Please read and send in as full discussion as possible at earliest date.

The Canadian Society of Civil Engineers.

INCORPORATED 1887.

ADVANCE PROOF—(Subject to Revision.)

N.B.—This Society, as a body, does not hold itself responsible **for** the statements and opinions advanced in any of its publications.

MAKING OUR WATER POWERS VALUABLE.

BY ARTHUR SURVEYER, M. CAN. SOC. C.E.

The utilization of the slope of rivers for power purposes is as old as history, but the harnessing of the larger and higher water falls has been a modern victory achieved in the last fifty years.

The chief factors in this conquest were the superseding of the old current wheel by the modern turbine developed by Fourneyron and Francis, and the discovery of the applications of electricity.

In this connection a few words of history may not be amiss. Between 1840 and 1850, the two French engineers Fourneyron and Girard both utilized water falls of over 325 feet in height to operate their turbines. These trials were not, however, entirely successful and it was only in 1869 that another French engineer, Aristide Berges, succeeded in operating steadily a turbine under a head of over 650 feet. This wheel was connected to the wood pulp grinders of a paper factory situated at Lancey. Because of the success of his first venture, Berges erected in 1873 another turbine, this time under a head of 1,640 feet.

Towards 1880 the Belgian electrician Gramme announced the development of his alternator, which was to be subsequently improved by Kapp and Westinghouse. Just at that time, or to be more accurate, from 1880 to 1883, the French engineer Marcel Deprez conducted some very important experiments on the transmission of electricity, on a line eight miles in length running between the town of Vizille and the city of Grenoble.

This was followed by the invention of the transformer in England by Gaulard and Gibbs in 1882, and of the automatic turbine governor by Piccard in 1885.

Previous to these dates energy had been transmitted by cables at Schaffhausen and at Fribourg, and by water under pressure at Geneva and Zurich.

These component parts of the modern hydro-electric plant were first assembled into a working whole at Lauffen, in Germany, in 1891. The energy was generated at 50 volts, then increased to 13,000 volts and transmitted to the Frankfort Exhibition 75 miles away.

The first development in America was a 15,000 h.p. plant constructed at Niagara Falls in 1893. Since 1895 the technics of hydro-electric work have progressed wonderfully, and the recent improvements in insulation have made possible the economical transmission of energy for distances of two hundred miles and over, whilst the improvement in modern turbine construction has allowed of the commercial development of low heads which could not have been considered ten years ago.

The conflict now raging in Europe has practically called a halt to our industrial development, and it has occurred to the writer that this marking time period is especially adapted for a review of past achievements and a survey of the work which may be done in the future.

Lately our economists, statesmen, and journalists have extolled our water powers and have been pleased to see in the number of our water falls the guarantee of our future industrial superiority. Without desiring to minimize in any way the importance of this national asset, it might be interesting to compare this wealth with the similar wealth of other countries and to examine whether or not we are making or are preparing to make the best possible use of it.

The following table has been compiled from various European sources, from the reports of the United States Geological Survey and from the report of the Canadian Commission of Conservation. It shows the total available and developed water powers in the different countries of Europe, in the United States, and in the various Provinces of Canada; it also indicates the percentage of utilization for each country and the horse-power per square mile.

TABLE I.

	Hydraulic Power Available on Turbine Shafts.		Percentage of Utilization	Available Power per Square Mile
	Available.	Developed.		
EUROPE	h.p.	h.p.	%	h.p.
Great Britian	963,000	80,000	8.3	1.00
Germany..............	1,425,000	445,000	31.2	1.18
Switzerland	1,500,000	380,000	25.0	3.71
Spain	5,000,000	300,000	6.0	3.86
Italy..................	5,500,000	565,000	10.2	4.22
France...............	5,857,000	650,000	11.1	5.80
Austria-Hungary	6,460,000	515,000	8.0	7.34
Sweden	6,750,000	550,000	8.2	7.72
Norway	7,500,000	920,000	12.3	14.12
	40,955,000	4,405,000	10 6	5.44
NORTH AMERICA				
United States	26,736,000	4,016,000	15.0	7.49
CANADA				
Saskatchewan	20,000	45	0.2	.19
Alberta	71,000	7,000	9.8	.69
Nova Scotia	83,000	15,000	18.0	3.93
New Brunswick	280,000	10,000	3 6	10.03
Manitoba	410,000	48,000	11.7	6.37
British Columbia	1.100,000	101,000	10.1	2.81
Ontario	3,400,000	504,000	14.8	15.41
Quebec	5,600,000	328,000	5.8	16.38
North West Territories.	6,900,000	....	0.0	3.19
	17,764,000	1,013,045	8.2	6.55

The data contained in this table refer to conditions in the year 1911, and the provincial areas used to calculate the figures of the last column are taken from the Canadian Atlas of 1906.

It would have been more interesting if complete figures for 1914 had been available. Unfortunately, nothing authentic could be obtained except in a few instances. The inclusion of the new Shawinigan development, the Canadian Light & Power Company's plant, and the large development at Cedars would raise the figures for the Province of Quebec to over 500,000 developed horse-power. Switzerland's present figures are about 550,000 h.p., Norway's over 1,000,000 h.p., and that of the United States between 5,500,000 and 6,000,000 h.p.

It is probable that the data concerning Europe and the United States are fairly accurate, whilst the Canadian figures are based on doubtful information. The Conservation Commission of Canada in its report of 1911 did not "consider advisable to make an "estimate of the total water power in Canada," adding, "one "estimate places it at nearly 17,000,000 h.p.; but it does not, and "cannot, rest upon any basis of reliable information."

A careful study of this table will alter many of our preconceived ideas: we must realize that our country is not the wealthiest in water powers, especially if we compare our different provinces with countries of practically similar area, say France, Austria, Sweden and Norway. It is true that the number of available horse-power per square mile is greater in some cases, but it is painful to realize that in the percentage of utilization, we are woefully behind the other nations.

In passing it may be interesting to note, at this particular time, Germany's high percentage, 31.2% utilized, and to observe that the next country on the list is Switzerland with 25%, chiefly acquired through the investment of German money.

Table II. and Table III. refer more closely to the subject of this paper and supplement to a great extent the information given in Table I.

TABLE II.

Provinces.	Developed Power.	Subdivision of Developed Power.		
		Electrical Energy.	Pulp and Paper.	Various Industries.
	h.p.	h.p.	h.p.	h.p.
Ontario	504,000	394,000	46,000	64,000
Quebec	328,000	198,000	88,000	42,000

Table II. has been compiled from the report of the Canadian Commission of Conservation and details the uses made of the developed water powers in Ontario and Quebec. It should be noted that 74,000 electrical horse-power are exported from the Province of Ontario to the United States at Niagara Falls, and this amount is therefore not included in Table III.

Table III. indicates the uses made of the *hydro-electric* energy generated in Ontario, in Quebec, in France, in Sweden, and in Norway. The data for the Provinces of Ontario and Quebec were taken from a paper by Mr. Watson Bain on the "Electro-Chemical Industries in Canada." The figures for the other countries refer to conditions previous to 1910, and have been compiled from different statistics. The conclusions resulting from the examination of Table III. are that up to the present we have only progressed in the more simple applications of electricity, and that we have practically neglected its utilization as an electrolytic agent and as a heat generating agent in electro-chemistry and electro-metallurgy.

TABLE III.

Countries.	Developed Hydro-Electric Power.	Subdivision of Developed Power.			
		Electro-Chemistry and Electro-Metallurgy.		Motive Power, Traction and Lighting.	
	h.p.	h.p.	%	h.p.	%
France	592,000	291,000	49.1	301,000	50.9
Norway	543,000	275,000	50.6	268,000	49.4
Sweden	370,000	120,000	32.4	250,000	67.6
Ontario..........	320,000	25 000	7.8	295,000	92.2
Quebec	198,000	28,000	14.1	170,000	85.9

It would probably be easy to explain this one-sided development of our hydraulic powers, but the important thing now is the patient search for ways and means to enable us to alter these conditions.

It is self-evident that the consumption of electricity for lighting or for traction depends on population. Neglecting the Montreal market, which is exceptional, the consumption of electricity per capita either for lighting or for traction is too small to be considered as an inducement to the extensive development of our water falls. A western statistician gives the consumption of electricity in small towns as roughly 1/10 of a horse-power per inhabitant, so that a plant of 1,000 h.p. would, on this basis, be sufficient to supply the requirements of a town of 10,000 population. On the other hand, the smallest electro-chemical or electro-metallurgical industry consumes more than 1,000 h.p. Plants of 10,000 h.p. are numerous, and those of over 30,000 h.p. are by no means exceptional.

The pulp and paper industries are also great users of power, but we in Canada are not so very far behind in this phase of development, although Sweden utilizes over 120,000 h.p.

An improvement in the situation might be brought about by attracting to Canada more electro-chemical and electro-metallurgical industries, thereby causing a notable increase in the development of our water powers. It has been thought advantageous to briefly review some of the industries which, either on account of the abundance of the necessary raw materials, or because of the large neighbouring markets, might be likely to prosper in Canada.

ELECTRO-CHEMISTRY.

Calcium carbide. Calcium carbide is obtained by causing quick-lime to react on coke at the temperature of the electric arc: its principal use is in the production of acetylene gas and more recently for the production of calcium cyanamide which will be treated in detail later in connection with the nitrogenized fertilizers.

The industry of calcium carbide was started in 1895, with Mr. Wilson, of Ottawa, as one of the pioneers. There are now over seventy plants situated all over the world capable of absorbing 360,000 h.p. in their operation. The world's production for 1910 was 250,000 tons; it was 300,000 tons in 1912, and increased to 340,000 tons in 1913.

Table IV., page seven, is taken from the "Revue des Eclairages," and gives the world's calcium carbide trade for 1913. One special feature of the carbide industry is that many of the producing countries are not users of the product and that the centres of consumption are located in places where it is impossible for want of water falls to manufacture carbide. Consequently, calcium carbide is a travelling product, and about 50% of the production of the different plants is exported to other countries.

Germany, England, Australia, and the South American Republics are the importing countries: the consumption of Germany has increased five-fold in the last fourteen years, having risen from 11,000 to 55,000 tons annually. The exporting countries are Sweden, Norway, Switzerland, and the United States. The production of the United States in 1913 was 70,000 tons, with an export trade of 15,000 tons. The American exports go to South and Central America, where the demand for acetylene for house lighting is rapidly increasing.

The manufacture of calcium carbide is the oldest of the electro-chemical industries in Canada. There are at present in operation

TABLE IV.

The World's Calcium Carbide Trade, for the Year 1913.

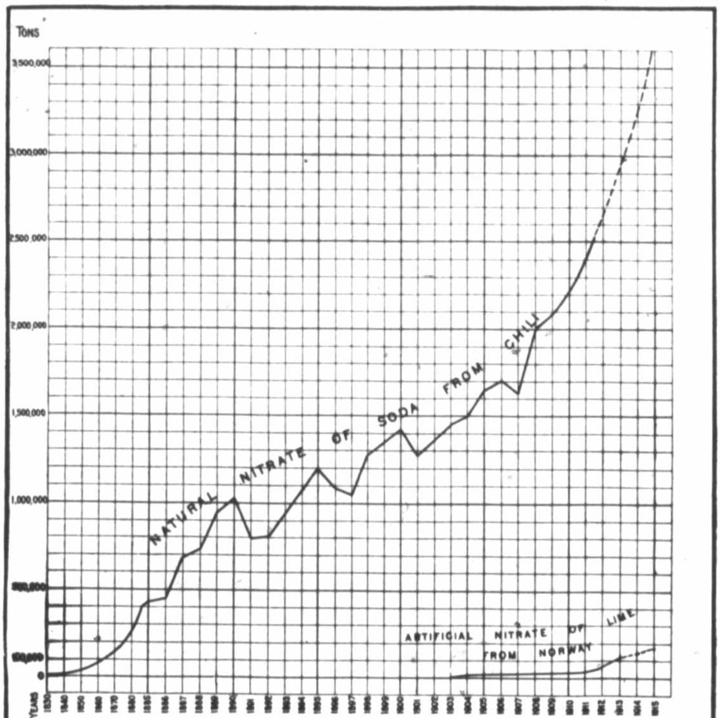
COUNTRIES.	No. of Plants.	Production in Tons.	Consumption in Tons.	Export in Tons.	Import in Tons.
Germany	6	8,000	52,000	..	44,000
Austra-Hungary	6	33,000	24,000	9,000	..
England	2	1,500	25,000	..	23,500
Belgium	..	..	5,000	..	5,000
Denmark	..	..	800	..	800
Spain	11	18,500	18,500	..	..
France and Colonies	16	45,000	45,000	..	..
Egypt, Turkey and Balkan States	1	1,000	4,000	..	3,000
Holland	..	..	4,500	..	4,500
Italy	9	32,000	22,000	10,000	..
Portugal	..	..	8,000	..	8,000
Russia	..	2,000	2,000	..	..
Sweden, Norway	8	75,000	3,000	72,000	..
Switzerland	8	35,000	3,000	32,000	..
United States	3	70,000	55,400	14,600	..
Canada	3	12,000	6,000	6,000	..
Mexico	1	..	1,300	..	1,300
Brazil	..	..	5,500	..	5,500
Peru, Venezuela	..	..	2,000	..	2,000
Argentine Republic, Uruguay	..	..	9,000	..	9,000
Chili, other South American States	..	..	3,500	..	3,500
Japan, China	3	6,000	6,000	..	..
Cuba	..	..	7,000	..	7,000
Africa	..	..	6,500	..	6,500
Australia and other Countries	..	..	20,000	..	20,000
	77	339,000	339,000	143,600	143,600

Published by "Revue des Eclairages."

three plants absorbing altogether 14,000 h.p., and producing every year about 12,000 tons, half of which is exported. The Thorold plant has been in operation since 1897, producing over 1,000 tons a year. The Ottawa plant supplies over 4,000 tons, and the Shawinigan Falls' works about 7,000 tons. These three plants have recently been amalgamated under the name of the "Canadian Carbide Company," with a capital of $2,000,000.

The nitrogenized products. The study of the consumption of the azotized or nitrogenized products leads into the domain of the agricultural engineer, and necessitates a statement of the part played by nitrogen in the vegetable kingdom. Plants must have nitrogen to live. The leguminous plants and a few others only can borrow from the atmospheric air the nitrogen required for their existence. The great majority of vegetables are obliged to obtain the azotized compounds necessary to their life from the ground itself.

The principal nitrogenized fertilizers are manure, dried blood, wool wastes, horn, leather, nitrate of soda, sulphate of ammonia, calcium cyanamide, and nitrate of lime.



PRODUCTION OF NITRATES IN CHILI AND NORWAY

Nitrate of soda or Chili saltpeter is the best known of the imported fertilizers; it is found in its natural state in immense deposits situated in Chili, Peru, and Bolivia.

The curve shown gives an idea of the phenomenal increase in the world's consumption of soda niter. It indicates that the exports of Chilian nitrates were only 100 tons in 1830, 147,000 tons in 1870; they increased to a million and a half tons in 1904, and are now over 2,500,000 tons annually.

It was in 1898 that Sir William Crookes, alarmed at the rapid draining of the nitrate beds of South America, delivered at Bristol, in his presidential address before the British Association for the Advancement of Science, the following opinion which has been since called "Sir William Crookes' dilemma."

"When provision shall have been made, if possible, to feed 230 "million units likely to be added to the bread-eating populations "by 1931—by the complete occupancy of the arable areas of the "temperate zone now partially occupied—where can be grown "the additional 330 million bushels of wheat required ten years "later by a hungry world?"

Sir William Crookes added:—

"I have said that starvation may be averted through the "laboratory. Before we are in the grip of actual dearth, the "chemist will step in and postpone the day of famine to so distant "a period that we and our sons and grandsons may legitimately "live without undue solicitude for the future." * * *

* * * * * * * * * * *

"The fixation of nitrogen is vital to the progress of civilized "humanity. Other discoveries minister to our increased intellec- "tual comfort, luxury or convenience; they serve to make life easier, "to hasten the acquisition of wealth, or to save time, health or "worry. The fixation of nitrogen is a question of the not far "distant future. Unless we can class it among certainties to come, "the great Caucasian race will cease to be foremost in the world, "and will be squeezed out of existence by races to whom wheaten "bread is not the staff of life."

This prediction has come true, and the studies of the last century by chemists and physicists of all nations have been crowned by the recent realization of the industrial production of nitric acid and nitrates by utilizing electrical energy to cause the direct combination of atmospheric oxygen and nitrogen.

The story of the fixation of atmospheric nitrogen can be summed up as follows: in 1902, the Atmospheric Product Company erected in Niagara Falls a trial plant for the manufacture of nitric acid by the Bradley and Lovejoy process. During the same year, de Kowalsky began in Fribourg a series of researches which were continued by Moscicki and led to the erection of a trial station at Vevey, in Switzerland; in 1903, Professor Birkeland, of Christiania, discovered a new process which was afterwards perfected by Birkeland and Eyde, and is now applied on a very large scale at Notodden in Norway. In 1903, also, Frank and Caro made public a new method of fixation based on a different principle and giving calcium cyanamide as the final product. More recently, Pauling and Schonnherr have taken out patents for other processes.

All the methods quoted above, with the exception of the Frank and Caro process, utilize electrical energy to combine directly the atmospheric oxygen and nitrogen. This combination gives nitric oxide which in presence of water and air in excess is transformed immediately to nitrous and nitric acid and finally into nitric acid only: this azotic acid is either sold as such or is led over limestone, giving as final product the nitrate of lime which is utilized in place of the Chili saltpeter or nitrate of soda for all agricultural uses.

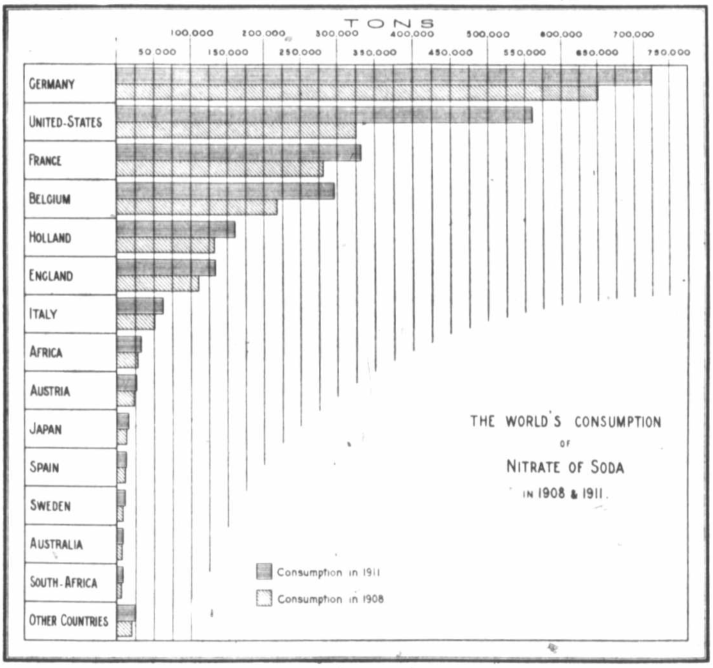
Nitrate of lime. Nitrate of lime was not at first received with favour by the farmers on account of its hygroscopic properties which demand the immediate use of the whole contents of a barrel once it has been opened. However, outside of this inconvenience, nitrate of lime has been proved entirely superior to the Chilian nitrate of soda and its consumption as a fertilizer has increased rapidly.

The manufacture of synthetic nitrate of lime has only been carried out so far in Norway by the Norwegian Nitrogen Company, and its subsidiary companies, grantees of the Birkeland and Eyde, and Schonnherr patents.

The chemical fertilizers manufactured at Notodden are nitrates of lime, of potash, of ammonia, of phosphate of ammonia, and of biphosphate of lime: this industry produces also nitric acid and nitrite of soda. The production of nitrate of lime was 9,500 tons in 1909, 14,000 tons in 1911, rose to 50,000 tons in 1912, reached 110,000 tons during the year 1913, and it is estimated that the production in 1915 will be about 160,000 tons.

The Norwegian Nitrogen Company and its subsidiary companies have undertaken, solely for the needs of this industry, the construction of a number of hydro-electric plants, the total capacity of which will reach the enormous figure of 540,000 h.p. There are at present four plants of approximately 180,000 h.p. in operation, with two others totalling 160,000 h.p. in course of construction.

We have seen previously that the world's yearly consumption of nitrate of soda was approximately 2,500,000 tons; but the Chilian saltpeter is not utilized solely as a fertilizer, it is also employed in the manufacture of powder and nitric acid. The statistics of the different countries do not subdivide the consumption of saltpeter, but it is generally acknowledged that industry does not absorb more than a 1/5 or 1/4 of the total production of nitrate of soda.



The above chart indicates the world consumption in nitrate of soda for the years 1908 and 1911. It shows Germany to be the greatest consumer of nitrate of soda, with the United States a close second. The value of the United States imports of soda niter last year was $21,000,000.

Mr. E. F. Côte, a well-known French economist and engineer, after having analyzed the progress of the different Norwegian industries in 1912, expressed the following opinion concerning the future of the manufacture of nitrate of lime:—

"Four hundred thousand horse-power with the efficiency men-"tioned above would probably produce 250,000 tons of nitrate. But "what is this? Chili exports every year 2,000,000 tons of natural "nitrate to Europe; in ten or fifteen years the Norwegian nitrate "plants will have attained their full development; but their produc-"tion then will not be sufficient to take care even of the increased "consumption. It is certain on the other hand that the Chilian beds "will not be able to indefinitely supply the rapid and continuous "increase of the demand, and it will be necessary for industry to "develop its own means of production in order to satisfy the urgent "needs of nitrogen of the bread-eating nations. This means that "the market for nitrogenized fertilizers is practically unlimited and "that is why the capitalists have given their backing to the electro- "synthetic processes with a spontaneousness which has only been "equalled by their boldness."

Limestone is the only raw material required in the manufacture of nitrate of lime, the economical production of which is entirely dependent on the cost of the electrical energy. In Norway, the cost of production of nitrate of lime is very much below the selling price of Chili saltpeter.

Nitric acid. Synthetic nitric acid is chiefly obtained by the Pauling process, which is similar in principle to the Birkeland & Eyde, and Schonnherr processes. It would seem as if the grantees of the Birkeland and Schonnherr patents had given greater attention to the manufacture of nitrates, whilst the owners of the Pauling rights produce nitric acid principally.

The Pauling furnaces are used in Austria-Hungary, at Patsch, near Innsbruck: there are twenty-four furnaces absorbing 15,000 h.p. Another plant of 8,000 h.p. operates the Pauling process in the north of Italy, whilst in France, the Roche-de-Rame works near Briançon, have utilized 8,000 h.p. since 1908, and will ultimately use 20,000 h.p.

Nitric acid manufactured synthetically is very pure, and is free from nitrous products, from chlorine and sulphuric acid. It is very superior to the general run of commercial acids as the ordinary preparation of it by nitrate of soda does not allow the entire removal of impurities. The by-product of this industry is nitrite of soda which is used in the manufacture of dyes.

The world's production of nitric acid is from 200,000 to 250,000 tons per year, Germany producing about 100,000 tons, and the United States 70,000 tons per year. The margin between the selling price of ordinary nitric acid and the cost of synthetic azotic acid is large and indicates that this industry can afford to pay more for its electrical energy than the nitrate plants.

Calcium cyanamide. Calcium cyanamide, also called azotized lime, or nitrogenized lime, is an artificial fertilizer containing carbon, nitrogen and calcium.

Experience has demonstrated that cyanamide buried in the ground liberates ammonia and acts in every way like an ammoniacal fertilizer. Cyanamide decomposed by steam under pressure is also used in the manufacture of ammonia.

It was in 1903 that Frank and Caro first made public their process of manufacture, which consists in causing a current of nitrogen to pass over powdered calcium carbide made red hot in an electric furnace. The necessary nitrogen is obtained either by the copper process or by the distillation of liquid air.

In this process electrical energy is used chiefly in the production of calcium cyanamide, which is the raw material and which is transformed chemically into an azotized compound.

Calcium Cyanamide is manufactured in fifteen different plants located in France, Switzerland, Norway, Italy, Austria-Hungary and Japan. In addition, the American Cyanamide Company has important works in the State of Alabama, and a plant at Niagara Falls on the Canadian side.

The world's production in 1911 was 110,000 tons, in 1912 was 153,000 tons, and in 1913 reached 226,000 tons.

The Canadian plant began operation on the first of January, 1910, with a yearly capacity of 10,000 tons, and has been forced to raise its production to 12,000 tons in order to satisfy the demand of the American compost dealers. The directors were so satisfied with the results of the first enterprise that they decided to double the capacity of their works, and in March, 1913, the production of the plant had been increased to 24,000 tons per year.

ELECTRO-METALLURGY.

Aluminum. Aluminum was the first metal manufactured in a hydro-electric plant. Its manufacture belongs to electro-chemistry on account of the electrolytic method employed, and to the electrometallurgy on account of the nature of the product.

Aluminum is manufactured by electrolysing alumina dissolved in a molten bath of cryolite, these materials being placed in an iron trough lined with carbon and connected to the negative pole of a dynamo while a carbon anode immersed in the charge is connected to the positive pole.

Alumina is obtained by refining bauxite: this ore is composed of impure hydrated alumina and contains besides ferric oxide, silicon and titanium oxide. France and the United States are the countries rich in bauxite. In 1910, the world's production of bauxite was 271,000 tons, and of this total, France had supplied 128,000 tons and the United States 129,000 tons.

In 1912, the United States produced 165,000 tons of bauxite and imported 27,000 tons from France. They exported in the same year to Canada 10,000 tons of alumina or concentrated bauxite.

The cryolite employed in the metallurgy of aluminum is a double fluoride of aluminum and of sodium. The only known deposit is situated in Greenland and belongs to the Danish government. The export of this natural cryolite had reached 8,000 tons in the year 1911. However, the double fluoride of aluminum and sodium is now prepared artificially in France and in Austria: the raw material used in this manufacture is the fluoride of calcium called fluorspar and the synthetic cryolite is considered a much better product than the natural cryolite of Greenland.

Since 1886, the increase in the world's consumption of aluminum has been phenomenal. The chart shown indicates this rapid rise, and also shows the corresponding drop in the selling price of the metal.

The manufacture of aluminum was towards 1890 in the hands of five companies who raised the production of aluminum from 175 tons per year to 7,300 tons during the period from 1870 to 1890. In those thirty years the average price of aluminum decreased from $1.00 a pound to $0.22 a pound in 1900.

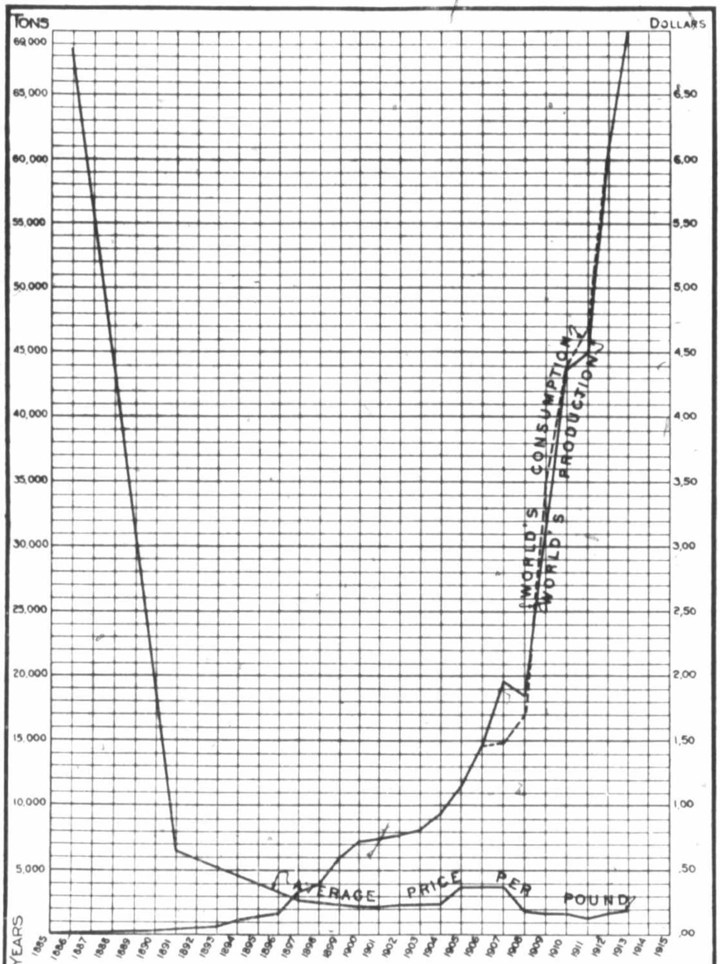
The price of $0.22 per pound did not leave a very great margin of profit, so that in 1900 the five companies amalgamated into an international syndicate to regulate the production and the selling price of aluminum.

This combine caused an immediate rise in the quotations, but in 1907, the patents for the manufacture of aluminum having become public property and the price of copper having fallen very low, the production of aluminum became much larger than the demand for it. This was followed by a crisis which brought about the dissolution of the aluminum syndicate in 1908.

In April, 1911, a new alliance was formed between the different manufacturers of aluminum. The object of this combine was to regulate the selling price, to put a stop to the cut-throat competition which existed since 1908, and to work for the constant enlargement of the market for aluminum.

The extraordinarily low prices of aluminum have resulted in the popularizing of the use of the metal and the increase in its consumption in a remarkable manner, so that a return to normal conditions will leave the manufacturers who have been able to face the crisis with a market for their product definitely enlarged and continually increasing.

In 1912, the United States produced 18,000 tons of aluminum, France 13,000 tons, and Canada 9,000 tons.



PRODUCTION, CONSUMPTION & AVERAGE PRICE
OF
ALUMINUM

In 1910 the total power used by aluminum works was over 320,000 h.p., of which 140,000 h.p. was developed in France.

The actual capacity of the plants of the Aluminum Company of America is 90,000 h.p. Moreover, this company has recently signed a contract with the Cedars Rapids Power Manufacturing Company for the purchase of 60,000 h.p. to be used at their Massena plant on the St. Lawrence. The Shawinigan Falls plant is the property of the Northern Aluminum Company, and has a capacity of 20,000 h.p. A French company, the Southern Aluminum Company has started at Whitney, N.C., the construction of a hydro-electric plant of 70,000 h.p., with furnaces of the same capacity. The whole plant should be in operation by the beginning of 1915.

In the United States the consumption of aluminum has increased very rapidly. Being only 130 tons in 1893, it rose to 3,750 tons in 1903, and to 37,500 tons in 1912, and it is expected that the operation of the Underwood tariff will cause a very noticeable increase in the use of this metal.

Zinc, nickel and copper. Zinc, nickel and copper are also extracted from their ores by smelting in the electric furnace.

Zinc. The production of zinc by the electro-thermic process has been undertaken chiefly in Sweden and in Norway. The production at Trollhattan in Sweden in 1912 was 3,228 tons with eleven furnaces in operation. This plant is to be increased, and will have an ultimate capacity of seventeen furnaces of 1,000 h.p. each and eight furnaces of 500 h.p. each giving a total installed capacity of 21,000 h.p.

In Norway two plants produced a total of 4,000 tons of electric furnace zinc in 1910, 6,600 tons in 1911, and 8,900 tons in 1912.

The Canada Zinc Company is supposed to be operating at Vancouver several Snyder furnaces for the electro-thermic treatment of zinc, but this plant is not described in Mr. Watson Bain's study on "Electro-Chemical and Electro-Metallurgical Industries of Canada."

Nickel and copper. Industrial reduction of nickel and copper ores by the electric furnace is not as yet an accomplished fact. Dr. Haanel, of the Canadian Department of Mines, and Héroult, the French inventor, who has specialized in electric furnace work, made some recent experiments at Sault Ste. Marie, which lead them to think that it would be possible in the very near future to obtain a commercial ferro-nickel pig by the electro-reducing process.

The Government of Chili has also been making extensive experiments in France on the industrial production of copper, and hopes to be able to effect a reduction of 75% in the cost of its production by means of the electric furnace.

ELECTRO-SIDERURGY.

Production of pig iron by the electric furnace. For many centuries it has been usual to obtain pig iron by reducing in the blast-furnace charges of iron ore mixed with the proper quantity of fuel and flux.

The modern blast-furnace is the most perfect of all heat utilizers and has a thermal efficiency as high as 80%. In order that electric-furnace pig iron may compete with pig iron produced in the ordinary blast-furnace, it is necessary to have electrical energy at a very low cost.

In 1906, the Canadian Government authorized Dr. Haanel to experiment on the reduction of ore in the electric furnaces known at the time. Dr. Haanel installed at Sault Ste. Marie a Héroult furnace of 250 h.p. in which he made 150 meltings. The experiments at Sault Ste. Marie lasted only a few weeks, but they were followed by experiments in Sweden extending over several years. At Domnarfvet, the tests took place between 1907 and 1909, and were made with several small furnaces which had been invented by three Swedish engineers.

The Swedish Association of Iron Masters considered that the results of the operation of the Gronwall furnace were good enough to warrant the construction in 1910 of a complete experimental plant at Trollhattan near the Government's hydro-electric plant. The Trollhattan experiments were continued until September, 1911, and were made in a furnace of 3,000 h.p. The new electric blast-furnace of Domnarfvet is of 12,000 h.p. and should produce 100 tons of pig iron per day.

Iron ores are smelted by the electro-thermic process in California, in Italy, in Norway and at many places in Sweden. The production of electric pig iron in this last country was 122 tons in 1900 against 8,900 tons in 1910 and 17,600 tons in 1912. The world's production in 1912 was approximately 25,000 tons.

The Noble Electric Steel Company of California has in operation three furnaces of a total capacity of 8,000 h.p. There are in Scandinavia twenty furnaces absorbing over 36,000 h.p.

Ferros. The name "ferro" is used to designate special varieties of pig iron which are used as a final adjunct in the metallurgy of steel. These are ferro-manganese, ferro-silicon, ferro-chrome, ferro-molybdenum, ferro-tungsten and ferro-titanium. The pigs produced in the electric furnace are expensive products of high quality. In 1910, according to the statistics of "l'Industrie Minérale" the average value of ferros produced in the electric blast-furnace was $21.00 per ton, whilst the ferros of the ordinary blast-furnace were sold at $2.00 per ton.

Ferro-silicon. Ferro-silicon is used in the converting of pig iron for the production of steel. The world's production is over 100,000 tons of ferro-silicon per year. Two Canadian companies manufacture this product: The Lake Superior Power Company, at Sault Ste. Marie, with an electric furnace of 250 h.p., and the Electric Metals Company at Welland operating four furnaces of a total capacity of 5,000 h.p.

Ferro-titanium. The manufacture of ferro-titanium in the electric furnace is particularly interesting on account of the large deposits of titanium ore in the Province of Quebec. The United States' production of ferro-titanium for the year 1912 has been estimated at 3,763 tons and nearly 600,000 tons of titanium-treated steel have been manufactured, as against 400,000 tons in 1911.

Production of steel in the electric furnace. It is an acknowledged fact that the cost of producing ordinary pig iron in the electric furnace is so high that it is only in special cases that electric pig iron can successfully compete against pig iron smelted in the ordinary blast-furnace, but the same does not apply to steel produced by the electro-thermic process. The electric furnace used for the production of high and medium grade steel has so many advantages over the other furnaces that its general use appears absolutely certain in the very near future.

There are already more than one hundred and twenty furnaces in operation in the world, and the production of electric furnace steel has risen from 33,000 tons in 1908 to 175,000 tons in 1912. Germany has tripled her production since 1910, and in 1913 had in operation fifteen plants producing about 102,000 tons a year, placing her in the lead of the other countries. The United States, after having manufactured, in 1910, 52,000 tons, including the large quantity of electric furnace steel rails, is now awaiting the results of the use of these rails and is only turning out in the electric furnace special high-grade steels to the amount of 18,000 tons annually.

The electric furnace is also extensively used for melting steel for castings.

Conclusions.

The different industries which have been enumerated absorb approximately one and a half million hydro-electric horse-power, and Canada's contribution to this enormous utilization of power is just about 3.5% of the total.

This paper can only be considered as a very brief survey of a very large field and it would be rash to attempt to draw from it any definite conclusions. It is evident that all the industries mentioned above would not be sure of success in Canada, and that every particular case should be studied with the utmost care before trying to attract the investing public.

A number of foreign engineers do not see a very rosy future for these industries in this country, and in order to guard us against an exaggerated optimism the following quotation is taken from an editorial by Mr. Robert Pitaval. Mr. Pitaval is a French civil and mining engineer, the Editor of "Le Journal du Four Electrique," and is very highly considered in France.

"Our opinion, however, after having visited some of the Can-"adian plants is that the development of Canadian water-powers "will take place very slowly. There are two centres of industry: "Niagara Falls and Shawinigan Falls, the first being exceptional "and unique in the world. It appears that outside of those two "power sites it will be very difficult for a number of years to "develop others. Every thing is against it: the severity of a "terribly cold and long winter causing the low-water period, and "the consequent shut down of mills to extend for at least six "months, the absence of means of transportation (railroads and "highways), and the little enthusiasm shown by capitalists for "these enterprises, notwithstanding the encouragement given by "the Canadian Government. It is impossible to think of enlarging "the Canadian works at Niagara Falls, the only place where this "might have been done, now that the American and British "Governments have agreed to limit the volume of water to be "diverted so as to save the beauty of the fall."

"It seems, then, that Canada, notwithstanding its water-falls "so complacently enumerated by Mr. Dushman, professor at Tor-"onto, and naturally the champion of his country, it seems, there-"fore, that Canada need not be considered as a serious competitor "of the other countries rich in water-powers, or of the world's "electro-chemical industry. The proof is in the failure of electro-"siderurgy which had every possible chance to succeed in Canada."

More recently, Mr. Pitaval, returning from a visit to Niagara Falls, published the following comment:—

"This means that in the near future there will not be any "extra energy available at Niagara, and that we know now the limit "of capacity of the great electro-chemical works of this region. "These works, situated along the road from Niagara to Buffalo or "to Echota, on grounds bought by the Niagara Power Company "for this very purpose, have reached their maximum capacity. We "will examine their production in a future article, but we can say "even now that the electro-chemical centre of Niagara, with a "cost per horse-power year of $15.00 on the average, with labor "at $3.00 per day, and with the legislative restrictions with regard "to the water diversion, will never constitute a serious competitor "for similar European plants. The situation at Niagara is far "from being comparable with that of the Scandinavian plants which "are much more advantageously located."

This opinion is also shared by Mr. Julien Dalemont, electrical engineer, and at one time a lecturer at McGill University. This gentleman writes as follows in the "Revue Economique Internationale" of December, 1909:—

"Besides the difficulties of operation of the hydro-electric "plants, it is important to note also a factor which from the very "beginning makes the success of these enterprises very doubtful. "All the available falls with a few exceptions are low head falls "with large discharge."

"There are now a few natural falls whose height exceeds 100 "or 130 feet—even 325 feet—but all the artificial falls created by "diversions of rivers starting from the heads of rapids, are falls "with a low head and a large discharge. Consequently the amounts "of money permanently invested in the hydraulic construction and "in the machinery are such that the economical return of the enter-"prise often tends to become precarious."

It seems as if Mr. Pitaval had shown chiefly the dark side of the situation. It is evident that he exaggerates the difficulty of winter operation and, moreover, this objection would apply to the Scandinavian countries as well as to Canada. The great advantage of the water-powers of Sweden and Norway is the remarkable height of their falls and the consequent smaller volume of water required for the same power. Referring to Mr. Dalemont's opinion, it is somewhat consoling to note that he claims to have applied the same criticism to the water-powers of Switzerland.

It would be possible on our navigable rivers to subdivide the cost of development between Navigation and Industry. This would so reduce the cost of the industrial part of development that the unit cost of these low-head hydro-electric plants might compare with the figures of the Scandinavian developments. This Government help has been given to several plants in Europe and America and explains in a measure the apparently low cost of some of their enterprises.

There is no getting away from the fact, however, that the criticism of the two foreign engineers is partly correct. We are in a measure handicapped and there are numerous obstacles, economical, educational and physical which interfere with the rapid development of our water-powers.

It is significant to note that the countries which have given the greatest number of years to the technical study of their water-powers have the highest percentage of utilization: Germany, the Scandinavian countries, France and Switzerland, for example, were the first countries of Europe to undertake the systematic study of their rivers and falls, and a glance at the third column of Table I. will show that these nations are now getting a greater return from their natural forces than the other countries.

It is only recently that such studies have been undertaken here. At present, the Canadian Public Works Department, the Department of the Interior, the Quebec Streams Commission, the Hydro-Electric Power Commission of Ontario, and the Province of British Columbia, have undertaken the scientific discharge measurements of some of our rivers and have established gauges all over the country. There has been a vast improvement in this direction, but we were so far behind the other nations that unless our studies are considerably accelerated, we shall forever lag behind our competitors.

It is undeniable that to utilize a greater percentage of our hydraulic forces, we must interest the foreign capitalists. The Scandinavian works have been largely built by the investment of French and English money, and there should be reasons why we could not obtain for our rising hydro-electric industries the financial support of our two mother-countries.

It is safe to say to-day, that through the lack of surveys, of discharge measurements, and of gauge readings there are very few of our water falls which could be offered to oversea bankers. To convince these men we must be able to lay before their technical advisers, complete plans to enable them to make in their office a rough estimate of the first development costs: we must, moreover, show them discharge measurements and gauge readings covering a sufficient number of years to allow them to calculate with accuracy not only the minimum power available, but also the average power on which they could depend. The electro-chemical and electro-metallurgical industries require energy at such moderate rates that it would be impossible in most cases to bank on the lowest available power only. These industries must have the help of the periodical power to lower the average cost of the energy utilized during the year.

The development of our water-powers has also been greatly handicapped by the difficulty in obtaining a clear title of ownership and by the uncommerciality of some of the clauses contained in Government leases.

Speaking now of conditions prevailing in the Province of Quebec, the following are some of the articles which affect the ownership of water-powers.

Article 400 of the Civil Code:—

"Roads and public ways maintained by the State, navigable "and floatable rivers and streams and their banks, the sea shore, "lands reclaimed from the sea, ports, harbors and roadsteads and "generally all those portions of territory which do not constitute "private property are considered as being dependencies of the "Crown domain."

It has been held by all our Courts that when a river is neither navigable nor floatable, the proprietors of land abutting on the river are the owners of the bed of the river up to the middle of the stream and have the right to utilize the water flowing in front of their property.

However, the interpretation of Article 400 has led to many lawsuits and to various decisions in the different Courts. Some jurists have held that a river is navigable and floatable within the meaning of Article 400 only when the volume of water is sufficient to float rafts or "radeaux," and that it is not floatable when it can only float loose logs. In the celebrated case of MacLaren *vs.* the Attorney General for the Province of Quebec, the Lords of the Privy Council adopted this definition and decided that the Gatineau River was not a floatable river in the meaning of Article 400, thus reversing the decision of our Supreme Court and of our Court of King's Bench.

On the other hand, the Quebec Streams Commission's report referring to the case of Pierce *vs.* McConville has the following: "The unanimous decision of the four judges of the Superior Court, "confirmed by the Court of Appeals, is that rivers or natural streams "capable of floating rafts of logs, loose logs or single sticks, either "throughout or at certain periods of the year, belong to the public "domain."

Even after a river has been declared non-floatable, the riparian owner is not sure of his title, as the claim has been made that where a grant of land bordering a navigable stream has been made by the Crown without mentioning the bed of the river, the intention of the Crown was not to transfer the bed of the stream to the grantee.

But irrespective of the difficulty in interpreting Article 400 there are in the Revised Statutes of the Province of Quebec, 1909, a series of articles which contribute to befog the issue.

Article 7295. "Every proprietor of land may improve any "water course bordering upon, running along or passing across "his property, and may turn the same to account by the construc-"tion of mills, manufactories, works and machinery of all kinds, "and for this purpose may erect and construct in and about "such water-course, all the works necessary for its efficient work-"ing, such as flood gates, flumes, embankments, dikes, dams, and "the like. R. S. Q. 5535."

Article 7287: "Every water-power formed by a lake, pond, "water-course or river, whether floatable or not, belonging to any "person, is declared to be a matter of public interest, and the pro-"prietor thereof may proceed to expropriate the adjacent lands so as "to allow him to utilize such water-power in the manner and subject "to the condition mentioned in this section, 9 Ed. VII., c. 68, S.L."

Article 7289: "Such expropriation under this section shall "not take place except for the benefit of a water-power of an average "natural force of at least two hundred horse-power, and large "enough for industrial purposes, and shall in no case prejudice an "industry already established, or water-works supplying a munici-"pality wholly or in part, 9 Ed. VII., c. 68 s. 3."

Coming now to the navigable rivers we meet with identical uncertainties, and the same water-power is frequently claimed by both the Federal Government and one of the Provincial Governments.

The Federal Government was given by the British North America Act control of the waters of all navigable streams: the contention of the Provincial Governments is that this control does not carry with it the ownership of the waters and that the possession of the bed of the river confers the proprietorship of the water fall. The claim of the Federal Government is, however, strengthened by the provisions of Section No. 108 of the North British America Act which reads:—

Section 108 (author's translation): "The works and public "properties of each Province mentioned in Schedule 3 annexed to "the present act, belong to Canada."

"Schedule, 3."

"1. Canals, including the adjacent lands and water-powers."

"2. River and lake improvements."

The view that all water-powers, on the navigable rivers which had been improved before Confederation, belong to the Federal Government has been taken by the Honorable Senator Belcourt in a debate in the Senate on February 27th, 1908.

Whoever may be the rightful owners, the fact remains that neither the Federal nor the Provincial Governments are willing to grant a lease absolutely guaranteeing the ownership of the water-power conceded. These leases generally contain a rider stating that the Government only grants "whatever rights it may have" or concedes these rights "in so far as the Government has power to "grant such privileges."

This most uncommercial feature of Government leases is generally made worse by the inclusion in the contract of clauses stipulating the beginning of construction within an absurdly short period and, in addition, the possible expropriation by the Government, of the whole part not as "a going concern" but only on the basis of the physical value of the works.

We have to depend for our financing chiefly on the bankers of England, of the United States and of France, and it is extremely difficult to induce capitalists to advance funds for water-power developments guaranteed by such leases.

Some of these leases were evidently drafted to suit conditions twenty-five years ago when the developments were small, and they should not be applied to the present large developments.

In the early days some valuable concessions were given at very low prices, but the tendency nowadays seems to be to exaggerate the money-making capacity of first developments, and to overload the fixed charges by excessive yearly rentals. For instance, to impose on a new enterprise a rental of $1.00 or $2.00 per horse-power year is the equivalent of an additional capital cost of $20.00 to $40.00 per horse-power. This burden is so high a percentage of the total development cost that it is often sufficient to throw back in the doubtful class, what would have normally been a fair proposition. In order to be in a position to set an equitable yearly rental per horse-power, the Governments should have at their disposal complete information enabling them to estimate the first construction cost. In the hydro-electric industry, the yearly fixed charges have more influence on the cost of the salable product than in any other industry: consequently, it would be advisable for the different Governments, when setting up yearly rentals per horse-power, to take into consideration not only the cost of development but also the probable uses of the electricity produced, in order to discriminate in favour of new industries.

It is probable that we need a separate water-power policy for each Province, and it seems to the writer, that so soon as the ballot for the formation of Provincial Divisions of the Society has been favorably voted upon, these Divisions should appoint Committees whose duties would be to place before their respective Governments the views of Engineers on this most important subject. This action could be considered as a very good form of publicity, and its result would certainly redound to the general welfare of Canada.

N. B.—It has been found impossible to insert in the text of this paper all sources of information: in order to give credit where it is due, and to facilitate further researches, a list of some of the books and articles consulted is given below.

Electro-chemical and electro-metallurgical developments in Canada, S. Dushman, B.A.Ph.D., 1911.

Electro-chemical industries in Canada, Watson Bain, 1912.

Report of the Quebec Streams' Commission, 1913.

Report of the United States Geological Survey.

Water Powers of Canada: report of the Commission of Conservation, 1911.

Water Power Proceedings, Fifth National Conservation Congress, U.S.A., 1913.

Les industries de l'électricité au Canada, Julien Dalemont, Revue Economique internationale, décembre, 1909.

La fabrication électro-chimique de l'acide nitrique et des composés nitrés à l'aide des éléments de l'air, Jean Escard, 1909.

La technique de la houille blanche, E. Pacoret, 1911.

Principes et applications de l'électro-chimie, O. Dony-Hénault, 1914.

Electro-chimie et électro-métallurgie, Henri Vigneron, 1911.

Le Haut-fourneau électrique, Paul Nicou, 1913.

Annuaire de la Chambre Syndicale des forces hydrauliques, 1913-1914.

Forces hydrauliques, Electro-métallurgie, Electro-chimie et industries qui s'y rattachent, Robert Pinot, 1911.

L'industrie de l'Aluminium, Georges Flusin, 1912.

Les installations hydro-électriques norvégiennes pour la fixation de l'azote, L.D.F., "La Technique Moderne," 1er février, 1913.

La production et la consommation des engrais chimiques dans le monde, due à l'Institut International d'Agriculture de Rome, et d'après M. E. Rouland, "l'Economiste français," décembre, 1913.

L'Etat actuel des industries électro-thermiques, G. Flusin, 1909.

L'Etat actuel et les tendances de l'industrie électro-chimique du nitrate de chaux, M. Georges Flusin, "La Technique Moderne," octobre et novembre, 1910.

L'industrie de l'azote atmosphérique, Alfred Tobiansky d'Altoff, 1914.

Les développements de l'industrie et du commerce des engrais chimiques, H. Nagant, "Revue Economique Canadienne," juillet et août, 1913.

L'utilisation des forces hydrauliques en Suisse, M. Elmer, "La Revue Polytechnique," 25 novembre, 1913.

In the "Journal du Four Electrique" for 1913 and 1914, Editorials by Mr. Robert Pitaval and several unsigned articles.

Articles from "La Houille Blanche."

La fixation de l'Azote atmosphérique au moyen de l'électricité, J. Blondin, avril, 1908.

La fabrication industrielle de l'azote pur, (Notes de l'académie Sciences), G. Claude, novembre, 1911.

Transport de force et électro-chimie, E. F. Côte, 1911.

L'utilisation des forces du Rhône, E. F. Côte, 1912.

Les industries de l'azote, E. F. Côte, mars, 1913.

Utilisation directe de l'azote atmosphérique pour la production des matières fertilisantes et autres produits chimiques, Franck, octobre, 1906.

Etat actuel de l'Electro-chimie, C. Gall, août et septembre, 1909.

Les nouveaux engrais azotés fabriqués avec l'azote atmosphérique, R. Guillin, avril, 1910.

L'électro-chimie sur les bords du Niagara, P. Pierron, juillet et août, 1903.

La fixation de l'azote atmosphérique par le procédé Pauling, Jules Vanderpool, janvier, 1911.

Le nitrate de Norvège. Les installations des Sociétés Norvégiennes, Jules Vanderpool, mars, 1911.

Conditions de formation des acides nitreux et nitriques, A. S. novembre, 1912.

Le four électrique appliqué à la production directe de la fonte et à l'obtention de l'acier doux en partant du minerai, F. Charles, janvier et décembre, 1912.

La fixation de l'acier au four électrique, G. Gin, janvier, 1906.

Limitation du rôle de l'énergie dans la métallurgie du fer, G. Gin, mars, 1906.

Electro-métallurgie du nickel, G. Gin, mai, 1906.

Fabrication de l'acier au four électrique dans les établissements de Paul Girod à Ugine, Savoie, M. Saconney, avril, 1911.

Traîtement des minerais de cuivre au four électrique, Vattier, novembre, 1903