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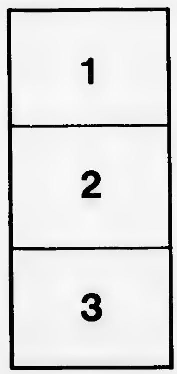

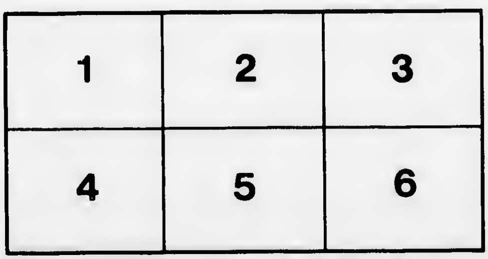

PRESIDENTIAL ADDRESS

(READ BEFORE THE ROYAL SOCIETY OF CANADA MAY, 1899)

CANADIAN WATER POWER

AND ITS

ELECTRICAL PRODUCT

IN RELATION TO

UNDEVELOPED RESOURCES OF THE DOMINION

BY

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PRESIDENTIAL ADDRESS

By T. C. KEEFER, C.M.G., C.E.

Canada with a small population and insufficient capital has nevertheless held a foremost position in the products of the Forest and the Fisheries, as well as in the quality of those cereals and fruits which attain their highest development in a northern latitude. In live stock she has not suffered by comparison with any other portion of this continent, while in dairy products she is pre-eminent. If she has not, until recently, made much progress in mineral development, it has been more from want of money than of mines. If she has been long in attaining a position as a manufacturing country, it is accounted for by the fiscal and financial conditions of a sparsely settled country, the smallness of a home market, and the competition of greater capital and out-put, and therefore cheaper production elsewhere.

Amongst the many partially developed resources of Canada, perhaps there is none more widespread or more far reaching in future results than her unsurpassed Water Power. The value of this has been enormously enhanced, first by the expansion of the wood pulp manufacture, and the introduction of electro-chemical and metallurgical industries for which this country possesses the raw material; and, more recently, in the revolution which has been brought about by success in transmitting the energy of water falls from remote and inconvenient positions to those where the work is to be done.

Electrical transmission brings the power to the work, and when the prime mover is water, we have the cheapest power, and perhaps nearest approach to perpetual motion which it is possible to obtain;—one which is always "on tap," and, like gravity, maintained without cost and applied without delay.

An examination of any good map of our broad Dominion reveals, as its most striking feature, an extraordinary wealth and remarkably uninterrupted succession of lakes and rivers, suggestive of ample rainfall, the first great requisite in the occupation of any country. This feature would be still more impressive if all the waters could be shown on the map. Over large areas only the more important rivers have been explored and delineated; while in the surveyed districts many are necessarily omitted to leave room for other information to be given.

These rivers and lakes have been the most important factors in the settlement of the country, as they formed the earliest lines of approach for the penetration and exploration of the interior, and for the exploitation of our forests. The lumberman followed the trapper and the fur trader, the axe supplanted the rifle, and thus the country was opened up by men who knew not only where to begin, but, by their calling, were best equipped as pioneers.

The frontier, where not already occupied by the French, was necessarily rapidly settled in the first place by the Loyalists of 1776, who could not stand upon the order of their departure after their homes were confiscated. These found the rivers their earliest friends from whence they obtained the means of shelter and of employment in the only industry by which money could then be obtained, viz., the floating of timber and potash to Montreal and Quebec.

Over a length of several thousand miles between Labrador and Alaska and over a width of several hundred miles, there is an almost continuous distribution of lakes, lakelets and rivers;—the lakes of varied outlines, dimensions and elevations above sea level, and many possessing facilities for the storage of their flood waters. This power of storage has been largely taken advantage of by lumbermen to retain the needed supply for their spring "drive" into the main stream. In many places the outlet from the lake, or the connection between a chain of lakes, is a narrow cleft in rock where an inexpensive dam will hold back the water supplied by the winter's accumulation of snow.

With the exception of her prairie region, the rivers of Canada differ from the Mississippi, Missouri and Ohio, and the larger part of their tributaries, in that they are not naturally navigable from their mouths, or above tidal influence to any considerable extent, except in detached sections; while the former are navigable for thousands of miles and are therefore without water power. Those great western rivers flow upon a nearly uniform grade of a few inches per mile, whilst the St. Lawrence and its tributaries are interrupted by rapids, chutes and cataracts, affording a great variety, quantity and quality of water power.

In the United States, between the Atlantic coast and the Rocky Mountains, as far south as the Gulf of Mexico, and as far north as the Dakotas, (with the exception of part of New York and New England) there is an entire absence of lakes; while throughout Canada, north of the St. Lawrence and stretching northwest toward the Mackenzie River Basin, these are innumerable, in fact have never been numbered, and thousands of the smaller ones have never been represented on any map.

The upper sections or sources of most of the Canadian rivers are chains of lakes, occupying in many instances the greater portion of the water course. These head waters are often upon nearly the same elevation and interlocked with the sources of other rivers flowing in opposite or different directions, and separated by narrows necks of land at a low "divide," rendering diversion from one to another possible, a feature which has in some places been utilized by lumbermen fearless of any legal injunction.

This terrace-like profile of the rivers and their frequent expansion into lakes, often dotted with islands, not only enhances the beauty of the scenery, but, for utilitarian purposes, constitutes a series of elevated natural mill ponds, containing latent power of unknown extent and value, awaiting that demand upon them which is now being made in consequence of the discovery that our second rate forest growth which has hitherto served chiefly to ornament their shores and islands, has become the most important, and can be ground into pulp and rolled into paper to meet the ever increasing demands of the newspaper, the bookmaker, and the innumerable forms into which wood pulp can be compressed for useful or ornamental purposes,—or as a substitute for wood or metal.

These steps from high to lower levels in every rivulet, branch, tributary or main stream of nearly every one of our northern rivers produce more or less broken water which never freezes over but remains open during the coldest weather, giving an alternation of closed and open water sections, of ice covered lakes and of broken water in rapids, which may cover miles in extent, as well as at chutes or cataracts with more or less open water above and below them.

It is an interesting question for specialists to determine what effect, if any, this often large percentage and almost general distribution of open water during the coldest weather (of which every stream large or small has a portion) may have in modifying the extremes of temperature in these northern latitudes. When all the ground is frozen solid and covered with a deep mantle of snow, extending over the lakes and checking increasing thickness of their ice covering, large bodies of water are impounded and maintained at a temperature above the freezing point, although there may be fifty degrees of frost in the air, and are constantly poured forth into this frigid atmosphere.

It is conceded that our Great Lakes modify the temperature of their border lands, and although these open water spaces in our northern rivers may be inferior in surface, they exist on every river having rapids or falls, and extend over such a vast field that their aggregate area must be very large. Unlike the Great Lakes these open spaces are constantly receiving fresh supplies of warmer water to temper the severity of the air. Such "breathing holes" (as they are sometimes called) are necessarily comparatively shallow, and are the only places, after all other water is frozen over, where "anchored" ice is formed and found. This differs from lake ice in that the latter melts where it freezes, while anchor ice, when compelled by milder weather to let go its hold upon the bottom, rises, and is immediately drawn under the fixed ice below, and does not dissolve until the river breaks up in the spring. The latent heat of water, disengaged in freezing,—which process occurs so frequently during the five months of winter,—is imparted to the atmosphere, but is not again absorbed by melting ice, as would be the case in lakes, or in deep sluggish rivers.

Again, radiation is supposed to play an important part in "anchoring" the floating particles of ice to the river bottom, which is said to be cooled so rapidly by the ice laden current above it as to become frozen, and then begin to attract the passing ice needles, and fix them to its bed.

If mother earth, in mid-winter, contributes any of her impounded heat to the outer atmosphere, these almost innumerable unfrozen spaces certainly offer great facilities for giving vent to her suppressed emotions.

WATER POWER.

From the Straits of Belle Isle to Montreal, and thence ascending the Ottawa, the tributaries of the St. Lawrence and of the Ottawa descend, through the Laurentian region, from elevations of 1,800 to 1,000 feet above tide, and debouche within a few miles of each other except immediately about the Saguenay. In many cases they bring their principal cataracts very near their outfall, notably in the case of the famous Falls of Montmorency, which, leaping directly into the St. Lawrence from a height of 250 feet, are utilized to light the streets and drive the tram cars of Quebec.

Somewhat similar conditions exist on the south shore of the St. Lawrence until the Richelieu river (the outlet of Lake Champlain) is reached, where at Chambly, water power is about to be used to send the electric current into Montreal in competition with steam and a similar water power from the Lachine Rapids.

The divide between the St. Lawrence and the Ottawa is studded with lakes, west of the Rideau Canal, a principal outlet for which,—on the south,—is the River Trent, discharging into the Bay of Quinte, with large mills and much undeveloped water power at its mouth : and on the north, some half a dozen important tributaries discharging into the Ottawa.

At Sault Ste. Marie, a water power canal fed from Lake Superior supplies the largest pulp mill yet erected in Ontario, and a similar work at the Lake of the Woods (which lake is 1,000 feet above tide) gives power to the largest flour mill in the Dominion. The waters of the Winnipeg river (the outlet of the Lake of the Woods) descend about 300 feet, unused, into Winnipeg Lake, adjoining Lake Manitoba, from whence the water system extends to the Saskatchewan, and thence via Athabasca, the Great Slave and the Great Bear Lakes, to the Arctic circle.

No reference has been made to the long established water power in the older districts, on the Saguenay, or those between Montreal and Quebec, and upon the Ottawa, nor to the more recent and extensive pulp and paper establishments;—it being the object of this paper to draw attention to the continuity and broad distribution of water power across the continent, on Canadian territory, and to the unnumbered natural reservoirs of water at elevations which impart to them latent powers for the future development of this country.

British Columbia has not been included in this field, because its occupied portion is separated by our great prairie region from the lake system of Eastern Canada, which system is deflected toward the northwest at the Lake of the Woods. This province is by no means deficient in water power, although it has been little used as yet where mines are on high levels, and because steam could be more readily applied. On the other hand, it is the only province in which hydraulic mining is in operation; and where gold is found in quantity sufficient to warrant the great outlay of capital necessary in connection with that system.

In the Kootenay, water wheels, with or without electrical transmission, are necessary for water power, in order to mine, pump, and crush the gold bearing rocks; but in the Cariboo district, water power is applied in the simplest form, without wheels or wires, by direct pressure from a nozzle, as is done in Ottawa from a fire hydrant.

While the mountains south of the Canadian Pacific Railway are rich in metallic veins, the region north of this railway extending into the Arctic Circle, appears to be a veritable land of Havilah, a continuous "Placer" gold field, in which much of the precious metal is to be obtained by hydraulic mining, wherever that is practicable.

This gold field, over a thousand miles in extent between the Fraser and Yukon Rivers, and of unascertained width, has been exploited at Cariboo, (from whence fifty million dollars has been taken), at Cassiar and Omenica, and recently at Atlin, all in British Columbia;—as well as in the far famed Klondike, in the Yukon district, said to be the richest gold field in the world.

Water, in whatever way it is used, is necessary to the recovery of this gold, but in many places water power alone will profitably unearth it from its hidden recesses. This is collected in quantity from lakes, and reservoirs on the high levels, and carried for miles by ditches, aqueducts and flumes, to the banks of a primeval, deserted river channel, at the bottom of which, under forest covered clay banks, lies the auriferous gravel studded with boulders and resting on the bed rock. Under a head of about 300 feet "six inch rapid fire" hydraulic guns are pointed against the bank, breaking down the earth, uprooting trees, scattering boulders and washing out the gold—which remains in the traps set for it in the bottom of the sluices after all else has been carried off by the power of the water.

These "machine guns," called "giants" and "monitors," are models of simplicity as well as of ingenuity and efficiency. While working they are great consumers of water,—and can only be used when the ground is unfrozen, but this season is generally sufficient to use up all the water which can be collected at the necessary elevation.

It requires at least two men to hold and direct the force of the issuing stream from an Ottawa fire hydrant, but a boy can direct the movement of a stream, twenty times greater in quantity and fifty per cent stronger in pressure, as it rushes forth from the nozzle of one of these "giants",—which is fixed to a well secured platform, and moved forward as the bank in front of it melts away.

A thin short tube, of larger diameter, projects beyond the nozzle to which it is fixed by gimbals, so that the tube can be moved independently, both horizontally and vertically, to touch the issuing stream, which immediately recoils from the obstruction, moving the "giant's" nozzle in the opposite direction. Thus a boy "behind the gun" can control its movement and compel the "giant" to fall back upon his own resources for motive power.

HORSE POWER.

It is impossible to give anything but an approximate estimate either of quantity or value of the available water power over so vast an area, because the first would involve the survey of every power site; and, as to the second, the value begins when the power is wanted.

All which now can be done is to state the conditions and endeavour to estimate the quantity, hypothetically. What is needed for an estimate is the quantity of water and the amount of fall which can be relied upon at the site for each power. To get the first, a measurement of the minimum flow at each point would be necessary in low water years, and for the second, some local knowledge as to river levels, back water, etc.

In the absence of such surveys we must fall back upon the average rainfall of the whole region as far as that can be procured for any time, and assume the proportion of this precipitation (of rain and snow) which, after deductions for evaporation, the demands of vegetation, or infiltration, would reach the wheels. An allowance must also be made for that portion of the rainfall which may be carried off in floods.

The area over which this precipitation would be in reach for water power purposes, would embrace all the main land of Canada south of the St. Lawrence, as well as all north of it in the St. Lawrence valley, and so much of the Hudson Bay and Mackenzie River watersheds as can be utilized, or imported by transmission.

As regards the power of the water thus estimated, we must embark in a much more speculative estimate as to the average fall which should be assigned to it for the whole region. We have in the undeveloped districts some scattered meteorological observations to assist us in estimating probable rainfall, and we have also a few barometrical observations giving the height above sea level of summit waters. On lower levels we have more numerous rain gauges, and summit levels ascertained by railway surveys.

For the whole river the total fall may be less than 100 feet, as in the case of the French river which has Lake Nipissing for a mill pond, or rise to 1,500 feet or more as at the rivers below Anticosti. In the case of the French river (which is the lower part of a longer stream) we have surveys, and know that its whole fall can be utilized, as would be done if it is made navigable by locks and dams. In the others (where no surveys have been made) some will be more or less like French river, while at others only a portion of the total fall upon them may be profitably utilized. The most valuable will be those which, like Montmorency, bring all their water with sufficient head to the point where it is worth most. The upper sections of the rivers will be the least valuable, as having less water and being more remote until reached by a new railway, or a transmission wire.

The chief difficulty with respect to the quantity of water is the want of rain gauges over so great an extent of unoccupied territory. Where the rainfall is known, the proportions which reach the streams have been ascertained in connection with reservoirs for water supply and other purposes. We can therefore only state a hypothetical case especially as to the power to be assigned to the available water.

Assuming, however, an average annual precipitation of twenty-four inches and taking one-half of this as available for water power, every ten square miles would yield an average of nearly one horse power for every foot of fall. A million square miles (and there is much more) would give nearly 100,000 horse power for every foot of fall. As there would be several hundred feet of fall which could be utilized, our water power must be immense,—and commensurate with this country in other respects.

The above applies only to the tributaries of the St. Lawrence and the Ottawa, and to the northern watersheds so far as these may be utilized. The Canadian portion of the water power of the St. Lawrence, from Lake Superior to Montreal, in which there is a fall of 546 feet, is not included, being below the level of the tributaries.

We have measurements of the flow in both the St. Lawrence and the Ottawa in cubic feet per second, as follows :

	c. ft. per sec.
In St. Mary's river, outlet of Lake Superior..........	80,000
In St. Clair river, outlet of Lake Huron..............	225,000
In Niagara river, above the falls.....................	265,000
In St. Lawrence river above the rapids..............	300,000
In Ottawa river, above Lake of Two Mountains........	35,000

Canada's share of the St. Lawrence water power from Lake Superior to Montreal would be about ten million horse power.

Canada has half the water of the St. Lawrence from Lake Superior to Cornwall, and all of it between Lake St. Francis and Montreal; but only a portion of this half could be utilized,—and this would apply more or less to the Ottawa and other rivers, where all the power could not be utilized without an expenditure probably beyond its value.

The power at Niagara has been estimated at seven million horse power, from less than half of the fall between Lakes Erie and Ontario, but the flow of the Niagara River, as given above, does not support so high an estimate. The whole of this fall (over 320 feet) can be utilized on the Welland Canal, but the quantity is comparatively insignificant, from the limited channel and necessarily low velocity of the current in it.

In like manner the whole fall upon our canals in the St. Lawrence can be utilized subject to the limitations imposed by the requirements of navigation. Because these canals have not had the work for which they were intended, they have in some cases become mill races rather than slack water channels. This has been the less felt, hitherto, on account of the lightness of their west bound traffic, the strong current toward the mills being in favour of the deeper laden east bound craft, thus incidentally compensating for a violation of canal maxims.

While water power was at first the only substitute for the windmill in new countries, and its economy as well as superiority has always been recognized, several causes have contributed to limit its more general application. Before the invention of the turbine in the first half of the present century heads exceeding about seventy feet could not be utilized on account of the comparative weakness and excessive cost of wheels of large diameter. In these days of structural steel, and "Ferris" wheels, this difficulty could be overcome; but, with the turbine, the conditions are reversed, the higher the head the less the size and cost of wheels, so that the most valuable water powers were the most cheaply utilized in this respect.

A previous check to the greater extension of water power was given in the latter part of the last century by James Watt's discovery of the steam engine, which by bringing the power to the work, to the city, and to the mine, revolutionized industrial conditions.

A still greater revolution has recently occurred which brings water power to the front again, by its amalgamation with electricity, whereby its economical power is transferred to the work, over many miles of distance, upon a single wire.

Within the last ten years high voltage electricity has been firmly established with annually increasing power of extension, and this has brought Canada into the first rank of economical power producing countries. Water is thus represented by a power to which it can give birth, but which is superior to its own, in that, where ever transplanted, it can do nearly all the parent power could do, as well as give light, heat and greater speed: moreover it has given rise to industries only possible with abundant cheap electricity. What is more important to us is that such industries are those for which Canada possesses the raw material, but which, without water power, she could not engage in.

There are important industries in which we have for some time utilized water power—for which electricity is not indispensable—but which equally require large amounts of cheap power, and are capable of indefinite extension : but while these may not need the intense electric current necessary for electro-chemical industries, they will find electrical transmission of inestimable value in many situations ; while, for lighting and heating purposes, water power is invaluable to all.

Heretofore we have cut our spruce into deals and exported it to Europe, and more recently into pulp wood and exported that to the United States ; but, manufactured by our water power into paper, the raw material would yield this country ten times the value it is now exported for.

The extension of railways combined with electrical transmission, will promote the local manufacture of such wood products (including all valuable hard wood) as can bear transportation; thus giving the largest amount of local employment, as well as tonnage to the railway; and delivering us from the position of "hewers of wood" for other countries.

ELECTRICITY.

In order to present more fully the recently enhanced value of our Canadian water power, some reference is necessary to certain properties of electricity, the power which has happily been described as "the most romantic form of energy" by Wm. Henry Preece, C. B., F. R. S., in his recent address as President of the Institution of Civil Engineers.

Inasmuch as the cost of production of electrical energy depends upon continuity of output, water power must be the ideal one for this purpose, at least until some cheaper power is discovered. In some places where steam is now used for electric light other industries have been added to secure the more continuous use of the power in daylight hours.

The only quality in which any deficiency has been exhibited by electricity is for lighthouse purposes, a lesser power of penetration in fogs, in which respect it is inferior to oil or gas: but even this, has in the present year, been more than compensated for by the successful application of "wireless telegraphy", by which, in any weather, communication between the ship and the shore can be established. The shores of the St. Lawrence from the Atlantic to the Lakes are lined with water power which can be used to light, in fair, or protect, in foul weather, the passing vessel; to ring the bell or blow the horn.

When water is applied for light and power purposes its economy is always the important factor; but it is chiefly to its value for electro-chemical industries that Canada will look to reap the greatest benefits, because, in these it is not merely a question of competition of power producers, but one in which intense electricity has the monopoly, and in the case of some of them, as in the production of aluminium, calcium carbide, carborundum, liquid air, etc., their existence depends upon ample supplies of an intense electric current, for the generation of which abundant and cheap water power is indispensable.

Touching electro-metallurgical processes Mr. Preece says :

"Every electrolyte requires a certain voltage to overcome the affinity between its atoms, and then the mass decomposed, per minute or per hour, depends solely upon the current passing. The process is a cheap one and has become general. Three electrical H. P., continuously applied, deposits 10 lbs. of pure copper every hour, from copper sulphates, at the cost of one penny. All the copper used for telegraphy is thus obtained. Zinc in a very pure form is extracted, electrolytically, from chloride of zinc produced from zinc blende, in large quantities. Caustic soda and chlorine are produced by similar means from common salt. The passage of electricity through certain gases is accompanied by their dissociation, and by the generation of intense heat. Hence the arc furnace. Aluminium is thus obtained from cryolite and bauxite. Phosphate is also separated from apatite and other mineral phosphates. Calcium carbide, obtained in the same way, is becoming an important industry."

"Electrical energy can be generated on a coal field where coal, of good calorific value, is raised at a cost of three shillings per ton, cheaper than by a water fall, even at Niagara."

Eastern and Western Canadian coal fields are separated by thousands of miles, but water power is abundant throughout nearly all this coalless region.

Our western coal fields are vast and their market at present limited. If coal can be raised cheaply enough and the raw material for the work be discovered in the neighbourhood, they may give rise to electro-chemical and electro-metallurgical industries without the intervention of water power.

The commercial production of calcic carbide (acetylene gas), by electrolysis, is the discovery of Mr. T. L. Wilson, (a grandson of the late Hon. J. M. Wilson of Saltfleet, Ontario,) who has established works on the water powers of the Welland Canal and has shipped this product all round the world.

The electric production, commercially, of caustic soda and chlorine is under the patent of Mr. Ernest A. Lesueur, son of the Secretary of the General Post Office Department, Ottawa. This manufacture is now being carried on by a Boston company at a New England water power.

MINING.

There is another field nearly as widespread as our water power in which electricity is destined to play a most important role, and this is mining, which is now spreading over the Dominion with the same rapidity as the utilization of our forests for pulp and paper purposes. Over this area, from the Atlantic to the Pacific, minerals have been discovered and in many cases tested and successfully worked, and from recent results we appear to be on the threshold of remarkable developments in this direction, especially as so small a portion of so great an area has been prospected sufficiently for mining purposes.

For power purposes alone, electricity is invaluable in mines, and its multifarious uses (as enumerated by Mr. Preece) are "for moving trams and for working hoists: it lights up and ventilates the galleries, and, by pumping, keeps them free from water. It operates the drills, picks, stamps, crushers, compressors, and all kinds of machinery. The modern type of induction motor, having neither brushes nor sliding contacts, is free from sparks and free from dust. Electric energy is safe, clean, convenient, cheap, and produces neither refuse nor side products."

The Canadian mining districts are well supplied with water power, and all the wonderful effects of electricity are available for us upon a larger and more economical scale than elsewhere.

In connection with this abundance of water power, and from the fact that an important proportion is now situated remote from existing railways and settlements, the question of profitable limit of electrical transmission is most important,—if indeed it be now possible to put a limit on anything connected with electricity, with or without the aid of a wire. If, as reported, Lord Kelvin has placed the profitable limit at 300 miles, this is sufficient to utilize the greater part of the water power upon the two watersheds north of the St. Lawrence River.

Professor Elihu Thomson says "Up to the present time it was practicable to transmit high pressure currents a distance of 83 miles using a pressure of 50,000 volts. If a voltage higher than that were used the electricity would escape from the wires into the air in the form of small luminous blue flames."

As showing how far we are yet behind nature, Prof. Thomson says the estimated voltage from a lightening discharge ranges from twenty to fifty million volts.

Wherever the raw material for electro-chemical, electro-metallurgical, or other industries, affords sufficient inducement, and the water power is at hand, the forest will be penetrated much more rapidly than heretofore, and settlements advanced in new directions.

What can be done in this direction is best illustrated by the development of a single industry in the wilds of Minnesota north of Lake Superior, and adjoining Canadian territory. Over four hundred miles of standard gauge railways have been built, through what was a trackless wilderness in 1885, to reach iron ore beds, the ore from which is shipped to Lake Erie and thence again railroaded 200 miles into Pennsylvania. This one business has, in mines, railways, docks and fleets of steamers, required an investment of $250,000,000, and has led to as low a rate, by water, as 1 cent per bushel for wheat between Chicago and Buffalo, and 20 cents per ton for coal from Lake Erie to Duluth, nearly 1,000 miles. One-half of the charcoal iron, and more than half of the pig iron made in the United States, is smelted from Lake Superior ore.

ELECTRIC RAILWAYS.

The substitution of electricity for steam, as the motive power for railways, is regarded as inevitable sooner or later on many roads. It has already taken place as regards suburban railways, notably in the case of the Charlevoix road and Hull and Alymer railway, where water is doing the work which has heretofore been done by coal. The chief obstacles to an early change on the larger roads are the hundreds of millions invested in locomotives, and the very large outlay required to equip existing steam roads with the electric system. The principal inducement would be the passenger service, owing to the increased speed possible,—it being confidently stated that, with electricity, a speed considerably over one hundred miles per hour could be attained. Moreover there would be entire abolition of the poisonous smoke which drops upon the Pullman in preference to any coach ahead of it.

While the conversion of trunk lines would be attended with a cost which is for the present prohibitory, this objection does not apply to new lines which may be worked independently, or in connection with electric ones. When the time arrives for such railways, water power will have a field of usefulness of which we can at present form little conception. Water wheels and wires would displace the coal docks, the coal laden vessels, the huge coal yards, and the trains required for distributing their contents over hundreds of miles of lines.

An interior line connecting Lake St. John, on the Saguenay, with Lake Temiscamingue, on the Ottawa, which could ultimately be extended, via Missanabi, Nepigon, and Lac Seul to the Saskatchewan, would be a colonization road—removed from the frontier—one which could be worked possibly altogether by water power, and would open a virgin tract in which electro-chemical and electro-metallurgical industries might arise, as well as those connected with the products of the forests and the mine.

TRANSPORTATION.

The more extended use of our water power, in the immediate future, for manufacturing and mining purposes, especially for the electro-chemical and metallurgical productions, naturally leads to the consideration of the character of the output, especially with regard to markets, and transportation problems generally.

Transportation, next to production, is the most important commercial question to a country of vast distances, and low priced products affording great tonnage such as we produce, and for which we have expended hundreds of millions in canals and railways, harbours, lighthouses and steamers,—a sum disproportioned to our realized wealth, as it certainly is to our population. But, *noblesse oblige*, we possess a vast estate, are compelled to develop it—and await results.

The question of transportation determines, to a great extent, the existence, or otherwise, of a possible industry, and enhances or diminishes the value of every article of export just in proportion to its efficiency and economy. On the other hand, where transportation is necessarily expensive, cheap production may maintain an industry;—and here is where our abundant water power may come in.

The geographical position of Canada in relation to the commercial centre of gravity of the North American continent is at least noteworthy. This centre is very near Lake Erie. From the western end of this lake the water route to the Atlantic, at the Straits of Belle Isle, follows the general direction of a great circle which cuts the commercial heart of Europe, and is therefore upon the shortest route, or "air line". Our two peninsulas, Sarnia-Detroit and Sault Ste. Marie, which are the railway gates of the Lake region, afford the most direct routes to the Atlantic for all the North-western States, and are traversed by the trunk lines of railway. From Lake Erie water communication on the largest scale extends through Lake Huron to the extremities of Lakes Michigan and Superior. One-third of the population of the United States are dependent upon the Great Lakes, largely as to exports and imports, and wholly as to rates,—which are fixed by the water for the rail routes.

One-half of the population of the United States is found within a radius of 400 miles from Cleveland, a Lake Erie port claimed to be second only to the Clyde as a ship building one, and also the largest iron ore market in the world.

The paper and pulp industry as well as some of the electro-chemical and metallurgical ones (to the present list of which many additions may be made) are distinguished by the large tonnage produced, the output of several pulp mills exceeding one hundred tons per day. For this the St. Lawrence is the natural route for exportation, and to it this heavy tonnage is of the greatest importance as a means of attracting "tramps" as well as liners during the open season.

Increase of sea tonnage into the St. Lawrence is essential to our inland commerce : by it only can sufficient west bound freights be secured to attract a proper share of the commerce of the Lakes, after all has been done to give to the latter quick despatch at Montreal or Quebec.

There is probably no place in the world where inland transportation is carried on with greater expedition and economy than in the valley of the St. Lawrence. This is due to the character of the inland navigation, unequalled elsewhere, and to the influence which this exerts upon the railways competing with it: and also, because the valley of the St. Lawrence is not only the greatest highway for agricultural products, but of mineral ones, as well as of the products of the forest and the fisheries.

More than half of the iron ore produced in the United States is mined around Lake Superior. Into this lake an increasing number of railways are pouring the produce of the vast wheat fields between it and the Rocky Mountains, and thus placing this grain within a thousand miles of Montreal, which is the nearest seaport by hundreds of miles, and the only one which can be reached by vessels capable of navigating the lakes.

Wheat grown in the foot hills of the Canadian Rockies has already reached Lake Superior by an all rail haul of fifteen hundred miles, a distance considered prohibitory in the early days of railways, as one which would absorb the whole value in the cost of carriage.

The all-rail rate for wheat from Edmonton, on the North Saskatchewan at the foot of the Rocky Mountains, to the Atlantic at St. John, N.B., 2,937 miles on the Canadian Pacific Railway, is 33 1-3 cents per bushel, equal to 0·38 of a cent per ton per mile. The lake and rail route between the same points is 93 miles shorter, with at least two transfers of the grain, and the rate three cents per bushel less, or ·35 of a cent per ton per mile.

The rate from Edmonton to Lake Superior, 1,458 miles all rail, is 31½ cents per 100 pounds, and to Montreal, 2,456 miles all rail, 56½ cents. The lake and rail route to Montreal, 2,363 miles is 46½ cents per 100 pounds, 5 cents per 100 pounds or 3 cents per bushel less in favour of lake and rail, against all rail whether to Montreal or to St. John, N.B.

The lateness of harvest in our Northwest, and the early closing of navigation in the St. Lawrence, will soon over-tax all our means of transport, both water and rail, during the interval between September and December. The Welland and St. Lawrence canals and the portage railways between Montreal and Lake Huron constitute the Canadian routes, and much, which cannot reach Montreal in time for export, will be stored up at nearest lake ports for winter railway carriage to tide water warehouses on the St. Lawrence, for export at Atlantic ports,—or for conversion into flour at Ontario and Quebec water powers.

What is looming up before us in the Canadian Northwest may be seen from the growth of the grain trade in Manitoba and our territories, where, already, storage capacity for twenty million of bushels has been provided in over five hundred elevators and warehouses between Lake Superior and the Rocky Mountains ; and where there are over sixty mills with a grinding capacity exceeding ten thousand barrels daily. From these the estimated export of wheat, including flour, in 1898, was given at thirty millions of bushels by the Winnipeg Grain and Produce Exchange. The crop of 1899 is estimated from forty to fifty millions of bushels.

This accumulating tonnage from our western plains and our eastern forests must call for a proportionate extension of export facilities which should attract tonnage to the St. Lawrence. Already Montreal has eighteen regular lines of steamers to transatlantic ports, exclusive of tramps. New York alone of the Atlantic ports exceeds this in number. Montreal has five regular lines to Liverpool and the same number to London, two lines to Glasgow and two to Hamburg, and one each to Bristol, Manchester, Belfast and Antwerp. Baltimore has twelve regular lines of steamships to Europe, Boston nine, and Philadelphia eight. No doubt all these Atlantic lines exceed Montreal in number and tonnage of vessels as well as in cargo carried, as they have twelve months navigation against seven for the St. Lawrence. The real significance of Montreal's eighteen regular lines of steamships is the demonstration, that, in spite of climatic drawbacks, or inferiority in other respects, the St. Lawrence is the route towards which northern exports will gravitate during its open season.

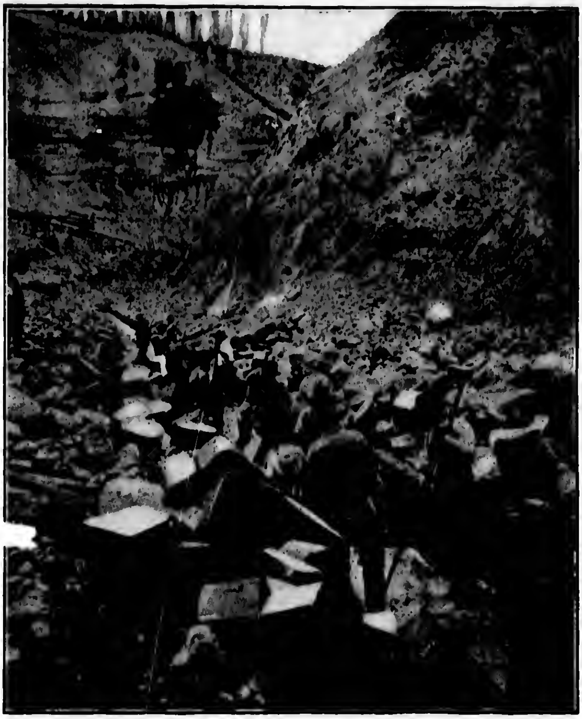
The "Water Power" map has been prepared by the Surveyor-General of the Dominion, E. Deville, F.R.S.C., under instruction from the Hon. the Minister of the Interior.

I am indebted to the Director of the Meteorological Service, R. F. Stupart, Esq., for the tables of mean annual as well as minimum precipitation of rain and snow in all provinces, excepting British Columbia. Some of these figures are printed upon the map, in blue, to distinguish them from others in black showing the height of lakes, so far as known, above tide level.

The map will not be engraved in time to be bound with the "Transactions," but will be distributed later.

Pair of Giant 7-inch Nozzles at Work at Cariboo Hydraulic Mine.

Giant, with 8-inch Nozzle, at Work 70 Feet from Bank (Close Quarters)
Cariboo Hydraulic Mine.



Cleaning up the Amalgam from Sluices, Cariboo Hydraulic Mine.

APPENDIX.

Hydraulic Mining.

The extraction of gold from soils, as distinguished from veins in the solid rock, has been carried on most extensively for the past fifty years upon the Pacific coast of the United States and Canada, and what is known as hydraulic as distinguished from "placer" mining has been brought to great perfection there. California has been more systematically explored and her resources estimated in this respect than Canada. Those of Canada are yet but partially known, but the probability is that they will prove far greater. According to the State Mineralogist, California has already produced over one thousand millions of dollars in gold from her auriferous gravels—in the working of which over one hundred millions of dollars have been invested. This gold was obtained from the beds of ancient rivers where it is found covered with drift and forest, which must be washed away by the power of water, before it is reached. California has four hundred miles of these ancient water courses, estimated to contain an average of two millions of gold per mile, or $800,000,000 in all. Besides those which may be called "free milling" deposits, there are ancient channels where the gold is found in cemented material and cannot be washed out; and, again, there are one thousand miles of ancient channels in which the gold is "lava-capped" and can only be reached by "drifting" for it. These lava-capped channels are estimated to contain $500,000,000.

For hydraulic mining the power canal or "ditch" should have an elevation of at least one hundred feet above the working level; and this may be increased to five hundred feet without becoming unmanageable. The higher the head the farther it will throw an effective stream, and such head is necessary when working against a high bank in order to secure a safe distance for the "giant" attacking it.

The elevated ditch terminates in a large wooden tank called the "pressure box," which feeds the pipe descending the slope to the field of action. This pipe is constructed of wrought iron or steel sheets, the strength proportioned to the head of water, rivetted with a double row on the straight seams and single on the round. According to Mr. Hobson, General Manager, Cariboo Hydraulic Company, iron is preferable to steel, because the latter is often of uneven temper, having hard spots which break in bending; besides which steel is more readily attacked and eroded with rust than even the common quality of sheet iron. The best quality of sheet iron has had, in hydraulic pipes, four times the length of life of the best quality of steel.

The sections are made up in lengths of fifteen to eighteen feet, such as can be conveniently handled by two to four men as the pipes may vary from fifteen to thirty inches in diameter; and are put together on the ground "stove-pipe fashion," caulked by sacking and driven home by a wooden ram, eight inches diameter by six feet long."

Though not frequently exposed to the pressure due to the hydrostatic head, these pipes are strong enough to resist this when necessary. Mr. Hobson states that "such iron pipe has been in use for years under a tensile strain of 13,000 pounds to the square inch, although," he adds, "most authorities would hardly admit this factor of safety." He gives the safe pressure for the three sizes of pipes used by his company as follows:

Gauge. B.G.	30 in. Diameter.	22 in. Diameter.	18 in. Diameter.	15 in. Diameter.
No. 14 Steel or Iron..........	150 ft. head	210 ft. head	252 ft. head	305 ft. head
No. 12 " "	230 " "	310 " "	385 " "	460 " "
No. 10 " "	300 " "	420 " "	505 " "	600 " "

These pipes, which are bell-mouthed, should be as large in diameter as can be afforded, to lessen the friction and increase the force of the issuing stream, and because their size must be decreased in approaching the giant so that here they can be easily handled by man power, in the frequent changes of position necessary.

Sheet iron pipes treated by immersion in a hot bath of asphalt have been in use in California, some for more than a quarter of a century, and are subjected to great pressures as shown in the following table, published by the Joshua Hendy Machine Company, San Francisco:—

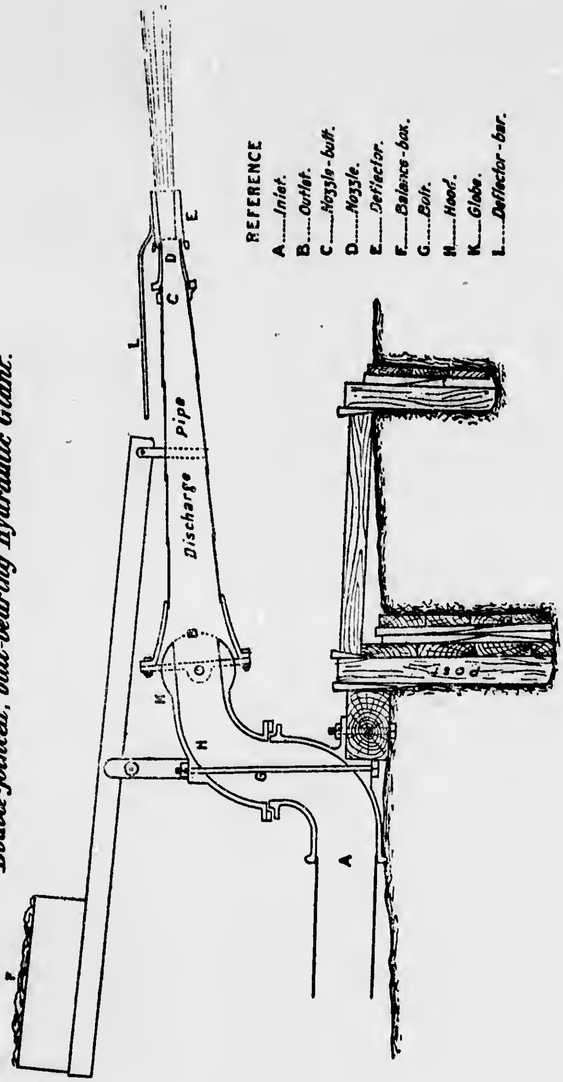
Locality.	Diam. Inches.	Thickness of iron.		Pressure.	
		B.G. No.	Inches.	Head in feet.	Lbs. per Sq. in.
Moore's Flat	12	14	.083	400	173
San Juan	16	18	.049	200	86
Spring Valley Water Co	30	11	.125	365	158
Cherokee..........	30	00	.375	887	384
Virginia City Water Co	11½	0	.344	1720	750
French Corral	22	10	.131	430	183
Malakoff Diggings.........	22	10	.134	450	194
Texas Creek	17	8	.165	760	329

THE GIANT.

The illustration shows the most improved pattern in "giants," in which the horizontal movement is around a bolt, made of the best quality of steel and thoroughly annealed, which holds in position the two cast-iron sections connecting the wrought-iron feed and discharge pipes. The vertical movement is provided for by a globe joint connecting the discharge pipe with the uppermost of the cast iron sections. The nozzle is cast iron attached by a screw thread, removable at will, as nozzles of various sizes are made to fit the same "butt" on any giant.

The nozzles range from six to ten inches in diameter, and Mr. Hobson says :—"A small stream, six to seven inches, is more effective in cutting down the banks ; and a large stream of eight, nine or ten inches is the most effective for removing the caved gravel into the sluices." The balance box is essential and is never omitted in giants of any size. The giant is anchored to the floor of the hydraulic pit as shown in the sketch with the addition of side posts at the end of the wooden bed piece in order to prevent a side movement. The greatest force is a thrust, by impact, of water at the angle, and if the giant can be prevented from moving at the forward thrust it will generally remain in place. Care must be taken to secure solid ground for the fastening posts, and in wedging the bulkheads at the front and at the ends of the "giant" bed piece, in order to withstand the enormous pressure from a discharge of fifty to seventy-five cubic feet of water per second under a head of several hundred feet. The discharge at the nozzle is very close to the theoretical in good machines connected by large pipe

Double-jointed, ball-bearing Hydraulic Giant.



AS USED BY THE CARIBOO CONSOLIDATED HYDRAULIC MINING COMPANY, QUESNELLE FORKS, B.C.

lines with the ditch, and will probably average 93 per cent of the theoretical discharge.

At the Cariboo mine a pipe line 1,000 feet in length is composed of a length at entrance of about fifty feet, tapering from forty-eight to thirty inches, forming the bell mouth, then 200 feet of thirty-inch pipe, and the remainder twenty-two inch to within a short distance of the giant.

The "deflector" at the end of the nozzle, which controls the movement of the giant is a simple cylinder of about two inches larger diameter than the issuing jet, swung, at its rear, in a joint similar to the gimbals on a marine compass. A lever is attached to this deflector of sufficient length to enable a boy, entering on his teens, to bring the cylinder into firm contact with the issuing jet, which then swings itself right or left, up or down as required. On letting go the lever the deflector swings free from the stream.

Water is usually measured on the Pacific coast by the "miner's inch," which varies in different localities; but the most widely used one is "the quantity of water that will flow from an orifice one inch square through a two-inch plank with still water standing at a depth of six inches above the top of the orifice,"—which quantity is 2,274 cubic feet (about 17,000 American gallons) in twenty-four hours. The duty of this inch is the washing of one and a half to four and a half cubic yards, according to locality and quality of material.

LAKE SUPERIOR IRON.

The Lake Superior ore beds of the United States have yielded 134,000,000 tons, of which 117,000,000 tons have been mined since 1882. The quantity mined in 1898 was 14,000,000 tons, the greatest of any one year, and more than half of the total mined in the United States in that year.

The production of pig iron in the United States in 1898 was 11,773,934 tons; the principal producing States being:—

Pennsylvania	5,500,000 tons
Ohio	2,000,000 "
Illinois	1,500,000 "
Alabama	1,000,000 "

The greater portion of the above was Bessemer pig, of which Pennsylvania produced 4,000,000 tons, Ohio 1,500,000 and Illinois 1,200,000, the last two having the higher proportion. Lake Superior ore and Pennsylvania coke meet at Chicago. About one and two-thirds to two

AS USED BY THE CARIBOO CONSOLIDATED HYDRAULIC MINING COMPANY, QUESNELLE FORKS, B.C.

tons of ore and one ton of coke made a ton of pig iron. The production of coke at Connellsville, near Pittsburg, Pa., is about 170,000 tons per week. This coke, which is free of duty, has been delivered in Lake Superior by rail and water at $4.25 per ton, while "Pittsburg" coal (from which it is made) has been laid down there by water at $1.85 alongside wharf, subject to duty of fifty-three cents per ton. About one and three-quarter tons of Connellsville coal are required to make a ton of coke. It may require nearly two tons of inferior coal to make one ton of coke.

Nova Scotia coal, water borne, is the only Canadian coal which might be used in Lake Superior; but as long as a supply of charcoal can be obtained it will probably yield a better quality of iron at a smaller cost per ton than any other fuel.

The iron ore deposits on the Canadian side of Lake Superior are said to be the most extensive known ; it is asserted that two million tons are in sight on a single quarter section in the Atikokan belt. The quality is both hematite and magnetite, and chiefly Bessemer ore.

I am indebted to Dr. George Dawson, Director of the Geological Survey, for the following account of Canadian ore west of Lake Superior:

Iron ores are widely distributed throughout the district west of Lake Superior. They occur in rocks of Keewatin (Huronian) age as magnetites and hematites and in the Animikie as carbonates and hematites. The principal belts are one extending from the Kaministiquia River westerly up the valley of the Matawin River and continuing to beyond the Township of Moss, and another following the course of the Atikokan and Seine Rivers.

Along the first of these, outcrops of ore have been found at many points, but notably in the neighbourhood of the Matawin River, where extensive deposits of both magnetite and hematite (hard ores) have been partial y exploited by open trenching and by the diamond drill. Though generally considerably banded with jasper, large deposits of clean ore occur here. On the Atikokan belt the ore is a high grade magnetite averaging over sixty per cent metallic iron. Along the Atikokan, the eastern part of the belt, the ore carries no titanium and but a trace of sulphur, and is consequently a good Bessemer ore. It occurs in long, lenticular masses which swell out to widths of upwards of fifty feet and which are vertical or nearly so in attitude. Three or more roughly parallel bands of ore are separated by belts of country rock (diorite and hornblende schist) from twenty feet to a few feet in width. The whole width is often considerably over a hundred feet and the bodies of ore which can be followed as recurring lenticules for many miles are traceable as continuous ore bodies for upwards of 500 yards. (See Annual

Report Geol. Survey, 1895, pp. 38 R and 83 S, et seq., for assays and description.)

Ore has been discovered at numerous other localities throughout the district, notably in the Gunflint Lake district just north of the International boundary, at the head of the Big Turtle River and on the north shore of Thunder Bay near Loon Lake. In none of these places, however, are the deposits as extensive as those noted above.

The Matawin area is about thirty miles from Port Arthur and five miles from the nearest point on the C. P. Railway. It is on the line of the Port Arthur and Rainy River Railway, now under construction.

The most extensive ore deposits on the Atikokan are about 100 miles from Port Arthur and forty miles from the C. P. R. This area is also on the line of the Port Arthur and Rainy River Railway.

Other iron ore deposits, chiefly hematite, have been discovered upon the north shore of Lake Superior and east of Nepigon, at Batchewaning Bay, Gros Cap and Little Pic, and are referred to in many reports of the Geological Survey from 1866 to 1876, but their extent and value is yet unknown.

PULP WOOD—AND THE WOOD PULP INDUSTRY.

According to "Lockwood's Directory" there are over one thousand pulp mills in the United States, and less than one hundred in Canada, but of the thousand, one hundred are idle ; while of the ninety-three Canadian mills only four are idle, one in each of the provinces of Ontario, Quebec, New Brunswick and Nova Scotia. Of the greater proportion of idle American mills some, are no doubt, closed for want of raw material, because the home product is being rapidly exhausted and importation is necessary. Canada has supplied some of these with both pulp wood and pulp. There is nearly as much difference, commercially, to an exporting country, between its wood pulp and pulp wood, as between the traditional horse chestnut and chestnut horse,—they are not convertible terms ; and there would be a still greater difference if we turned our wood into pulp and the pulp into paper at our own water powers. The same reason which exists for cutting pine logs into sawn lumber in Ontario holds good for turning our spruce logs into pulp and paper, throughout the Dominion.

Ontario, Quebec, Nova Scotia and New Brunswick possess an almost unlimited quantity of spruce of the strongest and finest quality for papermaking. It is claimed for this spruce (not only as against that of the Pacific Coast, but as against that of Europe), that its flocculent fibres possess an interlocking edge like bearded barley which seize hold of each other when passing rapidly from the floating to the fixed position, and can consequently be driven at a higher rate of speed through the machine than other kinds of spruce wood. The other woods for pulp-making, in order of value, are balsam, poplar, soft maple, basswood and tamarack, all abundant in Canada. Spruce and balsam are not only at the head of the list on account of their intrinsic value, but because they reproduce themselves more rapidly than others; this, in the case of spruce, being estimated to range between ten and twenty years according to situation.

"Lockwood" gives the Dominion list of mills under the two heads of paper mills, and pulp and chemical fibre mills. Their reported capacity for Ontario is a daily output of :—

Paper mills	172,000	lbs.
Pulp and chemical fibre mills	743,000	"
Total	915,000	"
For Quebec :		
Paper mills	564,000	"
Pulp and chemical fibre mills	493,000	"
Total	1,057,000	"

Nova Scotia has a paper mill of 8,000 pounds daily capacity, and Nova Scotia and New Brunswick have pulp and chemical fibre mills; the first with 174,000 pounds, and the second with 160,000 pounds daily capacity.

Numerous and varied as are the qualities and uses of pulp and wood paper, its abundance and cheapness have given it an extended field in architecture, in addition to the ornamental one, especially for a cold climate. By its use the cheap wooden houses can be made warmer than brick or stone ones ; and in many of these there is a greater surface of paper than of wood used, as it is doubled round the sides, and can be used to cover both roof and carpeted floor. The paper mills advertise their output as book, ledger, news, bag, tissue, manila, wrapping, writing, hardware, carpet lining, roofing, building, wall, leather board, binding, etc.

The other uses to which both chemical and mechanical wood pulp are put are varied and increasing, as in furniture, carriages, hollow ware of all kinds, water pipes, portmanteaus, horse shoes, bottles, clothing, paving blocks and fire and water-proof compositions. In the latter connection a most extensive and important field will be found in water-proof underground conduits for electric wires.

Mechanical pulp is wood ground in water ; chemical pulp, the same wood digested or cooked in sulphurous acid, or, by a soda process, filtered and refined, and is, therefore, worth three or four times as much as the raw product. The cooked article is used almost exclusively to improve the quality of the raw.

The wants of the United States are said to be the product of one hundred thousand acres annually. If this estimate be now excessive it must soon be reached and passed. One New York paper is reported to use the product of seven acres for its daily issue.

It is stated that owing to the expansion of this industry the greatest source of revenue in Sweden is derived from her forests; and that the Government are purchasing the private ones in order to secure their protection.

RAINFALL.

In the following tables the most noticeable feature is the small amount (as compared with the eastern provinces) of total precipitation with which Manitoba and the Northwest Territories produce such magnificent crops of cereals, dairy products and vegetables, as well as horses, beef, and bacon.

Wheat is there sown over a frozen subsoil which gradually yields its moisture to the influence of the sun, inciting and sustaining growth until the rain (more than half of which falls in the summer months) brings the grain to maturity. Of the total precipitation, nearly 75 per cent is rain between 1st April and 1st October, the remainder falling (chiefly as snow) during the other six months.

In these tables—stations in the watershed of the Great Lakes are placed together in alphabetical order for their respective lakes.

MEAN ANNUAL PRECIPITATION—RAIN AND SNOWFALL—IN INCHES, AS OBSERVED AT ALL STATIONS IN CANADA EXCEPTING BRITISH COLUMBIA.

STATION.	Mean Annual Precipitation.	Least Amount of Precipitation in one year	STATION.	Mean Annual Precipitation.	Least Amount of Precipitation in one year
MANITOBA.			NORTHWEST TERRITORIES.		
Aweme	16·19	12·20	Banff	19·44	.....
Brandon	16·20	9·35	Battleford	13·62	11·61
Burnside	14·96	11·46	Calgary	12·98	7·91
Cartwright	17·49	14·16	Chaplin	7·07	3·47
Channel Island	15·20	13·97	Edmonton	15·15	8·16
Clandeboye	16·70	12·01	Fort Chippewayan	11·05	10·09
Clarkleigh	18·10	14·32	Fort Dunvegan	23·23	15·27
Eden	17·14	11·19	Grenfell	13·49	10·05
Fort Ellice	16·07	10·48	Kilnap	11·67	6 31
Foxton	17·64	11·88	Maple Creek	10·18	7·73
Gladstone	20·51	18·15	Medicine Hat	12·60	6·72
Hartney	23·35	....	Prince Albert	14·45	9·59
Hillview	19·29	12·46	Qu'Appelle	15·89	10·14
Minnedosa	17·08	11·62	Regina	9·03	1·90
Norquay	22·26	14·33	Swift Current	17·04	9·66
Oakbank	20 24	15·28	Moose Factory	26·47	24·03
Oaklake	19·50	8·53	Norway House	19·26	15·74
Pilot Mound	18·74	14·25			
Portage la Prairie	18·84	13·89			
Posen	21·84	17·39			
Rapid City	15·78	5·94			
Rockwood	18·07	15·16			
Russell	18·04	14·07			Proportion of Snow, Inches.
Shell River	15·37	8·57			
Shoal Lake	12·90	11·50	Abitibi, 1897	20 in.	78·2
Sourisford	13·57	10·41	Do 1898	33 in.	121·8
Stony Mountain	13·94	8·25	York Factory	28·73	14·34
Treherne	10·09	11·53			
Turtle Mountain	20·40	17·52			
Winnipeg	20·92	14·84			

MEAN ANNUAL PRECIPITATION—RAIN AND SNOWFALL—IN INCHES AS OBSERVED AT ALL STATIONS IN CANADA EXCEPTING BRITISH COLUMBIA.—*Con.*

STATION.	Mean Annual Precipitation.	Least Amount of Precipitation for one year	STATION.	Mean Annual Precipitation.	Least Amount of Precipitation for one year
ONTARIO.			ONTARIO—*Con.*		
Biscotasing	20·45	16·23	Little Current	31·92	20·88
Cartier	29·51	23·42	Listowel	33·01	29·81
Heron Bay	21·04	18·71	Lucknow	38·42	30·40
Missanable	22·74	17·94	Midland	36·95	35·20
Nepigon	16·34	15·07	North Bruce	32·79	27·42
Port Arthur	31·38	19·12	Orangeville	30·51	28·31
Savanne	24·74	19·43	Orillia	32·71	22·23
Schreiber	24·98	.....	Owen Sound	38·74	30·63
Sault Ste. Marie	36·26	30·21	Parry Sound	37·73	32·62
White River	25·52	13·35	Point Clark	31·30	22·67
Ailsa Craig	33·42	29·84	Presqu'Ile	40·46	32·65
Aurora	28·61	22·06	Saugeen	34·17	27·25
Axe Lake	29·46	23·80	Seely	40·26	35·44
Alton	30·45	27·32	Sharon	29·36	25·98
Barrie	30·33	21·22	Sprucedale	35·32	30·80
Beatrice	42·40	28·09	Stayner	32·93	26·03
Bognor	38·35	29·17	Sunshine	36·91	32·03
Charlinch	38·68	29·22	Thetford	32·74	29·86
Coldwater	32·55	29·70	Uplands	41·90	32·69
Durham	40·42	29·86	Whiteside	36·18	32·01
Egremont	33·31	23·59	Wiarton	34·37	32·14
Georgina	28·36	21·93	Zurich	37·18	29·68
Goderich	32·64	17·32	Aylmer	36·92	32·43
Goderich (L'gt House)	33·39	14·17	Birnam	35·64	27·67
Granton	36·45	26·28	Blenheim	38·73	30·15
Gravenhurst	30·06	28·22	Brantford	26·25	18·73
Gwillimbury	25·06	22·08	Chatham	31·87	23·64
Haliburton	29·66	25·46	Coldstream	35·38	34·44
Hoodstown	43·02	30·61	Conestogo	31·72	22·03
Joly	36·51	31·78	Copetown	32·91	25·96
Kincardine	34·88	28·83	Cottam	33·73	25·57

MEAN ANNUAL PRECIPITATION—RAIN AND SNOWFALL—IN INCHES, AS OBSERVED AT ALL STATIONS IN CANADA EXCEPTING BRITISH COLUMBIA.—*Con.*

STATION.	Mean Annual Precipitation.	Least Amount of Precipitation for one y'ar	STATION.	Mean Annual Precipitation.	Least Amount of Precipitation for one y'ar
ONTARIO—*Con.*			ONTARIO—*Con.*		
Cowal	31·73	25·69	Woodstock	33·67	26·47
Dealtown	33·49	26·62	Wyoming	29·25	25·43
De Cewsville	32·47	20·72	Welland	33·05	25·87
Elora	34·18	29·17	Halleybury, Nipissing District	32·02	27·13
Fergus	36·32	28·68			
Galt	31·25	24·87	Belleville	31·42	28·78
Guelph	25·90	21·86	Bobcaygeon	27·71	22·55
Ingersoll	33·15	26·11	Brampton	29·07	21·00
London	36·84	27·45	Deseronto	33·03	29·95
Lyons	35·07	27·57	Ennismore	35·83	30·67
Maidstone	29·28	24·47	Georgetown	28·98	24·25
Oil Springs	28·97	25·47	Hamilton	30·39	19·17
Otterville	32·52	24·67	Harrowsmith	32·75	26.38
Paris	33·30	27·41	Kingston	33·14	26·03
Petrolia	31·36	20·88	L'Amable	35·52	31·88
Point Pelee	33·16	29·17	Lakefield	29·80	22·13
Port Dover	32·54	22·46	Lindsay	33·26	26·50
Port Stanley	31·79	27·02	Minden	32·85	30·07
Princeton	32·74	26·54	North Glanford	22·73	21·31
Ridgetown	34·07	29·19	Niagara Falls	34·41	30·75
St. George	32·56	26·83	Norwood	31·35	24·44
St. Marys	37·63	30·73	Oshawa	31·81	27·05
St. Thomas	31·22	28·83	Port Dalhousie	30·55	25·41
Sarnia	27·23	22·69	Port Hope	32·25	28·85
Strathroy	34·50	33·09	Peterboro'	31·65	20·19
Stratford	38·30	28·20	Scarboro'	29·00	26·36
Simcoe	31·69	20·97	Stony Creek	36·83	32·71
Sombra	33·72	28·01	Shannonville	27·72	25·22
Wilton Grove	30·70	24·74	Toronto	31·52	24·34
Windsor	29·66	25·66	Arnprior	36·02	32·43
Watford	25·42	24·06	Alexandria	37·92	30·19

MEAN ANNUAL PRECIPITATION—RAIN AND SNOWFALL—IN INCHES, AS OBSERVED AT ALL STATIONS IN CANADA EXCEPTING BRITISH COLUMBIA.—*Con.*

Station.	Mean Annual Precipitation.	Least Amount of Precipitation for one y'ar
ONTARIO—*Con.*		
Bancroft	35·06	32·15
Brockville	36·66	29·39
Cornwall	30·66	25·47
Clontarf	32·48	27·31
Denbigh	33·72	26·11
Edwardsburg	38·62	34·95
Fitzroy Harbour	25·52	21·55
Mattawa	25·66	18·80
Northcote	25·96	22·49
Oliver's Ferry	30·80	22·49
Ottawa	32·87	25·63
Pembroke	38·87	19·71
Renfrew	25·01	17·54
Rockliffe	30·44	22·10
QUEBEC.		
Anticosti, S. W. Pt.	27·74	13·44
" W. Pt.	41·32	34·49
Barnston	40·25	36·45
Bird Rocks	27·51	17·67
Brome	32·99	21·41
Cape Magdalen	32·22	26·68
Chicoutimi	30·33	24·42
Cranbourne	46·77	36·34
Danville	40·09	31·26
Father Point	32·19	19·03
Huntingdon	37·13	30·38
Montreal	40·23	30·88
Point des Monts	45·70	30·92
Quebec	41·68	31·70
Richmond	40·69	33·87
QUEBEC—*Con.*		
St. Francis	38·36	36·18
St. Hyacinthe	37·91	29·66
NOVA SCOTIA.		
Port Morien	39·39	30·45
Digby	29·10	22·30
Glace Bay	47·75	40·97
Halifax	52·20	45·32
Port Hastings	45·15	31·14
Pictou	42·02	32·30
Sydney	44·00	40·85
Sable Island	44·20	32·77
Truro	43·28	36·89
White Head	44·42	36·65
Yarmouth	49·57	36·04
PRINCE EDWARD ISLAND.		
Charlottetown	41·45	32·45
Georgetown	40·03	35·48
Kilmanagh	39·53	30·54
NEW BRUNSWICK.		
Bathurst	35·62	23·52
Chatham	41·26	32·63
Dorchester	44·96	33·16
Dalhousie	36·06	27·15
Fredericton	41·55	36·89
Grand Manan	46·72	35·20
Point Escuminac	32·35	.....
Parker's Ridge	46·01	39·81
Point Lepreaux	46·48	38·00
St. Andrews	39·46	30·04
St. John	47·38	42·65
Woodstock	40·76	35·26

MONTHLY PRECIPITATION AT FOLLOWING STATIONS IN MANITOBA IN 1898.

STATIONS.	JAN.	FEBY.	MAR.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.
	Snow.	Snow.	Snow.	Rain.	Rain.	Rain.	Rain.	Rain.	Rain.	Rain.	Snow.	Snow.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Rathwell	4·2	6·9	17·4	1·58	0·29	6·72	2·96	0·96	1·03	....	....	....
Turtle Mountain	1·7	3·5	8·5	....	0·20	2·84	4·60	2·46	1·80	4·40	9·5	1·00
Pilot Mound	5·5	5·00	13·00	1·12	0·62	3·42	2·92	1·15	1·04	4·30	5·00	4·00
Belmont	....	....	....	1·80	0·10	3·51	4·17	2·21	0·71	3·00	....	0·00
Morden	3·00	2·00	8·00	0·65	0·70	6·40	1·07	0·68	2·40	3·50	8·00	4·00
Mary Hill	9·5	1·5	17·7	0·86	0·24	2·63	4·64	1·27	2·23	3·34	11·2	8·00
Pembina Crossing	....	....	9·5	0·71	0·70	2·85	1·95	1·35	....	3·63	....	....
Rapid City	4·00	....	24·00	....	0·74	2·29	5·60	2·71	2·45	3·41	9·00	....
Hartney	....	5·00	13·00	0·78	0·72	4·26	5·22	3·92	2·37	2·21	10·5	1·00
Norquay	....	6·5	10·3	0·83	0·34	5·20	3·06	1·68	0·98	2·30	11·3	5·00
Beaver Creek	....	....	....	0·50	1·15	3·43	2·60	1·33	0·84	3·10	....	....

The light rains of April and May (seed time) the heavy rains of June and July (growing time) and the lighter ones in August and September (harvest) are noticeable. The average annual rainfall of Palestine is more than double that of Manitoba but it all falls in winter between October and April.

ELECTRIC RAILWAYS.

Under present conditions the superiority of the electric current to steam, as a prime mover, is confined to positions where it is required to move a single car or two, frequently, instead of a large number at wider intervals. For the current the power is generated at a central station, and must at all times be equal to any demand upon it ; while in the other case it is self-contained in the locomotive engine, the number of which may be increased or diminished as occasion requires.

An electric installation to produce the same power as the best locomotive will cost nearly ten times as much as the single engine, and can only compete economically with the latter where the demand for power is continuous. Where a single locomotive could do the same work, the interest upon nine-tenths of the cost of installation would handicap the electric system.

When coal is used to produce the electric current, the cost per horse-power produced is the same as for the locomotive. When water power can be obtained the fuel cost is saved ; but, since this item forms less than 20% of the operating expenses of a railway, the amount saved may be fully offset by interest charges upon the cost of electric installation, including that of the water power.

For urban and suburban passenger traffic there is no comparison in efficiency, economy, comfort and safety to passengers, between electricity and steam : moreover, the frequency of cars and absence of cinders and smoke lead almost immediately to a very decided increase of traffic. On the other hand, a breakdown at the central station puts an immediate and total stop to traffic, while a disabled locomotive would be dragged off or replaced by another. Grades up to 10% and above are surmounted by the electric car—because there is a motor under every car—while less than half this is the practical limit on steam roads. A steam motor could mount the same grade, but would require a licensed engineer and a dangerous boiler to every car.

For heating purposes electricity requires 25 times the horse-power needed to produce the same heat by steam: for tram-cars it will always be preferred on account of greater convenience and cleanliness; and because of the moderate amount necessary, as compared with houses. It will always be used for these cars when water power supplies the current—and should be even with coal generation.

We cannot foresee the future of this question. If the heavy locomotive which carries no paying load, can be got rid of—lighter rails and bridges than are now called for can be used ; and if the momentum of trains can be utilized to produce the electric current, every car may be provided with a storage battery for emergencies. Length of trains and strength of couplings would be reduced and speed increased, the reciprocating piston of the steam cylinder being unable to compete with the rotating electric motor;—the limitations being only air resistance and condition of track.