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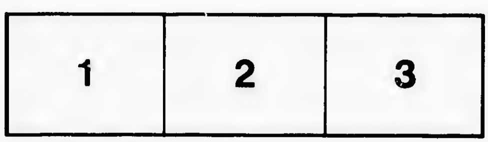

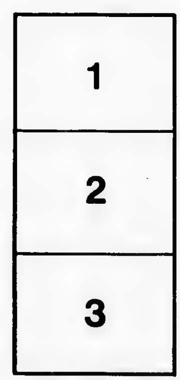

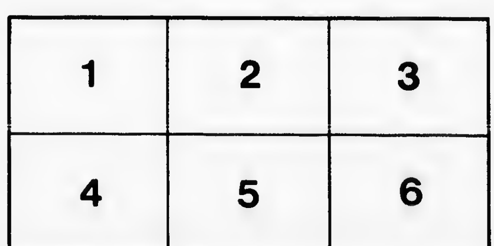

ADDRESS OF

T. C. KEEFER, C.M.G.

PRESIDENT

Canadian Society of Civil Engineers,

— AT THE —

ANNUAL MEETING,

JANUARY 12, 1898.

Canadian Society of Civil Engineers.

PRESIDENT'S ADDRESS.

At Annual Meeting, Jan. 12, 1898.

By T. C. Keefer, C.M.G.

Having been honoured by re-election to the Presidency, after an interval of ten years, I desire first to thank you most heartily for this renewal of your confidence, and at the same time to congratulate the Society upon its record in this the first ten years of its existence, during which total membership and revenue have increased about fifty per cent. Unlike our predecessors in England and America, we, as the offspring of later times, have encountered no early period of suspended animation, but have advanced steadily, if not rapidly, in numerical strength, and maintained satisfactory financial stability. If we have not progressed proportionately in public usefulness or mutual enlightenment, it may be ascribed (in some measure at least) to the fact that some from whom much could be expected are too closely occupied with daily duties to contribute, as they might otherwise do, to our "Transactions." Some may be too modest, and some too old, or possibly too indolent.

If, however, we have held our own as we have done in these recent years (which embrace several of world-wide depression), our prospects for the future seem brighter than when we began our organization in 1887. Then our great railway systems were practically completed; and although this was the case with our enlarged canal systems only as regards the Welland, the work on the St. Lawrence was in an inert condition. Ample leisure was then afforded Canadian engineers for organization, amusement or foreign travel.

Now, however, there is a decided change in our position at home and abroad. Canada is now a colony of national importance, the largest independent member of a world-wide Empire, and none have contributed more to this advanced position than engineers of every class embraced in our Society, which, while it excludes none, is composed almost entirely of the constructive rather than the destructive order.

In 1887 Canada was not a mining country; now, recent discoveries over a wide extent of our vast Dominion have brought the mining engineer to the front, and with him the hydraulic and electrical engineer, because water power is almost universal in our mining regions from Labrador to Alaska. Our vast prairies, where is grown the most valuable quality of the most important cereal, have hitherto been unable to attract much foreign interest, though accessible to all nations; but the recent discovery of gold has been of such a character as to invite world-wide attention. Its influence (however temporary) cannot fail to produce increased agricultural development in our great North-West.

Since the birth of our Society water power has attained a position of immense importance owing to electrical transmission, which has given rise to new industries only possible where there is cheap and abundant water power, which also secures cheap intense electricity.

The rapid extension of the pulp industry in Canada is one of the results of cheap water power coupled with our abundant supply of raw material, easy reach of navigation, of rail, and the best markets; but the more recent electro-chemical industries are the exclusive products of cheap intense electricity. Here (as in mining) is a new field for the chemical, electrical, hydraulic and railway engineer. I include the chemist among the engineers, because I regard him as such, with the electrician, the hydraulic or mining engineer, producers though not creators of power, and, it may be, the chemical force is more potent than any other. If dynamite is a chemical compound, the power maker or discoverer is worthy to be numbered with the power user.

An electro-chemical industry of recent origin has been established in Canada by the discoverer, a Canadian chemical engineer, Mr. Thos. L. Willson. This is the manufacture of calcic carbide for the production of acetylene gas by means of electricity produced by the abundant water power of the Welland Canal at Merritton, where the manufacture in commercial quantity was first started in 1896, and from whence the product has already been shipped to England, France, Germany, Italy, Spain, Australia and South Africa.

Another electro-chemical manufacture in which our profession is interested (on water power ground), which also depends on cheap electricity, is that of aluminum, for which the raw material is so widely distributed, but for which, as with the carbide, abundant and cheap water power is indispensable.

In view of its importance, owing to its wide distribution over Canadian territory from the Atlantic seaboard to the Rocky Mountains, where no coal is found, and on account of its vastly enhanced value since the discovery of high voltage transmission, even where it is within the coal fields, I have chosen water power as the subject of some observations for the Annual Address.

I have heretofore drawn attention to this widely distributed power outside of our coal regions as to some extent a substitute for coal, upon the assumption of local application of power in both cases, whether water or steam, and then the vast difference presented itself that with the last the power could be taken to the work, while with the other the work must be taken to the power; for there was no thought then of electrical transmission. The utilization of water power would be very slight and very slow if under the old conditions of advance into the forest (as in the agricultural portions of the valley of the St. Lawrence), because our greatest extent of water power is in the mountainous and sometimes barren regions, not inviting to agriculture though most favourable for the accumulation, maintenance and uniform distribution of water power throughout the year.

In considering the question of water power generally, and in comparison with steam, it may first be mentioned that while electrical transmission (where practicable) has enabled it to take the place of steam in many situations, the choice in others depends upon the work to be done as well as upon cost of fuel. For transmission purposes there are only the questions of the sufficiency and permanence of the power and its superior economy; but for lumber manufacture, although ample water power is at hand, and there is with it no question of ice difficulties, it is found in many cases that steam is preferable, because the mill site may be chosen in the best position for manufacture, shipment and storage of logs, and the waste material furnishes fuel for power. The cost and maintenance of a mill dam in many situations, with the necessary piers and booms for the logs, the damage and risk to mills, etc., during floods, are reasons urged (in addition to the questions of site and fuel) in favor of steam for this industry. But for other purposes the site of the water power (perhaps in a gorge) is unfavourable for many industries on account of difficulty of access and want of service ground; and here is the value of electric transmission of water power.

When adopting water power, one of the most important considerations is the possible need of future enlargement. Where all the water power of a stream of any point is secured by a dam, and this power can be drawn upon from time to time until the whole is applied, we have only to consider cost and maintenance in the first place, even though the additional power must thereafter be obtained by coal, or transmission (when this last is commercially practicable), not only because the water power is sufficient for many years, but, as far as it goes, it is more economical than any other. But if only part of the available water power is needed, and provision for the future must be postponed for financial reasons, then the question of how any future addition can be made without interruption becomes important in proportion to the purpose for which the power is required. If for water supply or electric light, either the original dimensions must be far beyond present wants, or there must be the power of duplication without interference with existing conditions, or else temporary power for this purpose on a sufficient scale, or permanent, if made auxiliary for future deficiency of water. Such considerations affect the question of the economy of water power for certain purposes and under certain conditions where a periodical increase of power must be provided for. It altogether depends upon local conditions whether an artificial water power, as it may be called, will be worth what it costs for any purpose; and more particularly if this is one in which power must be reserved for future needs. Temporary employment of surplus power could not be counted upon to build up permanent industries.

Electrical demand and transmission have created a "boom" in water power under which in some cases the schemes proposed may become financial failures. There is evidently a limit to the distance to which water can be artificially conducted in order to reach a fall under the most favourable conditions of route. For power purposes the only useful portion of the aqueduct is that which lies below the surface level of the water in it, and the value of this is in direct proportion to its size, and therefore its cost, which includes the cost of all required work above this level. The longer the aqueduct the higher must be the fall which it secures, and the lower the fall the larger must be its dimensions and cost if it is to be efficient. Whether it will be profitable in either case depends upon the cost. Such natural dams of rock as those of Niagara, Sault Ste. Marie, Rat Portage, the Chaudière, the Chats and others on the Ottawa are natural water powers of the first order; but the artificial powers created by our canals (apart from cost of every canal adjunct to the water channel) would never have been undertaken for water power purposes. There is a popular superstition that there is more in water than its weight, because that weight is felt "all over" as well as on the bottom, and a tendency to ascribe to it a fictitious value. This has possibly something to do with some projects.

In water power the discovery of lowest possible head level is of the first importance, and the one often of the greatest difficulty where this is not controlled by a dam, which (wherever practicable) is the only certain means of fixing it. When a dam does not exist, or is not obtainable, recourse is had to legend and the "oldest inhabitant," who has seldom proved old enough for the occasion. Our canal engineers have, with the best information, found their mitre sills in many cases very much higher than they intended them to be, because the river had gone very much lower than it had ever been said to have done. To secure at all times a required depth it seems necessary to add about three feet to the "oldest inhabitant." When, over fifty years ago, the Government first constructed timber slides on tributaries of the Ottawa, in the absence of any knowledge of the local range of water level, the mouths of these were found so high after the first flood that the timber could not be floated into them until a dam was built for this purpose.

The high water level is more easily provided against, and is often more important in connection with the tail-race in fixing the wheel level, where the discharge is into a reach subject to great variation, like that below the Chaudière Falls, where the extreme range between high and low water exceeds twenty-five feet; which, though of short duration, is about three times as great as the same range above these Falls. Where the wheels would be affected, as this is always the case at the season when the rise is greatest at the head, provision may be made to utilize this temporary increase of head level so as to maintain the necessary power during back water.

Where unceasing operation of power is required in our climate, duplication and separation of flumes (and it may be in some cases of tail-race) may, where practicable, warrant the additional cost in thus securing reserve of power (as well as of machinery) when any particular channel has a surfeit of ice;—as well as by so much contributing to a future enlargement.

Except upon our canals (where the least winter difficulties are experienced), our great water powers have been chiefly used as summer ones, in which the two independent questions connected with water power, viz., the power of enlargement and extension without interruption, and the possible ice difficulties of a northern site, do not come in question. The large saw mills have not worked in winter because their logs are frozen in. Before the railway reached them the mills stopped sawing when they could no longer ship their output; but where they depend upon the water for their logs, whether they are worked by water or steam, they are idle in winter.

The coming of electricity, bringing with it the demand for winter power, has produced ice difficulties where they did not before exist, and were therefore not anticipated and not provided for, although winter water power, to a limited extent, had been in use. Increased power brought increased current, and this under certain conditions brought the submerged ice.

There is no question of more importance to our water powers than this one of uninterrupted operation in our northern districts where nearly all are located, and where (with perhaps the exception of the southern portion of our Pacific coast) ice in one form or another must be dealt with. It assails the moving water sometimes both from above and below, and, if undiscovered, chokes off the motive power.

In artificial channels the fixed surface ice above may diminish the water power by its increasing thickness and depression from superincumbent weight of snow saturated by winter rains and thaws; and where these channels are fed from open water in which floating slush ice is moving, the latter may be drawn in to increase the throttling of the reduced water-way. The situation is greatly complicated by winter fluctuations of the open water from which the mill-race is fed, and in which the "slush" or "anchor ice" is running—a not uncommon situation in northern rivers which cannot be conveniently dammed, or where sufficiently large receiving basins cannot be created so that "slush" or "anchor ice" will not enter and travel through the mill pond to reach the flumes.

The ice question can be more fully appreciated by what has taken place in connection with water powers at Montreal and Ottawa. In the first case, the aqueduct of the Montreal water works, five miles in length, almost entirely in excavation, is fed from the St. Lawrence above the Lachine Rapids, where there is a smooth swift current which prevents the freezing over in winter, but is often covered with "slush" or "anchor ice" when that is running. The Lachine Rapids below the intake of this aqueduct are of that ragged character that temporary ice dams often form and break away during the winter. These dams produce a sudden rise which extends to the aqueduct two mile above.

From the setting in of winter until March the river level steadily lowers, except when temporarily elevated by the ice dam, so that in the early spring there is the least depth of water at the intake and the greatest depth of surface ice and saturated snow over the aqueduct, and the only water-way left is at the bottom where the width is least. The ordinary action of snow falls, winter rains and thaws (the accumulations of three or four months) would of themselves seriously encroach upon the water-way in the widest part of its earth section, but these are (in this case) enormously increased by the sudden rise of the river while the ice is frozen to the aqueduct banks. This ice is overflowed before it can be lifted, and as these winter floods always occur during the severest weather, the overflowing water is immediately frozen, forcing the ice covering of the aqueduct further down until the half or more of the area of its water-way may be closed off.

These winter inundations seldom last long enough to send the river water far down the aqueduct, but their action at its mouth is all that is necessary to affect its power. The first one experienced was during the first winter the works were in operation. Nothing like it has taken place in the forty years which have since elapsed, and it was the only one which extended throughout the five miles of the aqueduct. In January, 1857, after nearly five days of below zero weather, in the middle of the night the water suddenly poured over the flumes in the wheel-house, sending an icy stream over the frozen surface of the ground for miles beyond. This ice-dam on the rapids caused a rise of four feet in a few hours at the aqueduct entrance. Years later this flood might have destroyed the usefulness of the aqueduct for the remainder of the winter, but the power then required was so small that winter difficulties did not arise until a later date, when the conditions were aggravated from another direction,—below instead of above, and from another description of ice insidiously creeping into the winter-diminished water-way, due to the causes above described, and producing gradual suffocation. This did not take place until the combination of extreme low water in the river, extreme accumulation of surface ice and snow and increased draught to the wheels so quickened the current at the intake that it attracted the floating frasil or "anchor ice," which immediately that it touched the solid bordage ice at the aqueduct entrance was sucked under and soon arrested where the strangling process was slowly but surely closing the gap.

The lesson of this history is that in such situations, where anchor ice is wont to pass, an intake basin is indispensable where possible, so large, wide and deep that the necessary supply for the power channel coming into it from the river will never create a current sufficient to attract the frasil. Anchor ice is only begotten in open water, and this in our climate always means water too swift to become self-freezing; and it will not leave this until enticed from the old paths by stronger currents. It is therefore only a question of cost to form a mill pond which it will not invade. Where this is limited, the boom which separates the river from the basin (forming a bordage to the ice cover of the latter) should be made deep enough to prevent the ice which is passing and crowding outside from being forced under it.

An enlargement of the aqueduct was undertaken twenty-five years ago, but it was not carried farther than seven-eighths of a mile from the entrance. It has prevented the incoming of anchor ice and enabled the aqueduct in high water winters to pump its full summer average. But as the strength of a chain is that of its weakest link, so, for this purpose, the minimum power must be equal to the maximum wants, and auxiliary power will be required until the completion of the enlargement. Enlargement is not likely to be completed until the consumption is so increased that it will become cheaper to pump the whole by water power.

In high water mild winters when there is the minimum of ice obstruction, and an increased depth at its widest section, the aqueduct pumps its full summer average. Thus in March, 1890, it pumped 350 million gallons, while in March, 1893, it only pumped 46 millions, because when the river falls to a certain level all wheels are stopped to prevent further lowering of the ice in the aqueduct. This result would go to prove that, to meet our winter conditions in some situations, an increase of at least fifty per cent. on the necessary summer dimensions would be needed.

THE OTTAWA WATER POWER.

Until water power was required for pumping the city water supply in 1874, there had been no important winter use of the power of the Chaudiere Falls. The large saw mills did not work after November. The few establishments on either side of the river where winter water power was used had no effect on the ice question, nor did the larger demands for the city pumping change the conditions in this respect. The advent of electricity, however, in which three large users of power engaged, revealed the fact that winter difficulties existed where they had not been anticipated. Fortunately, they have not yet seriously affected the city aqueduct, where, in the absence of auxiliary power or reservoir, they might produce a calamity.

The conditions at Ottawa differ from those at Montreal in as much as the aqueduct is fed from Nepean Bay, which is ice covered in winter, and all the other mill-races upon the Ontario side draw under similar conditions. About a mile above these the foot of the Little Chaudiere Rapids is reached, and this is united with another rapid higher up, so that there is over a mile of open river in which anchor ice is manufactured and sent below in successive and frequent crops in severe winters. On the north, or Quebec side of the river runs the only deep channel between the Little and Great Chaudiere. This is generally open water throughout the winter, and in it much of the anchor ice is carried into "the Kettle" and away from the mill ponds on either side. From this a subsidiary channel of considerably less depth crosses diagonally to Nepean Bay, discharging into a depression in which there is a depth much greater than that of the channels leading into and out of it, and therefore a slower current. This is the point from which the supply to the city aqueduct is taken, and, in leaving it, the aqueduct begins between piers sixty feet apart placed in twenty feet of water, whereas the section through the rock after it leaves the river bank is only twenty feet wide with about thirteen feet depth of water. The excavation being entirely in rock, this aqueduct has the great advantage, for winter work, of having as great a width at the bottom as at the surface.

It was not known that any frasil passed through this bay under its ice covering, but it was believed that if and when it did, the slower current into the aqueduct would not attract it, and that it would pass outside in the main channel leading to the mills below. This has proved to be the case in the twenty-three years of the aqueduct's history, although there has been some frasil in the later years, causing a stoppage of the wheels on one occasion for a few hours, by which stoppage its presence was first made known.

Unless anchor ice is expected and watched for, the first indication of its presence may be a sudden collapse of the water power. When the Montreal aqueduct was first corked up at its mouth by anchor ice, the wheels ran on until the five miles of canal was emptied, and the ice tumbled in, ruining it, as an aqueduct, for the time being. The same experience overtook the electric power at Ottawa, and from the same causes, but under different conditions, emphasizing the necessity of local knowledge of bed as well as of the surface of the channels near and above the site of the power.

The whole Ontario side of the river bed is a submerged rocky plateau ten to thirty feet or more above the bottom of the north channel, so that if the river surface here at low water were lowered ten feet it would lay dry the greater portion of the southern half of the river bed, while there would still be deep water in all the north channel above the rim of "the Kettle." As at Montreal, in a moderate and high water winter ice difficulties are not experienced, but in very severe and low water winters the thickened ice settles down on top of the shoals, reduces the depth and increases the current in the channels between them until one after another is invaded by frasil, coaxed in by the increasing draft towards the water power, and gradually shut off.

In these winters the output of anchor ice is a maximum, while the storage room beneath the field ice is reduced to the minimum. Moreover, as channel after channel is closed, the velocity in the remaining ones is so increased that the anchor ice is carried under miles (it may be) of an ice covered surface, until it reaches the mill-races.

That anchor ice is carried long distances under the surface of an ice-covered river (or shallow lake with sufficient current) is proved by watching air holes near Montreal, where this ice is seen hurrying past, having come over the Lachine Rapids, below which none is formed after the river becomes ice covered.

On the other hand, in mild and high water winters there is the minimum of ice of all kinds and the maximum depth of channel, and therefore the slower currents in them, so that anchor ice is arrested by friction under the field ice and frozen thereto, leaving some water-way underneath it.

The best way to fight anchor ice (which is the sole cause of the winter floods in the St. Lawrence) is to abolish it wherever this is practicable. It cannot be got rid of in the St. Lawrence, but could be at Ottawa by a dam at the Little Chaudiere. This could also be done in the Back River behind Montreal by a succession of dams creating slack water (and water power) if this can be accomplished at a profitable outlay. On most of our tributary rivers this hoary enemy of water power can often be got rid of, and a valuable water power created at the same time by means of one or more dams.