitably situated with respect to cheap and reliable supplies of coal, of water, of raw materials, for shipment and other purposes, will receive increasing attention. In connection with all these matters the greatest care should be taken not to disturb ruthlessly existing organizations and installations, but rather to seek out ways and means by which they may be adapted in some ready and efficient manner to the new general scheme.

Fuel Administration Efforts in New York

Let us now consider more particularly some of the definite lines of investigation being conducted by the United States Fuel Administration. First, it may be instanced that in the Capitol district in the state of New York, which comprises the general territory adjacent to Albany, Troy, and Schenectady, there have been in operation six prominent power companies, namely, the Adirondack Electric Power Corporation, Cohoes Power Co., Hudson Valley Railway Co., Municipal Gas Co., of Albany, General Electric Co., of Schenectady, and the General Electric Power Co., of Schaghticoke. The two-first named companies, the Adirondack Electric Power Corporation, with power plants at Spier Falls and at Mechanicville, on the Hudson river, and the Cohoes Power Co., with a plant on the Mohawk river at Cohoes, are essentially hydro-electric companies using steam stand-by plants. The Adirondack Company also purchases power from a plant owned by the Hudson Valley Railway Co., at Mechanicville, which plant burns birds-eye anthracite coal, and from the steam plant owned by the Municipal Gas Co., in Albany. The Adirondack Company is essentially the distributing company for the entire district, although each power company has operated within its own territory without much competition.

*From letter to A. V. White, January 3, 1919.

Under ordinary conditions, operating independently, the power companies used *all* the water available at their respective plants, and then depended upon steam-plants for additional power, although, at the same time, one or other of the companies often had surplus water available, due to the diversity factor of their requirements.

At the request of the Fuel Administration, a special study was made of the various companies' load factors, equipments, and prospective requirements. This study developed the fact that the companies operating under a master load despatcher could make use of a considerable amount of the water-power which would otherwise go to waste. This condition was due to the existence of the new Barge canal with its storage reservoirs.

The Cohoes Power Co., situated as it is at the mouth of the Cohoes river, could take advantage of all the surplus water in the Barge canal. Under ordinary operation, it did not make use of the entire surplus waters of the canal. However, as the company was inter-connected with the Adirondack Co., that is, the distributing company, it was possible to pump this surplus power, so to speak, into the lines of the Adirondack Co., and thus, in a large measure, dispense with the steam plants which they were using.

At the suggestion of the United States Fuel Administration, the companies arranged to co-ordinate their developments, and are now operating under a combined system, in which the Adirondack Electric Power Corporation acts as master load despatcher. This co-ordination has necessitated practically no additional expense for new equipment in order to effect this considerable saving in coal.

Fuel Administration Efforts in Pennsylvania

In Pennsylvania special investigation has been made with the object of encouraging the power plants of the state, by co-operation, to develop, as far as possible, steam-electric power at the mines, transmitting the power by electricity instead of in the form of fuel. Incidentally, the development of power at the mines frequently enables a grade of fuel to be used which it would not pay to mine and transport.

Reporting upon this subject, the State Fuel Administrator of Pennsylvania has stated that "the generating of from 200,000 to 250,000 kilowatts at the mines will result in a net saving of transporting 1,000,000 net tons of coal annually from the mines to industries. This saving in railroad transportation will be more than enough to pay for the investment in transmission lines. The transmission would thus fulfil two functions, either one of which independently would be more than sufficient to justify the investment

by the demand upon our manufacturing resources and man-power. The net result of the investigation seems to indicate the annual saving of 500,000 tons of coal and obviating transportation of 1,000,000 tons of coal."

Fuel Administration Efforts in New England States

Several companies in the New England states are considering a complete inter-connection of the plants in Eastern Massachussetts. The plan under consideration would probably save in the neighbourhood of 70,000 tons of coal per annum and release about 50,000 k.w. generating capacity. The matter is in the hands of a conference committee of central station interests. Representatives of the War Industries Board, the Massachusetts Gas and Electric Light Commission and the Conservation Division of the United States Fuel Administration, have been in conference with representatives of the central stations, and all are agreed that the plan could be made effective. It is estimated that by inter-connection, the fuel consumption in the plants involved, about seventeen in number, would be reduced from an average of 2.38 pounds per k.w.h. to 1.93 pounds per k.h.w., representing a direct saving of 40,000 tons of coal. The plan does not involve the discontinuance of any of the generating plants composing the complete system. Each plant will be required to operate for a portion of each year, the most economical plants running more continually, the inefficient plants being used for peak-load requirements. The quantity of power involved is in the neighbourhood of 200,000 k.w.

Chicago, Milwaukee and St. Paul Ry. Electric System

One striking, if not the most striking, instance of the co-ordination of electric power plants is that effected by the Chicago, Milwaukee and St. Paul Railway Co., for the electrification of some 440 miles of its railway. Here twelve hydro-electric plants and four steam plants are co-ordinated so as to feed into the general transmission system.*

Co-ordination of Power Systems in Canada

The Hydro-Electric Power Commission of Ontario, in the extension of its various power installations, has also been seeking greater efficiency by interconnecting and co-ordinating several of its systems until, in effect, they form one comprehensive unit.

By way of illustration, interconnection has been arranged between the Wasdell Falls system, taking power from the Severn river, with a head of about 14 feet and an installation of 1,200 h.p.; the Orillia system, with development at Swift rapids, on the Severn

*For further description consult "Electrification of Railways," by S. T. Dodd, in *Ninth Annual Report*, Commission of Conservation, Ottawa.

river, under a head of about 50 feet, and with 5,000 h.p. installed; the Eugenia system, developing at Eugenia falls, on the Beaver river, under a head of 550 feet and with a machinery installation of 8,800 h.p.; and the Severn system, with development at Big chute on the Severn river, under a head of about 58 feet, with an installation of 5,600 h.p. The steam plant at Owen Sound has been kept in commission, and, at times, is used to help on the Eugenia system, and the steam plant at the Canadian Pacific elevator at Port McNicoll is correspondingly used on the Severn system.

It is under consideration to have the Muskoka system also co-ordinated to this group. This plant is situated at South falls, on the South branch of the Muskoka river, under a head of 106 feet, with installed capacity of 1,750 h.p. and a possible capacity of about 6,000 h.p.

The Commission has also proposed a new development at Port Elgin, on the Saugeen river, under a head of 80 feet, with an estimated complete development of from 10,000 to 15,000 h.p. This, when constructed, will supply some twelve to fifteen municipalities, which, at present, are utilizing coal for the production of light and power.

It may be explained that, at the Muskoka and proposed Saugeen developments, largely increased power may be obtained at times of flood flow. The Eugenia plant, on the other hand, is essentially a storage proposition, and can, therefore, at times of flood flow impound waters which, subsequently, can be released in order to augment shortage of power resulting from low-water conditions at, say, the Muskoka or Saugeen plants.

In the above districts we find the feasibility of co-ordinating at least six hydro-electric plants and two steam-electric plants. In addition, if future requirements so warrant, it is contemplated to install frequency changers, so that the Niagara system of the Commission, the transmission lines of which run close to the systems above referred to, may also be brought into parallel with them.*

From the foregoing illustrations we perceive how widespread is the movement to attain the efficiency possible by intelligent co-ordination and, also, how diverse are the basic factors admitting of combination. No doubt, in future, more than in the past, those installing new electric systems, or remodelling older systems, will

*For valuable résumé of activities of the Commission, consult "Electric Power Generation in Ontario on Systems of Hydro-Electric Power Commission," by Arthur H. Hull, in *Proceedings of American Institute of Electrical Engineers*, January 1, 1919.

ensure that designs are adopted which will facilitate taking advantage of the benefits resulting from possible paralleling with other systems.

Conclusion

The burden of many of the above comments and illustrations is this: On the principle that a 'penny saved is a penny made,' there should be careful investigation of some of the outstanding typical conditions under which coal is being consumed in Canada, whether in the home, in the institution, in the office building, in the small manufactory or in the larger industrial plants. If authorities, for example, find through the enforced utilization of insulation upon steam piping, heaters, etc., or by the shutting down of uneconomical plants, or the substitution of efficient for inefficient apparatus, or the repair of apparatus, or in other ways, that very substantial savings of coal may be effected, then such economies, according to some reasonable scheme of administration, should be made compulsory in Canada. It is not the intention here to suggest any unreasonable procedure in connection with these matters. Certain economies, involving radical changes, may not be made fully effective except over, possibly, a five-year or a ten-year period. In other instances, however, substantial economies can immediately be effected to the benefit of the coal consumer, to the transporter and to the country as a whole. These, then, should receive prompt and best attention. Why, for example, should Canada be compelled, especially under conditions of coal shortage, to provide for the obtaining and transportation year after year of, say, ten tons of coal per annum to a certain consumer, if, through the wise expenditure of a few extra dollars, either in initial outlay for better apparatus or by effecting certain changes in existing equipment, the individual would only require seven or eight tons? The days for the widespread use of anthracite coal are numbered. Doubtless, in relatively few years, its use will be authoritatively restricted. Bituminous coals and lignites will be subjected to by-product and other manufacturing processes with the object of producing a satisfactory and clean-burning fuel. Canada cannot and must not ignore the march of progress in these fuel problems, nor in effecting economies by the prevention of needless fuel and power wastes.