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OF THE

SCHOOL OF PRACTICAL SCIENCE

TORONTO

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PREFACE

The present volume consists of a number of papers which were read before the Engineering Society of the School of Practical Science during the session of 1898-9.

As in previous years, the papers deal with a variety of subjects, but all have a common basis in presenting some discussion, which is interesting to engineers. Without making invidious distinctions, attention may be directed to the admirable paper of Mr. Hare on the manufacture of wood pulp, which is very appropriate at the present time, and to the careful descriptions of modern interior systems of wiring which Mr. Chubbuck has contributed. Valuable in like manner, for the light which they throw on subjects of public interest, are the papers of the President and Mr. Neelands, on what may be called Northern Ontario, and those of Mr. Ross and Mr. Davidson on the Crow's Nest Pass Railway.

The Society has been singularly fortunate in securing contributions from well-known authorities. Dr. Bryce, Mr. Campbell, Mr. Southworth and Mr. Harvey have each papers in the present volume, which deal with the subjects to which they have given special attention.

The present edition is 1,500 copies.

Toronto, April 4th, 1899.

CONTENTS.

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ENGINEERING SOCIETY

—OF—

The School of Practical Science

TORONTO.

PRESIDENT'S ADDRESS.

The privilege accorded in the past to the President to address the Society at the first meeting of the year has always been greatly appreciated by him, as it is this year by myself, and I hope that what I may say in my remarks further on will prove of some real value to you.

Let me first of all extend a hearty welcome to the students of the First year, whom the Society has just voted into membership by acclamation. By taking a course at this institution of science you will receive an education that will not only enable you to keep in touch with this age of great advancement, but to make yourself a part of it, if you will.

It became evident soon after the School was opened that some means must be provided for the education of the students in all the requirements of a good public speaker, and to accomplish this desirable end our Engineering Society was formed, and I am glad to say that our graduates, some of whom are old engineers now, have ascribed their success as due in no small part to what they learned by attending the meetings.

I can but poorly express to you my appreciation of the confidence you place in me as your President, but I thank you for it and will endeavor to the best of my ability to further the interests of the Society for the benefit of us all. The difficulties which such an office brings to a student like myself are many, and it requires the aid of a committee both able and conscientious to overcome them. Knowing the members of the executive personally and that they are indeed competent, I feel sure of success in our endeavors. But success does not come from the exertions of the committee alone; it requires your own hearty co-operation, which I hope you will give by taking an active interest in all we do.

It is with sadness that I must here record the death of one of our honorary members—Col. Sir Casimir Gzowski, A.D.C., M. Inst. C.E., M. Can. Soc. C. E.,—who has been a good friend to the Society. As one of the leaders in the engineering profession, he was a much valued member and his loss will be felt deeply.

The chief subject of my address this afternoon is a description of the northern lands in the Province of Ontario, which I traversed this summer along a line of exploration running in a northerly direction to James Bay—the south coast of which is the extreme northern boundary of the Province. It is especially apropos since the projected railway to James Bay has awakened a great interest in this the largest part of Ontario—an immense area about which very little has hitherto been known. The old idea of it being a cold bleak waste is far from correct. It is true that there the summer is shorter and the winter as severe as the latitude calls for, but for all this the small colony of Moose Factory on James Bay have long enough season to grow their own vegetables and also pasturage for over a hundred head of cattle.

The passage up the Ottawa and Montreal rivers was made hurriedly, and of this part of the country only a general description can be given. The district in the vicinity of Lake Temiscamingue, already known to possess many good agricultural areas, is becoming yearly more settled. The soil is chiefly a rich clay in excellent condition for production. It is hilly and covered with spruce, Jack and red pine and birch, the first predominating. The rise to the watershed being comparatively sudden, has produced rivers swift and full of rapids and falls. In the 75 miles of the Montreal River from the mouth on Lake Temiscamingue to the Great Northern Bend, near which is Fort Matachewan, there are several French-Canadians and half-breeds' log huts. The inhabitants have made use of the fertility of the soil by putting small areas under cultivation. For the whole length of the river the banks are thickly covered with good spruce, which grows so densely and with so few breaks that the effect is depressing. Exposures of rocks of any kind are not numerous. However, this country is principally Huronian and is mineral bearing as may be seen from Mr. Burwash's geological report to the Bureau of Mines in 1896. His investigations were made along a meridian line running north from the north-east corner of Lumsden township and a few miles west of the Montreal River, which line traverses rocky country of the Huronian age. Several gold bearing quartz veins were found here by him.

Leaving the river at the above mentioned Bend and paddling through Lake Matachewan (about 10 miles in length) we crossed the long chain of portages and small lakes which lead over the height of land into James Bay waters. These trails traverse large areas of both sand and clay, all on about the same level. Swamps occur at intervals, covered with tamarack and tall, slim white spruce, the characteristic trees of these places. Night Hawk River, the first water entered flowing towards James Bay, winds through a swampy area over six miles in width. As the mouth on Night Hawk Lake is approached, the land rises and the more pleasant color of poplar and birch groves greet the eye.

Night Hawk Lake is a large expanse of very muddy water containing many islands. A river six miles long flows from its northern end into another similar but smaller body of water called Hollow Sand Lake, whose greatest breadth is 6½ miles. These lakes and surrounding country are very similar to the Abitibi lakes and country, being in the same latitude and about 40 miles west. The shore lines are formed of diminutive cliffs 10′ to 30′ high of a finely stratified and very pure clay or, more rarely, sand, both covered by a good depth of black mould. Around the lakes the poplars appeared for the first time in abundance, the average tree being about 30′ high and 5″-6″ in diameter, though some reach over 20″ diameter and are correspondingly high. This description applies with fair accuracy to all the poplar trees throughout the country to James Bay. The ash grows along the banks of some of the creeks as far north as the 49th Lat., but it is short and small in diameter—3″-5″.

The country for 10 miles west of Night Hawk Lake was examined by making use of some of the old trails which connect lake to lake over all these vast Indian hunting grounds. The land is of both clay and sand, generally swampy and covered with the slim spruce and some tamarack and here and there a cedar swamp, in which the trees were, however, not of much value. Outcrops of rocks seldom appeared except on the shores of the lakes and creeks and then were either green diorites or grey quartzose schists; but on the shore of Porcupine Lake a portion of one of these masses was exposed holding numerous small quartz veins that seemed to be gold bearing.

Northern Ontario possesses two varieties of lakes, each with its own distinct characteristics. One is that peculiar to the sand lands of the high altitudes in which the water is a clear crystal green and on whose bottom lies heavy calcareous deposits and growths shining up brightly to the surface. These lakes are not numerous as compared with the other class, which are found principally in the clay land. In these the water, a deep amber color, contains varying quantities of vegetable matter, but is always fairly transparent, except in the case of bodies of water like the Abitibi lakes, which hold such a dense mass of clayey material suspended in them that they are entirely opaque and have lost all trace of the amber color. Extensive marshes of alder and willow are commonly found around the mouths of rivers entering or leaving these bodies of water.

In the vicinity of Hollow Sand Lake is a high sand ridge or plateau about four miles in width, which extends away for many miles N.W and S.E. Beautiful crystal green lakes are scattered here and there over it, set down in hollows between steep banks; and there are other immense holes not filled with water, most peculiar for this remarkable emptiness. These are called "kettle holes." Nearly all of this land is now very old brulé of which but few signs remain and in its place scrub Jack pine has grown up. Around the shores of Frederick House Lake (adjoining Hollow Sand), which touches this ridge, is an extensive area of tall, 12″ diameter, red pine, with a few much larger white pine scattered amongst them. This is the northern limit for red and white pine.

To reach the Abitibi River from these lakes, the plateau had to be crossed again, but this time in a different part. The place is a very picturesque one. The only objects to break the view are the Jack pines, and by looking away in the distance through these trees one feels as though one were in a vast and beautiful park. The trail, leaving these high lands, descends to the lower country to the east and swampy land is again entered. This condition of the soil continues as far as the Abitibi River hills, with dry higher stretches only here and there. The reason is that proper drainage into the creeks has been barred by the deposits of debris and mud left along the banks by the water during the spring floods. The banks have thus been raised to a considerable height above the land behind and effectually hold back the surface water on it.

The creek by which the Abitibi River was finally reached is a typical one of the country. It is extremely tortuous, drops down in many places with short rapids and falls and is often badly log-jammed. Some of these jams are 200 feet across and have well-beaten portages around them, showing that they have for many years withstood the great rush of the spring floods when the waters rise a great many feet. This creek enters the Black River about ¼ mile from the junction of the latter with the Abitibi. The Black River is 200 ft. wide at its mouth and gradually narrows to 60 ft., which width it then maintains. For 30 miles up, the river is easily navigable for canoes, but at this point it becomes very rapid for a long distance and so shallow that only in high water can a canoe be poled up it. The general direction of the flow is north-west. In this 30 miles there are several short falls of which the greatest is 18 ft. The country passed through is similar to that already described, being gently undulating, swampy in parts and especially good for agricultural purposes along the river. The banks show many exposures of Huronian schists all more or less impregnated with pyrites or pyrrhotite. The spruce in this district is fair, the best growing near the river; but several areas covering a great many square miles have within the last few years been laid waste by the ravages of forest fires. The character of the lands along the Abitibi River as far down as the Big Bend—about half way to its mouth—is much the same. The river banks slope up to from 50′ to 75′, and then the land recedes back at this level in gentle undulations with occasionally a hill or range of hills. The soil is of clay and very fertile judging from the luxuriant growth of young trees and all kinds of berry bushes. Portions of the land are swampy, but here, with few exceptions, the depth of the moss is not more than a foot or two and this would soon dry up if the trees were cleared off. Most of the timber on and near the river banks is white poplar, growing in tall groves which are the natural results of very old brulés. There are still numerous areas of splendid spruce standing out at intervals along the shores and in strong contrast to the unimposing poplar. These extend along the river for as much as two miles in some places and inland for from ¼ to 1 mile. Now, the banks of the Frederick House River have not been visited by fire like those of the Abitibi. They are still densely wooded for its whole length with very little else than large healthy spruce. This river has its source in Frederick House Lake—one of the largest lakes mentioned at the start—is 150 ft. wide at its head, 150 yds. at its mouth, where it enters at the western angle of the Big Bend of the Abitibi and parallel in its general course with the latter river. It seems natural therefore, to suppose that in the intervening space between the two rivers there are areas of large red spruce and also of large poplar. Both of these big trees were found at several points from 2 to 5 miles inland, and Niven's Line, which traverses this country between the two rivers, passes through an extensive area of red spruce as large, Mr. Niven said, as any he had ever before seen.

The birch, unquestionably the most useful tree to the present inhabitants of the country—the Indians—grows quite plentifully here, generally intermixed with other trees. The large birch are only occasionally met with and then in groves or belts by themselves, the largest such found being at 8 miles above the Long Sault Rapids (or 30 miles above the Big Bend) and 1 mile inland. The trees, 12″ to 18″ diameter and 50′ to 60′ high, are beautiful specimens of their kind.

Six miles below Iroquois Falls or 16 miles below the mouth of the Black River, the Abitibi enters the Laurentian country, and after that the only rocks to be seen are pink and grey gneiss—except for a strip of Huronian 6 miles in width at the Long Portage—until the Devonian Limestone is reached about 125 miles further north at the Long Rapids, and this in turn extends without break to James Bay. No more quartz veins were found nor indeed any indications of the presence of gold-bearing ore. The country rock is so completely covered over with the surface deposits of clay and sand that whatever minerals there may be are effectually hidden from sight and from almost all chance of discovery.

Turning north from the Big Western Bend, the Abitibi River flows for several miles through a low flat area which, however, suddenly changes to a succession of high and steep hills—immense deposits of boulder clay (the first of the kind found, it being the southern limit in this Abitibi country) and in some cases of a fine sand capped by stratified clay. These hills, which extend far away from the river, are peculiar for their abrupt sides and unusually great height. From here on the soil is composed of areas of sand and boulder clay, about as much of one as the other. The river passes through an extensive area of sand hills in the vicinity of the Long Portage where sheer cliffs 75′ to 100′ high are exposed, and at one point at the head of the Cañon there is a drop of 120 ft. to the bottom of the valley.

Ten miles below this last place we come to the Hudson Bay Co.'s fort, New Post, which has stood here now for over 30 years. The officer in charge has cleared several acres of land and some of it is under cultivation producing excellent vegetables. The soil, a rich, dark, argillaceous sand, is so fertile that there would be no difficulty in raising all kinds of crops were it not for the liability of the country to frosts any night during the summer (see lower down the dates on which the temperature fell below freezing). The corn crop last year was a large one, but owing to the shortness of this year's season the stalks had by August 10th grown not more than 3 ft. and were not expected to mature.

From the Big Bend in the Abitibi River on down, the areas of high dry land gradually decrease in extent and a corresponding increase of the swamps takes place until at New Post, where the latitude is about 1° less than at Moose Factory on the south of James Bay, there is very little dry land except near the river, and 30 miles farther north where the Devonian limestone begins, even the river hills disappear and the swamps, which have so increased in depth and area as to be now safely called muskegs, come right out to the river banks. By walking straight away from the river, one passes through bush gradually decreasing in density until, at from ½ to ¼ mile in, the drear, desert muskeg opens up to view stretching out many miles with nothing in view but a dead stick here and there, and in the distance a small ridge or belt of scrub spruce. Numerous small ponds dot the surface, and they are surrounded with such treacherous ground (moss) that one dare not approach within 100 yds. of the water.

The timber in this stretch of country is quite plentiful but it is good for very little else than pulp wood, the large spruce being very scattered until the canon is reached and from there, with very few breaks for twenty miles down the river, fine spruce line the banks, extending back for over a mile in some places. The trees average 15″ diam. and 50′ high. Groves of 30′ Jack pine of a few acres in extent grow on the sand ridges, wherever these occur. The tamarack trees throughout this stretch of country are plentiful, but unfortunately have not grown to a useful size, that is, suitable for lumber. This summer they were attacked by an insect known as the Larch Saw-Fly Worm (Nematus erichsonii) with results that will become fatal if the worms survive one or two more seasons. Every tree was so completely stripped of its green needles that at the first glance they all appeared to be dead. The worm was first noticed in the second week of July and by the latter part of August had entirely disappeared.

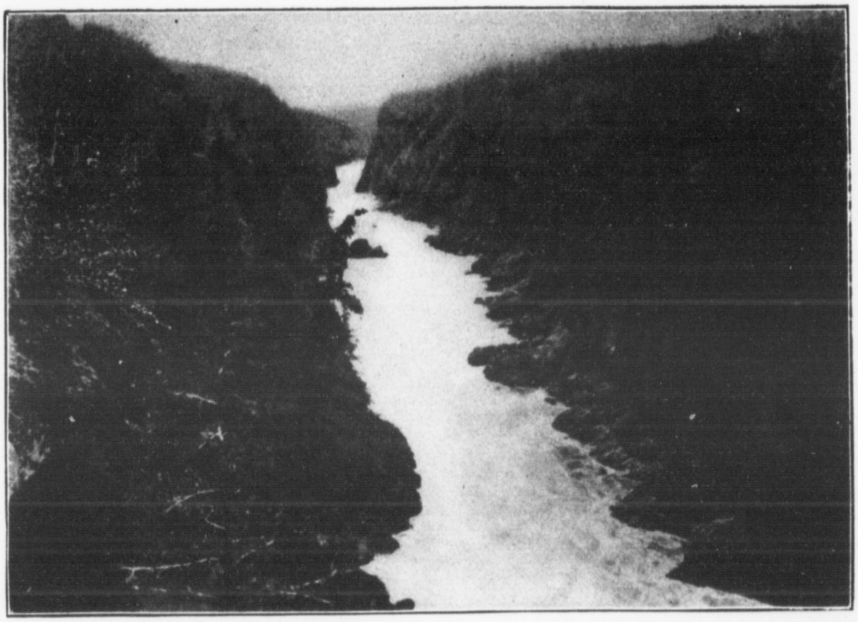
Northwards, as the bay is neared, the timber becomes very scrubby and scarce, the river widens out to about 800 yds. without a hill in sight, and a more dreary, unpicturesque country it would be hard to find.

The Cañon previously mentioned is situated about 60 miles up from the mouth of the Abitibi River, in a dyke of dark compact diorite. The gorge looks like an immense crack, for it runs almost in a straight line for two miles and is not over 30 feet wide at the bottom. The walls of rock present sheer faces often 100 ft. in height, while the highest point is 150 ft. above the water. The scenery along the heights and in the vicinity is indeed grand and impressive.

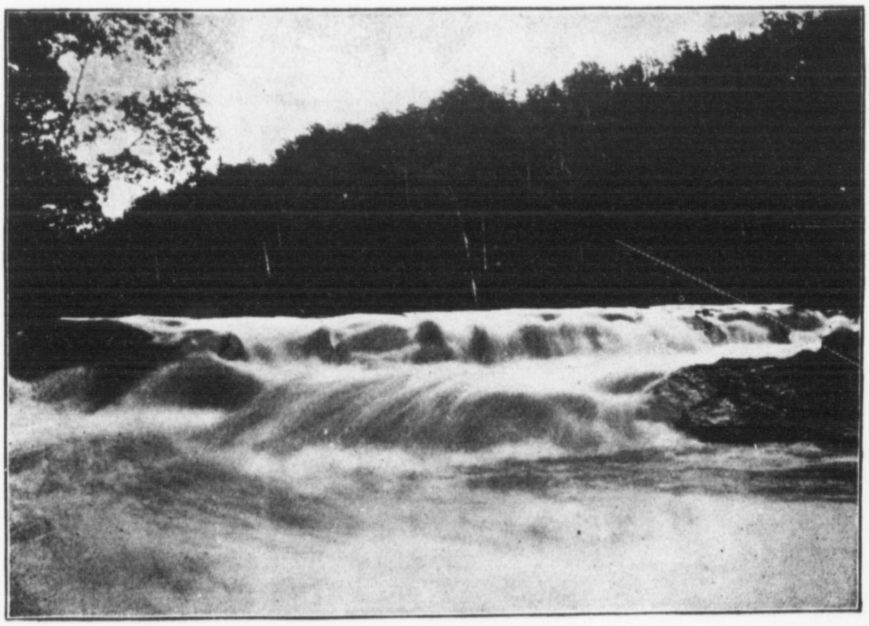
The bed of Devonian limestone which surrounds the southern part of James Bay is particularly remarkable for its fine stratification and for the great quantity of fossils it contains. It appears to be dolomitic in places, though with no perceptible change in the color, which is a yellowish brown or buff. Two large exposures of gypsum were found, one on the French River (which enters the Moose River near the latter's mouth) and the other in about the same latitude along the Moose River. This one contains a great deal of selenite.

The rivers of Northern Ontario seldom keep the same level for two days together, principally on account of their swiftness, and also since rains of only an hour or so cause sudden temporary rises. During the spring floods the water reaches the highest point which, on the small creeks, is about 15 feet above the usual summer level, and on the Abitibi, at New Post, where at high water the river bed is 200 yds. in width, the difference of 29 feet.

When in the region of the reported lignite beds, every effort was made to obtain some further information about them, but, unfortunately, without much better success than to merely substantiate previ-



THE CAÑON.



FALLS ON THE FREDERICK HOUSE RIVER.

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ous accounts. The first exposures on the Abitibi occur outcropping at intervals for a mile along the shore at the Blacksmith rapids, about 30 miles up from the mouth. As deep down into it as could be dug with the hammer, this deposit is simply a mass of boulder clay well saturated and jet black with the carbonaceous matter, and full of dark brown pieces of wood broken from what must once have been large trees, as the coarse fibrous structure is still distinct. Some parts of the clay are more saturated than others, but there is no stratification whatever, the nearest strata of any kind being the soft peaty shales 5 miles lower down the river; and, as to the thickness of the bed, this much only could be ascertained, that it is 4 ft. at the least. On the opposite bank, 300 yds. across, one single exposure has cropped out, and this also in boulder clay. A long face was laid bare to a depth of 3 ft., showing a bed much more like lignite than that on the other side, for it is composed entirely of carbonaceous matter quite compact, yet easily crumbled to a powder. Large chunks of hard blackened wood, some nearly 2 ft. long, are imbedded in it, giving a very definite strike of E. 10° S. and a dip of 75°. Weathered ends of some of the wood are jet black and brittle like coal. The crumbly property of these outcrops may be due to the continued action of the weather and the river waters, at whose lowest level only can they be seen; and to the latter cause may also be ascribed the saturation of the clay with the carbonaceous matter. Some years ago Dr. Bell found similar exposures along the Moose River at points S.W. from these on the Abitibi and in nearly the same altitude, but at distances from 50 to 80 miles away. It seems quite probable, therefore, that in the intervening area other deposits lie hidden at a not very great depth, which could easily be revealed by sinking a few bore holes.

Leaving the Abitibi River at its mouth, there remains about 23 miles to go down the Moose River before James Bay is reached. This latter river, where the Abitibi enters it, is one mile wide, and gradually widens out to 2 miles at the mouth; but along all this distance there are countless sand bars and long narrow islands situated down the middle, dividing it into really two rivers, with the muddy waters of the Abitibi flowing side by side with the clear, deep amber waters of the Moose without once intermixing. On the east side of one of these islands, over two miles long, about ¾ miles across and 2 miles up from the mouth of the river is the small colony of Moose Factory, the inhabitants of which are, with one exception (the Bishop of Moosonee), in the employ of the Hudson Bay Co., and this is the head station for the other posts around the bay. The ship, which comes here once a year from England, brings supplies to keep all these people and to trade off to the Indians for their furs. At one end of the island is the home of Bishop Newnham and his family and near by, the church, quite a respectable little building in which the English Church service is conducted and enjoyed just as much as in more civilized parts of the world. From here a road runs along the front near the high banks, back of which are the houses and buildings of the company and its servants. These latter number about 150 with their families, and in the summer there are added to this number from 250 to 300 Indians, who camp on the island, amongst the houses and away off at either end, until winter takes them off hunting again.

Outside the mouth of the Moose River several extensive bars have been formed in past years, and some are now quite a few feet above the highest tide level, which goes to prove that the land in this part of the country is being slowly elevated. In the last 100 miles south of the Bay, the slope is very gradual and this continues for many miles out to sea. At a point a few miles west of the mouth of the Moose River, said one of the officers of the H. B. Co., with a fall of 6 feet in tide level, the water recedes 15 miles. The bars just mentioned produce immense quantities of sea grass, a very nutritious growth which is reaped in as the winter supply for the cattle and horses of the company.

A few words might advantageously be said about the game that is to be found in this northern country. Moose and bear are plentiful in the vicinity of the height of land but become scarce farther north. The smaller fur-bearing animals such as the martin, fisher, otter, fox, beaver, rabbit, etc., are still numerous and distributed fairly uniformly, as is also the partridge. This last is not as plentiful as might be expected, and the same can be said of the ducks, which, however, are found in great variety together with geese in the vicinity of James Bay. Sturgeon and pike are the principal fish found in the rivers (the Abitibi River is too muddy for anything other than a few sturgeon), but in the small lakes and streams of the highlands pickerel are also numerous, and sometimes brook and lake trout.

The liability of the country to frosts at almost any time of the year is, in my opinion, the only drawback to its general usefulness for

Shooting the Long Soo Rapids.

Indian Camping Ground, Moose Factory.

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agricultural purposes. Appended are the dates on which the temperature was below the freezing point. The latitude of the place of reading is also given.

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June 10th,	" " 20′
June 15th,	" " 30′
July 5th,	" " 45′
July 10th,	" 49° 10′
July 30th, July 31st, Aug, 1st,	lat. 49° 50′
Aug. 18th,	" 50° 40′
Aug. 26th,	" " 50′
Sept. 6th,	" 60° 50′
Sept. 12th,	" 50° 45′

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Before I close, let me extend the congratulation of the Society to those of our members who have been recently appointed to the staff of the S. P. S. I refer to A. H. Harkness, B.A. Sc. Fellow in Architecture; H. W. Charlton, B.A. Sc. Fellow in Chemistry; T. A. Wilkinson, Fellow in Electrical Engineering.

I trust, gentlemen, that this year will be a very successful one for our Society in every thing that it aims to do. All that is necessary to make it so is for every one of us to have its interests at heart and endeavor to be present at the meetings, taking either an active part by reading papers, or at least an interested one, by entering into their discussion.

W. E. H. CARTER.

THE PROCESS OF MANUFACTURING MECHANICAL WOOD PULP.

By W. A. Hare, '99.

THE DEVELOPMENT OF THE WOOD PULP INDUSTRY IN CANADA.

Within the past two or three years there has been a marked impetus given to the pulp and paper industry in Canada. When one considers the vast resources we have at hand, coupled with the splendid waterways and canals for transportation, and other facilities for the building up of this great and important industry, he is apt to wonder why these conditions were not taken advantage of before. Changes occur in existing avenues of trade very slowly, and though the condition of the industry is at present in its infancy, Canadians may be expected to take full advantage of their opportunities in the near future.

Wood pulp will, for many years to come, be used to supply the world's demand for a filler in the manufacture of paper, in many of the coarse grades of which it is the only constituent. Its use is more likely to widen than to be curtailed. A very large amount of paper is made to-day from linen rags, esparto grass, etc., and for the manufacture of the finer grades of paper these materials may be expected to find a ready market. In the manufacture of news paper, wood pulp is used altogether, and as long as it can be produced cheap enough, there is little danger of a substitute being found. It is not confined, however, to the manufacture of paper alone, but is made into many useful articles of daily service, the market for which is increasing rapidly.

There is no reason to doubt that Canada will have a prosperous future, as far as this industry is concerned; and if the efforts put forth during the last two or three years are any forecast of the future, we will, in a few years, have good reason to be proud of the position this country will occupy as a producer for the world's markets. It is estimated that in the United States there are 1,200 pulp mills in operation, turning out an annual product of 1,500,000 tons of pulp, which require the consumption of 2,000,000 cords of wood. There is an ever increasing amount of this wood supplied from Canada year by year, which goes to show that the mills in the United States cannot obtain an ample supply from their own forests.

There is no country in the world that is so eminently fitted for the establishment and expansion of this industry as Canada. Any country to be pulp producing to any extent must possess three things which are factors in the development of this industry, i.e., water powers, spruce forests, and shipping facilities. Canada, fortunately, is abundantly favored in respect to these. Of the three the first two are natural advantages, while the third is artificial to some extent. In water powers we have all that could be desired. The rivers of the Maritime Provinces and Quebec have numerous falls and rapids, and those of Ontario are no exception; especially in the western part. Our share of the black and white spruce forests of the world is larger than that of any other country, producing the finest raw material for the manufacture of wood pulp known. Coupled with these two natural advantages is that of our transportation facilities, which are not surpassed in the world. The maritime provinces are directly on the sea coast, Quebec enjoys the use of our great national waterways, the St. Lawrence, while Ontario is intersected with canals and rivers, which afford easy and cheap communication to tide water. By our system of canals and waterways, we can transport pulp long distances by water, and in this way, those long hauls by rail, which are comparatively so expensive, are obviated.

With regard to markets, it may be mentioned that Great Britain imported in 1897, 330,000 tons of wood pulp, three-fourths of which came from Norway. Canada supplied less than 3,000 tons. Here is a good market for some time to come, for all the pulp that can be manufactured in Canada. Our great competitors in the British market are Scandinavia and the United States. From the latter country we have nothing to fear, as their wood supply is almost exhausted, and the mills now in operation there are dependent to a great extent upon our forests, so much so that if an export duty were placed on Canadian pulp wood their exportations would cease. Even the great forests of Norway and Sweden are showing signs of depletion, and it will only be by the enactment of strict forest regulations that the export trade will be kept up. It is a significant fact that the

Scandinavian mills are taking wood now that would have been rejected a few years ago. The quality of the pulp in Norway and Sweden is not as good as that made in Nova Scotia and in other parts of Canada. It cannot be denied that some of the mills there can and do make as good pulp as is made in Canada; but the average mill does not. The writer has seen samples from many different Norwegian mills, and can say that with one or two exceptions, the product was not equal to that manufactured in the Maritime Provinces. The Scandinavian pulp makers, in competing with us in the British market, have the advantage of a short ocean voyage, and also in that they employ cheaper labor. But our possibilities of development are far beyond those of Scandinavia by virtue of our great natural resources and advantages. Though we have to contend with the long carriage and high freight rates, it is only reasonable to suppose, that, with the growth of the industry, the rates will be reduced.

The Canadian wood pulp industry has grown very considerably of late years. Newfoundland, if we may consider her as among the provinces of the Dominion, is just entering on an era of development that has long been retarded. One or two mills are in operation at present, while others are projected that will, in all probability, be in operation soon. There are a number of valuable water powers on the island, while the spruce forests are extensive, the trees being of a smaller variety, and of slower growth, which adds to their value as pulp wood. Newfoundland spruce makes an extremely strong fibre and finds a ready market at prices in advance of the Canadian product. The maritime provinces are well favored with extensive spruce forests, numerous water powers, and easy shipping facilities. The industry has advanced very much of late years, and by next year a number of new mills will be building or projected. Pulp making was carried on in the town of Bedford, in Nova Scotia, as far back as 1837, but it did not exist as an industry until 1894, when two mills went into operation. These mills, as well as the more recent ones, are equipped with modern up-to-date machinery, nearly all of which was manufactured in Canada.

In Quebec there has been the most activity; and it is here that we must look for the bulk of Canada's exports in wood pulp and paper. The numerous rivers that flow into the north side of the St. Lawrence have many rapids and falls necessary to supply the required power;

while further up the stream are the best and most extensive black spruce forests in Canada. These splendid natural advantages, together with the St. Lawrence River as an avenue of commerce, only need the capitalist and the engineer to transform the wilderness into a hive of industry.

In Ontario the possibilities for development are of no small character, especially in the western part where there is more spruce, and where the water powers are more frequent. Along the Ottawa and its tributaries there are many good sites, and before long we may look for their development. I am also informed by explorers that in the north country there is an abundance of spruce especially suitable for pulp wood, and that numerous falls and rapids are to be found. Whatever the possibilities are of this part of the province, it is not likely that anything will be done there for many years to come, especially as so many good sites for mills are to be found nearer shipping ports.

Though British Columbia has as yet only one or two pulp mills, we may expect considerable activity on the western coast. While it is not likely that this province will market much pulp in Great Britain owing to the great distance, there might be a profitable industry arise in manufacturing pulp and paper for Japan and Australia.

MECHANICAL PULP AND SULPHITE FIBRE.

It is the intention of the writer to confine his remarks to the process of manufacture of mechanical or ground wood pulp, but as there may arise some ambiguity as to the distinction between this product and that known as sulphite pulp, a few words in explanation may not be out of place.

THE SULPHITE PROCESS.—The process of the manufacture of sulphite fibre is a more difficult one, than that of making mechanical pulp. Sulphite pulp is worth more in the market, and finds a ready sale if of good quality. It requires more raw material than "mechanical" to manufacture one ton of pulp, generally from $2\frac{1}{4}$ to $2\frac{1}{2}$ cords. It is altogether a chemical process, with the exception of cutting up the log into small chips. The raw material comes in the form of pulp wood, which is sawn, barked, split, and all knots bored out; then it is chipped up in a chipping machine. These chips are next broken to uniform size and screened to remove the sawdust. The wood is now prepared, and the next step is the chemical part, where the wood is digested to its constituent fibres. It is essential that a great amount of care should be taken to procure entirely good sound wood, so that the pulp will be uniform, and free from specks. It is for this reason that all knots are bored out. The acid is next prepared carefully, as too much care cannot be taken with this part of the process. The acid when made is kept in large tanks ready for use. The digestor is filled with chips, which have been prepared as described, and the required amount of acid introduced, when it is closed up. Steam is now turned in, and kept on for twelve hours, or until the wood is all digested, when it is blown into tanks. After being well washed to remove acid, and then screened twice, first coarse and then fine, it is passed through the paper machine, and comes out as paper pulp. It is now finished as far as the pulp mill is concerned.

The Mechanical Process.—The mechanical process is, as its name implies, purely mechanical. In this process, which will be discussed at length later on, the wood is prepared almost in the same manner as in the sulphite process, with this exception, that the bolt is not chipped, simply being sawn and barked. It then passes to the grinders where it is ground by revolving stones into pulp. It is then mixed with water and pumped to the screens, whose duty is to remove all pieces of splinters, etc., which are above a certain size. It is next passed on to the wet machine, which to be brief, removes the excess of water, and rolls it into large sheets. This is now finished as pulp; but it goes through a further process of removing more water, and baling, to facilitate shipping.

Uses of Pulp.—These two methods of manufacture are not rivals; each has its own place in the pulp industry, and one cannot supply the want of the other, more than to a very limited extent. Sulphite pulp can perhaps be used for many things that mechanical pulp is now used for, but it would not be economical, owing to the process of its manufacture being more expensive. It has a finer, softer and longer fibre than mechanical, and is used where these qualities are required, such as in fine writing paper, and paper for engraving, etc., in fact, all fine papers require more or less sulphite fibre, and some grades contain nothing else. Mechanical pulp is used in all papers of a more or less coarse nature, such as wrapping papers, etc. In making "news" paper, both kinds are used, the proportion varying according to the quality of paper required and the general practice of the paper maker. Some makers use 10 per cent. of sulphite to 85 per cent. mechanical, while others think 20 to 25 per cent of sulphite is necessary. Even 40 per cent. sulphite to 60 per cent. of mechanical is used in some mills, but when the per cent. of the former is as high as this, the quality of the sulphite is inferior. The introduction of from 8 per cent. to 15 per cent. cotton waste improves the softness and finish of the paper.

Raw Material.—The woods used in the manufacture of mechanical pulp are principally the spruce, poplar or aspen, fir or balsam spruce, and sometimes hemlock. The great bulk of the pulp ground is made from spruce, it being the most widely dispersed of the above mentioned woods, besides possessing qualities which eminently fit it for the manufacture of ground pulp. It is found in three principal varieties, i.e., the white, red and black spruce. Of these three, the white spruce makes the whitest pulp, and the black variety has the toughest and strongest fibre. Poplar or aspen makes a beautiful grade of pulp, being soft, smooth and very white. It is not as strong, however, as that made from spruce. The great difficulty in manufacturing poplar pulp in this country arises from the fact that it is extremely difficult to secure sound wood. In many districts, principally in Nova Scotia and other parts of the Eastern Provnces, the poplar is apparently firm and sound to the eye, but on being split through the centre, it is found to be discolored and rotten at the heart. This "black heart" has to be entirely removed before the wood goes to the grinder, or the pulp will be full of specks, and almost useless. If "black-knot" occurs it will also have to be removed for the same reason. When clean wood can be secured, poplar or aspen makes a beautiful pulp, that will bring a high price and find a ready market. Fir, or balsam spruce, makes a short mealy pulp. Its weight is less than the ordinary spruce, and consequently more raw material by measure is required to make a ton of pulp. It is also more bulky when baled, for the same weight, which adds to the freight charges. Fir pulp does not bring as high a price as spruce, and for the reasons mentioned, is very little used. Hemlock is used to a very small extent where an inferior quality of pulp is required. It is hard to grind, and splinters more than spruce, and is, therefore, more difficult to screen. It is sometimes used with spruce by grinding both together, introducing, say about 12 per cent. hemlock. This is only done, as in the case of fir, when an inferior quality of pulp is required. It is never introduced into "news" pulp.

It is the case with all these woods, that the best pulp comes from the wood that has the longest and toughest fibre, and this is found in the trees of slowest growth and of greatest density. The Newfoundland spruce, for example, is of very slow growth and of such a specific gravity that it will hardly float. It makes a splendid pulp, which I am told brings a higher price than pulp made from Canadian spruce. In the same way, Canadian spruce being of slower growth, makes better pulp than that from spruce grown in the United States. German experiments have proved that the slower the growth of the tree, the greater the strength of the pulp. Norwegian is said to be better than Swedish; and it is claimed that German is better than either, though it is hard to see how such could be the case, unless the wood were grown in mountainous districts, or on poor soil.

Mixing Woods.—Spruce and fir, when mixed, make a very good pulp, a little whiter than pure spruce, and to a greater or less extent, lacking in weight and strength according to the proportion of fir added, the fir being somewhat lighter than spruce. Spruce and poplar are sometimes mixed, and go very well together. The spruce gives strength of fibre and toughness, and the poplar adds whiteness, while the length of its fibre makes the mixed product softer than pure spruce. This product is also easier to handle on the wet machines, when the percentage of spruce is sufficient to give the strength of fibre that the poplar lacks. The great bulk of mechanical pulp made in this country is almost, if not altogether, pure spruce of either the white or black variety. This is the most widely distributed of the different woods, and is also the best of them all for this purpose.

DESCRIPTION OF THE MACHINERY AND THE PROCESS.

DEVELOPMENT OF THE WATER POWER.

Before describing the process, a few words may be said with regard to the water power. The installation of turbines, for the purpose of driving wood pulp grinders, presents more difficulties to the designer of the mill than would be found were the power required for ordinary uses. The process of grinding wood for pulp requires a great deal of power. One grinder which would have a capacity of five tons dry pulp per day would require about 340 horse-power, and for a daily output from the mill of 25 tons dry, which is only a moderate sized mill, a supply of 1,700 h.p. for grinding alone will be necessary. About five horse-power will be required per ton of output to drive the lighter machinery, or a total for the above mentioned output of over 1,800 h.p. Steam power cannot be used for this service, as the variations in the load are so great that no steam engine could stand it. We must, therefore, use water power, which is eminently suited for the purpose. When such large powers are necessary, it is very important when a site is decided upon that the head should be fully developed. If the full head is utilized at first, taking sufficient water to develop the required power, it is comparatively easy to add to the plant in the future by laying another pipe, or otherwise increasing the quantity of water passed per minute, and installing more wheels. To increase the power developed by an increase in the running head, will be found in most cases to be a costly remedy. This latter method is very unsatisfactory from the standpoint of a pulp mill owner. If a turbine is installed to run at a certain head, with full gate, and the head is afterwards increased, the wheel will develop more power certainly, but the speed will be higher also. As the turbines are directly connected to the shaft of the grinder, this means that its speed is also increased, which cannot be allowed if the correct speed were given to it at the first installation. If the speed of the grinder is not increased above 200 R.P.M., there is no harm done, but if it is above this, to any extent, the wheels will have to run with partial gate, and it is doubtful, if, in this case, you will get the efficiency of the wheels. In almost any other industry the speed of the turbine is of no consequence, as the machinery can be run at any desired speed, by means of belts or gearing; but where direct driving is necessary the wheels will have to run at the speed required by the machine. When the head is high, and, to get the speed low enough you are forced to put in a larger wheel, which will give more power than will be required for one grinder, the difficulty may be overcome by coupling another grinder to the shaft of the first, which will in all probability take the surplus power. Even three grinders are sometimes connected up in this manner.

LOG HANDLING AND SAWING.

Log Handling.—It is important that the logs, when being handled in the yard, should be kept out of contact with the ground as much as possible, as grit and dirt in the bark will cause trouble when the stick is sawn and barked. If the logs are taken direct from the pond to the saw, it is easy to keep the wood clean by handling the logs with a chain conveyor, driven by a log jack. In Fig. 1 is shown a jack and chain, made for this purpose by the Waterous Engine Works Company, of Brantford, Ont. By means of this machinery two men can handle from 60 to 90 cords of wood in a day. In some mills, where the logs have to be piled in the yard, a useful expedient to

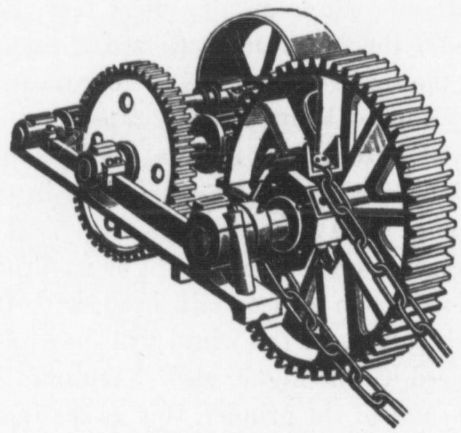

Fig. 1.—Log Jack and Conveyor Chain.

keep them clear of the ground is made use of. A strong staging is built of logs, to a height of about a foot or so, on top of which the logs are piled. Skids are sometimes used, but a log staging is better, as the space between the skids soon gets filled up with dirt and refuse. A conveyor can be run at one side of the staging, and when logs are wanted in the mill, they are simply rolled off the staging into the conveyor, which carries them into the saws.

Sawing.—On arriving in the mill, the log is automatically dumped by the conveyor on to the skids. It is next rolled on to the the saw-bed rollers, which enable it to be easily fed to the saw. In most mills the wood is ground from bolts 24 inches long, though some use wood 16 inches in length. If the wood is supplied to the mill in sticks 4 feet long, it only requires cutting in the middle to make

24-inch bolts. For such work as this the Waterous Engine Works of Brantford, make a very good saw, a view of which is shown in Fig. 2. The log is placed in the cradle, which is suspended from the top of the frame. A handle is provided on the cradle, by means of which the wood is swung against the saw. When the logs are supplied in long lengths this saw will not do, and another method has to be used. A swing saw can be used, the frame of the saw swinging on the

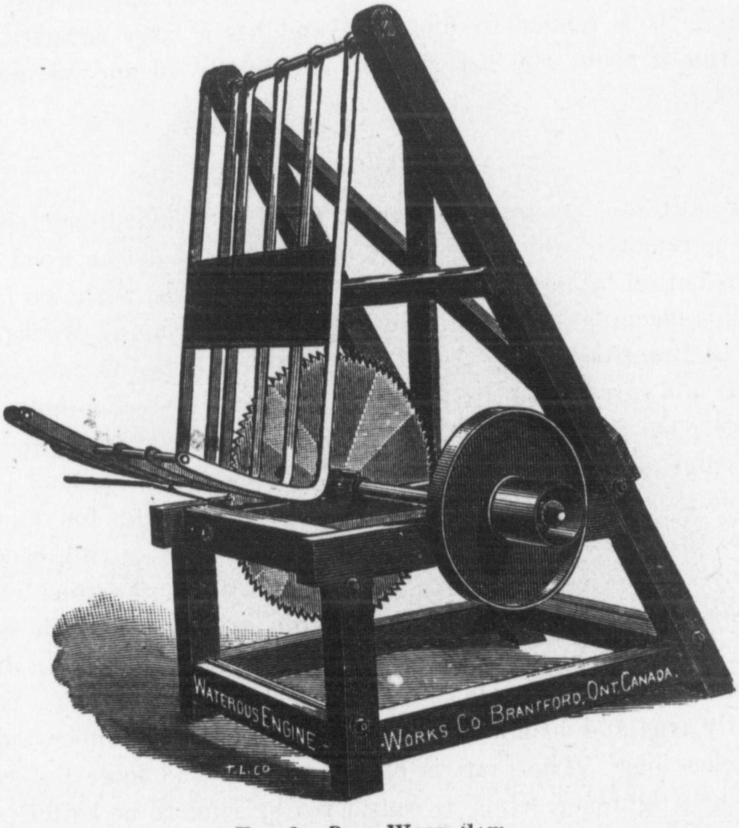

FIG. 2.—PULP WOOD SAW.

counter-shaft. In this way the saw is brought to the log. The capacity of a 38-inch saw, mounted in this way would be about one cord per hour. Jump saws are used in some mills. These are run by a steam cylinder and piston. The piston is secured to the saw frame which slides vertically in guides. On pressing the treadle, steam is admitted into the cylinder, driving up the piston and saw, which cuts through the log from the underneath. One of the mills in the maritime provinces has installed a very satisfactory system. It consists of 6 or 8 saws, mounted in pairs, and so situated that only two saws can cut at a time. Between each pair of saws is a conveyor chain, running the full length of the saw bed. A log is rolled onto the upper end of the bed, and is caught up by all the conveyor chains at once, and carried to the saws. On passing each pair of saws, two cuts are made in the log, and when past them all, the log has been entirely cut up into bolts, each 2 feet long. At the end of the saw table or bed is a chain conveyor, which carries the blocks to the barkers. It is tended by one man, and has a large capacity. The saws run at about 800 R.P.M., and are usually 36 and 38 inches in diameter.

BARKING AND SPLITTING.

BARKING.—To procure clean pulp, all bark and discolored parts must be removed from the stick, leaving only sound clean wood. The bark is cut off by means of a barker, a cut of which is shown in Fig. 3. This machine is also built by the Waterous Engine Works Company, of Brantford, Ont. It consists in a cast-iron disk mounted on a shaft and carrying on its face knives placed at regular intervals on a circle. On the reverse side of the revolving disk are bolted cast-iron wings, or fans, of suitable size. The whole disk, etc., is surrounded by a cast-iron frame which carries the bearings for the shaft. Part of the frame in front of the face is cut away, giving access to the knives, and a suitable rest is provided to support the wood while it is being barked. The frame is of large size, and is made of two pieces, fitted with planed edge. The knife disk is 52 inches in diameter, made of cast-iron, with a steel band shrunk on its edge, turned perfectly true and balanced. The knives are four in number, and are 11½ inches long. The shaft is fitted with fast and loose pulleys, or with a belt tightener, which is considered by some to be better. The capacity of this machine when running at 600 R.P.M., will be from 7 to 10 cords per day, though it can be forced up to 14 cords in 24 hours. In operation this machine works very well. The bolt or log is placed on the rest and pressed against the knives, the end thrust of the cutting action being taken by a roller and stud, mounted on the frame, as shown. Each knife as it passes cuts a strip of bark off the log throughout its whole length. By revolving the wood slowly by the hands, the knives cut the bark completely off. The chips pass through the disk by means of a hole provided in front of the knives, and are caught up by the fans and blown out through the outlet shown in the frame. A pipe is usually connected to this orifice, which carries the chips to a distance. By means of the fans the chips are prevented from lodging in the frame, so that the disk is always running freely. This also serves to automatically remove the shavings to any desired location.

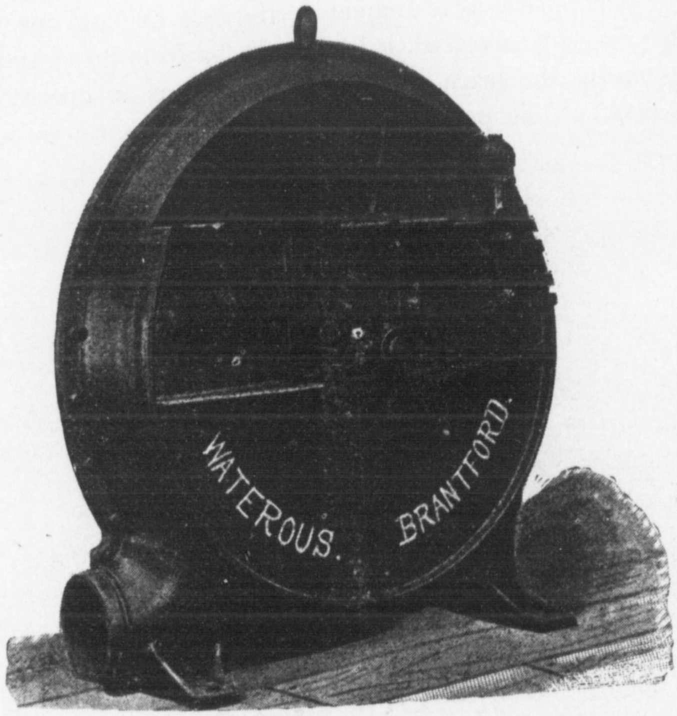

Fig. 3.—Pulp Wood Barker.

When the revolving of the wood is done by hand, it is not done regularly, and the output of the barker will vary considerably, according to the skill and industry of the operator. It would be advisable to revolve the wood automatically, and thereby maintain a constant feed to the knives, which will be independent to a certain extent of the operator. Various attachments have been invented for this purpose, all of more or less usefulness. One of the best is Butterfield's, which can be applied to almost any standard barker. By the constant relation of speed between the knives and the surface of the wood each knife cuts approximately the same amount of bark, and in this way the quantity of clear wood removed while barking is materially reduced. It is claimed by the makers of this attachment that from 5 to 8 per cent. more clear wood can be obtained from the same quantity of unbarked logs by using this device than by the ordinary method. The great point of its usefulness, however, lies in its increased speed and regularity of cutting. By the regularity in rate of cutting no time is lost, as the knives are prevented from cutting over the same space, as is frequently the case in hand feeding. The output is thereby increased, it is claimed, by from 80 to 100 per cent. By this means the price of a barker, as well as an operator's wages, can be saved. The power to drive the barker, however, will be in-

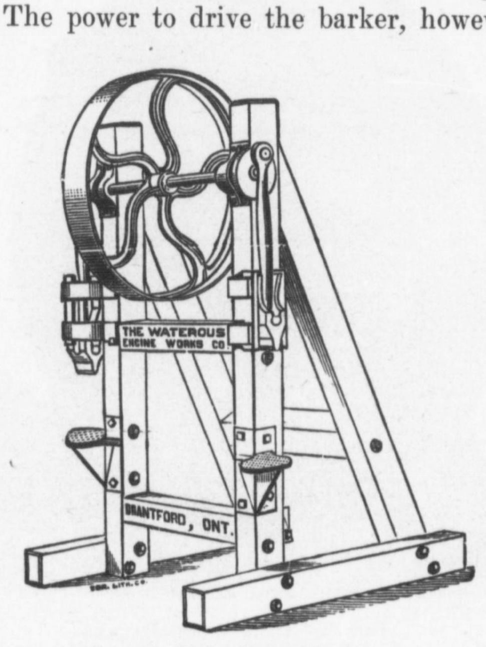

FIG. 4.—PULP WOOD SPLITTER.

creased in almost the same ratio as the output. When the wood is barked, it is thrown into the conveyor running to the grinder room; but if it requires splitting it is thrown near the splitter.

The knives require repeated grinding, especially if the wood has been in contact with the earth. When dull they should be ground on a special stone, used for this purpose, and no other.

SPLITTING.—Where large wood is used it is necessary to have it split if it is too large to enter the grinder pockets. This operation is done after the wood is barked, and before it is sent to the grinder room. The machine shown in Fig. 4 is a double wood splitter, manufactured by the Waterous Engine Works Company, of Brantford. The frame is made of well seasoned wood and strongly bolted together. A shaft carrying a pully and two disk cranks, is mounted on the frame as shown. From each of these cranks is driven a block, sliding vertically, and connected therewith by a pitman rod. A step is also provided upon which to place the wood to be split. It is made of cast-iron and is bolted to the frame. The wedge or axe is fastened to the sliding block, and rises and falls with it. The two cranks are placed 180 degrees apart on the shaft, to prevent two blocks being split at the same time, which would cause a sudden strain on the driving gear. Splitters do not demand much power for their operation, and consequently can be run with light machinery. The wood used in most mills is small enough to enter the grinder pocket without previous splitting, and when an occasional stick occurs that is too large, it is split with an axe.

GRINDING.

Description of Grinders.—The wood is conveyed from the wood room to the grinder room. Here it is ground on revolving stones by hydraulic pressure, being thereby reduced to pulp. Fig. 5 is a cut of a grinder manufactured by the Robb Engineering Company, of Amherst, N.S. The grinder is very strongly built, and is a good example of the closed frame type. As will be seen from the illustration, the grinder consists of a heavy cast-iron bed-plate which carries the bearings of the shaft, and two cast-iron side plates, between which the stone revolves, and where the pockets are situated. Above each pocket is fixed a hydraulic cylinder which furnishes the pressure required to force the wood against the stone. Doors are fitted in one of these side plates, through which the wood is passed in filling the pocket. The sides of the pocket are cast-iron plates, which can be raised or lowered to suit the wear of the stone, and are adjusted with screws and clamp bolts passing through the main frame. These pockets are made to take 24-inch wood and are 13 inches wide. The cylinders are made either 8 or 10 inches in diameter, and each is independent of the others, being controlled by its own lever and valve. These cylinders are lined with drawn brass tubing, which is an advantage. All valves and valve seats are made of phosphor bronze. The pistons are packed with double cupped leather packing, which works equally well in both directions. The shaft is of steel 7 inches in diameter in the bearings, and 7½ inches in the stone. The bearings are 7″ x 20″, lined with babbit, ring, oiled and cored out for water circulation. Heavy flanges of cast-iron are provided on each side of the stone, faced and turned true, and threaded right and left hand on the shaft. The shaft is provided with packing boxes, where it passes through the frame, which prevents leakage of pulp and water. The stones used with this machine are from 48″ to 50″ diameter by 26″ face.

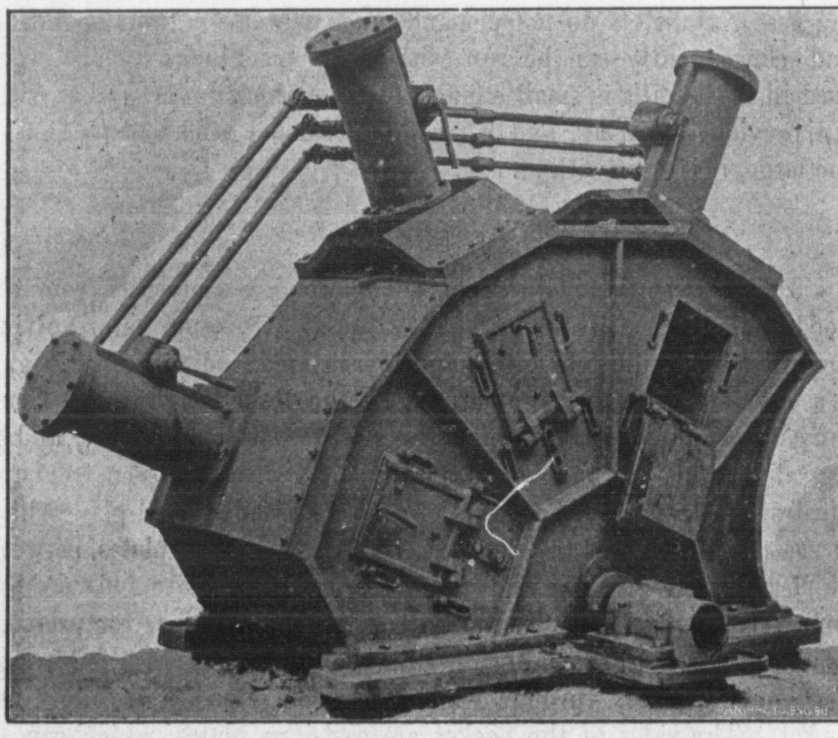

FIG. 5.—ROBB WOOD PULP GRINDER.

The capacity of a grinder depends on the power supplied. With 10″ cylinders and using 400 H.P., this one is capable of making about 6 tons of dry pulp per 24 hours, or with 8-inch cylinders and 250 H.P. the capacity would be between 3½ to 4 tons dry in the same time. The speed should not exceed 200 revolutions per minute, and may run as low as 175 without disadvantage, depending upon the material to be ground, pressure, and other considerations.

Fig. 6 is the standard open frame type of grinder, manufactured by the Jenckes Machine Company, of Sherbrooke, Que. This machine is constructed in a substantial manner, and has given good satisfaction. The cylinders are cast-iron, lined with brass, and fitted with

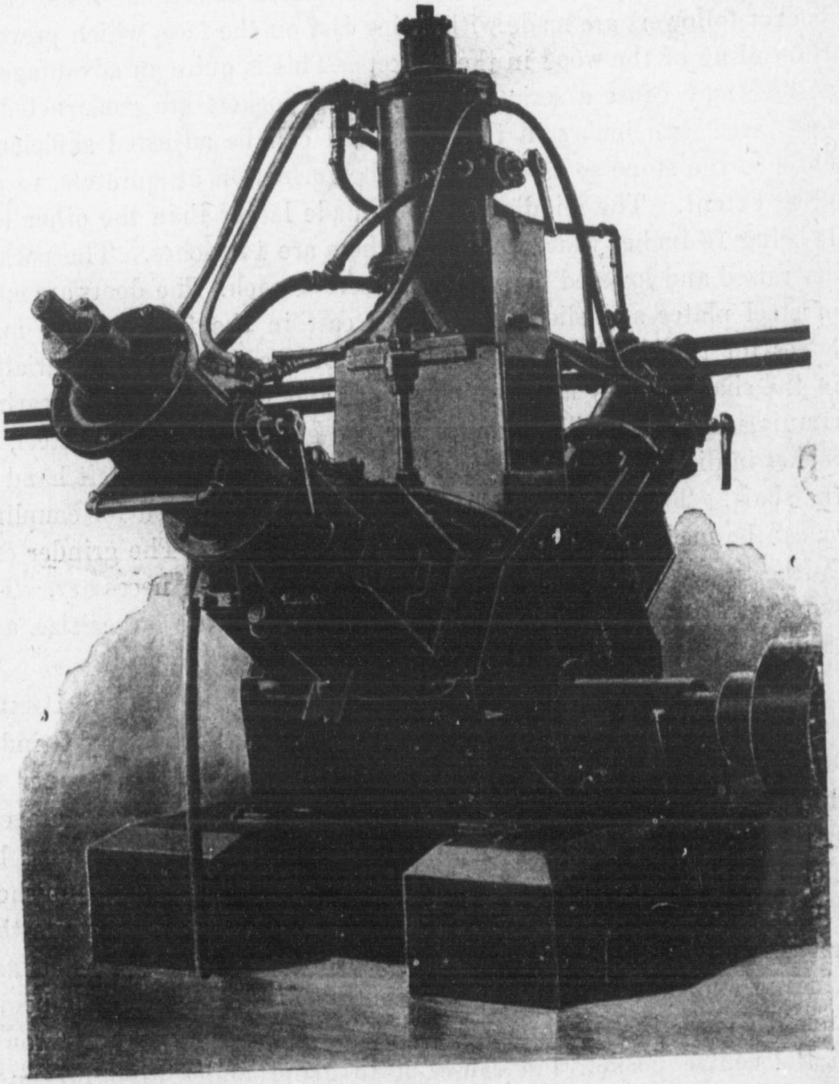

FIG. 6.—PORT HENRY WOOD PULP GRINDER.

cast-iron heads. The lower heads are bolted direct to the top of the pocket, and are hollow castings fitted with doors on each side, which can be removed should the lower glands require packing or adjusting.

The piston rods are made of steel, 3 15-16 inches in diameter, and are connected to the followers by striking, and also secured by two brass nuts, one being a lock nut. The piston is packed with four square rings ⅝-inch wide. Glands for piston rod are made of brass, secured by three stud bolts and brass hexagonal nuts. The pocket followers are made with strips cast on the face, which prevents the rolling of the wood in the pockets. This is quite an advantage, as rolling may cause a serious break. The pockets are constructed in one piece, two inches in thickness, and can be adjusted sufficiently close to the stone so as to prevent the formation of splinters, to any great extent. The middle pocket is made larger than the other two, it being 16 inches wide, while the others are 14 inches. The pockets are raised and lowered by two 2-inch screws each. The doors are made of steel plates and slide in a groove cast in the frame. The main boxes for the shaft are self-adjusting, and conform to any variation in the shaft. They are 18 inches long and wood lined, the bearings running in water. The flanges for the stone are made of steel, 38 inches in diameter, faced up true and threaded right and left hand on the shaft. The shaft is made of hammered steel, keyed for coupling, or can be made for a shrink coupling, if required. The grinder case can be tipped up, allowing access to the stone when necessary. The stone is 54 inches in diameter by 26-inch face in the larger size, and 18-inch face in the smaller.

Operation of the Piping System of the Port Henry Grinder.—In Fig. 7 is shown a side view of the Port Henry Grinder described above. This gives a good illustration of the manner of piping, which is claimed by the makers to possess many advantages. In the operation of any pulp grinder, one pocket at least must be idle all the time. This is necessary, for when a pocket has finished grinding, another must be thrown on to take up the load, while the first is being refilled. Suppose, in this case, the two side pockets are grinding and one of them requires refilling, the centre pocket being idle. By changing the three-way valve A, the high pressure is thrown on the centre pocket, and causes it to grind under high pressure. The empty side pocket being now relieved, the low pressure water automatically opens its check valve and acts upon the piston from the under side, lifting it and its follower from the stone. The pocket is then refilled. Valve B. is shifted, allowing the low pressure to bring the piston down until the wood is pressed firmly against the stone.

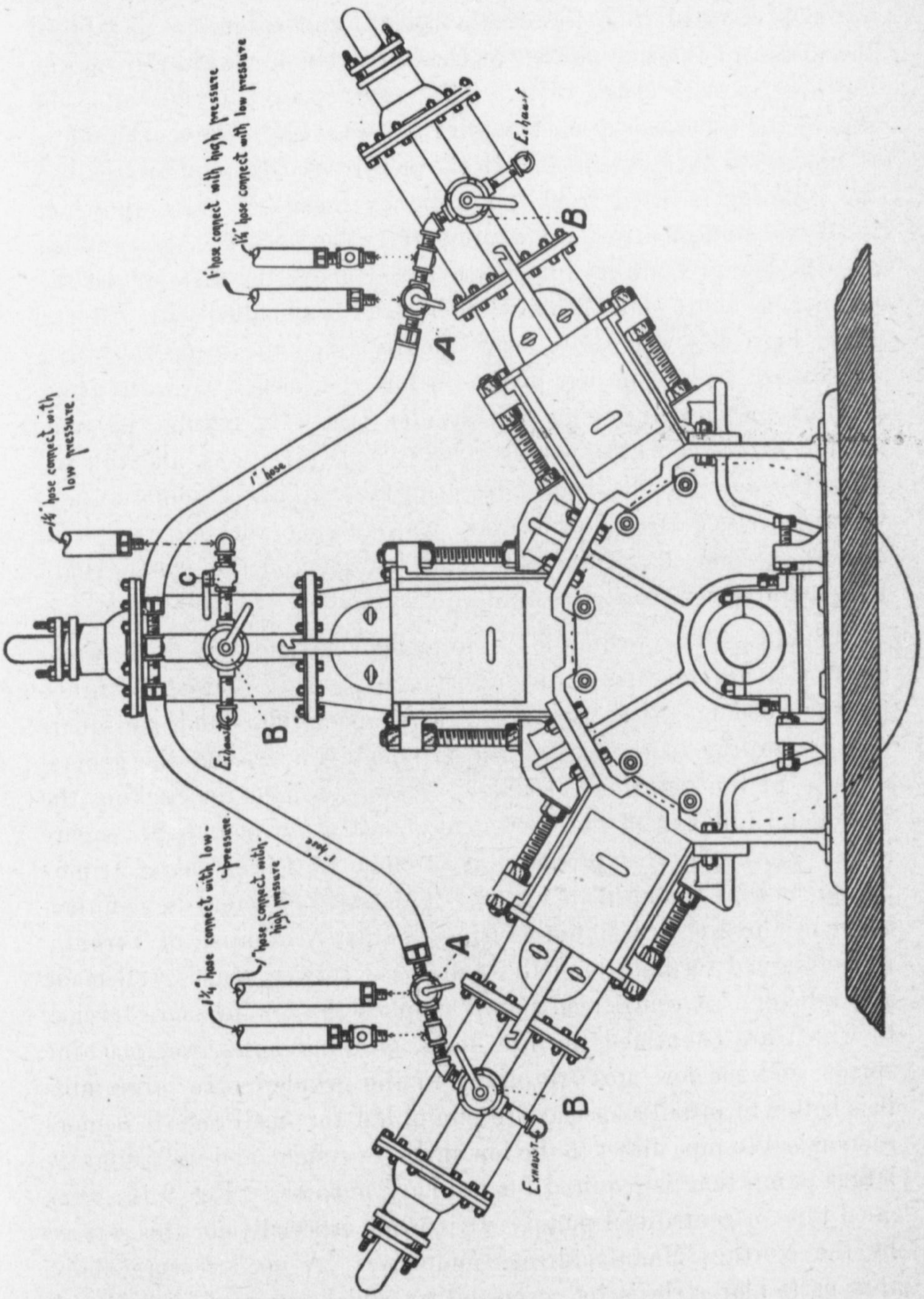

Fig. 7.—Piping System of the Port Henry Grinder.

At this point the three-way valve is turned, so that the high pressure water is diverted from the centre pocket, and enters on the top of the piston of the side pocket, at the same time automatically closing the low pressure check valve. The centre pocket is now idle, and should the other side pocket require refilling, the process of doing so is similar to that described. If the centre pocket requires refilling the follower is lifted from the stone by means of valve B, which is always connected to the low pressure. The pocket is then refilled, and the low pressure let into the cylinder above the piston. In this manner, as above stated, the cylinders are always filled with water at either high or low pressure, consequently when the three-way valves are shifted, there is no loss of time before the pockets begin to grind. By this method of piping the grinder is always taking the same amount of power within comparatively small variations, and this enables the speed to be kept fairly constant. This is important, as when the speed is allowed to vary considerably, the pulp is not of uniform quality, and if the stuff pump is driven off the grinder shaft, the regulation of the stock is not an easy matter.

Pumps.—The hydraulic pulp grinder is supplied with water under two different pressures. The high pressure is used for pressing the wood against the stone, and varies about 100 pounds per square inch, according to the size of the grinder cylinder, and the general practice of the operator. The low pressure is used for backing the piston and follower off the wood, and is only a few pounds per square inch. The high pressure system is supplied by a back-geared triplex pump, such as is shown in Fig. 8. This style of pump is manufactured by the Northey Manufacturing Company, Limited, of Toronto. It is designed for high pressures and heavy service, and is well made and reliable. A centrifugal pump supplies the low pressure service, to which are connected the fire hoses, cleaning hoses, wet machine sprays, and the low pressure piping in the grinders. In large mills it is better to install a special fire pump, but for small ones it is more economical to pipe direct to the low pressure system, and use a slightly larger pump than is required for ordinary purposes. Fig. 9 is a very good type of centrifugal pump. It is made especially for this service by the Northey Manufacturing Company. A good feature about this particular style is its reversability, which greatly simplifies its installation. Stuff pumps are used to handle the mixed pulp and water, and for mechanical pulp the centrifugal pump is very satisfactory. A pump, as is shown in Fig. 9, is suitable for this purpose. Stuff pumps handle the pulp in a large amount of water; generally the water contains one per cent. of dry pulp by weight. The speed and horse-power required for these pumps depends on the elevation of the discharge orifice above that of the suction. Many mill designers prefer to drive the pressure and stuff pumps by belt from the grinder shaft. In small mills this may be as good a method as any, but it is open to serious objections. Owing to the varying conditions under which the grinders are working, the speed cannot be kept

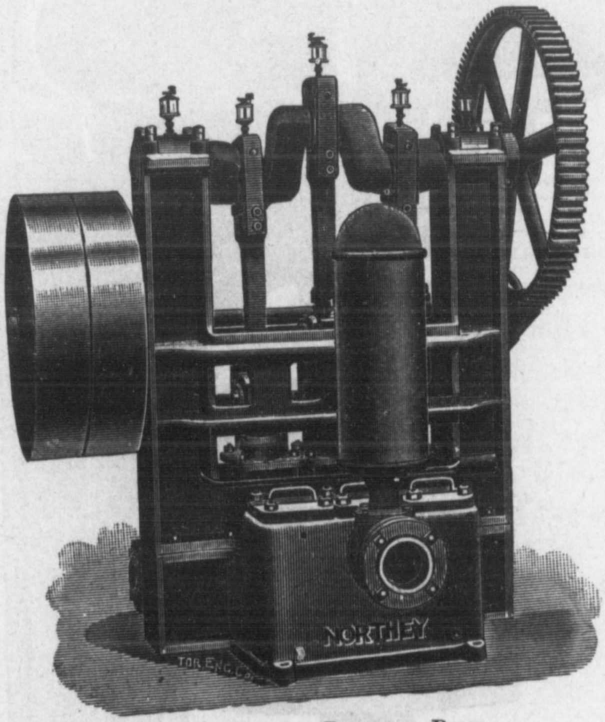

Fig. 8.—Triplex Pressure Pump.

constant, resulting in a varying discharge from the pumps. In case of the stuff pump, this is objectionable, as it causes trouble for the wet machine man in regulating the supply of stock from the vat. The best method of supplying the high pressure system is to do so from a separate triplex pump, belted to each grinder shaft. If there are two grinders coupled together, a 3″ x 4″ triplex at 45 rev. per min. would supply them. This may cost more than one large pump intended to supply all; but if that pump is shut down by accident or otherwise, the load is immediately thrown off all the grinders at once, which allows them to speed up.

It is exceedingly dangerous to allow any grinder to run very much above its normal speed. Owing to cracks in the stone which are not always apparent on the surface, a stone may fly in pieces, even

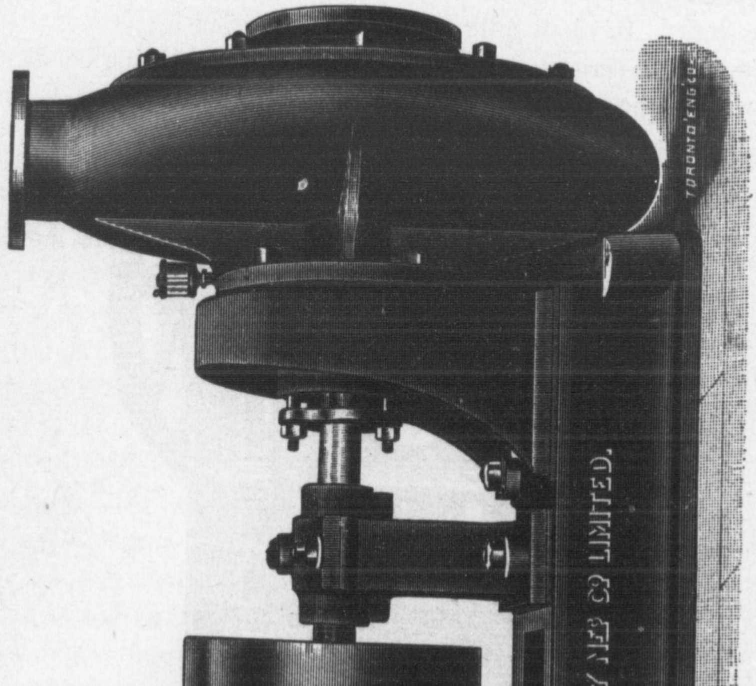

Fig. 9.—Centrifugal Low Pressure Pump.

at moderate speeds, and is very liable to do so if the grinder is allowed to run away. By supplying all the grinders from a common pipe system, and driving a separate pressure pump from each grinder shaft to supply the system, we have each grinder perfectly independent of the others, and we are, therefore, at liberty to shut down any one we please without regard to the others. When a grinder is started up, its pump is started also, and takes its share of the pumping, and we always have the supply directly proportionate to the demand. If a pump in the line should become disabled, its check valve, placed on its discharge pipe, instantly closes, cutting it out of the system. The remaining pumps can, for a short time at least, carry the increased load, giving the grinder man sufficient time to shut down the grinder or to cut out a pocket or two. The grinder, which was driving the disabled pump, has had no opportunity to race, as the other pumps in the line continue to supply its cylinders with water at almost the usual pressure. This system has, perhaps, the disadvantage of first cost; but even in this particular, when everything is considered, it would be the cheaper method for some installations.

METHOD OF DRIVING AND COUPLING GRINDERS.—Wood pulp grinders are generally run in pairs, coupled direct to the waterwheel shaft. Direct driving is the usual practice, which is seldom, if ever, departed from. In some small plants it might be advantageous to drive a grinder by means of a large belt, but these cases are extremely rare. There is no other method that is practicable. Gearing would be out of the question, as the sudden and excessive variations in the load would render it extremely difficult to keep them in proper repair. In most cases, the method that commends itself is to couple two grinders on the same shaft, and direct to that of the water wheel. With a certain head, for instance, the wheel that will run with a speed of about 200 R.P.M. would deliver more power to the shaft than is required by one grinder. If another grinder of suitable capacity is coupled to this shaft, it gives the correct speed and power for each grinder.

There is another consideration in favor of the above method of driving. If two three-pocket machines are run by themselves from separate wheels, only two of these pockets can be used at a time on each grinder, the third being retained as a change pocket. If, on the other hand, we have two three-pocket grinders, connected on the same shaft, we can operate five pockets altogether, leaving the other one for the change pocket. In this way we have gained the use of an extra pocket on two machines by driving them coupled. When a stone breaks on the inside machine, both will be idle until repairs are completed. If the outside grinder be damaged, the coupling can be removed, and the inside one run as usual.

Operation.—The first thing in starting up a grinder is to thoroughly clean it with a hose. This is to prevent specks from getting into the pulp, from dirt collected in the grinder. This should be done once a week or oftener, according to the make of the machine. The side plates of the pocket should be set down close to the stone, and as the stone is turned down by sharpening, they should be advanced. A great deal of waste from chips and slivers will arise if this is not attended to. It is important that the supply of water should be sufficient for two reasons, first, to keep the stone cool, and, second, to supply the ground wood with enough water, so that it can be handled easily by the stuff pump. In some grinders, the stone runs clear of the water underneath it and must therefore be supplied by sprays near the top, or elsewhere, to keep the stone from heating. In others, the stone runs in a vat of ground pulp and water, which, as the water is changing all the time, very effectually prevents heating. There should be, even in this case, a small spray near the top of the stone, for the purpose of washing the pulp down to the vat as soon as it is ground. The vat underneath the grinder is made by placing a weir on one side of a suitable height, so that when the pulp and water flow over it, the stone is submerged to a sufficient depth to prevent heating.

When the wood has been badly packed in the pocket, it will jam, and by bracing against the sides of the pocket, relieve the stone of the pressure. This is easily fixed by letting off the pressure while the wood is loosened up with a short bar, and then turning the water on again. This jamming is not so liable to occur with round sticks as it is when the wood has been split. Sometimes with round wood, the blocks will roll in the pocket. This can be prevented by having strips cast on the followers. When this is not done, it can be remedied for the time by loosening up the pocket, or by repacking. In a good grinder there should be very few chips formed. In many cases, in fact, in nearly all, this is caused by carelessness in setting the side plates of the pockets. As the wood grinds down to a thin shim, it is carried under the plate and is not ground. If the plates are just clearing the stone, the wood will be almost completely ground before the shim can get through. Grinders should be provided with sufficient space between the stone and the sides to allow for the free escape of the pulp and water, or else it will flow on the floor when the door is opened. This space should be so constructed as to prevent shims, etc., getting in, which might cause trouble. In some mills, machines are used for grinding chips and shims, but as far as the chips from the grinders are concerned, it is unnecessary unless the grinders are faulty. In any new mill, if good grinders are bought, this will not be required.

The principal agencies that influence the quality of the pulp ground from any given wood, are speed of the stone, pressure used to press the wood against the stone, and the sharpening. The first two have considerable influence, and should be carefully looked after; but it is in the sharpening that the secret lies for the manufacture of a good uniform product. The influence of the speed is important, and the best practice is not to exceed a circumferential speed of 2,800 feet per minute, which corresponds to about 200 R. P. M. on an ordinary sized stone. It may go higher than this at intervals, but it is not good practice to grind at a much increased speed. When the stone is running too fast, apart from the danger from bursting, there is a tendency to heat the surface, which cracks when it is chilled by the water, and so destroys the cutting surface of the stone. This is only true when the speed is excessive; but even if running normally, at a speed much exceeding 200 R.P.M., there is a tendency to gloss the stone, which is detrimental to its cutting capacity. With a slow speed, the wood is pressed completely into the stone, and thereby longer fibre is produced.

With regard to the pressure used, there seems to be a great difference of opinion among pulp manufacturers, but heavier pressures are of more common use now than formerly. To increase the pressure is, in nearly all cases, to increase the output of the grinder, provided that the power is sufficient. In some of the Nova Scotian mills a pressure of about 15 pounds per sq. inch is used on the grinding surface. This seems to be an average, though for special products it may be as high as 17 pounds per sq. inch of the cutting area. It is seldom allowed to drop below 13 pounds in any case.

The question of sharpening is also one upon which many different opinions may be expressed; but no attempt will be made to specify which is correct, the writer simply giving his own experience. In sharpening for different products, no rule can be laid down; each man has a way of his own which he thinks is the correct one. One fault that is often made is to use one jig too often. This, after one or two cuts are made, does not improve the surface, as the points on the jig run in the same holes. For "news" pulp, the writer has found an 8 to the inch jig to work first-class, also a 6 to the inch is another good size. A good surface is made by making a light cut with a 4 to the inch jig, over the other size, which breaks the holes and makes a more uniform surface. If the same jig is used too often, it will make a pitted surface, which is not a good cutting one. Over sharpening is a thing to be guarded against, as in that case the pulp is inclined to be short in the grain, or mealy, is hard to screen on account of the thickness of the fibres and is difficult to remove from the wet machine as the sheet will not hold together. When a stone has been over-sharpened by carelessness or otherwise, it may be restored by simply rubbing the surface with a brick. Some pulp makers prefer to sharpen in this way, i.e., by over-sharpening at first and then reducing the cuts on the stone by means of a brick, until the right degree is reached.

A very good point in the construction of a grinder is to have the stone accessible while in operation. Some machines have to be stopped and certain alterations made before the stone can be sharpened. While this is being attended to the opportunity is generally taken to clean them out, and in this way, the disadvantage of not being able to sharpen while running is in some manner counteracted. The sharpening jig is a cylinder of steel, about 3½ inches long, by 3 inches in diameter. It is cut on its surface by a heavy V-thread and also milled parallel to its axis by an equally heavy V cut. The resulting surface consists of a number of square, sharp pointed pyramids. The jig is drilled throughout its length with a 1-inch drill, and mounted in a frame by a bolt passing loosely through this hole, so allowing it to revolve freely thereon. The frame also has on it a forged ring, which is made to engage a bolt on the grinder frame. This bolt passes across the face of the stone, and a few inches from it. The frame has also a suitable handle, by means of which it is guided by the workman. In operation, the bolt is passed through the ring, and secured in the grinder frame. The workman can now guide the jig across the face of the stone, against which it revolves. By bearing on the handle, the pressure is applied, which causes the points of the jig to cut the face of the stone, making on it a rough cutting surface.

METHOD OF CHANGING AND MOUNTING STONES.—The stone is secured to the shaft by means of large flanges of steel, one on each side of it. These flanges are turned true on their face and are threaded right and left hand on the shaft. By this method the torsional strain on the stone due to the grinding tends to make the flanges grip tighter. There are two principal methods of securing the stone to the shaft, one being an improvement on the other. The first method is to screw the flanges up as tight as possible, taking care that the stone is centred, and then to pour in cement around the shaft and flanges through a small channel which had been previously cut in the stone. This method is in use in the majority of cases and seems to answer the purpose very well. The second method is very much like the first, but in addition to the cement and threaded flanges, the flanges are bolted together by 1-inch bolts, running through the stone from side to side, which are tightened up before the cement has become hard. When the cement has set perfectly hard, the stone can be turned off and trued up. The addition of the bolts in the second method adds considerably to the strength and solidity of the whole machine, as well as providing a safeguard against bursting. For this purpose alone it would almost be advisable to introduce them.

TURNING-OFF STONES.—When the stone is set in, it is very irregular on its surface, and must be turned off true before using. For this purpose an attachment is used, which in its motion resembles the slide rest of a screw-cutting lathe. It consists of a frame which is placed on the grinder base, where it is bolted down firmly. On this frame there runs a carriage which is moved laterally across the face of the stone by means of a screw and hand wheel. Mounted on this carriage is a similar one, which moves at right angles to the surface of the stone, and is actuated also by a similar screw and hand wheel. On this top carriage is fitted a jig, similar to that used in sharpening, though generally a dull one is selected for turning off a stone. With this machine a stone can be turned down to the required size, and made true on its face. It is best in turning off a stone to make the face slightly crowned or else to turn down the edges more than at the centre. This prevents, to some extent, the spauling of the stone from the pressure of the wood. Great care must be taken that in turning down the stone no cracks are made in it, for if any exist, the piece will, very likely, fly out when the pressure is applied.

This, of course, will ruin the stone eventually, even if it is a small piece, as when one piece is broken out, others quickly follow. It is a bad practice to run a stone after it has been spauled. In handling the stone, when bringing it into the mill, it should, if possible, be slung from a carrier by ropes passing through its centre hole. As this is not provided for in many mills, the next best thing is to roll it on strong planking, taking care that it is only bearing in the middle of the face and not near the sides. It should, in all cases, be eased by ropes and blocks, so as to have it at all times under control. If care is taken, a stone can be mounted without the edges becoming spauled more than will be completely removed by turning down and truing.

SCREENING.

Description of Screens.—When the pulp and water leave the grinder, it flows along the troughs placed underneath the floor of the grinder room to the large trough into which every grinder discharges. In this large trough are sprays which supply sufficient water for the pulp to flow along it. At the end of this trough is placed a large tank covered over with iron plates, which are perforated with holes about ¼-inch in diameter. The pulp and water falls on this screen, and flows through to the tank underneath, while all large splinters, chips, etc., are collected on the perforated plates. The stuff pump draws the pulp from this tank and discharges it in the large trough in the wet press room. The screen of plates prevents any large pieces from entering the stuff pump which would cause trouble if allowed. The trough into which the stuff pump discharges is made of 2½-inch pine planks, its size depending on the capacity of the mill. A 15-ton mill would require one about 20 inches wide by 24 inches deep. This trough runs the whole length of the wet machine room, and is tapped at intervals for each screen. Each outlet is provided with a trap gate, or if the outlets are wrought iron pipes, a valve is used. It is also necessary to provide the trough with an overflow connected to a pipe running back to the tank in the grinder room. This will be found extremely useful in case of a stoppage in the wet-press room, if the stuff pump is not driven from the same water wheel as the wet machines. From the large trough the pulp is led to the vibrating diaphragm screens, a cut of which is shown in Fig. 10. This type of screen is in general use in America,

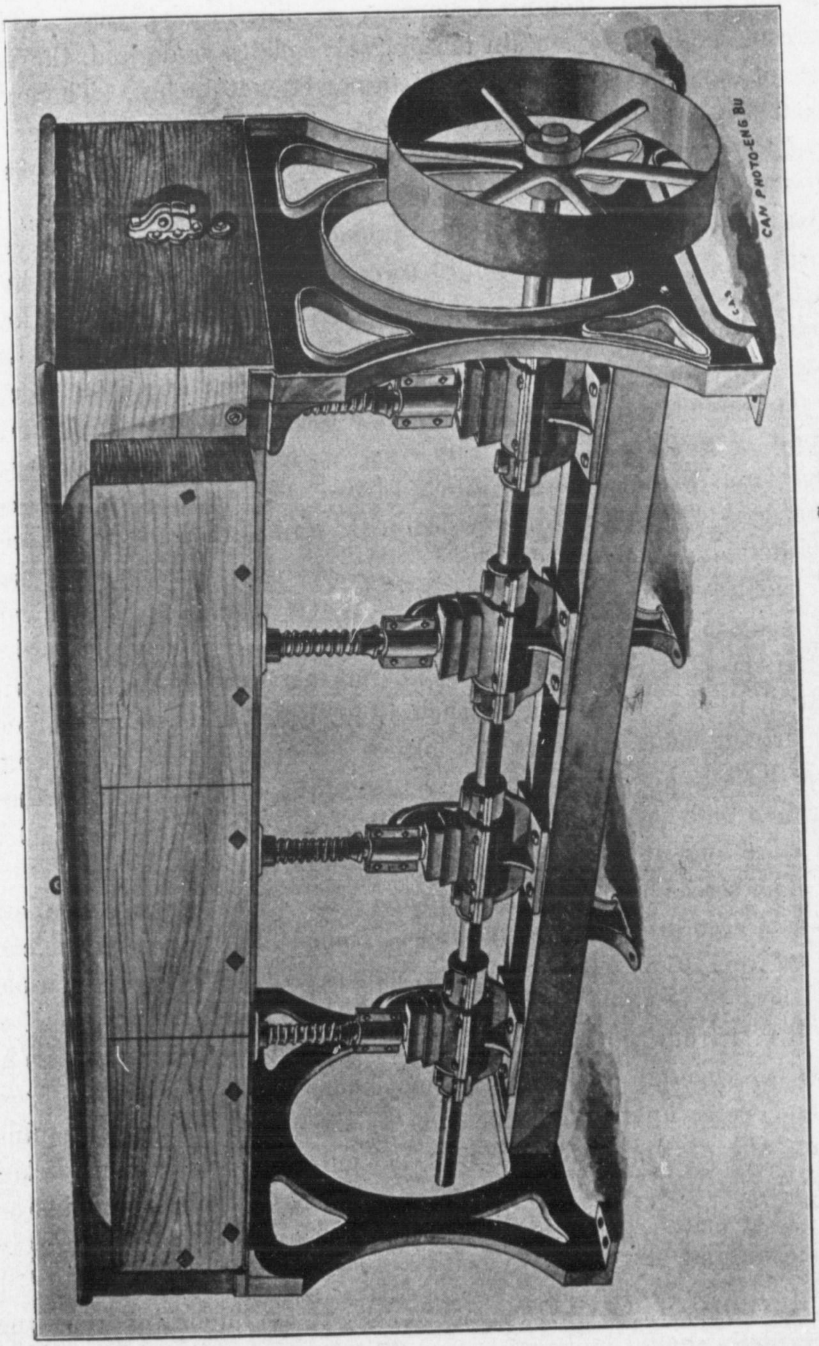

FIG. 10.—VIBRATING WOOD PULP SCREEN.

and has been found very satisfactory. This machine is manufactured by the Jenckes Machine Company, of Sherbrooke, Que. These screens are built to contain ten or twelve plates as desired, the usual size of the plates being 12 x 36 inches or 12 x 40 inches. The cradle, or frame containing the screen plates, is hinged to the water box and when raised permits the cleaning or examination of the plates. The water box is built with a partition in the centre, forming two compartments, each of which is provided with a diaphragm, supported on two vertical spindles passing through the guides, shown in the cut, and carrying the knockers, or cam shoes, at their lower ends. The usual flexible connection between the diaphragm and the sides is effected by india rubber. The stock box is bolted in front of the water box and is provided with a brass valve for regulating the supply of stock. The side frames are of cast iron, connected by an angle iron distance piece, which carries the bearings for the cam shaft and which is also provided with stands underneath, thereby considerably reducing vibration. The bearings for the cam shaft are babbitted and are placed on either side of each cam. These cams are made to give from one to four throws per revolution, according to the speed of the cam shaft. The arrangement of the cams with relation to the diaphragms is such as to insure a constant strain on the driving belt. Springs are placed on the vertical rods, which keep the knocker always in contact with the cam, thereby avoiding vibration and noise. The usual speed of the screen is about 350 to 400 vibrations of the diaphragm per minute.

The screen plates are cut in fine slits. The size of these slits will vary according to the stock to be screened. For fine stock the cuts will be from .012-inch to .014-inch, though larger sizes are more usual. The capacity of these screens varies with the speed. At a speed of 600 R.P.M. they should screen 5 tons of well ground stock per 24 hours. In operation, the upward movement of the diaphragm forces air and water up through the cuts in the plates, thereby cleaning them. On drawing down again, the pulp and water are sucked through the slits, and that which will not pass through remains on the screen plates. Sufficient water is necessary to keep the pulp in suspension.

Method of Cleaning Screens.—It is important that the screen plates should be kept clean. When it is found that it is difficult to get the stock to pass through, the plates should be examined, and if gummed up or clogged they can be cleaned as follows: Wet the plates thoroughly with paraffine or coal oil, and with a beater made out of an old piece of felt, beat or whip the plates. The oil dissolves the pitch and gum and the beater will free the cuts or whatever is there. Whip the plates afterwards with water, and if properly done, the plates will regain their capacity. When the stock is not ground well, being either full of slivers or uneven in grain, it is difficult to get the screen to pass it sufficiently fast. The wet machine tender has constantly to scrape the screen plates, removing the larger pieces which stop up the slits. There is no remedy for this but more care in grinding. By putting a centre board nearly the whole length of the screen and supplying the stock at one end, allowing it to flow down one side, around the end of the board, and up the other side, the screen will, to a great measure, clear itself, and therefore will require less attention.

Arrangement.—The general practice is to have one screen for each wet machine, to which it is connected direct. There is an advantage in having another pine trough, into which the screens discharge, and from which the wet machines are supplied. In the case of an accident to a screen, or if it should require cleaning, it is evident that with one trough the wet machine cannot run. If, however, the wet machine is supplied from a second trough, it can get its stock from the other screens, and the output is kept up. Suppose, for example, No. 1 wet machine breaks down, and also No. 3 screen is changing plates, or otherwise cut out; by means of the two troughs, No. 3 wet machine can be supplied from No. 1 screen, with the result that only one set is inactive, whereas in the other case, two complete sets would be idle. The extra pine trough does not cost very much, and may in this way save many times its cost in increased output. There are, perhaps, some objections to this method, but they all can be easily met. It will be found necessary to set the line of screens somewhat higher than the wet machine floor, to allow passage room under the second trough. In an existing mill, this would be out of the question, but in designing a new plant, it offers no serious difficulty. If found necessary, an extra screen could be installed, which will serve as a spare one in case of accident, or can be connected in when the stock is coming heavier than usual. With an easy load on the screen, it does better work and requires hardly any attention from the wet machine man. If the capacity is limited or the supply of stock irregular, it must be constantly looked after, and at a time when the man can least spare the time.

WET PRESSING.

Description of Wet Machine.—Fig. 11 is an illustration of a wet machine manufactured by the Jenckes Machine Company. It is a very good machine in design and workmanship. The main frame is cast iron of the usual web and flange construction. The standards are bolted to the main frame, and reinforced by tension rods, which can be removed when necessary. The lower press roll is of hard wood turned up true. The top press roll is of cast iron, turned and polished, and is very heavy. The usual hand wheels and pressure springs are employed to give sufficient pressure to the felt, as it passes between the two press rolls. These screws also serve to lift the top roll when necessary by means of the forged links shown in cut. The doctor, or knife, is slung from the top roll bearings, and is furnished with a steel blade, a spring for throwing it out of contact with the roll, and a handle for operating it. Small wood rolls are provided to direct the felt in its path, the front one being a stretch roll by which the slack is taken up, giving it the right tension. The two rolls shown close together, one above the other in the cut, are the squeeze rolls, whose duty is to remove some of the water from the felt after it leaves the beater. The top roll is the felt guide roll, by which the felt is kept running in the centre of the machine. The back roll of all is the couch roll, which is made of iron covered with $\frac{3}{4}$ inch of soft india rubber. Some makers still use a wooden couch roll, wrapped with felt, but the rubber roll is much cleaner, neater, requires no attention or cleaning, and does better work all round. It is supplied with this machine when desired. The duty of this roll is to pick up the pulp on the felt from the cylinder mould. To keep the felt clean and able to carry the supply of stock, a beater and spray pipe are provided. The beater consists of a shaft carrying three short armed spiders, connected by hardwood strips. In revolving the strips strike the felt on one side, while the spray washes it from the other. This not only cleanses the felt but whips up the hair on its surface, increasing its carrying capacity. A suction box is provided for extracting as much of the water from the felt and pulp as possible before it passes between the press

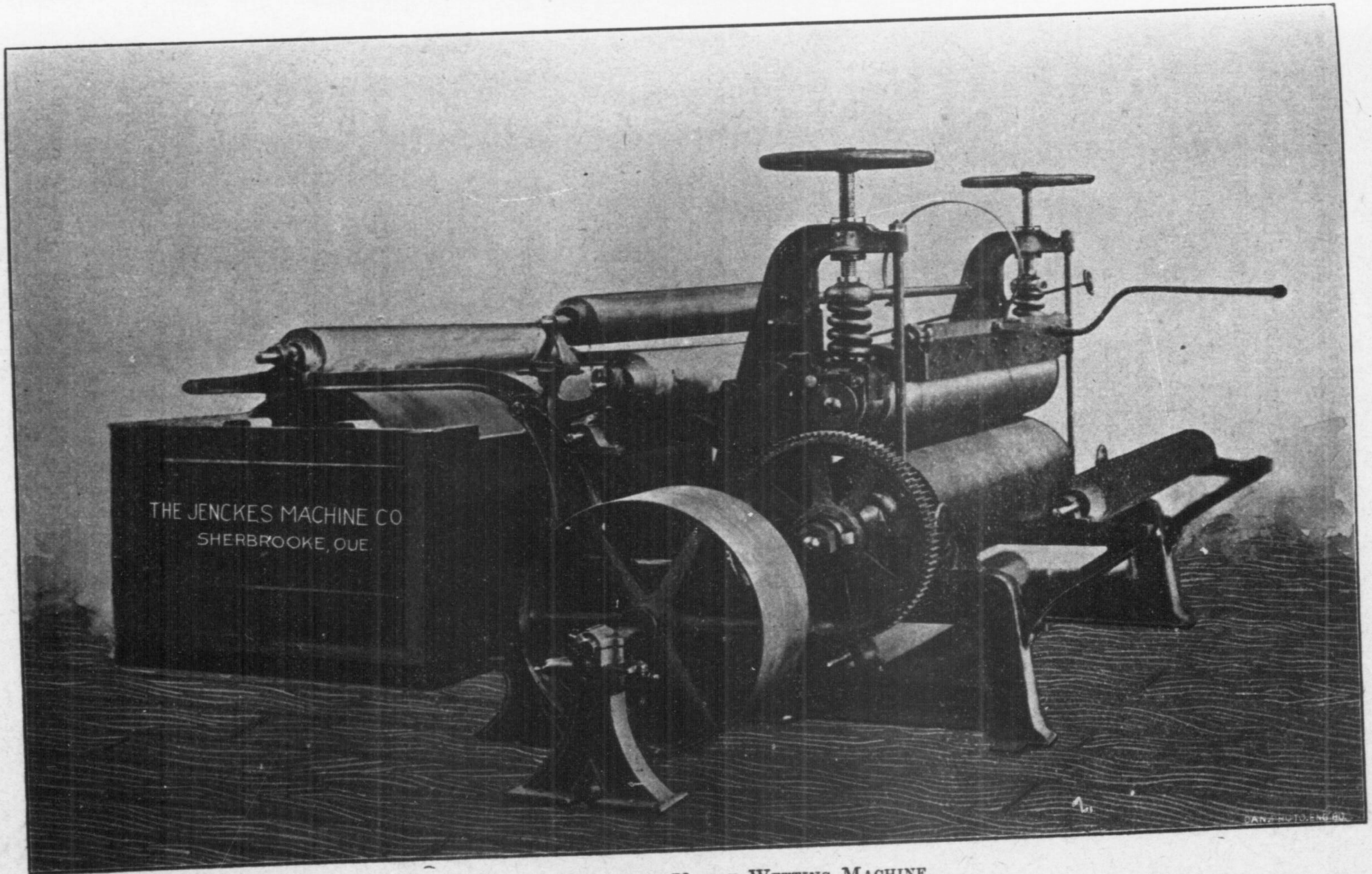

FIG. 11.—STANDARD 72-INCH WETTING MACHINE.

rolls. The box extends the whole width of the felt, and is tightly closed up except the top, where it is perforated with small holes. A pipe connects this box with the draft tube of the water wheels, or to a power driven suction pump. As the felt passes over the box, the water is sucked down into it, leaving the felt much drier. In large mills where there are many wet machines running, it is by far the best method to connect the suction or draft boxes with a power driven suction pump, as any considerable amount of air let into the shaft tubes of the water wheels means a loss of head, which is very expensive, when it means a decreased output. The vat is made of 3-inch pine bolted together, and provided with sprays as usual. The cylinder mould, which revolves in the vat, consists of a number of brass spiders mounted on a shaft, and covered with brass wire cloth. It is driven by contact with the couch roll. The felt in its path passes the stretch roll in front of the machine, goes down under the two rolls near the floor, up past the beater and cleaning sprays, through the squeeze rolls and back under the couch roll. From here it passes over the guide roll past the suction box, and through the large press rolls and so back to the roll in front.

Fig. 12 shows the interior of the Chicoutimi wet machine room. This is the usual arrangement of wet machines in either large or small mills. The machines are driven from a main shaft supported by the roof trusses. In the right foreground is shown the hydraulic press, which is used to force some of the water from the pulp. The screens and pulp trough are placed back of the wet machines. There are eight wet machines installed in this mill, handling about 90 tons of wet pulp per day.

Operation.—The pulp and water as it comes from the screen passes to the vat of the wet machine. In this vat revolves the cylinder mould. The vat and mould are so designed that the water cannot flow out of the vat until it has passed through the meshes of the wire covering on the mould, or, in other words, the outlet of the vat is led from the inside of the mould. The pulp, being in suspension in the water cannot pass through, and is spread in a thin layer on the surface of the mould, which, by its revolution, carries the pulp up under the couch roll, and in connection with the running felt. The pulp, on contact with the felt, fastens itself thereon, leaving the wire comparatively clean. By the motion of the felt the pulp is carried

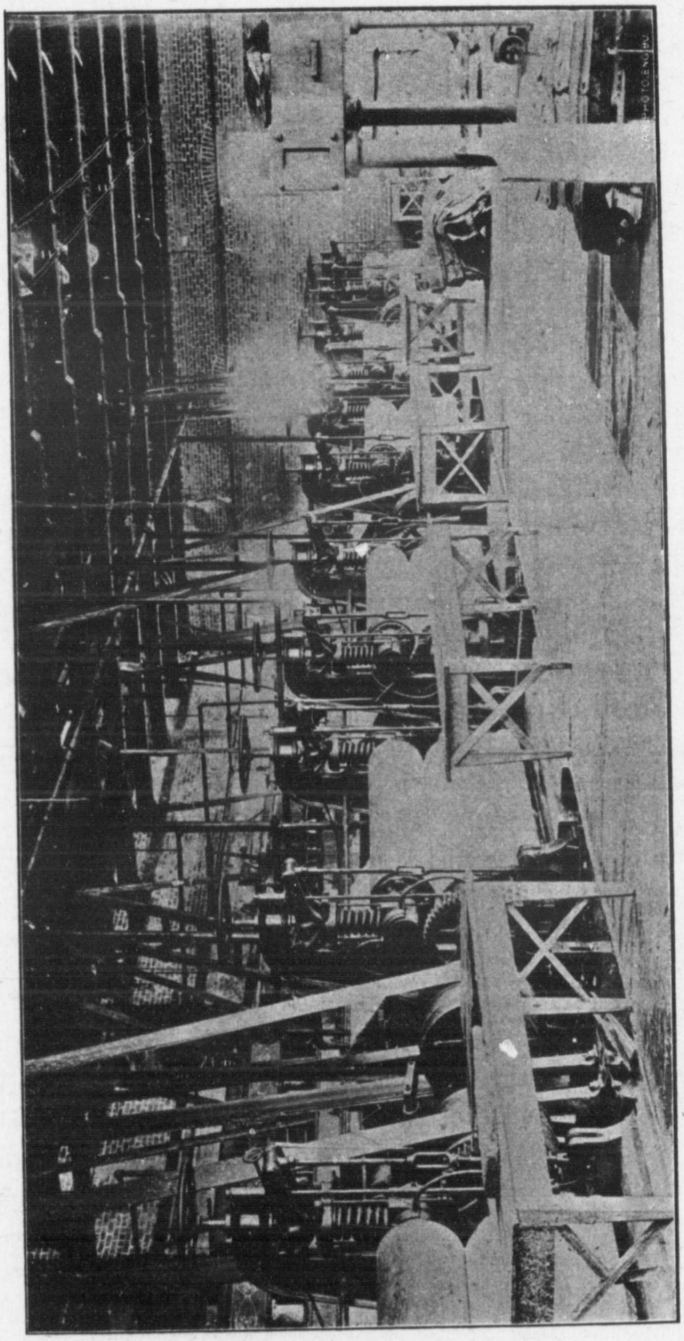

Fig. 12.—Chicoutimi Pulp Company's Wet Machine Room.

over the machine, and, after going over the suction box where a certain amount of the water is drawn off, it passes between the large press rolls. These rolls being very heavy and also being pressed together with the powerful springs, force out much of the water. The pulp, on coming through, leaves the felt and sticks to the top roll, where it is allowed to accumulate by the addition of a number of layers. When it has arrived at a proper thickness, it is cut off.

There are two methods of removing the pulp from the top roll. One is by means of a short sharpened pin made of hardwood. The operator sticks the point of the pin under the pulp, and by a quick motion across the face of the roll, cuts a gash in the pulp the whole width of the machine. By grasping the lower edge, and allowing the roll to make one revolution, the sheet falls free in his hands. The other method is by the use of a doctor and knife, such as is shown in Fig. 11. The machine hand, in this case, simply presses on the handle, which brings the knife against the roll, severing the pulp. The sheet unrolls as before, and is thrown on the table and folded. The first method has many objections to it, aside from the difficulty of cutting a straight edge. A workman, if he is at all nervous, is apt to stick the pin into the felt which completely ruins it. When the pulp is coming very fast and is allowed to roll up too thick, the workman may not be able to drive the pin across the roll at one sweep. On making a second attempt the roll has advanced, and there is great danger of his dropping the pin over the roll. It is now certain to pass between the press rolls, cutting a hole in the felt, and ruining the fibre of the under roll. Numbers of felts have been needlessly spoiled in this manner as the injury could have been prevented by the use of a knife. With the doctor the heavier layers can be cut off as easily as the lighter ones. The knife is apt to crinkle up the edge of the sheet; but this disadvantage is partly offset by the straight edge obtained. The sheet is folded so that there is no edges showing from the outside, making, when folded, a bundle about 24″ x 18″ x 8 layers thick. The sheet from a 16-inch roll will be 50 inches wide, the length depending on the width of the machine. The standard width adopted by most builders of wet machines is 72 inches, which is large enough. If larger than this there would be difficulty in throwing the sheet.

The pulp vat, at the back of the machine, is provided with inlet and discharge valves or gates, by which the wet machine man can regulate the level of the water in it. When the stuff pump is driven from the grinder shaft, the variations in its speed may cause considerable difficulty in keeping the water level constant. No trouble will be found in doing this if the variations in the speed of the stuff pump are small. When the wire of the cylinder gets dirty or gummed up, its capacity is limited considerably. It may be cleaned by rubbing with coal oil and playing upon it with a spray of water. Situated close to the wire gauze is a brass pipe into which have been drilled a number of fine holes. It is supplied by the low pressure system before mentioned. The spray is allowed to play upon the wire of the cylinder mould, keeping it comparatively clean.

The life of felt varies considerably with the treatment it has received and the quality of its manufacture. The gray Canadian felt is a better one to carry the stock, and will last longer than the white American ones. When a felt is new, the carrying capacity at a speed of about 50 feet per min. is about 5½ tons dry per 24 hours, and will sometimes exceed this output under favorable circumstances. The usual daily capacity of the felt is about 5 tons of dry pulp per day. The output will fall below this, however, when the felt is worn.

HANDLING PULP.—When the pulp is cut from the wet machine roll, it is thrown on a table placed behind the operator, upon which it is folded. This table is made of heavy boards and is about 7 ft. 8 inches long by 3 ft. 6 inches wide. When the sheet is thrown, a portion of it is folded in to give the operator a better hold. This makes the sheet taken from a 16-in roll to be about 3 ft. 6 inches wide by 6 ft. long. The extra length in the table is for the purpose of piling the pulp on until it is taken to the hydraulic presses.

Though it seems to be the general practice to erect the hydraulic press in the wet machine room, an advantage might be gained, especially if the output of the mill exceeds 20 tons dry per day, by placing the hydraulic press, baling press, together with their pumps, etc., in a room by themselves. If this method is adopted, a very convenient way of carrying the wet pulp from the wet machine tables to the tables in the hydraulic press room is by means of a small trolley running back of the line of tables at the wet machines, and sufficiently near to them to allow the pulp to be easily transferred to the trolley. If the mill were an exceptionally large one, making it difficult to keep the long line of tables clear, a cheap cable drive could be installed for moving the loaded trolley. By arranging a small lever and grip, so that the trolley could be easily started by throwing the lever to the right, and reversed by making a similar movement to the left, the carrying of a large amount of pulp would present no serious difficulty.

HYDRAULIC PRESSING.

DESCRIPTION OF PRESSES AND PUMPS.—When the pulp is cut off the wet machine it contains a large amount of water. The per cent. of dry pulp in wet pressed pulp generally averages about 35

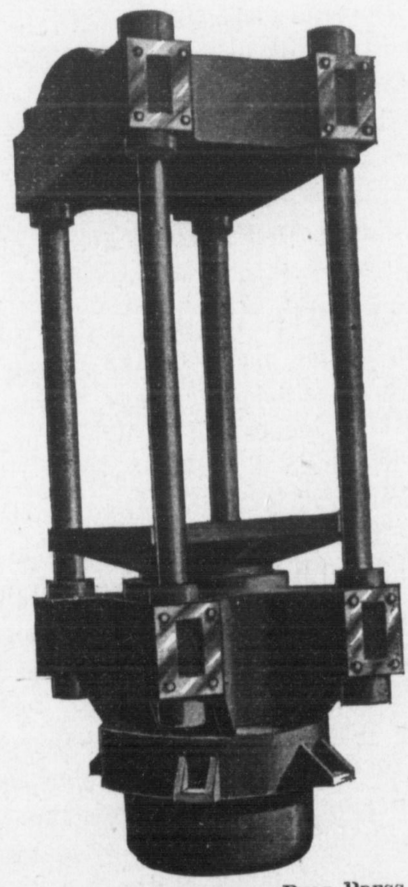

FIG. 13.—HYDRAULIC PULP PRESS.

per cent. To ship pulp having this amount of water would be very expensive, as freight would have to be paid on 65 pounds of water for every 100 pounds of wet pulp shipped. In order to reduce this loss, the pulp, after coming from the wet machine, is sent to the baling room, where are situated heavy hydraulic presses whose duty is to remove some of the water. In most of the mills in Canada, the percentage of the pulp is raised from 35 to 50 per cent. by means of these presses. It may be advantageous to take the pulp from the wet machine wetter than 35 per cent., relying on the hydraulic press to remove enough water to bring the percentage to 50 per cent. of pulp. Experiments should be conducted in each mill, to determine the most economical degree of wetness that the pulp should be delivered from the wet machine. The style and capacity of the hydraulic press will certainly make a difference in determining the above. Fig. 13 shows a hydraulic press, manufactured by I. Matheson & Co., Limited, of New Glasgow, Nova Scotia. It is made especially for this work, and is used in many of the mills in the Eastern Provinces. The lower frame is very heavy cast iron, containing the chamber and ram. Four large steel rods are situated, one at each corner of the frame, and serve to support the top casting, and also the whole strain of the ram. The ram is made of cast iron, of a suitable diameter, and on top of which is carried the platen. The pipes are connected to the chamber through the cast iron frame of the base.

In erecting, the press is let down through the floor, so that the platen will be of a sufficient height from the floor to accommodate the trolley. Owing to its weight, it is best to put the press on an independent foundation where possible, or else to introduce special bracing in the frame of the mill. The pressure which these presses use varies considerably, according to the size of ram and capacity of pump. In a large sized press a pressure of 150 tons on the ram is not unusual. The water is supplied to these presses by a triplex pressure pump, one of which is shown in Fig. 14. This pump is also manufactured by Messrs. I. Matheson & Company. It is made for use in connection with the press shown in Fig. 13, and is constructed in a very substantial manner. The plunger shaft is made of steel as shown, and is fitted with a spur gear for driving. The pump is back geared from a pinion shaft which carries the driving wheel. The speed of the crank shaft is 40 R.P.M. The pressure at which it is capable of working is 5,000 lbs. per square inch. The standards which carry the plunger shaft are made very heavy, and are cast in one piece with the base. In order to give the plungers a true vertical motion, without creating a lateral strain on the glands, they are provided with cylindrical guides, mounted on a cross bar, which is bolted to the two standards. The pressure pump is usually placed up on the roof trusses of the wet machine room and driven from the main shaft. It is connected to the press by special hydraulic piping and fittings. A pressure gauge is placed near the press, which shows the pressure per square inch and also the tons of the ram. A suitable valve is also connected at hand for operating the press.

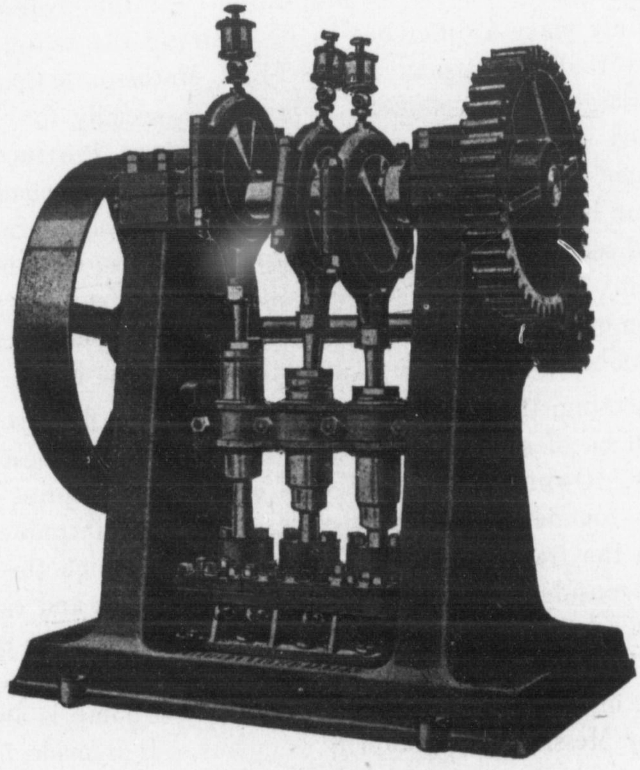

FIG. 14.—HIGH PRESSURE TRIPLEX PUMP.

The overflow from the press is led back to the water chamber of the pump, so that the water is used over again. In this way no attention is necessary to supply the pump with water. Some makers of hydraulic pumps prefer to make one of the plungers larger than the other two, and arrange so that when the pressure reaches a certain limit this plunger is automatically cut out, the pump then becoming a duplex. The reason for introducing this feature is to raise the ram faster, thereby saving time and increasing the output of the press. The result is not very satisfactory, owing to various reasons. When the three plungers are working together they are acting 120 degrees apart, giving an even strain on the gearing and belt. Now when one is cut out, the pump is simply a badly designed duplex, as the cranks of the remaining two plungers are not opposite each other. This causes uneven wear on the gear, and a periodic swing in the belt. If it is desirable to increase the output of the press by a special design in the pump, it would be better to have three of the plungers the same size and introduce a fourth one of larger diameter than the rest. As the three similar ones do the greater part of the work, they should be spaced 120 degrees apart as in an ordinary triplex, and the extra and larger one midway between any two of them. The strain on the gear and belt will not be even at first, when the load is light, but occurs when the pressure is heavy, when the pump is working properly as a triplex. There may be objections to this, but when it is remembered that the extra plunger cuts out automatically before 10 per cent. of the total load on the pump is reached, it will be seen that it does not disturb the balance of the pump as much as it appears to do at first sight.

ARRANGEMENT OF TROLLEYS.—A very good method of handling the pulp at the hydraulic press is shown in Fig. 15. It is supposed in this case that the pulp is brought to the press by the trolley shown at G. The wet pulp is delivered from this trolley to D, which is simply a large table mounted on a pair of wheels, so that it can be brought near to the press trolley that is being loaded, and within easy reach of the press man. One press trolley with its load of pulp is always under pressure, the other one in the meantime being either discharging or loading with wet pulp again. The operation is somewhat as follows: The pressman in loading trolley B places on it first a layer of felts, then a layer of pulp, and so on alternately until the pile will just go under the top of the press. B is now run into the press and the pressure turned on. While this load is being pressed, he proceeds to load up trolley C from the supply on the wet pulp table D. When B has been pressed sufficiently, the water is turned off, which lowers the trolley down on the rails again. It is now run out and trolley C is run in the press, and the water turned on as before. B is now unloaded, the pressed pulp being thrown on the dry pulp table at E, and the felts on the felt rack. When B is empty it is immediately loaded again, the trolley D being run up conveniently near for the purpose. In this way there is no carrying of the pulp by the workman, an advantage which will easily be seen when the quantity handled is considered.

The rails for the press trolleys are laid across the platen of the press, and are cut at each side so that the ram can rise. The trolley is made with the distance between the centres of its wheels a few inches greater than the length of the press platen, so that when the

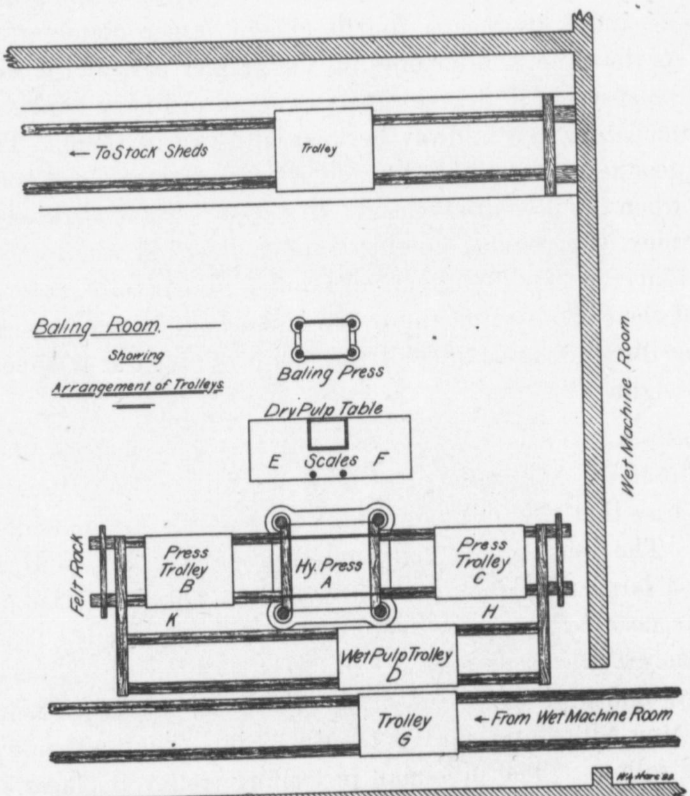

Fig. 15.—Baling Room

ram rises the platen clear the axles, and bears up the trolley with its load, without causing any strain to come on the wheels or bearings. The trolley is, in this way, able to stand the strain which otherwise would break it down at once. On lowering the ram again the wheels find the rails and it is rolled off as before stated. It is barely necessary to mention that under these circumstances it is necessary to build the frame of the trolley very strong, to stand the crushing load.

The felts used for the pressing are a good deal heavier than those on the wet machine, sometimes being ½-inch thick. Some mills use coarse bagging instead of felts, and find them very serviceable. The open grain or texture of the material facilitates the flow of the moisture. One of the difficulties encountered by Canadian shippers to the English market is the variation in the moisture test. Export pulp is supposed to be 50 per cent. pulp and 50 per cent. water; but it will vary from time to time, even with the product of the same mill, as much as 4 per cent. or 5 per cent. above or below the standard. Steps should be taken to increase uniformity of moisture not only in the product of any one corporation, but in that of all exporters. This is one of the many questions to be solved by pulp mill men who export. The percentage of 50 per cent. has been almost universally adopted as being the test, considering the present method of extracting the water. It is necessary from the standpoint of freight and carriage, that the amount of the water in the pulp should be reduced as low as possible. If this were all, the question would be much simpler than it is. It is extremely difficult, however, to press pulp much higher than 50 per cent. by present methods; it could be done, but the output of the press could not be maintained. Another consideration presents itself, i.e., that when the pulp is baled it is springy and often will burst the wires of the bundle when the pressure is removed. This springing is found to increase as the percentage of pulp is increased. These difficulties can be met, but it is not along this line that the solution will be found. Inventors are at work now on this problem, and some already claim a solution of it.

BALING.

Description and Operation.—After the pulp has been pressed to remove excess of water, it is next baled into suitable bundles for shipment. This part of the process is effected in a hydraulic baling press, which is somewhat similar in design to that shown in Fig. 13, though being of much lighter construction. On the platen of the press and also on the under side of the cast iron cap are bolted heavy blocks of hardwood, having grooves cut laterally in them to accommodate the wire for binding the bundle. The same result could be arrived at by having slots, or grooves, cast in the cap and platen at the required places. In the process of baling the operator weighs out a sufficient amount of pulp to contain 100 pounds dry. If the pulp is exported as 50 per cent. pulp, then the weight of the bundle will be 200 pounds. On the platen are put two wires which lie in the grooves prepared for them. Two lathes are now laid on, and on top of these a wrapper, if pulp wrappers are used. The 200 pounds of pulp being put in, then another wrapper with two lathes are placed the same as before. The pressure is now turned on, which compresses the bundle firmly. The two wires are pushed through the top holes and twisted to the ends which pass below the bundle. On the pressure being removed, the pulp expands and draws the wires tight, making a firm compact bundle. It is now sent to the store sheds to await shipment.

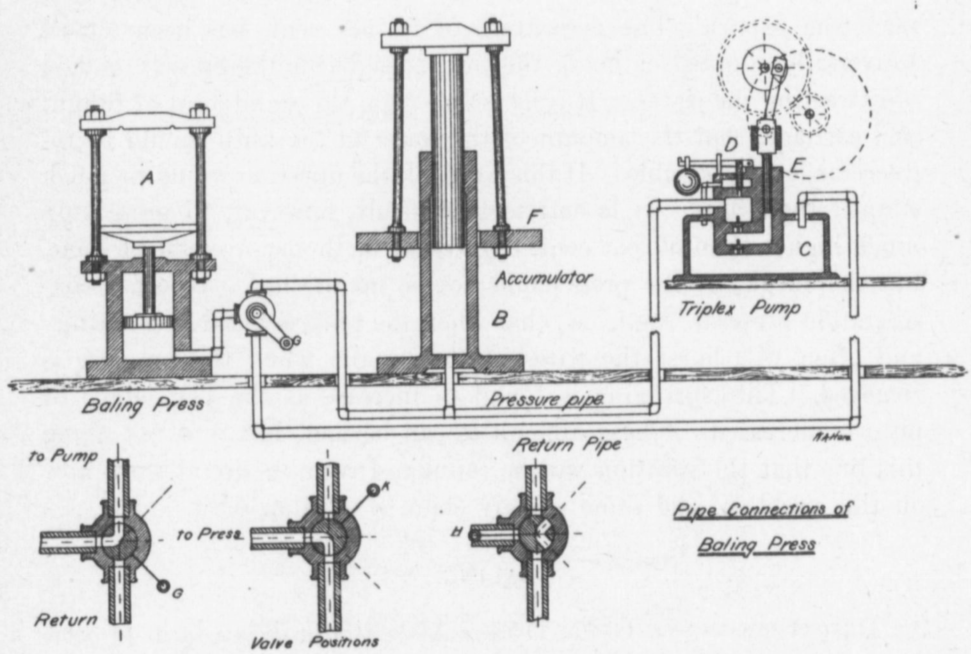

Fig. 16.—Baling Press Connections.

The arrangement of the piping and connections are different in this press than in the larger one. Fig. 16 is a drawing showing the pipe connections. The accumulator is connected in the pressure pipe between the pump and the baling press valve. When the press is not in operation or the valve closed at the point H, the discharge from the pump forces the plunger and weight of the accumulator up to the top, where it is stopped. Should the pressure rise higher, it will be relieved by the safety valve shown at D, the discharge from which is connected to the supply tank of the pump. If, for instance, a bale should be ready for pressing, the valve is thrown off to the position G, which connects the high pressure pipe to the chamber of the baling press, forcing the piston up and compressing the bale. This effect has been caused by the descent of the plunger and weight of the accumulator, very little coming direct from the pump. If the piston of the press is forced up far enough, simply by the direct fall of the accumulator weight, the valve may be turned to the point H, thereby stopping all communication between the pump and the press, allowing the pump to raise the accumulator plunger and weight so as to be ready for the next bundle. On the other hand, if the fall of the weight is not sufficient to run up the press piston, the valve may be left at the point G, and the pump will soon bring it up. The pressure will continue to rise until a point is reached which corresponds to that produced by the fall of the plunger, after which it will remain constant, as the accumulator with its weight rises.

Fig. 17 shows a longitudinal cross section of the accumulator. Upon the base F stands the barrel E, which contains the plunger A and is fitted with a gland at the top. The upper end of the plunger carries the cross-head, suspended from which is the platform D, by means of the rods. B B. At G the pressure pipe is connected to the barrel. Weights are placed on the platform D D, if necessary, until the pressure required to raise the plunger is equal to the pressure wanted at the press. By the use of this accumulator, the pump is doing effective work continually, and thereby saving much time. Before the introduction of this reservoir, the operator after opening the valve would have to wait while the pump slowly raised the press piston and pressed the bale. Much valuable time was lost in this way, while the capacity of the press was very limited.

In Fig. 15 is shown a drawing of a baling press room. This shows a very convenient arrangemeut of the hydraulic press and trolleys and also of the baling press. The accumulator can be placed anywhere out of the way, and piped to the pump and press, the pipes running beneath the floor. The pulp table E E is situated convenient for loading, and carries the scales in its centre. The size of the bale, if standard 72-inch wet machines are used, will be 24 inches long by 18 inches wide, while the height will vary according to the amount of pressing, generally about 12 inches to 14 inches. Its weight is 200 pounds if the pulp shows 50 per cent in the moisture test.

WRAPPERS.—Owing to the loss by abrasion and dirt that is always met with when pulp is shipped without a covering of some sort on the bundles, there have been many attempts made by different manufacturers of pulp to produce a serviceable and cheap wrapper. These efforts have been made with various degrees of success, using many different materials. The best form of wrapper yet introduced is a cloth bagging of either jute or calico. In some mills where this

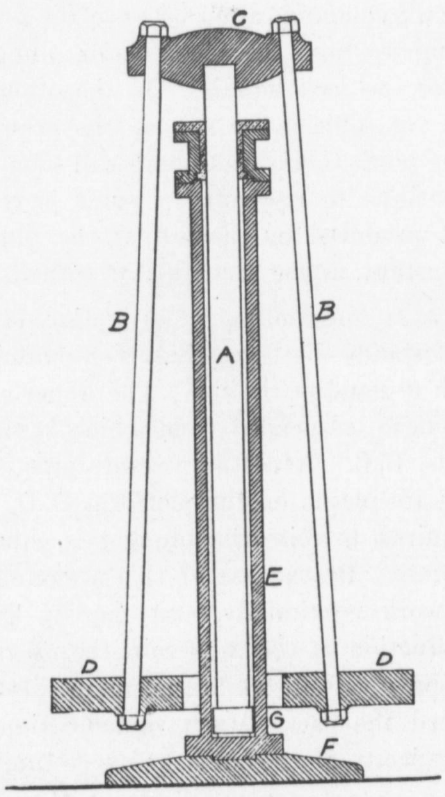

FIG. 17.—SECTION OF ACCUMULATOR.

wrapper was tried, it was given up on account of its expense. Wrappers are made in some of the mills of pulp. The wood is the usual spruce, such as is used in making the ordinary grade of pulp, but after being sawn and barked it is steamed in a steamer, under a pressure of 60 to 75 pounds per sq. inch until the wood is practically cooked. This steaming loosens up the fibres of the wood, which, when ground, produces a dark colored pulp with a longer fibre than is obtained from the raw wood. It is cut from the wet machine by a pin to secure a smooth edge, as the knife tends to crinkle the sheet. The wrappers are cut from the sheets, and afterwards air dried. Two are placed on the bundle, one below, and the other above, while their edges overlap. No covering is provided for the ends of the bundles when they are wrapped in this way. If more attention were given by Canadian manufacturers to secure a good cheap wrapper, which would insure their product landed in England in good condition, and also obtain uniformity in the moisture test, the demand for Canadian pulp would increase more than ever.

In conclusion, the writer desires to express his gratitude to the following firms, for the privilege of presenting the accompanying illustrations:

The Jenckes Machine Company, of Sherbrooke, Que.

Messrs. I. Matheson & Company, of New Glasgow, N.S.

The Northey Manufacturing Company, of Toronto.

The Waterous Engine Works Company, of Brantford, Ont.

The Robb Engineering Company, of Amherst, N. S.

MODERN SYSTEMS OF INTERIOR WIRING.

By L. B. Chubbuck.

When the incandescent electric light was introduced commercially about 1881, in order to supplant its rival gas, it was claimed that the new illuminant required merely the cheapest and simplest kind of wiring. Paraffin covered wire (i.e., copper insulated with two cotton layers soaked in paraffin) had been used before this time for electric bell and telegraph work, and was at once adopted for electric light wiring. This covering was found to be totally useless, however, as often an overheated wire would ignite the inflammable covering, the flame following the wire for long stretches, especially where concealed under the floors or between the walls.

When the underwriters discovered this, they demanded a covering that was non-inflammable. So-called "Underwriters" wire was then introduced, the covering of which consisted of a cotton fibre braid, with a coating of zinc paint on the outside. This wire, while being non-combustible, was not waterproof, and where moisture was present, electrolysis was set up, which soon destroyed the wire.

After the short stay of the "Underwriters" wire, a wire insulated with bitumen was brought forward to be used in moist places. This, under the name of "Paragon wire," gave good results for a time, but eventually its insulation was found to crack, and its manufacture was discontinued. Since then various grades of composite and rubber covered wires have been introduced which are water-proof and of high insulation. These have survived to date.

A little of the earliest work was done, by tacking the wires in place with small metal staples. This soon proved so objectionable, especially with the poor grade of insulations then used, on account of grounds, short-circuits, etc., that it has been condemned ever since. A great deal of wiring after this was done with wooden cleats to support the wires in position. The wires were carefully run in respect to being kept away from gas or water pipes, and though no attempt was made to keep them from touching wood or plaster, they have given good satisfaction in nearly all cases where the buildings were perfectly dry. But natural dampness in the atmosphere, a leaky roof or the accidental spilling of water, is most liable to impair the insulation to such an extent that considerable leakage might take place. Fortunately in this climate the small amount of moisture in the atmosphere has practically no effect on inside wiring, though in foggy districts near the sea coast, and especially in England, a great deal of trouble is experienced from grounds caused by a film of moisture forming over the surface of the fittings. In regard to wires imbedded in plaster, the effect on the insulation is uncertain, depending on the

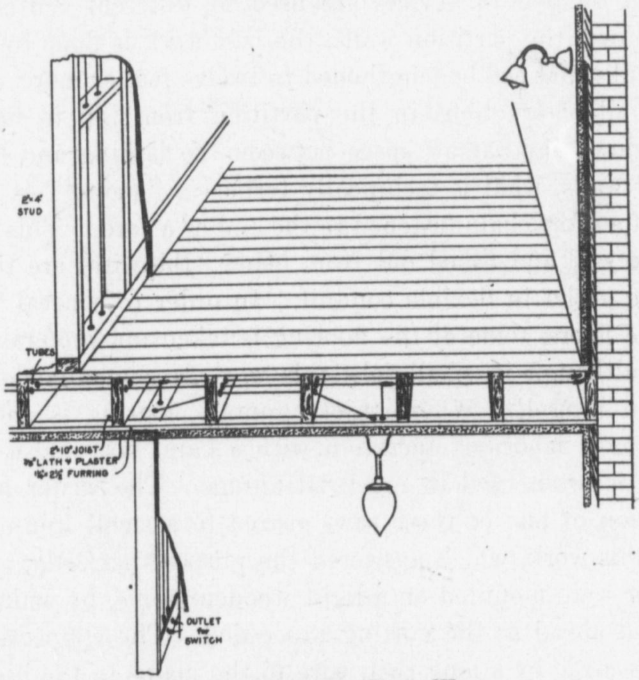

FIG. 1.—PORCELAIN TUBE WORK.

composition of the plaster and the covering of the wire. In some cases the alkalies in the plaster soon break down all insulation on the wire, while there are many instances in which specimens of wire have tested well, after being embedded in plaster for many years.

To prevent any liability of leakage or chemical action on the wire, it is now supported throughout on porcelain knobs or cleats, and where passing through timber or plaster is surrounded by a porcelain tube. In Fig. 1 is shown a sketch of this method of wiring as installed in the ordinary style of building. As may be seen from the figure there is considerable open space in the partition walls, under the floors, and in many cases on the outer brick walls, in which the wiring may be concealed. The joists, studding, etc., are bored to receive the porcelain tubes, and the wires run through these tubes, which are made in different sizes and lengths, depending on the size of the wire and the thickness of the timber they are to pass through. The wiring of such a building is most readily done while the building is under construction and before the lathing and plastering is commenced. In finished buildings, where the wiring is to be concealed, the problem is more complicated, and to avoid breaking the plaster, a number of devices are used by different contractors. In passing down the partition walls, the best work is done by using bits with shanks that can be lengthened to twelve feet or more, and boring through all obstructions in the partition from top to bottom. In passing down the narrow space between the lathing and brick work on outer walls, what is technically termed a "mouse" is used, consisting of a short chain fastened to the end of a cord. This is dropped down the wall and fished out from below; the wires are then drawn up to the outlet in flexible conduit. In order to conceal the wiring under the floors, some of the flooring is taken up, preferably by carpenters, although in small jobs this work is generally done by the electrician himself. Where thick, gummy flooring is encountered, this is a most laborious operation with a hand saw, and a small circular saw is often used to much advantage. The writer has seen a combination of one of these saws geared to a small iron-clad motor used for this work, which answered the purpose perfectly. Both saw and motor were mounted on a light wooden frome, by which the saw was moved ahead as the cutting proceeded. The connection to the motor was made by a long twin wire to the mains in the basement.

When it is considered too troublesome or expensive to conceal the wiring in a finished building by lifting floors, etc., the wires are often run in wooden moulding to diminish the unsightliness of open wires across the ceilings or walls. This class of work is much used on steamboats, and is especially adapted in wiring panelled rooms, as the moulding may be made to match the woodwork of the rooms Considered from an electrical rather than the decorative standpoint, wiring imbedded in moulding is inferior to wiring supported on porcelain and freely surrounded by air. The dissipation of heat is much easier effected in the latter case than in the former, and in a damp place the moulding will cause leakage, as wet wood is a conductor rather than an insulator. A case was met with recently where a No. 8 wire under the action of electrolysis had been entirely wasted away to a green trace of copper salts, by being imbedded in moulding, which has been soaked by a break in an adjoining water pipe. In practice the use of moulding is confined to work which is in full view and quite dry, and is not allowed in concealed work, such as between floors and ceilings, because of uncertainty as to dampness.

A method of wiring especially adapted to fireproof buildings, and known as the concentric system, is used to a great extent in Eng-

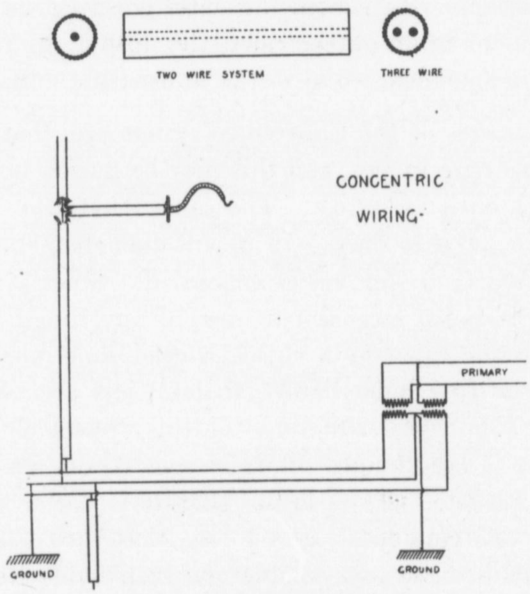

FIG. 2.—CONCENTRIC WORK.

land and Germany, though not yet in America. In this system, as illustrated in Fig. 2, instead of using two separate wires, one conductor is enclosed inside of an outer armor, which is used as the outer conductor. The inner conductor, is a tinned copper wire, which is surrounded by vulcanized rubber, taped and bedded with jute. Over all is bound a layer of galvanized iron wires twisted spirally, forming a complete tube about the inner conductor, and having a conductivity equal to it. For three-wire work, there are two inner conductors, insulated from each other, and from the outer covering, which in this case is used as the middle wire of the system. In both the two and three-wire work this outer armor is grounded where the mains enter the building, and at different points along the wiring, if the stretches are long. A case may occur where the terminals of two separate concentrics, which are on long circuits, come a short distance apart. If one of these cables is fully loaded while the other is idle, there may be a "drop of 2% on the loaded cable to no "drop" at all on the other, which will cause a difference of potential of 1% between the outers at the ends of the two cables. This under certain conditions is sufficient to set up electrolysis, which in time would destroy the covering of one or both cables, unless they are both well grounded at these ends. For alternating current work, unless for short runs, both conductors must be run in the outer covering, as in the case of a single conductor in an outer armor, the drop along the line will be increased by independence due to the alternating current.

The advantages of the Concentric system are, that there is practically only one wire to run, and this may be buried in plaster or run over iron work with impunity. The cable itself also, is quite small, being for a No. 12 wire only 5-16 in., in diameter, and as no insulators are required it is very easily concealed. Since it is armored, it is unaffected by nails, etc., and in case of any rough usage, such as the rupture of the cable by a chisel, a dead short circuit is formed, which blows the fuse immediately, without any arc being formed to the external cable. The adherents of this system claim, like Mark Twain, that it is best to put all your eggs in one basket, and then "watch that basket." They argue that it is better to put all the insulation on one conductor, and to see that this insulation is well protected, than to have two conductors, each liable to a breakdown. The disadvantages of this system are, first, the obvious difficulty in making the joints, and, second, having the outer grounded, which is a disputed question. This system is used chiefly in isolated plants or in buildings using alternating current and supplied from separate transformers, as there would probably be considerable electrolysis of gas and water mains where there was a network of bare outer conductors all over a city.

The concentric system is not used in America, and in the modern type of fireproof buildings, having brick partitions and floors of brick arches across the steel floor beams, the frail system of wiring on porcelain knobs is unsuitable. There is usually no free space along the floors or in the walls for running the wires, and even if there were such a space, the chances are great that falling mortar or brick would either break the wires or ground them on the steel frame work. To provide protection and accessibility to the wiring in such buildings, the conduit systems have been evolved. As far back as 1885 there are instances of wiring on some steamers being run in small brass pipes. The inside of the pipes was smooth, and as the runs were not long, the flexible cord used was easily threaded through the pipe from one opening to the next. Speaking tubes were tried about this time to act as a channel for the wires, but it was found that the conductors could not be inserted or withdrawn freely, and speaking tubes for this purpose were discarded. Since that time there has been very largely used a tube of papier-mache, impregnated with a bituminous compound, to render it impervious to moisture and also to increase its insulation. It was found, however, that when this "plain conduit" was concealed in plaster, it was ultimately destroyed by chemical action. Another form of conduit, called circular loom or flexible conduit, is now used extensively. The inner portion consists of a tube formed by a strip of treated paper wound in a spiral; over this is a braided covering coated on the outside with flakes of mica. Though the inner tube is rather inflammable, the outer tube will withstand quite a flame for some time.

The next step was to cover the plain papier-mache tube with a thin brass sheath having a longitudinal seam. This brass-armored conduit was thought at one time to be near perfection, but even it was found to have its faults. It withstands chemical action to some extent, but is not completely waterproof, and, like all the preceding forms of conduit, it is very susceptible to mechanical injury. Much of the trouble with brass-armored conduit has been due to the poor manner in which it was installed, as moisture entering at the outlets or at poor joints is absorbed by the inner lining, which in time will ground the wires on the outer covering.

Several tests were made in the school laboratories on both the circular loom and brass-armored conduit, to determine their insulation under the presence of moisture. These tests were made by the condenser method in connection with an electrostatic voltmeter. It was found that in the case of the circular loom, though of fairly high insulation when dry, the insulation resistance fell off very rapidly under the presence of much moisture. The brass armored conduit tested well when dry, and also with moisture for a short time. When exposed, however, to damp for some time, especially if the armor was defective, the insulation fell off, the effect of grounding being more noticeable in the case of the brass armored conduit than with the circular loom, on account of the metal covering.

For absolute mechanical and moisture protection, the iron armored conduit is now used. It has been made with insulating linings of paper, wood, rubber, cement, enamel and asphaltic compound. The metal tube should be the minimum of metal for strength and rigidity, and the lining, besides being capable of bending with the pipe without cracking or splitting, must be impervious to heat and moisture. There has been much discussion as to whether an insulating lining is necessary in a metal pipe which is perfectly waterproof and the wires it contains are insulated up to many megohms per mile. At the World's Fair (1892) all forms of pipe tubing and conduit then manufactured were rejected, and plain iron pipe was finally adopted, in which the distributing wires were run. Although some of these wires were carrying a 2,000-volt alternating current, no faults whatever were developed. There are also thousands of miles of plain iron pipe now used for underground service for high potential mains in cities, which have given perfect satisfacton.

In spite of these facts, a thin insulating lining is always used for interior conduit work, for several reasons. All the iron pipe, as now manufactured on a large scale, is very rough on its interior, due to burrs, fins and splinters, and in pulling a wire through a long stretch of this pipe the insulation is very liable to be torn, especially in rounding corners, elbows, etc., in the smaller sizes of pipe. A plain iron pipe is also liable to sweat internally, and any rust due to moisture in the conduit is a menace to the insulation on the wire. Thus a thin lining is useful as tending to preserve both the pipe and the insulation.

There are two styles of iron armored conduit very extensively used, one having a lining of treated paper and the other a thin coating of enamel both inside and outside. The lining in the latter conduit is very hard and as smooth as glass, which is an advantage in inserting the wires. These iron armored conduits are manufactured in the regular gas pipe sizes externally, and in coupling the standard gas pipe threads are also used.

DISTRIBUTION.

The system of distribution to be used in a building depends to a large extent on the character of the building, whether the lights are scattered, as in the case of a business block, or arranged in groups in a large electrolier, around the stage, etc., as in the case of a theatre. One of the most general methods of distribution is shown in Fig. 3, which gives an isometic sketch of the feeder system in one wing of a modern office building. In this system of wiring all the branch circuits (not shown) on each floor are run from one or more distribution boxes or cabinets on that floor. The panel-boards in these cabinets are supplied from the switch-board in the basement by a system of risers or feeders running up one of the side walls to the cabinets. In conduit work a two-wire system is usually employed throughout the building, and a separate pair of feeders run up from the switch-board to each distribution-box. Or where the load is light, and separate control for each floor from the basement is not required, the panel boards on two or three adjacent floors are supplied from one pair of feeders. In order that the public lights along the halls, staircases and elevators may be independent of the other lights in the building, it is customary to run a pair of feeders from the basement to one or more separate panel-boards on certain floors from which these lights are wired. In case current is required for running motors for printing presses, etc., on some of the floors, the main panel-boards on these floors are divided into two sections, one part for the lighting and the other for power service. This power section of the panel-board is supplied by separate feeders from the power panel of the switch-board, from which are also run the mains for the elevator motors.

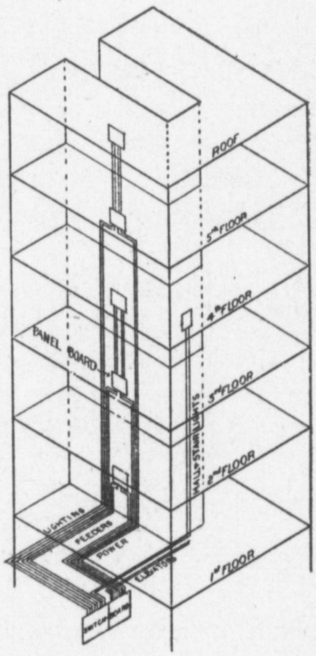

FIG. 3.—FEEDER SYSTEM.

Where ventilating motors are used in a building, they are usually placed immediately under the roof and wired from the power panel in the top floor. To start or reverse these from the basement, a magnetic switch is often placed in the branch circuit to the motor, and the four small controlling wires from this switch run to the basement in one conduit. By the use of these automatic switches, motors, lights, etc., may be controlled from distant points without the expense of diverting the heavy main wires. They can be used in controlling dummy waiters from different floors, and also as the ordinary three and four-point switches in lighting an electrolier from several different places. Where the building is to be wired for electric bell, tele-

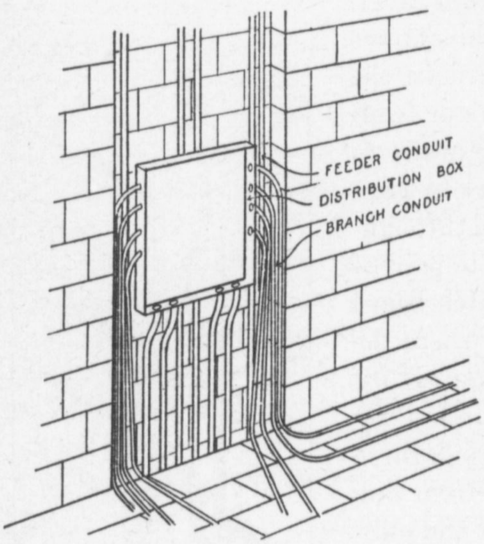

FIG. 4.—WIRE-WAY.

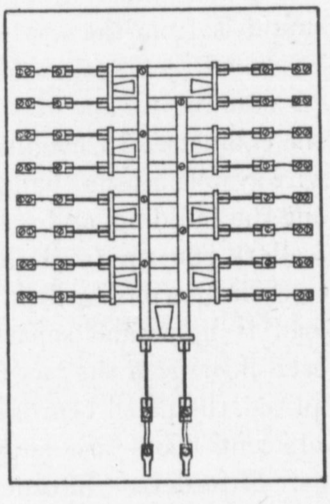

FIG 4a.—PANEL-BOARD.

phone or ticker service, weather-proof wire is generally used throughout for this purpose, and all the wires from each floor run in a single conduit to a distribution box in the basement.

INSTALLATION.

In Figs. 4 to 11 are shown details of different parts of conduit electric wiring as installed in a fireproof office building. The conduit is installed at that stage in the construction of the building after the brickwork in the flooring and walls is finished, but before any plastering is started. Since even the smallest size of conduit (3/8") is generally too large to be covered by the layer of plaster on the brick walls, it is necessary to cut shallow channels in the brickwork wherever the conduit is to run on these walls. This is a tedious job, and is usually done by a gang of men with hammers and cold chisels before the regular conduit work is started. Where there are a number of vertical feeders requiring large conduit to be run, arrangements are made with the architect to have a recess left in the brickwork of sufficient width, and one brick deep, from the basement, right up to the roof. A good place to run this channel for the feeders is up the elevator enclosure. This is generally in a central location, which is convenient for the panel-boards, and besides this there are no windows, partitions, walls, etc., to dodge around in running the feeders to the basement. Fig. 4 shows the manner in which the feeder conduits are run in the wire way and their connection to the distributing box, also the smaller branch conduits leading from the box to the different circuits.

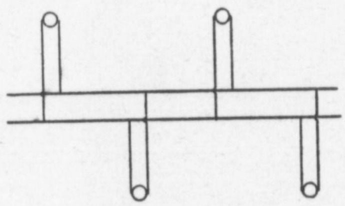

FIG. 5.—ORDINARY WIRING.

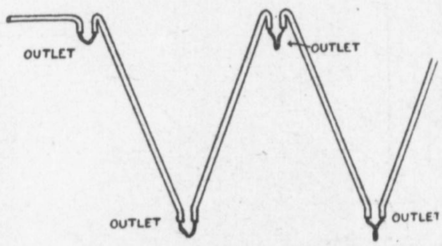

FIG. 6.—LOOP SYSTEM.

On account of the large size of wire used for the feeders, a separate conduit is generally run for each wire. If, however, an alternating current is to be used in the building, this arrangement of one conductor in an iron tube will cause a loss of energy by induced currents set up in the iron. It is thus necessary to use brass-armored conduit or to neutralize this effect by running both wires in the one tube.

In the branch circuits two wires or a twin wire are almost always run to a single conduit, and the wiring differs in some respects from ordinary methods. In ordinary work, where a number of lights are installed in a room, the mains are run down the length of the room and branches tapped off to each lamp, as shown in Fig. 5. In conduit work, however, no tees are placed on the conduit, and a zig-zag path is taken from one outlet to the next. In afterwards inserting the wires they are run to the furthest outlet, and, working back, a loop is left at each of the other outlets, to which the wire from the fixture are connected. Thus, in this "loop system" (Fig. 6), the branch wires are not cut at any place between the panel-board and the furthest outlet, so that if larger wires are afterwards required the different fixtures may be disconnected, the old wires pulled out from end to end, and the large wires inserted.

Some details of the conduit work on branch circuits are shown in Figs. 7 and 8. It will be noticed that the conduit is run on the brick flooring and not across the ceilings. This is because the plaster on the ceilings is not thick enough to cover the iron-armored conduit, and since the brick flooring is afterwards covered by two to four inches of cinders, over which asphalt or the floor boards are laid, the tubes

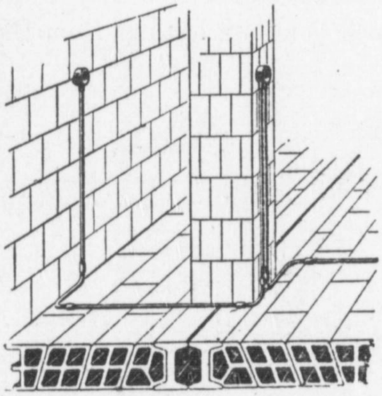

FIG. 7.—DETAILS OF BRANCH CIRCUITS.

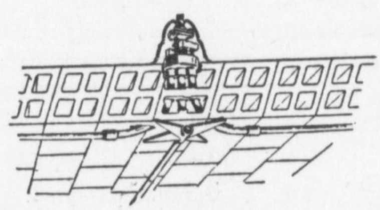

FIG. 8.—DETAILS OF BRANCH CIRCUITS

are completely concealed. In both these figures outlet boxes are used, into which the ends of the conduit are sealed. These outlet boxes are made of iron, with a lining of the same material as that used in the conduit. Two common forms are shown in Figs. 9 and 10, the first of which is an outlet box shaped to act as a receptacle for a flush switch. Fig. 10 gives a form at a bracket outlet, showing the nipple on the cover by which the bracket is supported. In many buildings, however, outlet boxes are not used, especially for bracket and ceiling lights, the conduit being trimmed off nearly flush with the plaster and the fixture connected up in the usual manner. When one or more branches are to be tapped off the mains for an electrolier, etc., a "junction box" is used. These are very similar to outlet boxes, and often contain a branch cut out, making them practically a distributing box on a small scale.

The wiring in the basement is usually run open, i.e., not concealed in the plaster, and is often run in flexible conduit or on porcelain knobs, though for fireproof work the iron-armored conduit is continued to the switch-board. A very useful support, made from gas pipe, for carrying the conduit in the basement is shown in the upper portion of Fig. 11. This figure also shows a form of switch-board suited to the feeder system in Fig. 3, each pair of feeders being controlled by a double pole switch.

It is not permitted when installing the conduit to run cords in the stretches as they are put up, to facilitate pulling the conductors though afterwards, as this might make poor construction possible; that

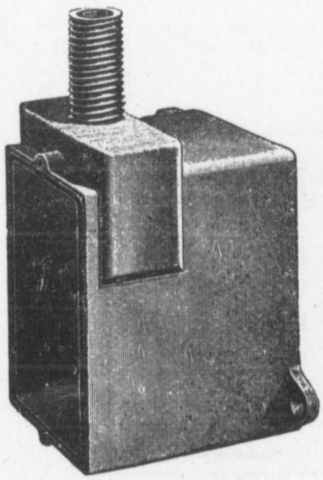

Fig. 9.—Outlet Box.

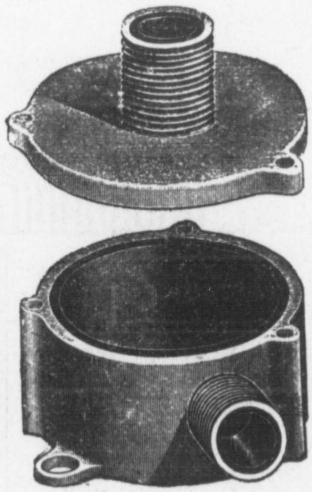

Fig. 10.—Outlet Box.

is, it would be an easy matter to pull even large wire through a conduit having rough, poorly made joints, which would abrade the insulation on the wire. When the wire is run through the conduit properly, it is practically a guarantee that the conduit has been well installed or the conductors could not be inserted. For this same reason it is important to have all necessary curves as gradual as possible or difficulty will be had in running the wires afterwards. In making a correct joint in iron-armored conduit, a wheel pipe cutter is used to cut merely through the outer iron-armor, a hack-saw being used to saw through the lining. A reamer is then used to trim up the end of the conduit before it is threaded. A jack-knife is often used instead of the reamer, but a poor job is generally the result. Care should also be taken that the white lead used in sealing the joint does not get between the ends of the conduit. This can be prevented by giving the coupling a turn or two on the conduit, and then applying the lead to the thread on the outside of the conduit.

The actual wiring of the building by running the conductors through the conduit is not done till all the plastering, flooring, etc., is over and the building is nearly finished—in fact, the wires are often run and the fixture work done at the same time.

There is not much difficulty in running the risers of feeders, as the conduit is large, and the wire, where larger than No. 6, is gener-

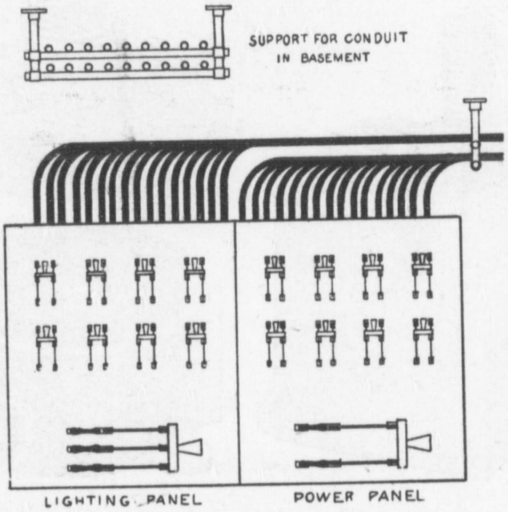

FIG. 11.—SWITCH-BOARD.

ally a stranded conductor. On the horizontal branch circuits, however, with many turns and using twin wire, the problem is not so simple. The inside surface of the conduit is first rendered smooth by blowing some powdered soapstone out of a horn through a section of the conduit. A steel tape about 3-16" wide and as thick as a clock spring is then passed through the conduit, after which the wires may be run. The tape is always run downwards, if possible from a higher to a lower outlet. An ordinary stretch for a run is from fifty to eighty feet with three or four turns, though it is sometimes possible to thread the steel tape nearly two hundred feet on a horizontal run.

In conclusion, it may be stated, that on account of the high standard of insulation now used on wire, any system of wiring is practically perfect where the insulation is protected from mechanical and chemical injury. The system to be employed in any special case depends on the circumstances. In some cases one system may be perfect, while in others it is expensive and unnecessary. In the best practice iron armored conduit is used in fireproof buildings or where the wiring is embedded in the plaster or brickwork. For the ordinary class of buildings with wooden joists, etc., where there is no liability of mechanical abuse, porcelain work is perhaps as good a system as can be used. In any case, where the wiring is properly done, the incandescent electric light—in contrast to the explosive and poisonous character of ordinary lighting gas—is probably the safest method of illumination yet devised by man.

ELECTROLYSIS.

F. WALTER THOROLD, '00.

It seems to me that the subject of Electrolysis, in so far as it relates to the decomposition of underground mains and cables, is one which should be of interest to the Civil as well as the Mechanical Engineering students of this school.

This subject is one which must occupy the minds of our Engineers to a considerable extent, for some time to come. The great damage done to gas mains, water mains and the cables of the various electric and telephone companies by the return current of the electric railway systems, is now assuming such large dimensions that something must be done to overcome it. If this trouble is left to take its own course, there will, no doubt, be numerous law-suits in which the railway companies will be the losers. They will have to pay for damages done to these pipes and cables, and will also have to so equip their outside plant, that this trouble will not occur again.

There may be a doubt in the minds of some people, as to whether the electric railway companies can be held responsible for the damage done by their heavy return currents. The argument amounts to this: Certain companies have capital invested in metal, which is placed underground. Another company comes along and destroys this metal. The question then is, is this last company responsible for the damage they have done and are still doing? They may not be doing this damage intentionally, but they are doing it knowingly.

It is a well-known fact that electricity will choose the path for itself which offers the least resistance, but that it is impossible to confine the current to one conductor, when there is another open for it, no matter what the resistance of the other may be. Still it is the duty of the electric railway companies to provide a conductor on their return circuit, over which the greater part of the current will flow, and that conductor must offer so little resistance, that all the current which does not return over it, will not be enough to cause any damage to the underground pipes and cables.

Electrolysis may result to a small extent from the leakage of overhead wires, but as this leakage takes place to such a very small extent it is not worth considering. Of course any large leakage of this kind, or a "ground" as it is called in practice, would soon be known at the power house and taken off at once.

The circuit of the ordinary trolley system is very simple. The current comes along the trolley wire from the dynamo in the power house, thence through the car to the rail, and along the rail and underground pipes, etc., back to the dynamo in the power house. If the current all returned along the rails, there would be no damage done by electrolysis, excepting perhaps at a few bad joints between the rail and its connections.

A few words might be said as to the connections between the rails now generally used. The rails are bolted together by means of ordinary fish-plates; but to make a better electrical connection, they are bonded together by heavy copper wire. This bonding is supposed to so connect the rails, that the current will flow on unmolested to the power house. The method of bonding now used is to take a piece of No. 0 or No. 00 bare copper wire, as short as possible, but generally about eighteen inches in length, to each end of which a rivet, called a channel pin, is soldered. There is a small hole drilled in the end of each rail, into which the channel pin is put, and the end is then flattened out, thus connecting the rails together. However, it has been found that this is not enough, as some of the current leaves the rail, on account of the resistance between the joints, and follows along the underground mains and cables to the power house. If the current, while travelling along these pipes, was not increased or diminished on the way, or in other words, if the potential between the pipes and the rails was always the same, there would be comparatively little harm done. The trouble is that the current takes jumps to and from the pipes as the resistance of the rail increases or diminishes, and at every point in the pipe where this takes place, and the points are many, electrolysis sets in.

The method of bonding before mentioned, does not make a true electrical connection. The connection between the pin and the wire may be all right, but it is the connection between the pin and the rail, which causes the trouble. By continual pounding of the cars on the rail, the joint is loosened, and the result is that an oxide of the metal is formed, thus increasing the resistance of the joint, and ultimately of the whole circuit, and thereby causing more of the current to return through the pipes, etc.

One system which is used, is to connect the rails every short distance with an overhead insulated copper wire, which carries the current back to the power house. Of course the system of bonding mentioned is also used, or otherwise it would be necessary to connect every rail with the overhead wire. It will readily be seen, that with so little resistance offered, very little of the current would seek any other path.

A sixty-pound rail is said to be electrically equivalent in carrying capacity to one square inch of copper, and therefore, in a double-track road, the rails offer a combined carrying capacity for the current equal to four square inches of copper. If the bonding between the rails is made perfect, and the overhead return wire is used, then, I think the trouble of electrolysis would be a minimum.

In several cities, the rails have been casted together at the joints, by placing a mould about the rail ends, and pouring molten iron in, which on solidifying formed a solid joint. A first-class electrical connection may thus be obtained, but it has been found to be almost impossible to have an easy running road with joints of this kind, and as this is an expensive connection, it is not very largely used.

The effect of electrolysis is first noticed near the power house, as it is near this point that the current, which has been collecting on the pipes, jumps up to the rail to return to the dynamo, thus causing the oxidation of the pipes at this point. This oxidation, it must be remembered, has been and is going on at many other points of the pipes, although not to such a great extent, but it is only a matter of time, when the same trouble will be located on these other sections of the pipe, throughout the city or town.

The seriousness of electrolysis to the citizens generally may be imagined, if we suppose a great fire to break out in one of our high buildings, all the pressure we can get is required to force the water up to the roof of the building. Now suppose that electrolysis had set in to such an extent as to cause a break in the water main, just before the alarm had sounded for this fire. What would become of our fine building? What would happen to the adjoining buildings? The firemen would be helpless, and we would simply have to stand by and see this and the adjoining buildings destroyed.

In the case of the gas mains we might be subjected to even a worse calamity. Suppose a gas main to give out for the same reason, and the gas force its way into the sewer. A man goes down the sewer to clean it out. He carries a torch or is smoking a pipe, and the mixture of gas and air takes fire. We might just as well be seated on the crater of an active volcano.

Outside of all damage done to other property, the electric railway companies are wasting money. To decompose a metal some force must act, and in this case the force is supplied by the railway company. They are, therefore, spending money to decompose these metals, as well as spending money to operate their cars. Why not put in good return wires and save this money? The saving just now would be a negative quantity, but in the end they would probably be the gainers.

In conclusion, I can only express the hope that, for the benefit of the present undergrads of the S. P. S., this trouble may last for a few years longer, so that some of them will have a chance to see what they can do with this new trouble of electrolysis.

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CONSTRUCTION OF THE HAMILTON CATARACT POWER COMPANY'S PLANT AT DECEW FALLS.

WM. HEMPHILL, '99.

I feel somewhat backward in coming before the Engineering Society of the School of Practical Science, to read a paper on engineering, where so many able papers have been read by graduates, and other engineers, but I think a work, that shows such a marked advance in the development of electricity, should be brought to the notice of our Society. From time to time, last summer, I had the opportunity of seeing this work advance in its various stages. Before coming to the electrical part of the work, it will be necessary for me to state some of the difficulties that had to be overcome, and refer to the part of the work that was done by civil engineers.

Mr. John Patterson (of Hamilton) was the one to whom the possibility of building an electric plant at the DeCew Falls, and sending the current by means of wires to Hamilton, a distance of 35 miles, suggested itself. He consulted the most eminent English and American electricians as to the advisability of undertaking the work. They thought it could be done, but would not guarantee the work successful for the limited amount of money offered. Mr. Patterson did not give up, but consulted Mr. Kammerer, the electrical engineer in charge of the branch office in Toronto, of the Royal Electric Co. of Montreal. Mr. Kammerer guaranteed to put in dynamos of the famous S. K. C. type, that would give satisfaction in every respect. Mr. Patterson next had the ground surveyed, intending to utilize the water of the Beaver Dams Creek and the DeCew Falls to supply the water power necessary to operate his plant. But after considering the matter, he found that, by following the Niagara escarpment about a mile from the Falls, he could get an additional drop of 70 feet. On finding this out, he resolved to build a private canal, from Allanburg to the edge of the mountain at the DeCew Falls.

In building this canal, there were not many heavy cuts to make, as the natural contour of the country made the task comparatively easy. The canal at Allanburg forms a junction with the Welland Canal above the head gates, thus allowing the water to be drawn from the two Welland Canals, from Allanburg to Port Dalhousie, without interfering with the supply of water for the new power canal. (The canal here is almost on a level with Lake Erie.) At this junction, suitable gates are placed to control the supply of water for the private canal. Following the canal from Allanburg, you come to Beaver Dams Creek; here it was necessary to build a large wooden flume to carry the water across. This flume rests on heavy steel trestles, and is built so that the flume is below the level of the water at both ends; by means of this, the sides of the flume are kept under constant pressure, to keep it from leaking. Following the canal still farther, you come to three large reservoirs, comprising about 33 acres in all. These reservoirs are built as near the edge of the mountain as possible. Around the banks of the reservoir, and also along the canal, wherever the sides had to be built up, or where there could be any danger of the bank giving way, the banks were rip-rapped to make them secure. Some places, where the ground was low, it was necessary to build the canal right on top of the ground. The canal is large enough to give 10,000 or 12,000 h.p. without creating an erosive current. The reservoirs will supply all the water needed for 48 hours without a further supply. At three different places, gates are placed, so that the water is completely under control. The canal was constructed by Angus Macdonald and Co., under the supervision of T. E. Hillman, C.E.

The large steel pipe, that leads the water from the reservoir at the edge of the mountain to the wheels, is 735 feet long, 8 feet 6 inches in diameter at the top, and 7 feet 6 inches at the bottom; it is ¼-inch thick at the top and gradually increases to a thickness of 13-16-inch at the bottom, both tranverse and longitudinal seams being double rivetted. This pipe is large enough to supply 6,000 h.p. At the top of the mountain, the stone was dug out to a depth of 8 or 10 feet, the pipe laid in this, and securely fastened by concrete in the mason-work, heavy flanges having first been rivetted to the pipe. The flanges were necessary as a great part of the weight of the pipe is supported at the top. At the upper end of the pipe, suitable grates are placed, to keep out ice and drift wood. As the current in the canal is very slow, there is not much danger arising from drift ice. At distances of 15 feet down the side of the mountain solid blocks of mason-work are built for the pipe to rest on. About two-thirds of the way down the side there is a ledge on the mountain about 60 feet wide, the pipe follows this, and then runs down at an angle of 20° to the power house, where it turns almost at right angles, and passes under the power house. Near the edge of the ledge in the mountain there is an expansion joint, to take up any elongation or contraction that may occur in the pipe. This joint is constructed so that it supports the remainder of the weight of the pipe. The joint, being larger than the pipe, rests in a hollowed-out portion of the mason-work, making it very secure.

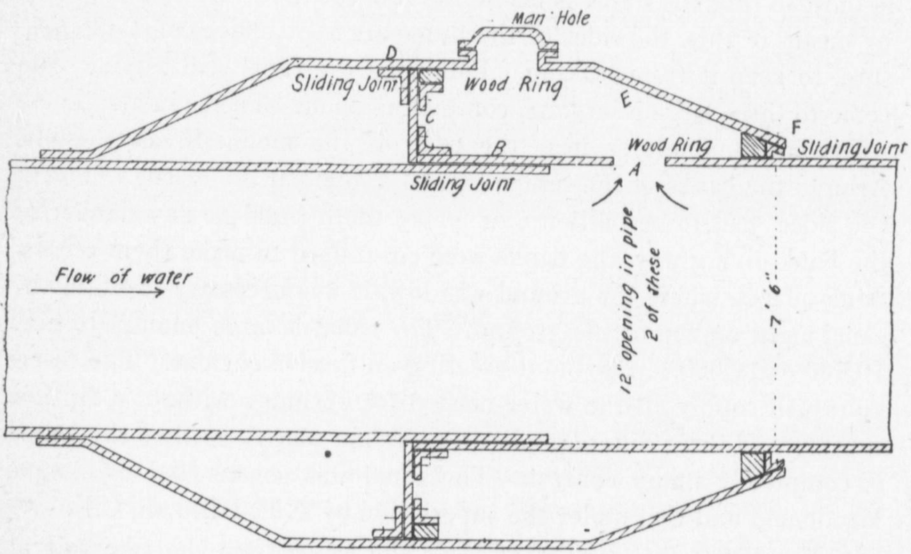


Fig. 1.

Fig. 1 shows a longitudinal cross-section of this expansion joint. At B is shown how two sections of the pipe slide, one inside the other, with a piston and cylinder action, forming a sliding joint. At C is shown an iron ring, fastened with angle iron as shewn, and this forms a sliding joint at D. At A is a 12-inch opening in the pipe, through which the water can flow. There are two of these holes. The water fills this portion of the joint, and the pressure of the water against C has a tendency to keep the lower part of the pipe in place. The water presses against E, causing a little spring in the joint. The combined action of the spring in the iron and the pressure of the water against C takes up any elongation or contraction that may occur. It was found necessary to pack the joints with wooden rings, as shown, some six or seven inches thick, and when the wood swelled, it stopped the leaking to a large extent, but this swelling of the wood will not allow the joint to move much. At F is an iron ring around the pipe; this ring is flanged and rivetted to part E, as shown, forming another sliding joint. The idea is good, but it is very difficult to make the joints tight on such a large pipe without making it too expensive. I was unable to get the dimensions of the joint, but this rough sketch will show the principle of it.

The power house is a very substantial structure of iron and brick, 174 by 42 feet. It is large enough to accommodate four large dynamos and the necessary step-up transformers. The building is lighted by incandescent lamps, and also heated by electricity. It is situated on the bank of the Twelve Mile Creek, 265 feet below the reservoir at the top of the mountain. Just after the pipe enters the building, it widens out into a large steel reservoir, 10 feet in diameter, which is embedded in concrete below the floor. From the receiver, four branch pipes come up through the floor, to lead the water to the turbines. In these branch pipes are placed large vertical hydraulic gates, which are 36" in diameter, and are operated by hydraulic pressure, by means of a four-way valve, controlled by a lever. The valves open and close very rapidly. In connection with each gate valve, is placed a 12-inch spring relief valve, to relieve any over-pressure that may occur. The turbines and all the hydraulic machinery were supplied by Stilwell Bierce, and Smith Vaile Co. of Dayton, Ohio. The turbines are 1,950 h.p. each and run at 400 R.P.M. under a head of 280 feet and a pressure of 110 lbs. per sq. inch. The water-wheels are of the inward flow, central discharge, reaction type, with cylinder gates, the water entering the wheel horizontally, and being discharged vertically downward, through a draft tube, 14 feet in height. I think this is the highest head employing this type of turbine, as most high-head plants use the impulse turbines. Each wheel is governed by an electric governor of the Giessler design, made by the same firm. On the outer end of the shaft is placed a 7½-ton fly wheel. The combined action of the enlarged receiver, the relief valves and the heavy fly wheels is expected to overcome any tendency to water hammer.

The large S. K. C. dynamos, so named from Stanley, Kelly and Chesney, the inventors, are placed in direct contact with the water-wheels. The two shafts are coupled together with strong couplers, and perfectly insulated with the special S. K. C. insulation.

Fig. 2 shows how the dynamos, turbines, Giessler governors, and the tank with the relief valves are situated; and at the far end is a view of the generator switch-board. The dynamos were made very large, each of 1,000 K.W. rated capacity. They are of the S.K.C. two phase, alternating type of machines, generating a two-phase current of 2,000 volts. The generators rest on base frames of Georgia pine, to insulate

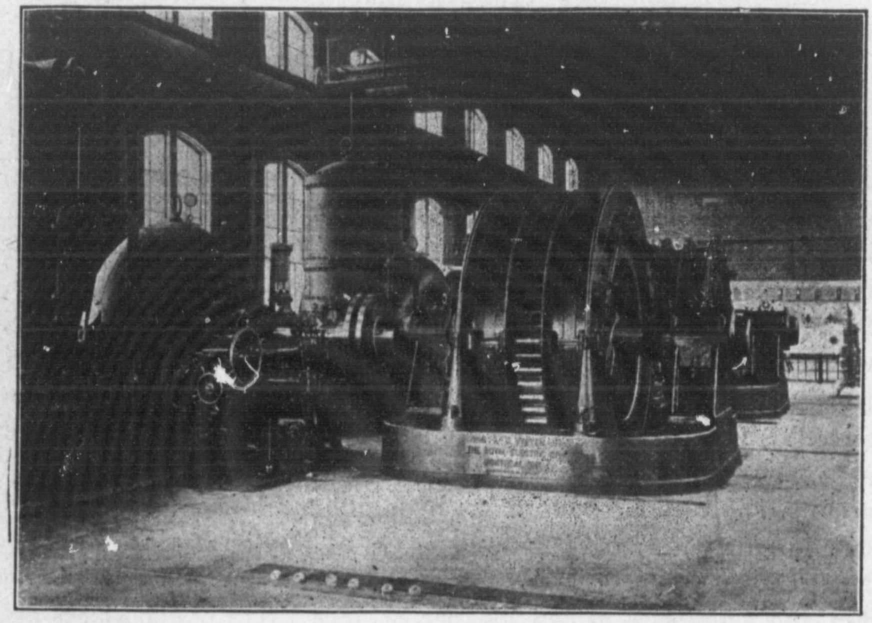


FIG. 2.

them from the foundations. Each inductor in the generators weighs about 12 tons, and this weight running at 400 R.P.M required very careful workmanship. All the electrical plant was made at the Royal Electric Co.'s shops at Montreal.

Fig. 3 shows an S.K.C dynamo with the armature drawn back to show the interior of the machine. This dynamo is not one used in this plant, but illustrates an S.K.C machine. You first see the inductor, which is the part that revolves in these machines; it is made of a steel casting, upon the periphery of which polar projections of iron laminæ are securely fastened. There is no wire wound on the inductor, so that there is no danger of a break in the insulation, which is often the case in other designs of dynamos, where the armature wound with wire is the part that revolves. Around the centre of the inductor you see a heavy copper spool wound with perfectly insulated wire; this is the field coil of the machine. The spool is fastened securely to the bottom of the frame, and the inductor revolves in this spool as it forms a complete circle around the inductor. The field

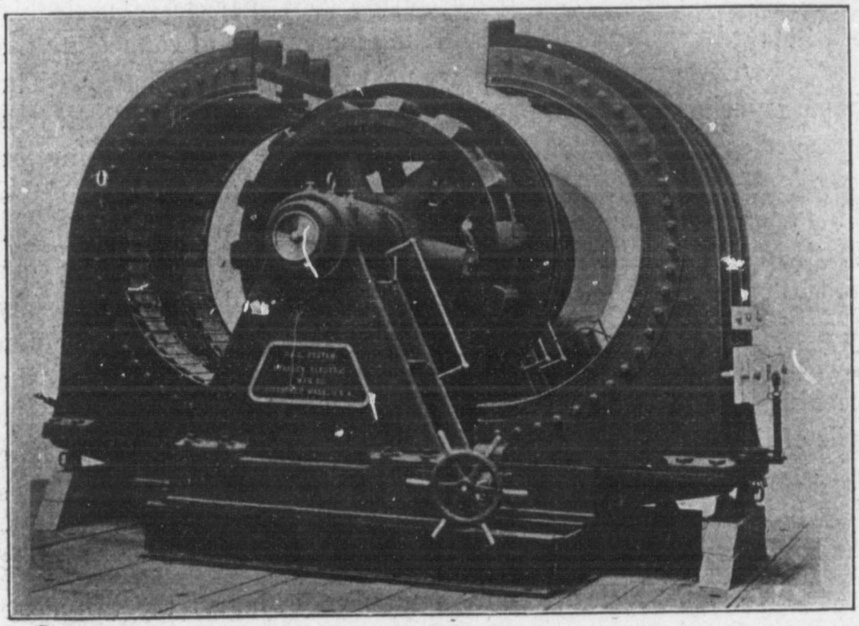


FIG. 3.

coil is magnetized by a separate dynamo. The inductor, revolving in this magnetized field becomes a magnet itself, and is really the field of the generator, in this way reversing the usual method of dynamos, as the field is the part that revolves, and the armature is stationary. You will see that the stationary armature is made up of iron laminae, and constitutes the body of the machine. The individual coils are very small, the wire is perfectly insulated, and wound on forms made especially for this purpose; they are then secured in grooves, made in the laminations for them. As they are so small and stationary, there is very little danger of a break in the insulation, and therefore they will safely stand pressure, which it would not be safe to put on another machine. Next you see the marble slab, called the terminal board, fastened to the outside of the frame. There are two of these slabs, the one, fastened to the frame, the other, forming a removable cover. This cover, on its inner surface, is divided into partitions, so that, when in place, each terminal is in a compartment by itself. It is so arranged that fuses may be inserted in the leads if desired. In the plant I am describing there are no fuses in the mains as it was thought better to run the risk to the machines from an overload than to remove the load suddenly from the water-wheels. By simply changing the connections on this board the armature coils may be connected in parallel, or in series, as desired. This arrangement of connecting the terminals is very neat, as there are no wires to be in the way. The frame is made very strong, and if the machine is run by a belt, it is arranged so as to be able to tighten or loosen the belt, by turning the small wheel at the side. In this case, the machine rests on slides. This open view shows how the armature can be unbolted and drawn apart, in case a coil needs fixing. Anyone can put one of these coils in, without any special tools. The machine I have described, is exactly like the generators used at the DeCew Falls, with the exception that they are much larger, and if you look at Fig. 2, you will see the armature is bolted at the two sides instead of at the top. To fix the coils of the armature in these machines, all that is necessary is to take out the bolts, and lift off the top, which can be done quite easily, as they have a movable hoisting machine, running on the tracks overhead in the power-house.

The wires, which are four in number, owing to the two-phase machine, run right down to the floor, and are laid in conduits to the switch-board, and are covered with iron griddles, so that the wires are accessible at any point. There are two exciters of 30 K.W. capacity, which are run by separate turbines. The exciters are calculated to be able to supply the full equipment of four generators. At present, there are only two generators put in. They have power enough for two more, which will be put in when needed.

Fig. 4 shows the high voltage switch-board, which is made up of three white marble panels, one for each generator, and one for the two exciters. On the generator panels, the connections are made on the back of the board, there being no wires on the front. The switches are of the S.K.C. slide, quick-break type, and are provided with automatic shutters to prevent arcing. They are double throw, connecting to two separate bus bars, so that the machines may be run on two separate lines, or in parallel. Each generator panel contains a volt meter, with a double throw switch connected to both phases; an ammeter on each phase, and a direct current ammeter in the field circuit of the generator. On the exciter panel, are situated the usual instruments for operating two shunt-wound direct current machines in parallel.

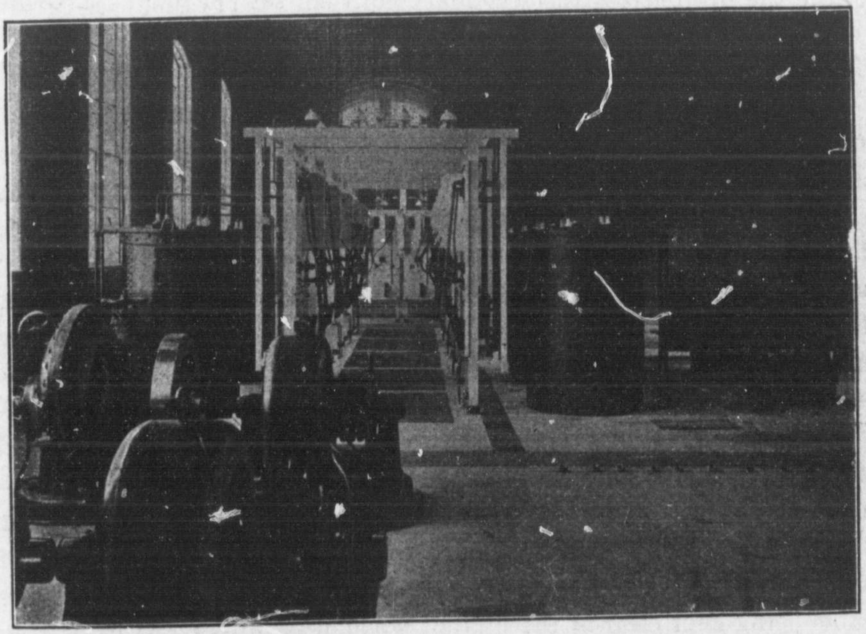


FIG. 4.

Right back of the switch-board, are placed ten of a new type of S.K.C transformers, used to raise the potential of the generators from 2,000 volts up to 23,000 volts, and at this pressure it is sent along the lines to Hamilton. The transformers are arranged in batteries of five each having a capacity of 200 K.W. They are encased in tanks, made of steel boiler plate. The coils are wound in sections, carefully insulated with large air spaces between them. After the coils are fastened in place, the tank is filled with mineral seal oil, and is artifically cooled, by means of water pipes running up inside of it. The water is taken from the large receiver, and the pressure reduced by means of throttle valves.

Supposing you have placed across the terminals of a dynamo, a coil of wire with ten turns in it, and that this coil is then attached to another, or secondary coil with 115 turns in it. As the current passes around the coils, it will set upon an E. M. F. at right angles to the direction in which the coils are wound. It will set up a certain E. M. F. in the first coil, and as the secondary coil has 11½ times as many turns, the E. M. F. in it will be 11½ times as great as in the first. So if the drop across the terminals of the dynamos is 2,000 volts, the drop across the terminals of the first coil will be very nearly the same, while the drop across the secondary coil will be 11½ times as great, or 23,000 volts. This is the method by which the pressure is raised from 2,000 volts to 23,000 volts.

The switch-boards, which accompany each transformer, are made of white marble, and contain two single-pole high voltage switches, and one double-pole 2,000 volt switch, the two high voltages being separated from a marble barrier. The high voltage switches consist of a flexible cable, having a screw plug attached to one end, and a socket at the other, which is attached to a hardwood pole, four feet long for safe handling. The socket and plug are tipped with non-arcing metal. Each transformer is also equipped on both the primary and secondary sides, with enclosed non-arcing fuses.

The high voltage wires in the building are perfectly insulated with heavy rubber, supported on porcelain line insulators on an overhead rack. These wires, four in number, are brought out of the building through the brick wall at the gable of the power house, by means of a lead encased, rubber-covered cable, protected by vitrified pipe, the cable being kept clear of the pipe by wooden bushings. After passing over a cross-arm, the lead-covered cable is joined to the bare copper transmission wires, by means of a long carefully made water-proof joint. The transmission lines, which are of No. 1 B. and S. bare wire, run from the power house across private property to a concession road, thence along this road due north to the G. T. R. tracks, then westward along the railway to Hamilton, to the step-down station. Along the top of the poles, is stretched a barbed wire as a lightning arrester, and at each pole a leader runs from this wire to the ground. At the step-down station the wires enter the building, the same as they were taken out of the power house, and pass to the transformers in a direction opposite to that in which they left the power house. The current is stepped down again to 2,000 volts, and distributed to the different parts of the city, by means of the distributing board.

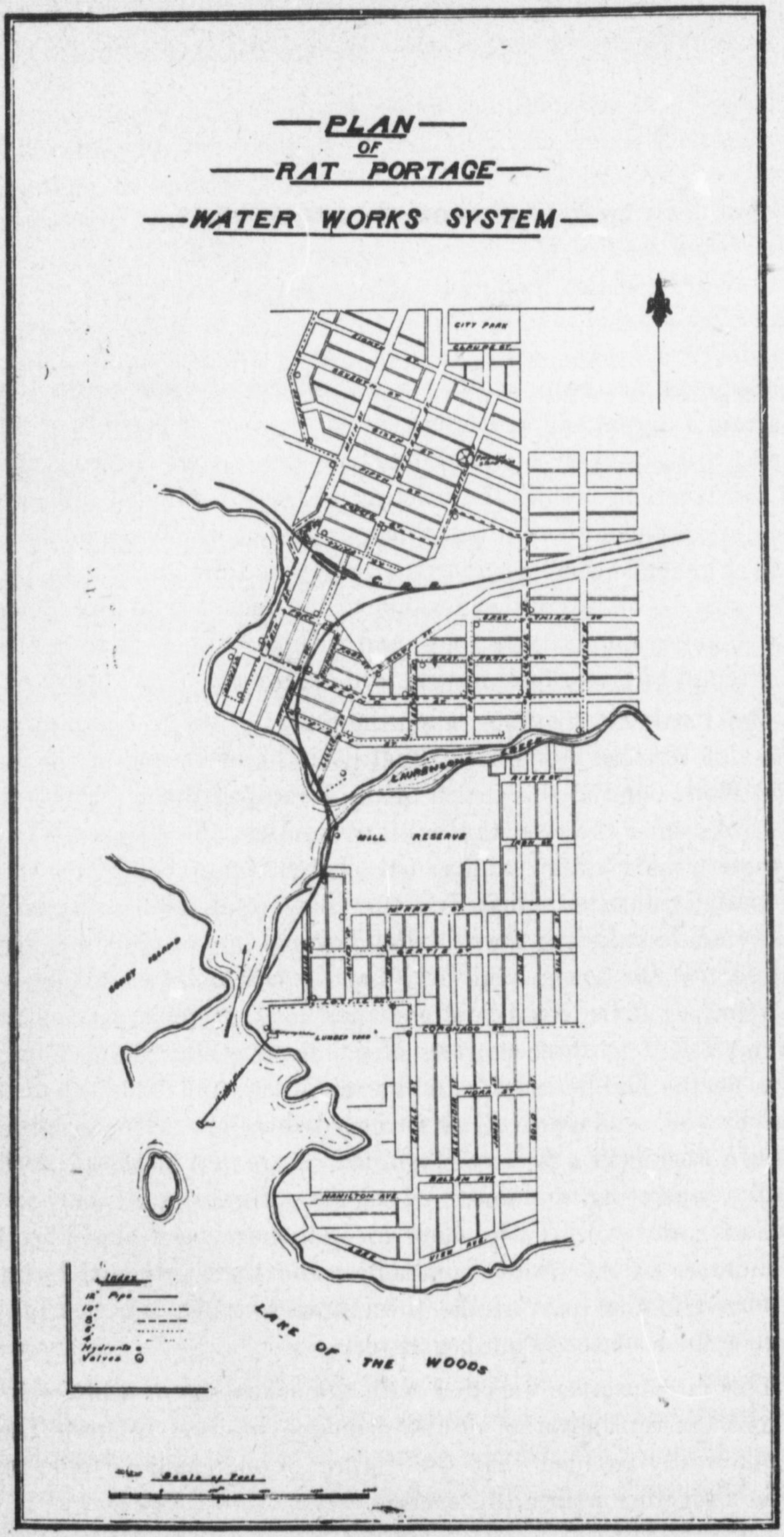
RAT PORTAGE WATER WORKS.

JOHN CHALMERS, O.L.S.

So much has been written on the subject of water works that I am afraid I cannot add anything that will be new or possibly of much value. Still, in every undertaking there are matters covering design and construction, besides the meeting and overcoming of difficulties, which are peculiar to each particular work, but which cannot be said to affect general principles of construction and design, that in themselves may be of interest and value to the members of this Society. It is, therefore, along these lines, and with that object in view that I will attempt to give a brief outline and description of the above work.

Rat Portage, sometimes called the centre of the free-milling gold district of Western Ontario, is situated at the north end of the Lake of the Woods, and at the mouth of the Winnipeg River. The waters of the lake enter the river through three outlets, the distance between the eastern and western points of discharge being about three miles. The westerly outlet is situated in the village of Keewatin, whilst the easterly one divides the town of Rat Portage into two distinct parts. That part of the town, lying between the east and west branches of the Winnipeg River, consists of a strip of land, or delta, varying from one and a half to three-quarters of a mile in width, divided in the centre by the middle branch of the said river, and bounded on the north by the confluence of its various tributaries. This section of the town was, until a few years ago, the centre of a large saw-milling industry, operating a number of plants. However, of late years, these, with the exception of one saw-mill, have been closed by the consolidation of the several companies, and their principal business transferred to that part of the town proper, which lies east of the eastern branch of the Winnipeg River.

This circumstance, together with the advantage of a better town site, and the centralization of the principal business interests there, has practically decided that the future development of the town will lie altogether within this section.


PLAN
OF
RAT PORTAGE
WATER WORKS SYSTEM
CITY PARK
MILL RESERVE
LAKE OF THE WOODS
Index
Hydrants
Valves
Scale of Feet

Like most western towns the history of Rat Portage may be all included within the past twenty years, the time of the construction of the Canadian Pacific Railway marking its inception. Previous to that time the Hudson's Bay Company had a trading post here, and owned most of the land on which the town is now built. It was not, however, until the construction of the railway began, that Rat Portage began to assume any pretensions towards becoming a town and business centre, the railway and construction companies making this a divisional point, and centre of supplies received from both east and west.

Since its inception, the town has had a steady growth, until now it has a population of about 6,000, and forms a distributing centre for the district surrounding the Lake of the Woods. Apart from the saw-milling industry, the other sources of revenue are principally derived from mining and the Canadian Pacific Railway, the latter making this a divisional point with a round-house and repair shops in the town.

The rocks of the immediate locality belong to the Keewatin series of the Huronian formation, and consist principally of chloritic and micaceous schists, and altered traps. These are thrown up in regular hummocks and ridges to an elevation of from fifty to a hundred and forty feet above the level of the lake, running in an easterly and westerly direction. Between these ridges are glacial deposits of sand, gravel and boulders, with very little productive soil; while numerous depressions are filled with peat, resting on a sub-stratum of blue clay.

In the majority of streets through the town, rock is encountered in considerable quantities, which, from its hardness and tough character, makes improvement very expensive.

The first step taken by the town towards modern improvements of any kind was in 1894, when an agitation was set on foot for a system of water works. During the summer of that year William Kennedy, C.E., of Montreal, prepared a report for the Council, embodying a system of water supply to serve the business portions of the town. Nothing further was done with this report, or in the way of other improvements until 1897, when a limited sewer system was established, which during the past year has been somewhat extended under the Local Improvement Act. In the summer of the same year, the question of securing an efficient and pure water supply for the town became imperative. The water supply had, up to this time, been supplied from wells, mostly fed from surface drainage and from water carts, which took their supply from points in the lake near the shore that in the summer time were polluted by drainage and offal thrown from steamers lying in the harbour. This, along with other unsanitary conditions, brought on an epidemic of typhoid fever, which called for immediate and decisive action on the part of the town to abate.

In November of that year, a by-law was voted on and carried, to raise seventy-five thousand dollars by debentures to put in a system of water works. This amount, whilst thought scarcely sufficient to establish an extended system throughout the town, would meet the present urgent demands , and be extended from time to time as the growth of the town required.

In January of last year a Board of Water Works Commissioners was appointed, and, in the following month, I received the appointment of engineer, for the purpose of designing and carrying out the work on hand.

At this time nothing had been settled as to the source of supply. Two bodies of water were available, one, the Lake of the Woods, and the other Rabbit Lake, the latter, a small body of water about a mile and a half in length, and a third of a mile in width, situate about two miles north of the town. The water in this lake was found to be of good quality, and very well suited for domestic uses. Upon examination for sufficiency of supply, no discharge was found other than a highwater flow, or source of supply to the lake, other than surface water from the adjacent water-shed. The examination of this lake was principally with the object of obtaining a gravity supply, but the elevation proved to be only eighty-seven feet above the Lake of the Woods, and hence not sufficient for the desired requirements. This deficiency in elevation making a pumping plant necessary, and the additional first cost of bringing the water so long a distance, a great portion of which work would be through rock and swamp; and the superiority of the water, over that of the Lake of the Woods, not being sufficient to warrant the additional expenditure, set aside the advisability of considering this lake as a source of supply. The Lake of the Woods being the other alternative, the selection of the best available location was a matter of considerable importance, as a point had to be selected which would be safe against any chances of future pollution, and at the same time keep the first cost within a reasonable sum. After considering several possible locations, the one finally selected is the one shown on the plan of the system. This point is one thousand feet away from the shore, and situated at the confluence of two currents, which come in from the outer body of the lake, one through the Devil's Gap, or eastern channel, and the other through the western or Keewatin channel. The possibility of the water at this point ever becoming contaminated is very remote, as between here and where the sewage of the town empties into the lake, the water passes through a narrow channel between the mainland and Coney Island, through which there is a strong current leading toward the Winnipeg River, thus preventing any sewage from ever being carried south of this channel. Outside of this point there is not likely to be any building further than a few isolated summer cottages, scattered on the various islands, the presence of which will not affect the purity of the water.

The water of the lake is very soft and almost entirely free from lime; in color it has a faint brown tinge, and at times a slight odor of peat, which is more marked during the warm weather of summer.

The principal objection taken to the water of the Lake of the Woods is the presence, during the summer months, of vegetable growths, or algae, resembling a mossy fibre, which is disseminated through the water in considerable quantities, mostly, however, floating on the surface.

No investigation has, up to the present, been made here of this plant, or its origin, but from observation either of two theories may apply to its growth and distribution through the water during the warm months of the year. The first is, that it belongs to a submarine plant, propagated in the bottom of marshy bays, which abound around the shores of the lake, and are very extensive at the mouth of the Rainy River. This growth, similar in appearance to certain mosses found in the waters from flowing springs of low temperature, continues to grow rapidly while the water of the lake is cool. When, however, the temperature is increased, due to the heat of summer, the growth of this moss is arrested, and the fibrous particles become loosened, and rise to the surface. Here it remains inert, and as the season advances is carried by the wind and currents to the lower end of the lake, where it is washed up on the shore, and part of it carried down the Winnipeg River. Towards the end of the season it looses its fibrous nature and becomes granular, collecting in small masses, which attach themselves to the rocks and shore line. Before the ice forms in the fall it has entirely disappeared, and but little trace of it can be found in the water until the following summer.

The other theory of propagation, which is probably the more correct of the two, and is practically opposite to that just advanced, is, that the vegetable growth remains practically dormant during the period of low temperature, and when the water becomes warm, the growth of this plant is very rapid, that portion coming to the surface being presumably the old growth of the previous year. Neither of these theories may be correct, but are advanced merely as the probable reason for the presence of this substance in the water. The general opinion of old residents, who have used this water for years, is, that this vegetable matter is not injurious in any way to health, while in the condition in which it is found in the waters of the lake. How it will act in the water mains, after their long continued use, must remain a subject for future investigation. However, from several small private water services drawn from the bottom of the lake at a moderate depth, no trouble has been experienced from this source, and as the point of supply for the town is twenty-three feet below the surface, I do not think any great trouble will result from the presence of this vegetable growth in the water.

The distribution system, as shown on the plan, comprises about twenty-seven thousand feet of pipe, and thirty-six hydrants. The pressure is maintained by direct pumping into the mains, though at some future time with the erection of a stand-pipe, constant pumping may be avoided, and a pressure maintained sufficient for domestic use.

As will be seen from the plan, the distribution system commences with a twelve-inch main at the pumping station, and extends up to the centre of the town at the corner of Second and Matheson Streets. From there, as a main distributing point, smaller mains lead to different parts of the town. A ten-inch main extends along Second Street to Main, and north, along Main to Fourth Street. From there an eight-inch main passes easterly along Fourth, Mining and

Fifth Streets; south along Julius Street, and west along Second Street to connect with the twelve-inch main on Matheson Street, thus forming a belt line along the principal portion of the town, and from which all future extensions may be carried. The location for a proposed future stand-pipe is at the corner of Mining and Sixth Streets, which is the highest point in the system, giving an elevation of a hundred and twenty-five feet above the Lake of the Woods. The stand-pipe will be connected to the eight-inch belt line by three hundred and fifty feet of ten-inch pipe, which will give a uniform distribution, and keep all parts of the system well supplied. The object of extending the ten-inch main so far along Main Street is that a portion of the town lying about two thousand feet to the north is being rapidly built up, and in a short time it will be necessary to carry a branch main into that section. Hence, by continuing the ten-inch main up to Fourth Street, this can be done without affecting the pressure or supply passing into the eight-inch main at that point. Also, in the event of a large demand made in case of fire, it will give a greater effective pressure at the hydrants, and reduce the loss of head through friction to a minimum.

Six-inch pipes are the smallest to which hydrants are connected, the best practice of late years demanding that nothing less be used to secure an effective hydrant pressure. Four-inch mains are used to connect dead ends, and otherwise complete circuits. Wherever possible, all parts of the system form a complete circuit, which enables the hydrants to receive a supply drawn from both directions. Where several hydrants are on a line of pipe, this is particularly desirable; otherwise, should all be in use at one time, and the main supplied from only one end, the hydrant furthest from the source of supply would be seriously affected, both as to pressure and quantity of water. Several dead ends it was found impossible to connect, on account of the heavy rock work which would have to be done. The valves are so located that but a small part of the system will be shut off to make any necessary repairs, thus maintaining the efficiency of the fire protection and domestic supply.

The mains are laid at an average depth of seven feet below the surface of the ground. This depth is much greater than it is customary to put water mains in the more southerly parts of the Province, but from the experience and advice obtained from Duluth, Winnipeg, Brandon and other towns of practically the same latitude as Rat Portage, a less depth was not thought justifiable, more especially as the frost follows the rock to a considerable depth. The snowfall here, in the early part of winter, is usually light, and with the thermometer standing at forty-seven degrees below zero for several days, which was the case during the present winter, the frost will penetrate the ground to a considerable depth.

The pumping plant, which was supplied by John McDougall, of Montreal, consists of two independent duplex, triple expansion, surface-condensing pumping engines, built by Henry R. Worthington, of New York. The steam to run the plant is furnished by two horizontal tubular boilers, sixteen feet long by sixty-six inches in diameter, each containing a hundred and two three-inch tubes. The machinery is enclosed in a brick building sixty-nine feet seven inches in length, by thirty-one feet seven inches in width. The walls are hollow, with two-inch air space in the centre, and have a total thickness of fourteen inches. The roof trusses are steel, covered by corrugated iron sheeting, fastened by clips directly to the steel frame work. The cornice is also constructed of heavy galvanized iron, thus rendering the building practically fire-proof. As the pumping station is built on the edge of a large lumber yard, this precaution was rendered necessary. The floor of the boiler room is cement, and the interior walls of the building are finished in brick, the whole being commodious and well lighted. The base course, window and door trimmings are made of dark grey granite, which gives the building a pleasing effect.

The capacity of each pump is one and a quarter million Imperial gallons per twenty-four hours, working against a pressure in the air chamber of eighty-five pounds per square inch, and carrying a steam pressure of a hundred and twenty pounds at the pumps. The diameter of the steam cylinders are six, nine and sixteen inches respectively; pump plunger, ten inches, with a fifteen-inch stroke for all parts. The pumps are of the outside packed plunger type, and capable of being worked up to a pressure of a hundred and seventy-five pounds. The domestic service pressure carried is sixty pounds per square inch. Steam may be supplied to either pumps from either of the two boilers, or both pumps may operate together. Each pump is provided with a separate air pump and surface condenser, the water supply from the well passing through the condenser before reaching the pumps. The effect of this is to slightly raise the temperature of the water discharged from the pumps, but from observations taken the increase in temperature does not exceed four degrees above that of the water in the well. A vacuum of twenty-seven inches can be kept, with the air pump working at a moderate rate of speed, which amount is above that called for in the specifications. Above the throttle valve of each pump is an automatic governor, by which the water pressure controls the supply of steam, thus regulating the piston speed according to the amount of water drawn from the mains. The governor is very sensitive and responds quickly to the variations of draft on the system. A by-pass is also arranged, so that in case of fire the pressure can be raised quickly by shutting off the governor and using the steam direct. For fire pressure the pumps are run non-condensing, though by admitting a little live steam into the low pressure cylinder and keeping the vacuum above fifteen inches they can be worked up to give a pressure of a hundred pounds per square inch. For the comparatively short time fire pressure is kept up the factor of economy does not enter largely into consideration, and it was found better to change from condensing to non-condensing immediately upon receiving the fire alarm. The engine room is fitted up with steam, water and vacuum gauges, so situated that the engineer in charge can see, from his position at the throttle, the constant working of the entire plant. A recording clock is kept in the office, on which the water pressures are recorded throughout each twenty-four hours. These records are dated and filed, and show the pressure and times at which the pumps have been working on fire service, as well as a continuous record of domestic service.

The boilers are set in brick, and separated by an eighteen-inch wall. The exterior walls are two feet in thickness, carried up perpendicular to within six inches of the top of the boilers, with an air space of four inches in the centre, extending from the foundation to within one foot of the top. The smoke and gasses are led into the chimney by a forty-inch circular iron flue, extending transversely across the top of the boiler, immediately behind the fronts.

The chimney is brick, surmounted with an iron cap, and of the following dimensions: Height, eighty-three feet; side of flue (square), forty inches; base at foundation, eight feet one inch; batter of sides, one-quarter inch to the foot. This was designed to give an effective draught for both boilers working together. Provision is also made for the addition of another boiler, should extra power in future be required.

After the brick work was completed a very low fire was kept up for a week to thoroughly dry up the brick work, and prevent the cracking of the walls.

After one of the boilers had been in use for a month, it was found necessary to allow it to cool in order to set up some rivets which were leaking slightly. One hundred and ten pounds of steam was being carried when the fire was drawn, and twenty-four hours elapsed before the pressure fell to zero, the temperature outside the building at the time ranging from zero to ten degrees below. This shows a comparatively small loss from radiation, and when the domes are covered with a proper non-conductor, this loss will be still further reduced. In service the pumps and boilers run interchangeably, each pump running for one week, while the boilers are usually fired for a month without change. The relief boiler is constantly kept under steam at a pressure of from thirty to forty pounds. This is done by an inch pipe from each boiler fitted with globe and check valves, passing into and extending down to near the bottom of the other. Thus, by passing a small jet of steam into the relief boiler, the above pressure can be easily maintained, and having the furnace full of dry wood, ready to light, one hundred and twenty pounds of steam can be raised within twenty minutes from the time that the fire alarm is received at the station, it requiring the service of both boilers to run one pump at its full fire capacity.

The following is the guarantee called for, and received from the builders:

Duty in foot pounds per hundred pounds of soft coal consumed, not less than 75,000,000 ft. lbs.

Pounds of water evaporated per hundred pounds of soft coal from temperature of air pulp injection, not more than 900 lbs.

Coal consumed per square foot of grate surface when working at rate capacity with natural draught, not over 20 lbs.

Amount of feed water evaporated per indicated horse power, not over 27 lbs.

Coal consumed per indicated horse power, not over 3 lbs.

Water required to condense steam per Imperial gallon evaporated (Note "A") none.

Vacuum, not less than 26 in.

Temperature of feed water entering boilers, not less than 180 degrees.

Note "A," tenders were called for both jet and surface condensers. For jet condensers the lowest amount given was 24 gallons.

The feed water to the boilers passes through two heaters, one heated by the discharge from the low-pressure cylinders and the auxiliary heater receiving the exhaust from the air and boiler feed pumps. The low-pressure cylinders are steam-jacketed, and the whole covered with a non-conductor of magnesia, under a lagging of mahogany. The steam supplied to the pumps passes through a separator, which removes any moisture it may contain. This, together with the condensed steam from the jackets, is discharged into the sewer, the advantage secured by returning this to the boilers being practically off-set by the cost of operating a jacket pump. All steam and feed water pipes are covered with mica, which reduces the radiation to a small amount. As the official test has been deferred until spring, I cannot give any records as to the efficiency of the plant, but from observation during the time the pumps have been working there is little doubt but that they will meet all requirements.

The work of excavating the trenches commenced about May 25th, and proceeded very slowly, on account of the quantity of rock encountered. Considerable hindrance was met with in this work from the excessive and almost continuous rain-fall during the season. This caused considerable trouble on account of the sides of the trenches caving in, and the time required in pumping out the water. As rock was encountered in the bottom of most of the trenches it was impossible to use shoring to protect the sides of the trench. Usually these would stand open from one to two weeks, or until the rock could be excavated and the trench ready for pipe laying. In most cases the shock from blasting would loosen the soil, and the first heavy rain practically fill the trenches with mud and debris.

The character of the rock also made trenching very slow and difficult. The method of procedure was to strip the rock from four to five feet wide along the centre of the trench, then complete the drilling and blasting in rotation. Three steam drills were employed on the work, each averaging about thirty feet of drilling per day of ten hours. This is rather a low average for machine work, but, from the nature of the rock, which appeared harder at the surface, the presence of numerous cracks and fissures, which often caused delay owing to the sticking of the drills, very seldom over thirty feet of drilling would be done, and, at times, as low as twenty feet was all one machine would do.

About the middle of August the contractors threw up their contract, and in September the work was taken over by the Board of Commissioners, and carried on vigorously under my superintendence until the winter set in. Upon assuming charge of the work, I increased the plant and number of workmen, and pushed the rock-work as rapidly as possible. The contractor had allowed the rock excavation to get behind, though drilling was completed on about eight hundred feet of trench. The holes on this work were drilled about two and a half feet apart, on a line along the centre of each trench. This I soon found to be a mistake, as the rock would not break out under such a heavy burden, and much additional drilling was required as the excavation proceeded. The most economic work was done by placing the holes not over twenty inches apart, staggered from eight to ten inches, and put down, at an inclination of about eighty degres, to six inches below grade. By doing this the rock broke out clean, and very little "plugging" had to be done on the bottom. This increased the cost of drilling somewhat, but it effected an ultimate saving in explosives and labour, besides reducing the risk of damage to property, as lighter charges could be used to break the rock.

The method of firing was to load from ten to twelve feet of trench, and lead the wires from each charge out to the surface. Several bundles of brush were then placed on top, over which was rolled from five to six logs, securely chained together. A battery of short logs were also placed vertically across the trench, near the face of the rock, and supported by a transverse piece set into the bank at each end, thus preventing the rock from scattering. All firing was done with a battery, and each charge set off separately, which insured the rock breaking to grade. The principal trouble experienced in separate firing was the occasional cutting of the connecting

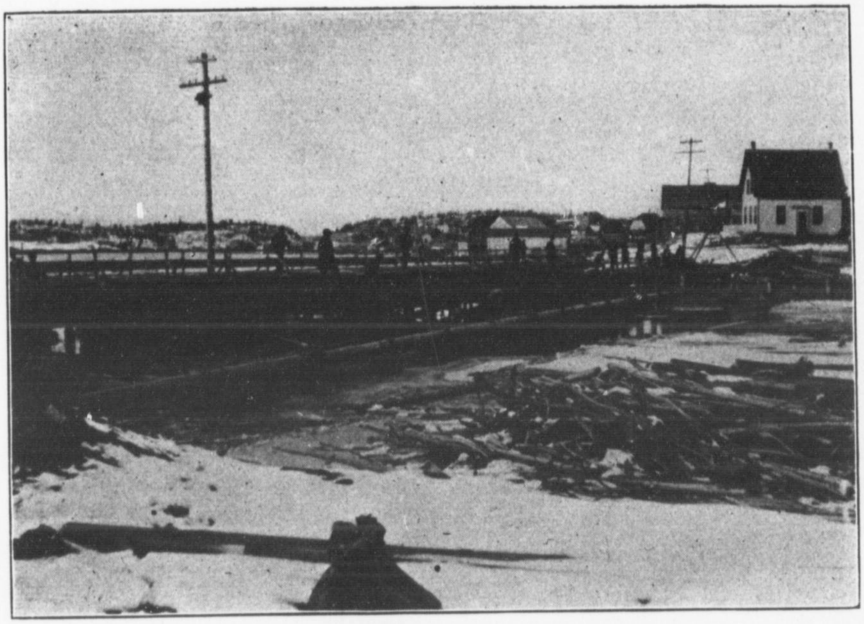


FIG. 5.—PIPE CROSSING LAURENSON'S CREEK.

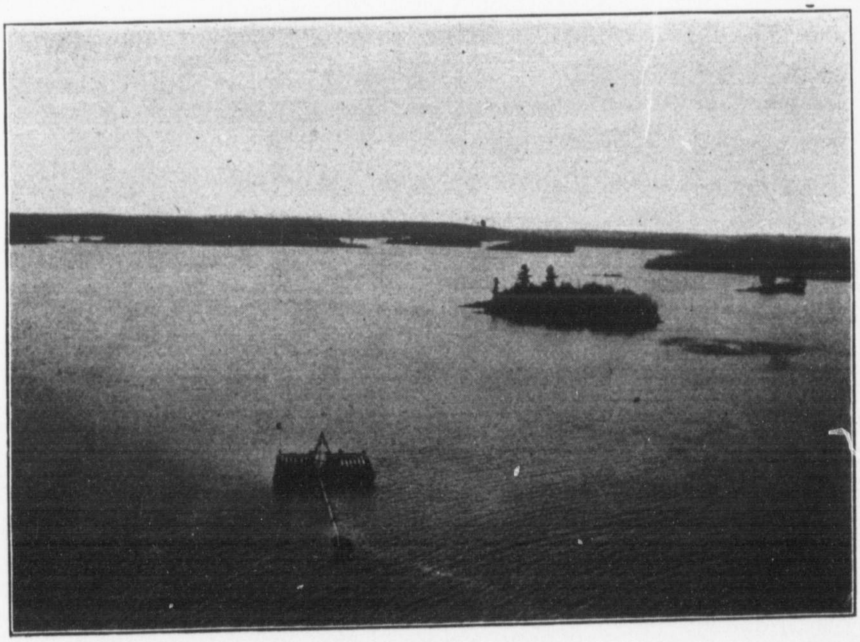


FIG. 6.—INTAKE PIPE.

wires, which necessitated the removing of part of the covering in order to repair the connections, also the blowing out of the powder through the seams of the rock. The method pursued by the contractor was to fire from six to eight holes at once. This, with the heavy drilling, proved unsuccessful, as the back holes had to be charged very heavily, and even then did not break out well. Besides, from the excessive charging necessary, considerable damage was done to the adjoining property.

Hand-drilling was paid at the rate of forty cents per foot, and two good hammer-men could drill from ten to twelve feet per day. Up to the depth of four feet I found hand-drilling to be the cheapest, beyond that machine work became less expensive, the cost per foot decreasing as the depth of the rock cut increased. This was due to the time required to move and reset a machine.

As most of the rock in the Keewatin series is tilted up at all angles and directions, much was gained by having the drilling done, where possible, so that the inclination of the hole would be in the same direction as the dip of the rock. By doing this the rock would lift towards the surface, and the explosion be more effective. Sixty per cent. dynamite was used throughout the work, and with the exception of a few small windows broken by concussion, no damage to any extent was done while the work was under my supervision, though blasting was carried on along the principal streets of the town.

In rock cuts the pipes were raised six inches clear of the bottom, and the trench filled with sawdust to the top of the rock, first being well tamped around the pipes, this preventing the frost from following down the rock and affecting the mains.

Some difficulty was experienced in connecting the pipes at both sides of Laurenson's Creek. The land on both sides had been made up of strips and sawdust, which in most cases laid on an irregular rock bottom. This made a coffer dam difficult to construct, the presence of sawdust also affecting the working of the pumps. After the bottom of the creek was prepared, and the pipe lowered into place, the connections at each side were made in a box-dam, large enough to work in. The boxes were made on the shore, and lowered into place, the pipe placed in position, after which a puddle of clay was placed around the outside, held in place by sheet piling of two-inch plank. Cast iron flange pipe was used in crossing the creek, with a flexible joint every forty-eight feet. Between each flange was a corrugated copper gasket, which, when the pipes were bolted firmly together, made a perfectly tight joint.

Latterly, when some repairs were being made at the south side of the Creek, I made use of a hydraulic syphon instead of a pump, to take the water out of the coffer dam, and found it more effective than a pump for the work in hand, as the presence of sawdust did not affect it. The syphon was operated from a hydrant, with the required length of hose attached to reach the coffer dam. In the end of the hose, was screwed a hydrant cap, in the centre of which was inserted an inch-pipe about two feet in length. This was screwed into a four-inch T, reduced to the proper size, and allowed to project a short distance past the single branch of the T, to which branch was attached a four-inch suction pipe. On the end opposite the entrance of the inch-pipe, was attached a four-inch discharge, and with a pressure of seventy pounds per square inch at the hydrant, and a suction lift of eight feet, an inch-jet produced a discharge equal to the work done by a Cameron Pump working under the same conditions, having the same sized suction pipe, which pump had previously been used on the work.

The principle advantages claimed for the syphon were that the sawdust, and other loose material, did not affect it, besides no attention was required to keep it in operation. During the time the syphon was in use, the temperature ranged from twenty to thirty degrees below zero, and to keep up an effective steam pressure in an exposed bolier, sufficient to operate either a steam pump or steam syphon, would not have been an easy matter, under the existing conditions.

In assembling the pipe to cross the creek, a low pile railway bridge was made use of. To each pile was fastened at the surface of the water a 3 x 12-inch plank, projecting out horizontally about four feet from the bridge. To the ends of these were fastened plank driven on an incline into the bed of the creek, which had been previously prepared to receive the pipe. The pipe was assembled on this platform, and lowered evenly on the skids into place, the ends of the pipe being first closed to keep the water out, and thus lessen the weight, the average depth of water being at this point about eight feet.

In laying the in-take pipe, which extended out one thousand feet from the shore into twenty-eight feet of water, two flat ore barges were used, fastened four feet apart, over which were erected two derricks. As the pipe was connected together, the barges were pulled out by means of a capstan and anchors. As the depth of water increased, two additional barges were used to support the pipe. A flexible joint was put in every one hundred feet, and two hundred feet of pipe usually suspended from the barges to the point at which it lay on the bottom of the lake.

The in-take pipe was sixteen inches in diameter, made of quarter-inch steel, and in lengths of twenty feet, each length being made from one sheet of metal with a lap welded longitudinal joint. Heavy cast-iron flanges were rivetted on the ends, and when connecting the pipe, a gasket of tar paper, heavily coated with coal tar, was used for each joint. The outer end of the in-take pipe is finished with a bell mouth three feet in diameter, covered with a screen made of one-quarter-inch galvanized steel wire, having a half-inch mesh. This is supported on a crib work of timber twelve feet square, extending six feet up from the bottom, and giving a depth of water over the centre of the pipe of twenty-two feet.

The in-take pipes discharge into a well thirteen feet in diameter and fourteen feet deep, built of concrete, from which the water is taken by the pumps. Inside the well is a valve, by which the water can be closed off from the lake, allowing the well to be cleaned out, without much delay.

In filling the system, the mains were filled slowly under a heavy low pressure, and care taken to get all air pockets out of the pipes, after which the pressure was raised to the 140 pounds per square inch, and held at that for several hours. No leaks developed during this short test; however, on account of the extremely cold weather, and the ground being frozen hard at this time, a more extended test was deferred until spring when repairs, if any, can be more readily and effectively made.

J. Chalmers, O.L.S.

Rat Portage, Jan. 28th, 1899.

SILICA PORTLAND CEMENT.

M. J. BUTLER, C.E.

Silica Portland Cement, as manufactured in Canada, is a mixture in equal parts by weight of a high grade Portland Cement and clean dry Silica Sand; ground together to an extreme degree of fineness in mills, specially designed for the purpose.

	The Portland Cement used has the chemical composition and properties shown below.		The resulting Silica Portland Cement has the chemical composition and properties shown below.	
	STAR PORTLAND CEMENT.		SILICA PORTLAND CEMENT.	
Chemical Analysis.	Lime	62.0	Lime	31.0
	Silica	22.0	Silica	61.0
	Alumina and Iron	12.0	Alumina and Iron	6.0
	Magnesia, Sulphuric Acid, etc	4.0	Magnesia, Sulphuric Acid, etc	2.0
Fineness.	Residue on No. 100 Sieve 10,000 holes to the square inch	8%	Residue on No. 100 Sieve 10,000 holes to the square inch	Nil.
	Residue on No. 200 Sieve 40,000 holes to the square inch	35%	Residue on No. 200 Sieve 40,000 holes to the square inch	7%
Tensile Strength—pounds per square inch.	Neat Cement Mortar,		pounds per square inch.	
	1 day in air, 6 in water	500	1 day in air, 6 in water	350
	1 day in air, 27 in water	600	1 day in air, 27 in water	450
	Three parts Standard Sand		to one part Cement.	
	1 day in air, 27 days in water	200	1 day in air, 27 days in water	350
Soundness—Absence of free lime unhydrated.	Very great care is taken to ensure a Portland Cement that is absolutely sound, *i.e.*, free from unhydrated Calcium Oxide.		As Silica itself is wholly inert the resulting mixture of sound Portland pure Silica must likewise yield a sound cement, the small percentage of lime is a further assurance against the possibility of a blowy cement.	

Portland Cement and clean dry sand are weighed into the Tube Mill in equal quantities by a continuous, uniform feed adjusting device. And in order to make clear the process of grinding it will be necessary to give a brief description of the Tube Mill.

It consists of a horizontal steel cylinder, 18 feet in length by four feet in diameter, lined with specially hard cast-iron plates which slowly wear away. The Mill revolves at the rate of 27 revolutions per minute, and is filled half full with flint pebbles. The sand assists the pebbles in the grinding action being itself, at the same time, reduced to a very fine state. The cement is reduced to an impalpable powder and is thoroughly intermixed with the ground sand, in fact each minute particle of silica is enveloped with a flour of cement. Silica Portland has all the good qualities usually found in the best Portland Cement, and the question naturally arises, Why is it? How is it possible to add 50% of inert material to a barrel of cement, and by the mere act of grinding them together to secure practically the same cementitious value as before the addition? An effort will be made to explain the seeming anomaly, as compared with the fineness of the molecule, the finest ground particle is coarse, yet the more nearly we approach the ultimate molecule, the more nearly we render it possible for the elements present in the cement to unite together and crystallize into the silicates which form cement.

A barrel of Portland Cement when ground to the finest degree commercially practicable, has quite 50% of the material too coarse to admit of crystallization, the unground particles are for all practical purposes inert matter, sand if you please, the active material is the impalpable flour. Now, in the case of Silica Portland, the whole of the cement is ground to this impalpable flour-like condition and therefore in a condition to do work, the silica is reduced to a minute degree of fineness also, but not to the same extent as the cement, each speck or particle of silica is enveloped, wrapped up, in a layer of flour-like cement, and offers a clean sharp surface for the cement to adhere to. All very finely ground cements show strong adhesive properties. Hence we see the useful function the silica performs, it takes the place of primarily, the unground clinker, and, secondarily, is an excellent filling material; wholly inert under the usual conditions to which cement mortar is exposed, and in itself is stronger than the unground particle of clinker is has displaced. Owing to the exceeding fine conditions of the material, when tested neat it does not give as high a tensile strength as the more coarsely ground Portland Cement, yet when made up into mortar with three parts of sand it actually equals in strength a like proportioned mixture of the Portland.

It is a peculiar fact that mortars made from very finely ground cement do not show quite as strong a resistance to abrasion; although they excel in adhesive properties. Hence the concrete for pavements and such like works preferably should be made of Silica Portland and the top wearing surface of the coarser Portland Cement.

There are certain uses which Silica Cements are peculiarly well adapted to. Speaking generally, all cases where the low percentage of lime is an important factor: notably in lining digesters for the manufacture of Sulphite Wood Pulp, it has been found of the very highest value. In sewers where free ammonia or acids are likely to attack the mortar, and in all such cases.

In pointing fine stone work, the color and permanent properties are peculiarly valuable.

Silica Portland Cement has already largely entered the market and proven itself a valuable cement. The following partial list will show to what extent and the nature of the work where it has stood the test of experience:—

The Laurentide Pulp Co., Grand Mere, Quebec, in concrete, masonry, floors, brick work, etc.	21,000 bbls.
Montreal Street Railway Company, in concrete and floors, etc.	2,500 "
Canada Paper Company, Windsor Mills	1,000 "
W. W. Ogilvie, Montreal	1,000 "
Holland Emery Lumber Co., Byng Inlet, for saw foundations	750 "
Riordan's Paper Mill	1,000 "
Dalhousie Street Station, C. P. Railway, Montreal, masonry, floors, etc.	2,200 "
Longue Pointe Asylum, Montreal	800 "
Ottawa Pavements	3,500 "
Cornwall Pavements	600 "
Waterloo Pavements	900 "

Also been used in sidewalks and pavements in Ontario towns to the extent of some 10,000 bbls.

Among other users, the Grand Trunk and Canadian Pacific, Central Ontario and Bay of Quinte Railways, the Public Works Department, Ottawa; in all over 75,000 bbls. of Silica Portland Cement have been used in Canada, although the manufacture was not undertaken until the season of 1897. Arrangements are being made to double the output for the ensuing season.

It has been said by rivals, that the cement gives facilities for adulteration not equalled by other cements, and objections have been made by "smart Alecs" that they had plenty of sand without buying it in the form of cement; of course, all such objections are met at the outset with every new material. When Portland Cement was first produced it had to undergo an equally hostile criticism. And this naturally brings us to consider the testing of cement, a subject on which there has been a great deal written.

The following scheme conforms to the best thought and experience in the Engineering World:—

TESTING.

Hot Bath Test.—Fay's apparatus is so simple and well-known that it is unnecessary to describe it, but let me draw attention to a point sometimes overlooked. The sample when trowelled on the glass, should be well worked up, the air and excess of moisture worked out and the sample be covered with a wet cloth, otherwise drying cracks may show up across the thickest part of the slab. This drying crack is sometimes mistaken for an expansion crack and the cement condemned. Too much importance is sometimes attached to the fact that the sample leaves the glass, if, as is usual smooth glass is used, the slightest jar will loosen the slab. If it preserves its shape and does not curl up, or show fine hair cracks at the edges. There is no danger to be apprehended from free lime, in fact from the low percentage of lime present a blowy Silica Portland Cement is almost an impossibility.

Specific Gravity, Weight per Bush. or other Density Test.—Silica Portland Cement weighs a little less than Portland Cement. It is so very finely ground that for equal measure, owing to the greater bulkiness, it must weigh less. In any case, the old test of weight per bushel, should be abandoned as being unscientific and misleading; offering, as it does, a premium on coarse grinding. Specific Gravity:

The Specific Gravity test is a delicate laboratory test and is one requiring a high degree of care and skill, as usually conducted by volumetric displacement, confined air, a minute error in reading, a slight change in the temperature of the liquid used, or irregularity in measuring apparatus or weighing may give widely varying results. The object of the test is to determine the density of the cement, i.e., the sufficiency of the burning, in other words, the soundness, hence the hot bath test practically suffices and is much more easily made.

Tensile Strength.—Neat tests as usually made show Silica Portland to be slightly weaker than Portland Cement, this is probably due to the fine grinding. Mortar tests however are the best of all and show the real working qualities of any cement, and it is as a mortar maker that Silica Portland proves its good qualities.

Having satisfactorily determined the safe qualities of the cement, having shown it to be sound, strong, both in neat and mortar tests; all of which should be a condition precedent to beginning the work, it sometimes happens that, still the concrete or masonry shows poor work. Well, what are we to do then? Condemn the cement? No. suspect the sand, examine the gravel or broken stone, the water, the temperature of the air, the methods of mixing and measuring the aggregate, depositing in place, raming, etc. After all, the cement is only one of the factors in the problem; for a complete solution we should investigate the whole of them.

Do not try the experiment of building works out of cheap, lean concrete, consider the relatively small saving a few barrels more or less of cement amounts to in comparison with the value and importance of the work at stake. Your reputation as Engineers will depend upon your capacity to do sound work.

No. 1 Test.

Hollow cubes made of Sand Cement (1 to 1) Aalborg used.

Hollow cubes made of (Stettin Triangle) Cement. Neat.

	Sand Cement. N'T.	Portland Cement. N'T.
One and one-half hours		Entirely saturated, and water down $1\frac{7}{8}$ inches.
Three and one-half hours	Water down $\frac{1}{2}$ inch. Water appeared on outside near top edges only.	Water down $2\frac{1}{8}$ inches.
Three days	Upper third of cube more or less saturated.	
Six days		Water entirely absorbed.
Ten days	Many dry places on sides and cube still half full of water.	

No. 2 Test.

Hollow cubes made of Sand Cement mixed with 3 parts sand.

Hollow cubes made of (Stettin Triangle) Portland Cement mixed with 3 parts sand.

	Sand Cement.	Portland Cement.
Three minutes		Water appeared on sides.
Twenty minutes		Entirely saturated.
Thirty minutes	Water appeared on sides.	
One hour	About three-quarters saturated.	
Two hours	Entirely saturated.	
Five hours	Water down $\frac{1}{2}$ inch.	Water down $2\frac{7}{8}$ inches.
Two days		Water entirely absorbed.
Nine days	Cube nearly half full of water.	

PAVEMENTS.

A. W. Campbell, C. E.

On the two previous occasions when I have addressed your Association, we have discussed in a general way, if I remember rightly, country roads, and the use of broken stone (or macadam) on urban streets. This afternoon we may perhaps with profit glance over the higher class of pavement used on town and city streets.

The word "higher" in its reference to pavements, I have used more out of deference to the popular idea of what is a "higher" class of pavement, than as any distinction which I myself would care to draw. A broken stone roadway, it is true, is not usually so expensive as one of asphalt, vitrified brick, or stone block, and yet in its right place, there is no higher form of pavement than broken stone.

I am to-day more than ever convinced that broken stone should be the general pavement for residential streets of towns and cities, but in order to their successful construction and maintenance, they are worthy of quite as much study as the so-called "higher" pavements. The fact that they have not received the attention they deserve is accountable for the disrepute into which they have fallen. Business streets, heavily travelled thoroughfares and certain residential streets of course require a more durable surface than macadam, for the sake of economy, cleanliness or for appearance.

The relation which I wish to express may, perhaps, be instanced by Toronto in which only 7.52 per cent. of the streets are now paved with stone and scoria block, asphalt and brick; 5.53 per cent. (such streets as College, McCaul, the greater portion of Queen, King, etc.), has asphalt, brick or stone setts between the street railway tracks; while the remaining 86.95 per cent is either paved wholly with cedar block, macadam, gravel, or is still unpaved. Of that paved wholly with cedar block, the greater part could be profitably paved with macadam; so that the importance of the latter material, and the need of a thoroughly scientific understanding of it, scarcely permit it to take a lower place on any score.

In the construction of any pavement the grading is of course the first part of the actual work of construction, then follows the tile underdrainage, which usually consists of two rows of tile at each side of the pavement, to reduce the elevation of the water line. The soil underneath every pavement must be kept free from an excess of water, otherwise the upheaving action of frost is exceedingly destructive, a point on which we need scarcely dwell, as its importance to students of physical science is doubtless so apparent. The depth of the tile drains in practice is usually two and one-half or three feet below the surface of the sub-grade—preferably the greater depth. The sub-grade must next be thoroughly compressed and consolidated with a steam roller, which, having been done, the curbing may be put in place. For macadam and for cedar blocks, wooden curbing is frequently employed, but for asphalt, brick and stone setts, stone curbing is more suitable. When rolling is completed, the sub-grade should be perfectly hard and with a contour similar to that which it is intended the finished roadway shall have. The roadway is now ready to receive the foundation of cement-concrete. A concrete foundation is absolutely essential for an asphalt pavement; is greatly to be recommended for a brick pavement, although some have been laid on gravel or broken stone; and stone setts are needlessly strong and expensive where concrete is not required.

Up to this point the construction of the higher varieties of pavements are very much the same, the details of drainage, rolling, thickness and composition of the concrete, varying with local requirements and conditions. In all this it is to be remembered that the sub-soil really supports the weight of the road and the weight of the pavement as well, hence the necessity for its careful treatment. The concrete acts as a monolith to distribute the weight of the load over the sub-soil, preserve a more even contour of the finished surface of the pavement, and to resist the upheaving action of the frost. The chief function of the surface coating of asphalt, brick or stone is to resist wear—not support actual weight, which, as pointed out, is finally borne by the natural sub-soil.

ASPHALT.

An Asphalt surface of a roadway may best be regarded as a solid held together by a liquid—sand held together by an asphaltic mastic. The effect of water on sand of the lake or sea shore is believed to be a good index to its utility in asphalt paving. Sand when wet becomes more solid than when dry and the effect is very similar to the use of the sand combined with asphalt in a pavement (which is, we have said, a solid held together by a liquid). Wet sand may be driven or walked over with ease, while a dry sand yields, sinks and renders progress very laborious.

The composition of an asphalt pavement is about ninety per cent. sand and the remainder asphalt, combined of course with a fluxing agent, usually a heavy petroleum oil, or a maltha or asphaltic oil. Asphalt obeys the laws of capillarity, being one of the liquids which rise in capillary tubes. At a reduced temperature it becomes brittle, for which reason the softening agent (or flux) is introduced. To obtain an asphaltic cement which will not be brittle or crack, when subjected to the low temperatures of a Canadian winter, and which will not become too soft under the extreme heat of summer, is a matter which has been the subject of much speculation. It is evident that the quality of sand used (which forms 90 per cent. of the pavement) may afford a solution.

The finer the sand the firmer it becomes when wet. We conclude, then, that to be using fine sand in the composition of an asphalt pavement instead of a coarse sand, a softer mastic may be used which will be firmer under excessive heat, and less liable to crack when subjected to low temperature. The quality of sand which forms so great a percentage of the pavement, manifestly becomes of much importance as the quality of the asphaltic cement itself.

A sand the grains of which are sharp and angular, should be used; otherwise the effect is much the same as to use a coarse sand, since the rounded edges do not unite firmly in the mass, and the mixture if so hard that it will not soften in summer will in all probability crack in winter.

The selection of the sand is a matter to which too little attention has been paid in the past. Contractors usually choose the sand of the locality, and it is well known that the quality varies with different strata in the same pit, and varies still more widely with different localities. The sand comprising such a large percentage of the composition is no doubt largely responsible for the success or failure of asphalt pavement in different cities, and even in the same city where proper and improper qualities of sand have been used. This also is undoubtedly responsible for good and bad asphalt on the same street, where the same workmanship and care in the construction has been used.

Moisture is the great enemy of asphalt, causing rapid disintegration, wherever it finds a way underneath the layer of asphalt and concrete, and for that reason the cracking of the pavement causes very great injury. The effect of water on asphalt is most noticeable at the sides of the pavement unless a stone or concrete water-way has been placed next the curb, this being largely followed in later practice.

Underneath the surface of asphalt (which is ordinarily two or two and one-half inches in thickness), between it and the concrete, there is placed a thin "binder" coat composed of asphalt and sharp broken stone, to secure a better union between the asphalt and concrete. Unless a perfect bond is obtained between the asphalt and concrete, creeping of the asphalt results under heavy traffic, causing a wavy surface, an examination showing that the asphalt has become "bunched," a series of thick and thin spots.

In addition to the artificial mixture of pure asphalt and sand to form the pavement, a natural or rock asphalt is used very extensively in Europe, but less commonly here. It is usually a limestone impregnated uniformly with mineral bitumen. The rock is ground to a powder, is heated, and is applied to the road in this condition, and thoroughly rolled with an asphalt roller, its method of application being similar to that of the artificial mixture.

To enter upon a discussion of the chemical composition is a somewhat tedious and intricate matter. The pavements are laid by contracting companies which jealously guard and retain as far as possible, all information regarding their methods. Our information therefore is not complete, and a discussion is not entirely satisfactory. Of late a few of the larger cities have taken up the matter, and from their testing laboratories we may look for more reliable data it is to be hoped, in the near future.

VITRIFIED BRICK.

This pavement has come in a most timely way to take the place of much of the decayed cedar block pavements which are disgracing the streets of so many towns and cities. Vitrified brick is becoming popular, and presents features which tend to cause it to become more so. The surface is not so smooth as asphalt, and in consequence radiates less heat and light and is quite as sanitary with less liability to become dusty.

The majority of failures which have occurred with brick have been traced to defects which better material or better construction would have obviated. Its ease of construction and repair offers a great advantage over asphalt, ordinary laborers being taught to do the work. Few repairs are needed if good brick is used, and in the first cost as well as in maintenance, brick should be; and generally is, cheaper than asphalt.

Although brick is one of the oldest paving materials, it has been used on this continent for only a quarter of a century; and only in the last ten years has it attracted wide-spread attention. In the United States it has been used very extensively, but in Ontario, experience with the modern vitrified brick is limited.

Of its success as a paving material little remains in question. Brick pavements have been in existence in the United States for eighteen years, remaining in good condition. It was feared that the climate of northern countries, with severe frost and rapidly alternating conditions of moisture and temperature would be unfavorable to its use, but the experience of various northern cities shows that vitrified brick of a good quality is a most valuable addition to our list of paving materials.

The best vitrified brick is made of shale or clay or a mixture of the two. It is not "vitrified" as the name indicates, but is raised by intense heat to the point of fusion. More than this fuses and melts the clay, permits it to run together and the product is then glassy or vitrified, and brittle in consequence. The process of cooling must be very gradual. A brick if too rapidly cooled or "annealed" will be brittle, but with a thoroughly pulverized and well-mixed shale, brought to the proper temperature and then slowly annealed, the resultant brick should be sufficiently hard and tough to scratch steel.

The chemical composition is a matter of importance. The chief defect is likely to arise from too much lime. Brick which contains an objectionable amount of lime or other soluble substance, when immersed in water for three consecutive days and then kept in a dry atmosphere for a corresponding length of time, will show signs of spalling and pitting and indicate a faulty composition of the clays of which they are composed.

When broken, brick should show a smooth and straight fracture and the texture and color should be uniform throughout. A granular appearance is very objectionable. Bricks externally should be straight and smooth, not warped, and should be free from fire checks and cracks.

Brick should absorb the least possible amount of moisture. A large amount of water in brick, freezing, has a bursting effect which in this climate cannot be guarded against too carefully. A good brick will not absorb more than two per cent. of its weight in water. To absorb three per cent. may be permissable if in other respects it reaches a high standard.

The quality of brick is fairly well shown by the rattler or tumbling barrel test, as this most nearly approximates to the wear from the blows and chipping of horses' feet. A tumbling barrel or rattler consists of a cylinder of about three feet long and two feet in diameter placed on a shaft. Samples of the different makes of brick are first weighed and are then put in the barrel, together with 150 to 300 pounds of scrap iron in from two to eight pound pieces. The rattler is then revolved for two or three hours at a rate of about thirty revolutions per minute. The comparative loss in weight will indicate the relative efficiency of the brick in resisting this class of wear.

A valuable test is that of transverse strength. In this the brick is laid on two knife edges, placed about six inches apart. An upper knife edge centrally between the two lower blades is slowly brought to bear on the brick, and the weight required to break it is carefully noted.

Other tests are sometimes used, to determine crushing strength, the depth to which oil will penetrate the surface, etc. The specific gravity of brick is valuable as indicating density, and therefore the extent of probable absorption. The chief tests, however, are those above described; that of absorption, representing the probable effect of atmospheric action; the rattler test, showing the effect of impact and abrasion as found in the chipping of horses' feet and the grinding of wheels; the transverse strength, showing the power to resist the breaking strain of heavy loads.

The general manner of construction is to cover the foundation of concrete with a layer of sand, one inch or so in thickness, then laying the brick in this, on edge, breaking joints and bringing them by a careful use of sand to an even and uniform contour, tamping them into place. A quantity of sand is swept into the joints, and their filling is then completed with a grouting. The composition of the grouting is of importance (one of Portland cement to one of sand is favored), since if this gives away the edges of the brick lack support and are chipped off. A paving pitch is sometimes advocated in place of the grouting, on the score that the disagreeable rumbling of the brick pavement is thereby lessened.

STONE BLOCK PAVEMENTS.

Stone block is the oldest of paving materials; is extensively used in cities, and is the strongest and most durable that can be had. It it well adapted to grades up to ten per cent., yields little dust, requires little repair and suits all classes of traffic. It is however very noisy and very rough unless dressed stone is used. It is therefore not suited to residence streets nor business streets where there are retail stores and offices. It is best adapted to streets on which there is a large amount of slow, heavy traffic. It should be used, also, on steep grades in place of asphalt.

The stone generally used is granite or trap. Excessively hard stone wears to a smooth surface and becomes slippery. No examination or test which can be made of stone is perfectly satisfactory in distinguishing the best variety. Different kinds of the same stone and even stone taken from different parts of the same quarry, have different wearing qualities.

The stone blocks should be cut into rectangular blocks about seven inches deep, three inches wide, nine inches long. The price paid for quarrying and making these blocks will average about thirty dollars per thousand. Slabs of a kind which can be handled by one man are split out in the usual manner. These are sub-divided into sections corresponding to the size of the paving blocks, which are then trimmed and finished.

In constructing a stone block pavement, the natural earth is first prepared by draining, grading and rolling with a steam roller. On this a layer of concrete is laid, say six or eight inches in thickness, according to the traffic to be supported. On this is spread a layer of sand about one inch in thickness, and in this the stone blocks are imbedded.

The blocks are laid stone to stone in courses at right angles to the street line and so that the joints will be broken. A slight variation in size of the blocks is permissible as regards depth and length, but the width (if three inches as previously specified) should be exact.

On hills and grades a better foothold for horses may be obtained by using rough-finished blocks, or the blocks may be imbedded in the layer of sand on a slight incline in such a way as to present a series of steps. At street intersections the blocks are laid obliquely in what is termed the "herring-bone" fashion, so as to give a secure foothold to horses turning the corners. The joints between the blocks are filled with sand and tar cement.

WOOD PAVEMENTS.

In Canada and the United States wooden pavements are very much in disrepute. They have been found to decay rapidly, settle unevenly, become rough and unsanitary, absorbing filth and giving off bad odors. Much of this is unquestionably due to the method of constructing these wooden pavements in this country. They are usually laid very carelessly as to foundation, concrete being rarely used. A bed of sand or gravel is commonly employed, which is not even consolidated with a roller, and very little under-drainage has been attempted. Very little care is taken in the selection and preparation of the wood, the round cedar block still bearing the bark, far from sound in many cases, being the most common material. It is not difficult to understand the failure of any pavement under such circumstances.

In England and France wooden pavements are regarded with favor, but the timber used there is carefully selected, so as to exclude any blocks showing signs of decay. Oblong blocks are cut, all of equal size, and are laid in a manner similar to vitrified brick. Soft woods are treated with creosote, tar and other preservatives, and are laid on concrete foundations. The life of such pavements being about ten years. The best wooden pavements are made, however, from Australian hardwoods, particularly the jarrah, karri and other of the hard eucalyptus woods of South Australia.

FORESTRY.

THOS. SOUTHWORTH, CLERK OF FORESTRY FOR ONTARIO.

An unscientific person called upon to address an audience composed of Professors and Students of Science occupies a somewhat delicate position, and that is exactly the predicament in which I find myself in appearing before the Engineering Club of the School of Practical Science.

I take it for granted that I am expected to refer more particularly to that part of the Government service placed in my charge, that of Forestry, or the Department of Agricultural Science in which the crop to be grown and harvested is made up of the monarchs of the vegetable kingdom, trees. In using the term "crop to be grown and harvested," it might be well to reverse the sequence and say "the crop to be harvested and grown," for we started out with a magnificent crop already grown and our first business was to harvest it. As you all know, the Province of Ontario was entirely tree-covered (except where the industrious beaver, the first great engineer of whom we have record, built his dams, and by flooding killed the trees), and the first business of the white settler was to remove the original crop to make way for crops of grain and grass and roots for the sustenance of himself and his domestic animals. It is needless to say he found the work no sinecure. With no market for the giant pines and hardwoods, he had with infinite labor to pile the fallen trunks in heaps and burn them, his only direct return, and for some time his only source of cash, being the potashes distilled from the residue of the burned logs. For years pot and pearl ashes formed a standard of value or took the place of currency in the system of barter among the earlier settlers. This fight for existence with the apparently limitless forest was a hard one, and it is not much to be wondered at that our fathers were not content to know that they had conquered the forest but were inclined to proceed to a war of extermination.

So much so has this been the case that in some of the older counties of the Province only five per cent. of the total area is classed as woodland, and even this of such a scattered, scrubby character as to be of little economic value, and it is no uncommon thing in this "wooden" country to find farmers heating their houses with Pennsylvania coal.

When it is borne in mind that for climatic and economic reasons it is expedient to preserve at least twenty per cent. of the land in forest, it will be seen how imminent is the danger from deforestation in the southern counties of the Province. It is quite true that Ontario is largely tree covered yet, and it is not likely that the future settlers in the now undeveloped part of the Province will be so improvident in regard to their wood supplies, but the climate and the crops of that part of the Province in which we live have already suffered from the want of forests, and it was because of a knowledge of this that the Bureau of Forestry has been organized by the Provincial Government, to endeavor to restore the due proportion of wooded to cleared land where it is needed, and to prevent, if possible, similar conditions in the yet to be settled districts.

To the latter question the efforts of the Bureau have so far mainly been directed, and it is chiefly in the solution of the problem of the perpetuation of an adequate forest area that I appeal to the gentlemen of this Society on behalf of the Province for co-operation and assistance. In the first place let me say we have no trained Foresters in this country, at least, none that I know of. In fact Forestry is quite commonly understood to mean the keeping of trees free from the axe for esthetic and climatic reasons, instead of what it really is, the art of growing the most valuable kinds of trees in the quickest and cheapest way, to be harvested to the greatest profit and in such a way as to insure successive crops of the same kind. Of course the beneficial effect of trees in masses on climate, stream flow, and even our physical and moral welfare are important adjuncts to be considered by the Forester, but they are not his first consideration, which is an economic one, a business affair of profit and loss.

For this reason what would be correct forestry practice for the State would be quite the reverse for the private or individual holder of forest lands. In the latter case the benefit to the community of the presence of the forest is eliminated from the problem, and it might be wise for him to make a clean sweep of his forest for present profit and abandon the land or divert it to other uses. Not so with the State—a hundred years is a short time in the history of a nation and the State can afford to wait for return where the individual cannot.

Thus it will be seen that we can only hope for a perpetuation of our timber supplies by the retention of large areas of timber land by the Crown. Fortunately for us, the policy pursued by our legislators in disposing of our timber wealth has made this possible. The standing timber only is sold to the lumber operator, the title to the land remaining in the Crown to be disposed of to the actual settler when the more valuable timber is removed. As a great deal of the land now being lumbered over is not suitable for other crops than trees it will remain the property of the whole people, and thus large areas for future timber growth be secured.

And it is not to the Government only to whom the services of skilled foresters would be valuable. Some of the most progressive lumbermen have spoken to me of this, and would be glad to avail themselves of such expert assistance if they could. There are some lumbermen in Ontario that would be glad to pursue more economic methods if they could, that is to say, if it would pay. One of the great problems confronting lumber operators here is the profitable disposal of much forest produce that now goes to waste.

A lumberman on the north shore of Georgian Bay pointed out to me a grove of young red pine (pinus resinosa) tall, but standing so thick that they were mere poles. These trees would never make good timber unless they were thinned out, and I was appealed to to point out how the owner could afford to do this. As there would be absolutely no market for the thinnings, I could not see that the extra growth of the other trees would pay for the expense of thinning, and I told him I thought he would have to wait and let nature do it for him.

In many parts of the Province there is a considerable growth of Rinus Banksiana or Jack Pine. This timber, though it makes fairly rapid growth, has had very little value because of the very hard and knotty nature of its wood. Can we not find some profitable use for this tree? Would it not make a good material for street paving.

In this connection I desire to refer to a matter that comes more within the purview of the Engineer than the Forester, but we cannot very well get along without each other. To my mind the ideal street pavement is made of wood. It is noiseless, elastic, affords a good foothold for horses, and is durable. True, the "cedar block" pavements in Toronto do not come up to that standard, but I do not mean that kind of a pavement. Placing a lot of small, round tree sections on a bed of sand as has been the practice here, is not the kind of pavement I allude to. These round blocks, laid in soft sand make a very attractive looking pavement, but the first heavy load over them drives some of them deeper down into the sand than others, making holes, disturbing the level surface; the sapwood of the tree section wears out more rapidly that the heartwood, and long before the pavement is paid for it is worse than any corduroy road I ever saw. Because of this, wood pavements have been condemned here, but in England, where they are supposed to know a good deal about roads, increasing amounts of wood pavements are being laid down each year. There is carcely an issue of the British Timber Trades Journal that does not contain requests for tenders for wood paving. Over there the wood pavements are built much as our brick and asphalt are. On a solid concrete bed are laid square creosoted blocks, 3 x 6 x 9 inches, close together, diagonally across the road to within two inches of the stone curb, the two inches being filled with puddled clay to allow for expansion. In Australia also this style of pavement is mainly used, and is found very durable. In Sydney over fourteen miles of the principal streets are of this description, and a report recently received states that the pavement on two streets was repaired last year after 11 years' wear. The blocks were taken up and cleaned, the ends sawed off, dipped in non-absorbent solution, and relaid at a total cost of 57 cents per square yard. They were found to be worn but slightly. In Australia the Australian hardwoods are used and the same applies largely to England, but "creosoted deal blocks" of pine are coming more into use.

All this is preliminary to my asking the assistance of the School of Science. This despised Banksian Pine of which we have considerable quantities, would in my opinion, make first class paving material. It is harder than our other pines, and much heavier. Of its characteristics we know but little, and I would suggest that the proper tests, for which I believe you have the facilities, be made here. If we can determine the wearing and non-decaying qualities of this tree, and it is found to be suitable for this purpose, it means a great deal to the Province.

The authorities of the Province have now definitely entered upon a policy of making the income from forests perpetual by setting aside considerable areas of rough and broken land at the headwaters of our streams, that shall be exempt forever from settlement and kept under forest cover. This land is likely to be selected largely from territory where the original crop of timber has been removed, or partly so, and to properly manage it, to make it properly productive will require skilled labor and a knowledge of the sylvicultural characteristics of our native trees we do not now possess.

Many of you will doubtless have more or less to do with the Crown Lands of the Province in the future, and I venture to suggest that some knowledge of at least the general principles of forestry will be found useful. For instance, I venture to say, that not all of you are able to identify all our native trees and to give them their common and botanical names. Most Land Surveyors in reporting on timber give merely the local names of the commoner trees, and as these vary in different parts of the country it is very confusing. This applies of course to some of the surveyors now practicing, not to my present audience. I pointed out to the members of the Surveyors' Association last year that some of their members in their reports have referred to a tree they called "cypress," and as no cypress grew in Canada I was at a loss to know what tree was meant. Some of them said it meant Jack Pine, or Pinus Banksiana, others that it meant white cedar, or Arbor Vitæ, while one had always supposed the cypress was another name for the Tamarack or Larix Americana. One of these same gentlemen has recently referred to a report on a survey, to "Pitch Pine" being met with in considerable quantities, and I do not yet know what tree he means as we have no such tree, unless it is Pinus Resinosa, which is commonly called red or Norway pine.

There are various other aspects of Forestry well worth your attention, such as the effect of forests on the flow of our streams and the future of our water powers, the effect of masses of trees on temperature and climate, and other matters. I am not fully posted as to your present range of studies and may be advising a course of reading and investigation in lines that you are already familiar with. As a mark of the importance we attach to this, I may say I am authorized by the Commissioner of Crown Lands to offer a small prize for a thesis to be written in competition by the graduates of the School of Practical Science on some subject related to Forestry, the subject and terms of competition to be arranged by the Principal of the School, and approved of by the Commissioner of Crown Lands. The successful article for the year will be published in the Report of the Bureau of Forestry.

LAND DRAINAGE IN ITS SANITARY RELATIONS.

By Peter H. Bryce, M.A., M.D., Secretary Provincial Board of Health, of Ontario.

Mr. President and Gentlemen of the Engineering Society:

We have not the time to enter upon the history of the development of drainage works, though we have evidence going to show that the subject was treated of very intelligently by a Captain Blyh even in the time of Cromwell, as regards the drainage of water-meadows and swamps; but the glory of having instituted drainage on a broad and scientific scale belongs to that celebrated Scotch engineer, John Rennie, F.R.S., whose attention was drawn as early as 1789 to the rich but drowned lowlands of the Lincolnshire Fens. It was he who suggested the use of Watt's steam engine to pump the water out from some 75,000 acres near Ely in Lincolnshire, instead of by the uncertain wind-mill power used generally in Holland. Rennie set himself to solve the problem of carrying out to sea the surplus waters of a district extending from the Lincolnshire coast almost to the centre of England. He had not only to consider the rainfall of the Fens themselves, but of the whole district lying at a higher level, and it was he who designed the first great "catch-water drain" for carrying those upland waters to the sea instead of allowing them to flow down to add to the waters of the Fens. After careful surveys he further instituted large outfalls from the fens, provided with sluice gates, so that, while at low tide the fresh water would be allowed to escape, yet the sea waters would be effectually prevented from coming in from the river wash upon the lands at high tides.

We see in the recognition of the causes which flooded these drowned lands, both the main facts upon which the necessity for drainage depends, and the measures by which such is effectively carried out. First there is the fact that the wetness of land is due to the rainfall; second, that the rain percolates into the soil in greater or less proportions; third, that it may be mechanically retained there, as where the fens were practically at the level of the sea, and fourth, it may sink into the soil in varying proportions, and be retained there to a greater or less extent according to the nature of the soil, all the water above saturation point moving along by gravity beneath the surface, as an underground stream until it comes to the surface on some lower area, as was the case with the Fens of Ely.

In any given area whose drainage is under condition, we have therefore, to consider first, the local rainfall; second, the rainfall of the watershed, which trends towards the lowlands; third, the nature of the superficial and deep soils of the district as regards their depth and thickness; and fourth, the physical constitution of the several soils whether superficial or deep as regards their capacity for moisture.

In no country can there be found more interesting examples of the variations both of the quality and arrangement of soils than in Ontario. Underlying the older settled parts of Ontario are the rocks of the Silurian and Devonian ages, and upon them with their surface eroded, with here and there syn-clinals, and anti-clinals, have here deposited sometimes in a shallow layer, sometimes to a depth of over 100 feet, clays, loams, sands and gravels, as the post-glacial deposits of an earlier age. While in the area covered by the blue or Erie clays (Logan), there is much regularity in the character of these soils, yet we find that as we go inland from the lakes these are covered with the Saugeen sands and gravels, in a very irregular manner; while to both of these we have added a rearrangement, as an alluvium, of these soils mixed with much vegetable mold in the broad valleys of ancient streams, such, for instance, as of the Grand River and Thames, which the streams of that time made by erosion.

It is thus, dependent upon such broad causes, that we find the many conditions affecting the local soil conditions of our 40 counties; and while some of them, as Middlesex, Oxford, Brant, Waterloo and Wellington, have superficial soils much in common, yet these are again wholly different from those of Essex, Kent and Lambton, lying at a somewhat lower level. Not only do the streams starting in this former group of counties, flowing westward, bring down the waters upon the lands of the second group, but they have sands, gravels and loams predominating on the surface, while the second group have little else than a superficial soil of heavy clay covered with a rich alluvium. In addition, however, to these broad divergences in the post-glacial deposits overlying the rock strata, we have the innumerable local differences, nowhere better marked than about Toronto, depending upon the denuding agencies which have hollowed out the whole Lake Ontario basin, and produced the valleys of denudation, such as the Humber and Don valleys and the many smaller ravines distinguished by the sharp-cut outlines with deep erosion of these blue clays everywhere present.

Assuming, however, as correct the general statement that some 50% of the rainfall in our climate is absorbed by the soil, we would naturally expect that with soils varying in their constituents this amount will be exceeded or lessened under differing soil conditions. This to-day is especially true since the leaf mold of the virgin soil which absorbs nearly all the water which falls upon it has largely disappeared from the surface of the extensive deforested and cultivated areas of the Province.

Regarding the different soils as clays, loams, leaf-molds, sands and gravels, we must remember that there is a difference between the absorptive power of a soil and its perviousness or capacity to hold water. Thus Prof. Shubler, of Tubingen, tells us that as the result of experiments it is found that sand holds by attraction but 25 parts of water in 100 parts by weight; loamy soil by attraction but 40 parts of water in 100 parts by weight; pure clay by attraction but 75 parts of water in 100 parts by weight. Thus we see that perviousness is the opposite of the capacity to hold moisture in its interstices. Again, we know, in practice, that a rain falling upon a sand may be practically all absorbed or pass into the soil, yet a clay, puddled—as where a waggon passes over a wet road—may have its particles pressed so closely together that no water will pass through it until broken up by the frost or by cultivation. Deep soils similarly become by pressure impervious to moisture.

We can now understand from these illustrations, how important, as regards drainage, becomes the arrangement of pervious and impervious layers of soil. If several feet of pervious soils lie over clays, we may have for practical purposes a perfectly drained soil. This is well illustrated by the sewage farm of the London Asylum, where there are some 12 feet of sharp sand overlying the bed of clay; and experience has shown that the field tiles laid by the engineer some six feet below the surface carry no water, the water sinking below them until it flows along the underlying clay. We know that it is upon the arrangement of these different soils that the question of the depth of subterranean water streams, or water tables, depends. Add to this the depth of strata, and the question of whether artesian-wells will be found in any area will be determined. Thus an artesian supply will depend upon, first, a pervious water-bearing stratum; second, an impervious stratum below; third, a second impervious stratum above the water-bearing stratum; fourth, a dip or incline of the strata; fifth, a sufficient collecting area of pervious soils above with sufficient elevation; sixth, the continuation of the pervious bed for considerable distances; seventh, the absence of any flaw or fissure in the underlying clay or rock; eighth, a dip, as suggested by Chamberlain, of at least one foot per mile of area. French hydrographers have given us the following as a law with regard to the flow in such cases. "The flow along the water-table will increase with the effective charge (i.e., the volume), and diminish with the thickness of the layers traversed by the water stream, which lengthens the conduit and auguments the friction against the soil walls with a resulting loss of flow."

It is hardly necessary to say that the latter varies with the character of the soil, that is, its degree of porosity, as well illustrated by the Chatham and London water works. Thus the interstices in different materials, according to Durand-Claye, cause a loss of volume as follows:

Broken stone	45 to 50%	of volume.
Chalk	32 to 42%	"
Various gravels	36 to 40%	"
Recent alluvium of the Seine	30%	"
Ancient alluvium of the Seine	16%	"
Sand from pulverized gneiss	17%	"

As we would expect, impermeable beds of soil have no true water zone. Filtration may go on in such soils when covered with vegetation or when well cultivated. And such produce small springs or oozings. Wells, however, dug in such soils afford only feeble supplies, and are called weepers. Hence, summing up the amount of flow in any underground stream we may apply the law of Durand-Claye: "The flow is proportionate to the body of water, the thickness of the water zone, and to its coefficient of permeability." What amounts of water will be present in a given water zone may be understood when we see that in a water-bearing stratum of three feet in thickness a square mile will hold 585,446,400 gal.

Such, gentlemen, are some of the principal physical facts which we have to keep in mind when we come to the special subject of our lecture. Take the single question of the pollution of a well, and we shall see that some of these facts have a practical bearing. Assume, if you please, two wells, with the water stream 25 feet from the surface, each with a cess-pit within 100 feet of it, the difference being that in the first a pervious sand extends from the surface down to the clay at 25 feet; and in the second that a heavy clay of 22 feet lies upon a water-bearing sand of three feet in thickness upon a subjacent clay, both being conditions of common occurrence in the Province. From the first we would expect that all the soakage from the first cess-pit will tend toward the well in the degree that the water is freely used; while in the second, the well may be pumped dry, so far as the soakage from the cess-pit is concerned, the water from this latter well, depending upon its water-bearing sand, extending it may be a great distance till it comes to the surface as a pervious stratum. This illustration of soil pollution brings us to speak of the chemical compounds contained in ground waters. From the varying nature of the numerous constitutents of soils, we naturally conclude, as is the case, that the rain water flowing over and percolating through the soil dissolves such soluble matters as it comes in contact with. Such may be called, if we like, impurities. These with minute amounts of organic matters may be called obligatory or normal impurities in contra-distinction to the accidental or facultative impurities, most of which are of an organic character. The two common impurities, the results of organic decomposition, are carbonic acid (Co_2) and ammonia (NH_3). These, as we know go to form with the minerals of the soil bicarbonate of lime, magnesia, etc., and nitrates, as of lime, potash, and other mineral salts. In addition to these gases there are, however, innumerable living organisms in the soil of the surface, millions in a cubic centimetre of soil, being those natural to the soil and others carried to it by the rain from the air, by the wind and by actual deposit upon it. These may be simply carried into the soil mechanically, or in the case of typhoid bacillus and other forms, as baclus coil, may live as parasites in the soil; they may extend and progress from point to point through porous soils, along the line of progressive organic pollution, say soakage from a manure pile, a cess-pit, or a leaky or clogged sewer.

Now, as we have seen, the porosity of the soil will determine the rate of movement of such with the rains or soakage through the soil, this varying, as in the case of wells, with the amount of rainfall and the depth. A single rain may not pollute a well, except from an area immediately near it, but continued rains will. An important factor, must, however, be remembered, viz.; that the microbes of the soil tend to attach themselves, as the water passes by capillarity through the soil, to the solid particles, and as the degree of capillarity depends upon the fineness, the closer soils will more perfectly impede the passage of bacteria. Another factor, however, plays an important part, viz., the destructive influence on the food supply of the bacteria of the oxygen which is drawn into the soil with the downward movement of water. If the movement of waters be not excessive in rate, and the amount of organic matter not too great, we find that the nitrifying microbes practically destroy the organic matter in the upper zone of soil. As warmth is a further factor of bacterial multiplication, it will be apparent that a sandy soil will tend to cause bacterial growth to extend deeper than in a closer soil.

Such are some of the principal physical facts which we have to remember in dealing with the drainage problem. Obviously the first point is to withdraw water from such positions, as by its remaining in the soil prevents the entrance of air to promote the destruction of an excessive amount of organic matter of a deleterious character. Again, we must lower the water in the neighborhood of inhabited dwellings to such a depth that it shall not percolate into cellars, bringing soluble organic matters with it to encourage by moisture further organic decomposition and fungus growth, even though the water may again flow out of the cellar by weeping tiles.

As regards ground drainage generally it is quite apparent what the principles to be carried out are, and what the results to be attained. From the agricultural standpoint the withdrawal of ground water to a depth of three feet and more is productive of the most valuable results. In the peat bogs of Europe, the drawing off of the waters and the subsequent burning of the dry turf makes the cultivation of buckwheat immediately possible.

Naturally with the aeration of the soil there goes on the nitrification of humus and settling of the soil. The same results and much more important ones are obtained in Essex and Kent counties of Ontario, where many thousands of acres of corn, oats, etc., are now grown on what were black, saturated loams overlying the clay.

To what extent the work of drainage has gone on since the first Municipal Drainage Act was passed in Ontario in 1869, may be gathered from the fact that $1,339,331.00 has been loaned by the Government at 5% debentures to the municipalities for township drains, and since 1878, $104,531.00 has been loaned for tile drainage on the same basis. One of the most remarkable results of these expenditures has been that the fevers and agues of those parts of the Province, which made early settlement in them a very serious matter, have practically disappeared.

There seem to be two factors entering into these results, the first being the increased temperature of the soil by the removal of the ground water.; and second, the destruction of organic matter by the free movement of oxygen into the soils. It is apparent that either, or both, conditions affect the ability of the soil to supply a culture medium of the plasmodium malariae, the minute form of life, now known to cause the disease; and which is spread from dried surfaces of marshes, by the mosquitos bred on them, and by the waters which flow in the streams from such marsh lands.

In no place, however, do we see the immediate effects of drainage more marked than in the sewerage of towns. Even though glazed tile are laid supposedly tight, in clays, as in Toronto, they nevertheless become ground drains by soakage towards them. These with the house drains on every succeeding lot, have helped to make of muddy York a well-drained city.

It may be quite true that many houses have weeping tiles laid within the cellar walls, and yet fewer with them laid outside the cellar walls, thus draining away the ground waters from cellars into the sewers; but it all shows that except when the house-drainage is neglected, our damp cellars are relatively dry. Perhaps no single cause contributes more to ill-health than the dampness of cellars. The cellar air contains the gases due to decomposition of organic matter in the surrounding soil, and as the walls and floors dry out, this air containing gases, is not only drawn up into the house, but spores of fungi, and probably various other micro-organisms along therewith.

How far city sewering has improved the public health is difficult to estimate, but Dr. Buchanan, late President of the Local Government Board of England, has given in his annual reports, statistics going to show that the sewering of towns has very directly lessened the number of cases of consumption in different cities. This we may fairly conclude has been due to the drier and more wholesome air of houses, by which the tendency to chilling of the body, and the congestion of the mucous membranes of the respiratory passages is prevented. Statistics relating to the frightful mortality of persons in dark and damp dungeons of former times in every country, have become historic. For instance, in an old English report on the Millbank Penitentiary between 1825-42, Dr. Baly reported that tubercular disease had caused more than three times as many deaths as in the same number of persons in London for the same period. In the annual report for 1866, the Chief Medical Office r for England, Dr. Sir John Simon, refers to the results of exhaustive enquiries in the cases of 24 English towns before and after their sanitary works were constructed. Thus, in Cardiff, the death rate from typhoid had fallen from 1.75 to 1.00, and from diarrhœa, from 1.7 to 0.4 per 1,000. In Newport the gross reduction in the death rate was 32%.

Regarding consumption, Buchanan's own words in the report are: "the drying of the soil which has in most cases accompanied the laying of main sewers in the improved towns, has led to the diminution, more or less considerable, of phthisis." Thus in percentages the reduction in Salisbury was 49%; Ely, 47%; Rugby, 43%; Leicester, 32%, and so on; and as Dr. Simon remarks, "in some of the towns up to that date, the remarkable falling off in phthisis is by far the largest, and in some almost the only marked amendment which has taken place in the local health." But, gentlemen, we do not have to go alone to foreign statistics, for we have found that it is on the clay soils, and, therefore, those where drainage has been most required, that the largest mortality from consumption in Ontario has occurred from year to year. Especially was this seen in the earlier years in the Essex and the Niagara Peninsulas, taken as a whole, and in the counties along the St. Lawrence, with their flat, heavy clays and undrained alluvium.

It must be remembered, too, that where local causes have promoted such prevalence, the infection once in houses, has served only to add to the mortality. We have already seen how extensive have been the drainage improvements, notably in the western peninsula and in the towns and cities of Ontario, and there have been undoubtedly some ameliorations in conditions previously bad. But if we have referred to the effects of town sewerage added to pure public water supplies, we have the further remarkable fact patent to us, that the deaths from typhoid fever have fallen from the period 1882-1886 to 1892-1896, in Ontario more than 50%; and in this period the public water works of the Province have grown from 12 to 105 in 1895, and the sewerage systems more or less complete from 11 to 45.

Now, gentlemen, it is something for us to know that we belong to those two professions which have been instrumental in bringing about so great and enduring improvements in the public health of our country. It may be that the sanitary officer as constantly dealing with disease and its inciting causes, is the pioneer in such reforms, but it is to the engineer and surveyor that he looks for the practical work necessary to carry such reforms into effect. But on the part of the engineer there is possible more than the work of merely executing such reforms. He is, if trained in all the sciences of geology, chemistry and biology, in a position to observe and collect such experimental and statistical data as will serve to make unanswerable arguments which the medical officer and Local Boards of Health may use to induce our municipal authorities to submit by-laws for the extension of such works as we have spoken of. From the days of Smeaton, Rennie, and Watt to Durand-Claye, Latham, and George Waring—the real creator of the separate sewerage system, the most scientific and sanitary drainage reform in the last 25 years, who died last month of yellow fever contracted at Havana, a martyr to science—we have had engineers who have made men better and happier because they have taught them how to be healthier and therefore better citizens.

But in a new country such as Canada, with its millions of miles of undeveloped territory, where may our coming generation of engineers not find employment in the dozens of avenues which your splendid science and profession fit you for entering?

In conclusion, I would say to you study broadly, not mere draughting, or the calculation of the tensile strength of materials, or the gauging of the capacity of sewer pipes, but the real science of things. In the soil of our Province alone are ample problems demanding closer study and investigation, and I can assure you, having studied them somewhat closely for 20 years, that, as with the farmer, who left the legacy of a hidden treasure buried in his fields to his sons, that one will most assuredly find it who delves most diligently and intelligently, whether as farmer, engineer or geologist. But more than the golden treasure will be the knowledge that true work will endure. May you all take Smeaton as your model, and may you have the pleasure of leaving, like his lighthouse on the Eddystone rock, still standing since 1789, some beacon to light up the pathway of some one—some mariner seeking light and safety!

RAILROAD LOCATION IN THE CROW'S NEST PASS RAILWAY.

Don. A. Ross, B.A.

The telegram had come at last, after a month's waiting I was to start for the Crow's Nest Pass, and that on twenty-four hours notice. The next evening I left Toronto, and arriving in Montreal on July 1st, I found that I must wait there for two days. Saturday morning found me bright and early at the station, where I made the acquaintance of the rest of the party.

After a pleasant five days journey we reached Golden on the main line of the C. P. R., where we had to wait three days for the palatial stern-wheeler "Duchess." Fortunately for us there was a delayed Jubilee celebration the day after we arrived. Horse races, foot races, miner's races and pigeon shooting followed one another with true Western rapidity. In the evening there were fireworks, a royal salute of twenty-one sticks of dynamite, and on the hillside above the town blazed forth the well-known letters "V.R." In the town below all was excitement and hilarity; there were lumbermen, railwaymen, cow-punchers, commercial travellers, smooth-faced card sharpers, the omnipresent old-timer in the person of a white-haired negro, and a blue-eyed English "tenderfoot" with gaiters and mocassins, who leaned on both elbows, his back to the bar, and listened with a far-away look, to the sweet familiar strains of "Home, Sweet Home." In the next room, above the twang of the banjo and guitar and the hum of voices, could be heard the cries of the various fakirs—"Red wins, try your luck again, gentlemen! Seven wins! and your money is doubled. Luck's against the Bank to-night. Everyone come in, you're bound to win."

The following morning found us on the forward deck of the "Duchess." All day long we struggled on against the current, now running on a mud bank, again backing water to get around some sharp bend, while mile by mile we left civilization behind us. Just before sunset we reached the head waters of the Columbia River, Lake Windermere, and a more beautiful lake I have never seen. Before us it lay without a ripple, reflecting on its surface the colors of the surrounding hills; at the shore a sage green, then a bright emerald shading off to the deep green of the pine and tamarack, while above all stood, as sentinels, the dark-blue snow-capped summits of the Rockies.

By noon the next day we had reached the head of navigation, where the Columbia and Kootenay Rivers are joined by a short canal. Here we were transferred to a stage, and after an exhilarating drive through dust, mosquitos and heat, arrived at Hanson's, where we spent a sleepless night. The next morning we rattled down into Ft. Steele, where we were joined by our transitman and fore-chain. They had come through the "Pass" with our pack-train, and had arrived an hour before us.

Two days were spent in Steele, an exceedingly lively mining town, and then we moved out to Cranbrook. Here our troubles began. From Cranbrook to the foot of Moyie Lake is twenty-five miles, all up and down hill, and we were "soft." Moreover, during the two days occupied in the trip it persisted in raining, and by the time we reached the foot of the lake everything was soaking wet. However, we made the best of a bad job, and soon had the ground cleared, our tents pitched, and fires blazing in the stoves. It had taken us two weeks to reach our destination, as it was now the 16th of July.

The country through which we had to run the line was heavily wooded, and it took us seven weeks to run the trial line over twenty-one miles. Rockslides, windfalls, beaver meadows and dense brush succeeded one another with a discouraging regularity, while occasionally a rock point or hornets' nest added some excitement to our labor. The beaver meadows were mostly deserted, although one or two were still inhabited, and caused us some annoyance when the water became colder. Owing to the dense brush, progress was very slow. No one who has never been in the bush can realize what it is like. Jack pine, small fir and spruce are all locked together in an indistinguishable mass, and often one is unable to see ten feet ahead.

While at first sight it appeared rather formidable, the country furnished an excellent line. The general character of the topography was very much the same. A range of high foot-hills flanked the river on both sides, with an occasional stretch of meadow-land between the foot of the hills and the river. High rock points jutting out into the middle of the stream seemed to form an almost impassable barrier to the uninitiated eye, but when plotted on the profile it was seen that a few charges of dynamite would make them yield to the onward progress of the road. Often what seemed a good opening for the line would prove, on closer inspection, to be a pocket ending in a high ridge; but as the chief always went over the ground beforehand, we were only once caught by this deception. There was one other feature, however, which proved very troublesome. The mountain streams, which have enormous spring freshets owing to the sudden melting of vast areas of snow, carry down large quantities of gravel and boulders. These are deposited on the flat land at the base of the hills, and thus each year the bed of the stream is built up. We found that the rise on the average for about five hundred feet on each side of these streams was from two to three per cent. As a consequence of this the line had to be swung off down stream, till we could cross on an easy grade.

Our total descent along the Moyie for twenty-one miles was only 250 feet; when we left it we climbed 150 feet in three miles till the summit of the Purcell Range was reached, and from that on, there was a quick, steady drop down the Goat River Canon to Kootenay Lake. The grades on the whole line were restricted to one per cent., and the curves to ten degrees. This restriction gave us a great deal of trouble when we left the Moyie and turned up Meadow Creek to the summit. Here a high sharp peak jutted out into the river, and formed an elbow with steep gravel side hills and rocky bluffs which fell sheer to the river and afforded scanty foothold. We tried six lines here, one jumping the river twice and another going along the top of the slope, while the other four crossed and recrossed one another on the side of the hill. At last we got around on two ten degree curves, a forty foot rock cut and a heavy fill on the far side. Going up Meadow Creek, the only line we could get, owing to our being restricted to a one per cent. grade, was at times below the level of the creek. The chief proposed to run up the centre of the gulch and either divert the creek, or run it into the side ditches. Whether this was done or not I do not know.

We had seven camps altogether. When we had worked about one and a half or two miles past one camp, a new spot would be chosen three or four miles further on. Before leaving for work the next morning everybody had to roll up his dunnage and blankets, help to strike the tents and leave everything ready for the packers. Mr. Grant, the leveller, and myself were usually left on that day to help the packers, clear the new camp ground, pitch the tents, put up the stoves and draughting table and collect the "Rocky Mountain Feathers," i.e., spruce boughs, for our downy couches. This occupation was no sinecure, as there was sure to be a howl from somebody that a stone had been left under his bed, or that he had not enough boughs whereon to lay his tired body.

The pack train, one of the most indispensable institutions of the West, deserves to be noticed. Ours consisted of twelve horses, and it required two trips to move camp. These "Cayuses" are pastured on the meadows along the river and on moving days are brought reluctantly up to camp. After much grunting and groaning the pack saddles are all "cinched." Then comes the packing. Side packs of equal weight are roped on to the saddle, then the top packs, and over all a canvas cover is thrown. The cinch rope is produced, the "diamond hitch" thrown, and then ensues a comical scene. The cayuse braces his four feet firmly and heaves a sigh, the "off" packer places one foot against the pack, and heaves backwards on the rope; the cayuse grunts and appears as if about to die. Then the head packer on his side repeats the performance. The cayuse's ribs must surely be crushed thinks the uninitiated; but if in a quarter of an hour he happens to pass the same sad-faced beast, he will find that the girth is comfortably loose. The cayuse was not born yesterday.

Our life was simple. Early to bed and early to rise was the universal law, and nine o'clock was our hour for retiring. The gong, a frying-pan, was sounded at five thirty in the summer, breakfast was at six. Then after a scramble to make up our lunches, pipes were lighted and we "hit the trail." An hour's halt was made at noon for lunch, a smoke and a nap. The long hot afternoon at last wore through, and at six o'clock we started home to camp. After dinner we would sit around a roaring fire (for the evenings were always chilly), smoke, talk, sing and dream till it was time for bed. November, however, was not conducive to such a pastoral existence. Snow was on the ground and it was not pleasant to lie down or sit in the snow. The noon hour nap was omitted, and in its place we hugged the fire and stamped our toes. No longer did we waste wood in a camp fire, but gathered every scrap for our tents, and someone even gathered in the cook's pile, whereupon the cook got wrathy, and made nasty insinuations about our tents, and dire threats.

As regards the method of procedure, Mr. Lang gave an outline several meetings ago of the duties of the various members of the party, as well as the scheme of location. There had been several reconnaisance parties over the route since the original C. P. R. survey (in '82, I think), but the one upon which we based our work was that made by Mr. Hogg in 1895. This was scarcely more than a guide to the country. They had taken the distance along the trail by means of stadia hairs and run flying levels through, establishing "bench marks" every few miles. The levels of occasional ridges and of the river were ascertained by means of a barometer and proved to be very accurate. The distance of the river from the trail had been guessed at. This of course could not be relied upon unless the river was quite close to the trial.

The chief of our party, as I have mentioned before, went ahead with a hand level in order to get a more accurate idea of the country. With the aid of his hand level he picked out points along the hill sides which corresponded to the grade he desired, and when the transit party came along, the line was run to these points. Where the bush was too dense for the transitmen to see the chief, the latter would yell, or fire his revolver, and the transitman would turn his instrument towards the sound. The forepicket man then went ahead to give line for the axemen, and he was followed by the chainmen who put in stakes every hundred feet and measured the "plus" of the hubs. The stakes on the preliminary line were marked "P" and on the location line "L." If two or three trial lines were being run over any point they were marked A, B, C, etc. When the picketman reached the chief he put in a hub; the transitman checked on the back sight, for we had no back picketmen, noted the angle turned, and then moved forward to the new hub.

Behind him came the leveller and topographer. The latter had no assistants, but was provided with a ten-foot rod and a clinometer. With these he took the slope of the ground across the line and for some distance on both sides. If the river was near he would pace out the distance; if too far away for that, he would approximate it. He also noted the distance to the foot-hills and to the trail, if it were near. The leveller took the profile along the line every hundred feet or wherever there was a sudden break in the profile of the land. The levels were carried from a Bench Mark at the foot of Moyie Lake, which had been established by Mr. Hogg, and when we checked on another of their benches at the summit the difference was only 2-10ths of a foot. Bench Marks were put in every quarter of a mile, and we had to check on these again when the location line was run. When it was found that the line was rising or falling too rapidly (as for instance on approaching one of the mountain streams), the line would be directed up or down hill, as required.

When the trial line was finished we moved back to Moyie Lake and began the location proper. This was much slower than preliminary work. By aid of the cross-sections which the topographer had made and the profile of the trial line, the chief was enabled to tell approximately what would be the elevations along his final line. If the latter when found did not correspond fairly well to the approximate profile, new lines would be tried, till one was secured which suited the desired grade. In place of the angles secured in the trial line, curves were of course substituted and the original tangents were moved up or down hill as required. In order to save time in chopping out the curves, the transitmen deflected three hundred feet chords and the chainman put in the two intervening stations by offsets.

Mr. Haney, the Manager of Construction, adopted a system of supervision, i.e., one engineer would be sent on to supervise the work of his predecessor, and wherever possible improve on it. By this method several important and economical changes were made, as the supervisor could pick out what he considered the weak points in his predecessor's line and bend his whole energies towards improving them. Besides this supervision, there were of course the usual changes made by the engineers on construction.

About the beginning of December I commenced to think of Varsity and examinations. For fifteen dollars I bought a cayuse with saddle, bridle and halter, but without a pedigree. On the fifth I set forth on my two hundred and twenty-five mile journey to MacLeod, and arrived there on the tenth day. The trip out was anything but pleasant; rain, snow, frost and slush are my chief recollections till I reached Crow's Nest Lake, where I was "put up" for the night Stan Gzowski. The next morning I set out in the teeth of a howling snow storm. The cayuse trotted on bravely till we got out of the shelter of the "bluffs," but then he stopped and no amount of argument, physical or vocal, would make him go ahead. After a fierce controversy I had to clamber off and tow that brute against what seemed to me to be a thirty-mile-an-hour wind. That night I gave him away to one of the contractors, and the next day drove into MacLeod with one of his freight teams. After waiting there three days I caught a train to Calgary and arrived in Toronto the day before 'Xmas, after an interesting and instructing summer with the engineers.

LOCATION AND CONSTRUCTION OF CROW'S NEST PASS RAILWAY.

J. L. DAVIDSON, '00.

The construction of the Crow's Nest Railway was notable, from an engineering standpoint, for at least two features, the celerity of construction and the skill shown in overcoming serious obstacles. To build a road through the Rocky Mountains with a maximum grade of 1%, seems well nigh impossible, yet this has not been exceeded, and the railway is, at the present time, the best which crosses the mountains.

Location was commenced in April, 1897, at Lethbridge, and, since preliminary lines had been run in 1892-3, there was a good idea as to the general route to be followed. Starting from Lethbridge, in Alberta, it ran to Fort MacLeod, thence to the Pincher Creek, following the middle fork of Old Man River to the summit of the Rocky Mountains, down Michel Creek to Elk River, thence to Kootenay River, to Cranbrook and to Moyie Lake, along Moyie Lake, down Moyie River to Goat River Summit, down Goat River to Kootenay flats, round the west side of Kootenay Lake to the Narrows, and down the Narrows to Nelson; in all, a distance of 290 miles.

Location was carried on from five or six different bases; westward from Lethbridge, starting in April; westward from Elk River to Kootenay River, starting in May; westward from Wardner to Moyie Lake in May; down Moyie River from the foot of Moyie Lake to Goat River Summit, starting in July; from the summit westward to Kootenay Flats in November; and from Kootenay Flats round the lake to Nelson in April, 1898. All the location proper was finished in March, 1898, although a good deal of re-location was going on during construction.

On leaving Lethbridge it is about a half mile to St. Mary's River, where there is about three miles of trestlework. A fly-line was run down along the side hill to the flats, so that the steam pile-drivers could be working below, as well as above. Three tracks were run along the course of the road, one outside of the trestle-work, and two inside. The steam pile-driver, driving the outside sloping piles, came first, followed by the one driving the upright piles. The first pile-driver was on two flat cars, one on each track, and was shifted from side to side as the piles were driven. With the upright piles the driving was done at the rear end of the cars, as the piles were driven in between the tracks. In the meantime, material was brought along on the track outside, and a steam timber derrick putting it in place for the pile-driver. Pile-drivers were at work up above from the east end of the bridge. In this way the trestle was constructed in remarkably quick time.

Temporary work was constructed under the span by means of decks, the decks being brought along already made up. One deck is laid on top of another till the necessary height is reached; the span is then placed in position, and the temporary work is taken away.

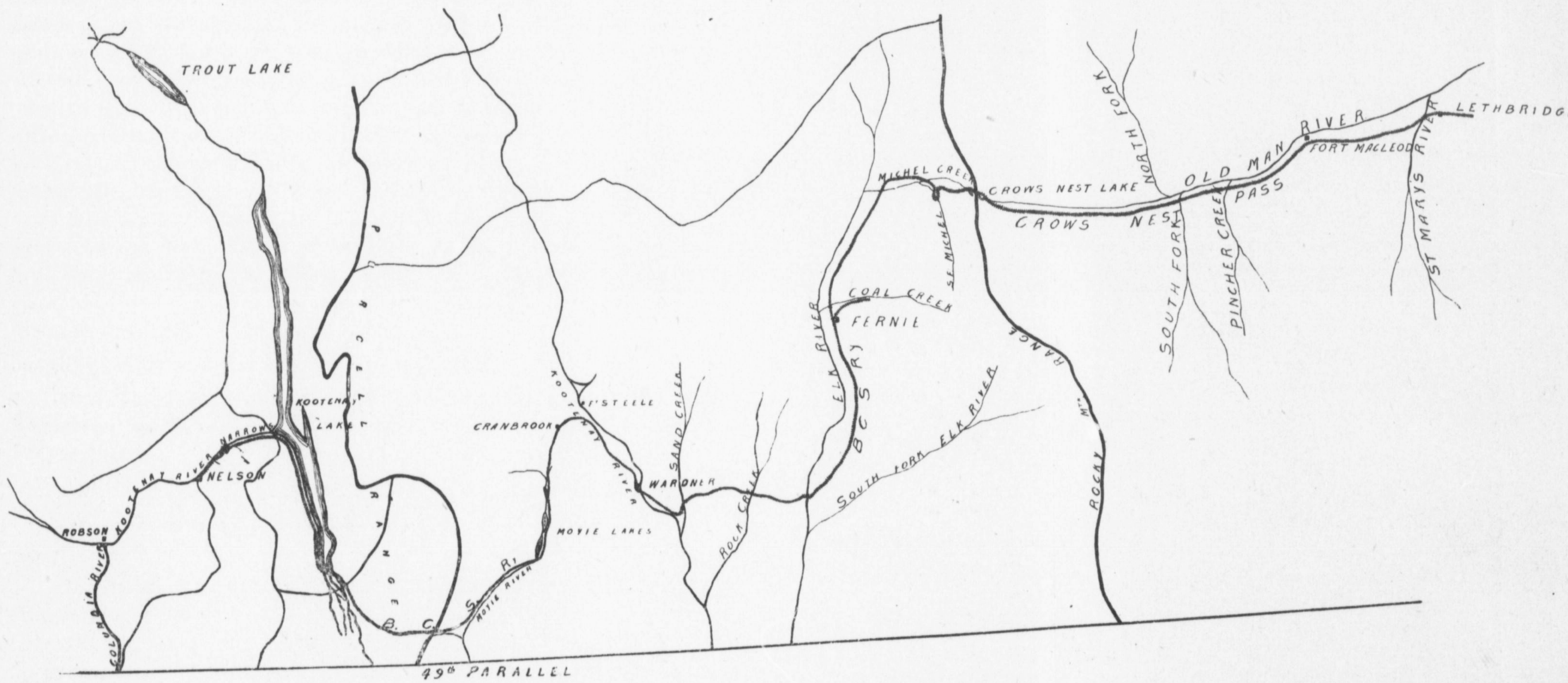
The line crosses the valley, swings around a 10° curve on the trestle, and follows along the coulees. Very heavy cuts are encountered here; one, after the slopes being taken out, was 120,000 cubic yards. A trestle, 900 feet long, is next with a 200 foot span. Heavy cuts again intervene, and six-mile coulee bridge is reached. Piles were driven to a height of 40 feet, and then decks of 15 feet were strung across on the temporary work, and pulled up into position. A cable is stretched across the coulee, block and pulley are attached to the cable, and the bents placed in position one by one.

It was impossible to locate around the hogs backs that jutted out from the side hill, so that it was necessary to have trestles and heavy cuts.

Eight-mile Coulee trestle is next reached; this is 600 feet long and 110 feet high. The piles were driven to a height of 50 feet. There is a 15-foot deck and bents up to grade here. After passing through a very heavy cut a trestle 900 feet long on a 3° curve was constructed in the same manner as the one above. Heavy cuts and fills with a few small trestles are encountered till 16-mile Coulee trestle is reached. This trestle is 800 feet long and 133 feet high, with 200 feet span.

The temporary work consisted of three decks for the span, 35 feet each, the bents being 15 feet apart.

The line now comes out on the rolling prairie, and no difficulty



Open culverts are used up to a height of 5 feet for spans of 12-14 feet. Eight stringers are used.

would be working below, as well as above. Three tracks were run

with 200 feet span.

The temporary work consisted of three decks for the span, 35 feet each, the bents being 15 feet apart.

The line now comes out on the rolling prairie, and no difficulty is encountered to MacLeod, 37 miles. The road then follows up the Old Man River, and crosses Pincher Creek, 22 miles distant, with a trestle 1,200 feet long and 122 feet high, with a span 250 feet long. It then follows the south side of Old Man River, with a rising grade, till the south fork of Old Man River is crossed. This bridge is 840 feet long, and 135 feet high; two spans of 150 feet each; piles 30 feet and decks of 15 feet bents: temporary work for spans, 15 feet bents 15 feet apart for 70 feet in height, then 30 feet deck to span. The road then winds in and out along the south bank of the Old Man River, and the foot-hills of the Rockies are soon reached. Heavy rock cuts are encountered now. A trestle was erected on a 4° curve over a dam, but the whole side-hill, 1,200 feet across started to move toward the river; the trestle had to be abandoned, a lower grade taken, and a fill was made instead of trestling. It was necessary to keep ballasting this, as the grade kept sinking. The cause of this, from all appearances, is that there is loose material embedded in the hollow, the sides and bottom of which are solid rock.

The entrance of the pass is made at 92 miles.

In the mountain division trestling and culverts are of the greatest importance, as they are used in very great numbers.

The trestles consisted of single deck trestles up to 40 feet on soft material piles to be used and on hard ground mud sills are used.

The standard trestles run up to 110 feet, with diagonal bracing on all over two decks.

The culverts employed are box, pile and open; box culverts are the most used culverts in a mountainous country, and on this road are used in great numbers. Where there is a fill in a drain a culvert is put in, unless the water can be drained along the side of the dump. If there is a small stream the size is generally 3 feet × 3 feet. Box culverts vary in size from 2-4 feet in width, and from 2-5 feet high.

Sometimes it is necessary to put in a double box culvert; these are generally 4 × 4 feet. Some of these on this road are over 100 feet long. Open culverts are generally pile culverts, and are from 6-14 feet in width. Mud sills used on hard ground.

Open culverts are used up to a height of 5 feet for spans of 12-14 feet. Eight stringers are used.

The line follows up and crosses the Old Man River with a single span. In three places the course of the river is changed, as a much better location was to be had by this change.

There is a steady rise in the grade, heavy cuts and fills are now the order. Crow's Nest Lake is next reached at 100 miles from Lethbridge. Very heavy rock cuts are encountered along this lake, with the grade still going up. The divide or summit of the Rockies is reached at a distance of 105 miles, which is passed at an elevation of 4,434 feet. Summit Lake is next reached, only a few hundred feet from Crow's Nest Lake, but the latter is drained to the east by the Old Man River, and Summit Lake is drained to the westward by Michel Creek.

By the Government contract 100 miles was to be finished by January 1st, 1898. This was finished December 13th, 1897.

There being no waggon road west of Crow's Nest Lake it was necessary for the company to have one. It was started in July from Crow's Nest Lake and from Kuskonook in September, these met on Moyie Lake in November. Over 200 miles of waggon road was built in four months.

The location being nearly all complete to Kootenay Flats, contractors were put in all along the line from Crow's Nest Lake to Kuskonook by January 1st, 1898.

Store-houses were built on an average of 25 miles apart in the mountain divisions. Supplies were rushed in from MacLeod and from Nelson to Kuskonook, and in the centre from Jenning's, Mont., by Kootenay River to Wardner. Mail service was established along the line, and by February between six and seven thousand men were employed on the line.

On leaving the summit the grade begins to fall steadily, heavy rock cuts and fills are very numerous here at 4½ miles from the summit the line enters the Loop. A long narrow hill jutted out from the side-hill, which is between the main fork and south fork of Michel Creek.

A tunnel was located here, which was to have been 1,100 feet long, but this had to be abandoned. The construction of the tunnel was first started at the east end, and about 40 feet had been taken out, when the whole side hill began to cave in, and the casing of the tunnel began to sink; this will finally be made an open cut.

Location was then made down the north side of Michel Creek, but this was impossible unless a greater grade be used. The location was then started at the eastern end of the tunnel, down along the side hill, heavy gumbo cuts and fills and sharp curves of 10° and 12° being mostly used till the nose of the hill is reached, which is about 1½ miles from the abandoned tunnel. The line turns on a 20° curve around the nose of the hill, coming out of a 40-foot gumbo cut onto a trestle 55 feet high, which is also a part of the curve; special permission had to be given here for the 20° curve, as no greater than 12° is allowed. The reason the trestle was erected here was that the dump could not be made owing to the steep side-hill, and the material would slide down the side-hill to the dump below.

On rounding this curve the line follows up the east side of the south fork of the Michel Creek for three miles; sharp curves and heavy cuts and fills are numerous. At the end of the loop the line turns on a 10° curve, crosses the south fork of the Michel Creek, and follows down the west bank of the creek; sharp curves and heavy jumbo cuts are very numerous here. The grade is still dropping steadily. The south fork is again crossed, and the line follows down the east bank of the creek, and comes out of the Loop at the bottom of the hill it went in on, some 350 feet below. The track laying machine had great difficulty here in laying the rails, as the soft gumbo dumps kept sinking, and the machine was derailed every few hundred feet. The line follows down the main creek to Elk River. The main Michel Creek is crossed with a single span 150 feet long. The line follows down Elk River to Coal Creek (140 miles from Lethbridge). Here is situated Fernie, which is a divisional point, a branch four miles long has been built up Coal Creek to the coal mines. The grade of the latter runs as high as 3%.

Coal Creek is crossed with 160 feet span, follows down the east side of Elk River for 17 miles, and crosses at a distance of 157 miles.

The first location line that was run kept along the east side hill of the river, and crossed three miles below the present crossing; this location necessitated two tunnels, one on each side of the crossing, and after crossing the line kept 4-6 miles south of the present line.

On crossing the river a 78,000 cubic foot gravel cut is the first heavy work encountered, and a 945-foot trestle on a 4° curve. Heavy rock and earth cuts are met with, and heavy fills. Rock Creek is crossed with a high trestle, and Sand Creek with 100-foot span. Heavy earth cuts and fills are encountered every few hundred feet. Kootenay River is next reached; the line follows along the east bank for 13 miles; heavy earth and rock cuts with two trestles, one 110 feet standard, and 70-foot trestles, till Kootenay River crossing is reached.

This bridge consists of four spans and a 180-foot steel arch swing. Before the rails reached this bridge piles were driven, and temporary bents put in place; the stringers were run across, and all was in readiness for steel swing. The steel swing was brought along on the construction train, and put up in eleven days. The first train crossed the Kootenay bridge on July 29th, 1898.

From Wardner west to Kuskonook the dump was all completed but 12 miles on August 15th, a distance of 112 miles.

Kootenay River crossing is one of the lowest points on the line, having an elevation of 2,400.

On the west side of the crossing there are heavy rock cuts and fills. Wardner is reached, which is 188 miles from Lethbridge.

The line follows up the west bank of the Kootenay River for six miles, with a rising grade. The work to the Isidor Canyon is alternately light and heavy. The work in the canyon is very heavy. Rock cuts and heavy fills; there are also a large number of sharp curves. The grade is still rising till the summit of the canyon is reached, here heavy rock cuts are again encountered, with heavy fills. The grade begins to drop till Cranbrook is reached; this is the next divisional point, a distance of 210 miles.

From here there is a branch located to the North Star Mine; this branch runs north, and crosses the St. Mary's River at the St. Tugene Indian Mission, which is five miles north from Fort Steele, and then runs in a north-westerly direction to the North Star hill. This will tap the west part of the Fort Steele mining district.

From Cranbrook to Moyie is down grade, and the work heavy. Palmer's Bar Creek is crossed with trestle on a 4% curve. Moyie River is crossed with a single span. Heavy rock and earth cuts are now encountered till Moyie Lake is reached; this lake is 10 miles long, and the narrows between is one mile long.

The grade along this lake is level at 3,000 feet. A tunnel 650 feet long in solid rock on the East Lake was the heaviest piece of work.

Two tracks were laid with a switch at the outer end. Horse cars side dumping were used to draw the blasted rock out. Work was started from both ends, so that the construction was done in remarkably quick time.

The rock cuts are very heavy along this lake, very little of which is needed for fills. The grade being only 14 feet above the level of the lake at low water, and six feet at high water.

The line now follows down the Moyie River for about 22 miles. A great deal of piling was done on this section, as there were numerous marshy meadows. Irishman's Creek is crossed with a single span. The work is not very heavy till about five miles from Goat River Summit, where the grade begins to rise. Very heavy cuts and fills are encountered; the line follows along the north side hill, and swings around in a north-westerly direction, leaves the valley of the Moyie and follows up Summit Creek to Summit Meadow, the elevation of which is 2,860 feet. The line follows down the centre of the meadow, and it was necessary to pile the greater part of this. The line now follows Kid Creek, the grade begins to fall, and work becomes very heavy, and sharp crosses have to be used in great numbers. The line keeps to the west side of Kid Creek. A mile and a half from the summit the line enters the loop on Carrol Creek, and winds up along the south side hill for three-quarters of a mile. Very heavy rock cuts and fills are encountered. The line then crosses Carrol Creek on a 12° 30′ curve, the angle of the curve being 228° 110 feet. Standard trestle is used here with a 150-foot span The cuts on both sides of the crossing are very heavy; 76,000 cubic yards of rock on the south side, 55,000 on north side. The line follows down the north side of Carrol Creek, and swings around on a 12° curve, and follows the valley of Kid Creek once more. Heavy cuts and fills are encountered. Kid Creek runs into Goat River, and the line follows down the west side hill of Goat River. The heavy work continues, and Goat River Canyon is reached. Very heavy cuts are met with; two especially heavy ones, one on each side of the crossing, 62,000 and 53,000.

The river is crossed with a single span 200 feet long, at a height of 165 feet above the river bed. The walls of the canyon are solid rock, and nearly perpendicular.

The approaches of the bridge were all in readiness for the span, and as soon as the rails arrived at the bridge, work commenced at once on the span, it being brought along on the construction train. The span was completed in eleven days. The line now follows down the east side of the valley, and passes on the right of Duck Lake. Duck Creek is crossed with a trestle and 70-foot span. The work along the lake is heavy, rock cuts being the main feature. Another branch of Duck Creek is crossed with a span, and the work is heavy till the Kootenay River is again reached, after its wanderings in Montana and Idaho. The river comes out on what is known as the Kootenay Flats, and is divided into three branches. To cross this flat $4\frac{1}{4}$ miles of trestlework was necessary, with three bridges, with three, two and four spans respectively, and one steel arch swing bridge of 200-foot span. Temporary bents were driven, and the piles for the abutments; then stringers were strung across. These bents on the trestlework appeared to be much higher than they need be; this is on account of the height to which the water rises; at high water Kootenay Lake rises 38 feet.

The work ceases at the end of this trestle, but the charter and contract extends to Nelson, but the company have two years' time from October, 1898, to build this in.

The work around the west side of Kootenay Lake and the Narrows is the heaviest work on the line, being solid rock, and will cost on an average $35,000 per mile, and the distance is 53 miles.

There is a transfer slip, which is used to transfer the cars from the line to the boats, this is very long, owing to the great height to which the water rises on Kootenay Lake. Barges are used to carry the cars across the lake; these are towed by the steamer.

The cost of the road was very heavy. The first hundred miles cost, on an average, about $14,000, the second 100 miles about $13,000, and the third 100 miles about $19,000 per mile.

JUNKERS' GAS CALORIMETER.

W. H. Ellis, M.A., M.B.

The great extension of the use of gas as a source of heat which has taken place of late has rendered imperative some reliable means of ascertaining the heating power of gaseous fuel.

The apparatus devised by Professor Junkers of Dessau, enables such determinations to be made very easily and rapidly, and with considerable accuracy.

The principle on which this instrument is constructed is that of a condenser, within which the gas is burnt while the temperature of the inflowing and outflowing water is observed, together with the quantity of water which passes through the apparatus during the combustion of a measured volume of gas.

These data give us the value required; for if $t =$ the temperature of the inflowing water; T the temperature of the outflowing water; W the number of grammes of water which have flowed out during the combustion of V litres of gas, measured at normal temperature and pressure; then if H equal the heating power of one litre;

$$H=\frac{(T-t)W}{V}.$$

The calorimeter consists of a cylindrical chamber, in which the gas is burned from a Bunsen or other suitable burner, surrounded by a water jacket, traversed a number of tubes down which the products of combustion pass from the top of the chamber to a flue at the bottom, through which they escape into the air.

Outside the water jacket is an annular air space to prevent radiation. For the same purpose, the outside of the instrument is nickel plated, and brightly polished.

To promote transferrence of heat from the gases to the water, the cooling tubes are made of very thin copper. Since the apparatus remains at the same temperature throughout the experiment, its water value does not come into consideration. The volume of gas used is read off on a meter. Thermometers, divided into $\frac{1}{10}$ of a degree, are fixed in the inlet and outlet, and the water is measured in a graduated glass vessel.

To illustrate the use of the instrument, I will give the details of a determination of the heating power of the gas supplied to the School of Science from the city mains.

Three litres of gas, at 18°c., and 744mm. pressure, in burning raised 1005 grammes of water from 4.85°c. to 21.46°, or 16.61°c. Reduced to 0°c. and 760mm., 3 litres becomes 2.764l. Hence

$$H = \frac{1005 + 16{\cdot}61}{2{\cdot}755.} = 6059 \text{ cal.}$$

The heating power of the city gas is then 6059 small calories, or 6.059 great calories per litre; or 6059 great calories per cubic metre; or 6.059 × 28.315 = 171 great calories per cubic foot; or 171 × 3.968 = 678.6 B. T. U. per cubic foot.

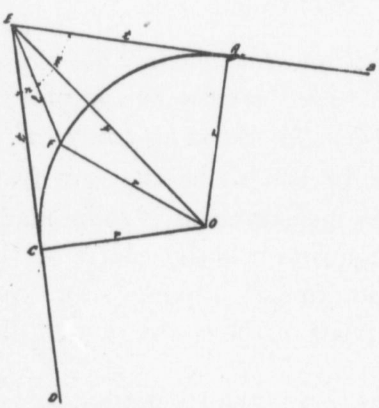
So complete is the cooling, that the products of combustion leave the apparatus at a temperature below that of the atmosphere when the inflowing water is very cold. This introduces a slight error of excess. On account of the low specific heat of the gases, however, this error is only trifling. Thus, Mr. H. W. Charlton and the writer obtained for hydrogen, a heating power of 3095 cal. per litre, which corresponds to $[H^2, O] = 68790$. Thomsen's value being 68360; our number is 0.6% too high.

The result of a three months' test of the instrument at the Physicalisch Technische Reichsanstalt at Charlottenburg, was that Junkers' Calorimeter gave a value for the heat of combustion of hydrogen not differing from that of Thomsen, by more than 0.3%.

An instrument manufactured in England under the name of Dowson's Calorimeter, is constructed on the same principle as Junkers'. Judging from a description of it in the catalogue of an instrument dealer, it appears to differ chiefly in arrangement, by which a constant supply of water is secured.

NOTES FROM AN ENGINEER'S POCKET BOOK.

By A. E. Lott, Grad., S.P.S.



Problem.—*AB and CD are two tangents intersecting in E and F, a point between them such that the distance*

$$EF = l$$
$$\text{Angle } AEF = m$$
$$\text{Angle } CEF = n.$$

To find the radius r of circular curve connecting the tangents and tangent distance AE and CE = t.

In the triangle $CEO + \frac{t}{r} = cot.\ \frac{1}{2}\,(m+n)$

$$\therefore\ t = r\ cot.\ \tfrac{1}{2}\,(m+n) \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

" " $+ \frac{r}{k} = sin\ \frac{1}{2}[(m+n)$

$$\therefore\ r = k\ sin\ \tfrac{1}{2}\,(m \times n) \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

In the triangle $EFO + \frac{r}{k} = \frac{sin\ E}{sin\ F} = \frac{sin\ \frac{1}{2}\,(m-n)}{sin\ F}$

$$\therefore\ r = k\,\frac{sin\ \frac{1}{2}\,(m-n)}{sin\ F} \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

From (2) and (3)...$sin\ F = \frac{sin\ \frac{1}{2}\,(m-n)}{sin\ \frac{1}{2}\,(m+n)}$ which is determinate

since the angle F is greater than 90° in this case.

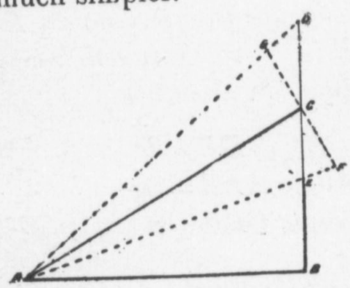
The angle.... $O = 180^\circ\ [\frac{1}{2}\,(m-n)+F]$

$$\text{also} \ldots\ldots\ldots \frac{r}{l} = \frac{\sin \frac{1}{2}(m-n)}{\sin O}$$

$$\therefore\ r = l\,\frac{\sin \frac{1}{2}(m-n)}{\sin O}$$

$$\text{and from (1)} \ldots t = l\,\frac{\sin \frac{1}{2}(m-n)}{\sin O} \times \cot \tfrac{1}{2}(m+n).$$

When the angle AOC is greater than 180° the construction still holds but in that case the angle EFO is less than 90°. Where the tangents are parallel the construction fails but the problem is much simpler.



Calculation of a table for the reduction of inclined stadia measurements to level when the rod is held vertical.

A is supposed to be the zero from which the measurement is to be made, in some transits it is the centre of the instrument and in others a short distance in front of the centre, which distance may be called c.

B is a point on level of A so that AB is the level distance.

C is in the direction of the centre hair or axis of telescope so that the angle CAB is the angle of elevation, and DE is the distance indicated on the rod.

GF is at right angles with AC so that $CG = CF$.

$\angle CAB = \angle DCG = \angle ECF$.

$AC = k\ GF$. (Of course in most instruments $k = 100$.)

$CG = CD \cos DCG - a$.

$CF = CE \cos ECF + b$.

$\therefore GF = DE \cos DCG - a + b$. But as the angle FAG is very small when $k = 100$, a and b may be considered practically equal at all elevations which can be read on an engineer's transit.

$\therefore GF = DE, \cos DCG = DE, \cos CAB = DE, \cos$ elevation.

$AB = AC, \cos CAB = k\ GF \cos CAB = k\ DE \cos^2$ elevation.

Therefore,

Hor. distance = 100 × Dist on rod × $\cos^2$ elevation when zero is centre of telescope.

Hor. distance $=(100 \times \text{Dist. on rod} + c)\, cos^2$ elevation when zero is not at centre of instrument.

The table may therefore be said to be a table of multipliers, which multipliers are merely the squares of the natural cosines of angles from 0° to 45°, for since $sin^2\, a = cos^2\, (90 - a)$ and also $sin^2\, a = 1 - cos^2\, a$, therefore, to find the multiplier for any angle greater than 45° subtract the multiplier for its complement from unity.

Usually a table for even degrees will be sufficiently accurate, but may also be calculated for each ten, fifteen, twenty or thirty minutes as follows:—

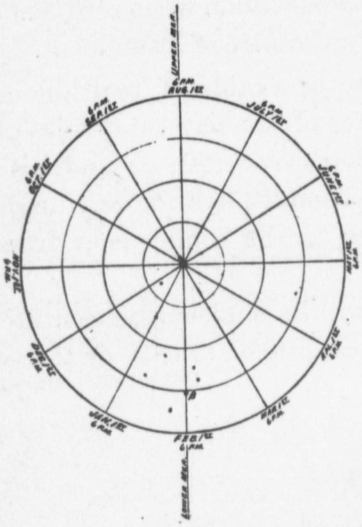
Take the angles of 20° and 30°.

Angle.	Tab. Log. of cos.	Tab. Log. of cos × 2.	Corresponding number from table.
20°	9·9729858	9·9459716	·88302
30°	9·9375306	9·8750612	·75000

Of course, in the third column marked, "Tab. Log of cos × 2," instead of 9·9459716, the number corresponding to $\bar{1}$·9459716 is taken from the table of logarithms of numbers, and the third column is derived from the second by multiplying by 2 mentally

TABLE CALCULATED BY ABOVE METHOD.

ANGLE OF ELEVATION.	MULTIPLIER.	ANGLE OF ELEVATION.	MULTIPLIER.	ANGLE OF ELEVATION.	MULTIPLIER.
1°	0·99970	16°	0.92402	31°	0.73474
2°	.99878	17°	.91452	32°	.71919
3°	.99726	18°	.90451	33°	.70337
4°	.99513	19°	.89401	34°	.68730
5°	.99240	20°	.88302	35°	.67100
6°	.98907	21°	.87157	36°	.65451
7°	.98515	22°	.85967	37°	.63782
8°	.98063	23°	.84733	38°	.62096
9°	.97553	24°	.83457	39°	.60396
10°	.96985	25°	.82139	40°	.58682
11°	.96359	26°	.80783	41°	.56959
12°	.95677	27°	.79389	42°	.55226
13°	.94940	28°	.77960	43°	.53488
14°	.94147	29°	.76496	44°	.51745
15°	.93301	30°	.75000	45°	.50000



Approximate method of obtaining the mean time at night.

May be used at any place in the northern hemisphere north of Lat. 20°.

The circles represent circles of declination on the celestial sphere from the centre or north pole to 70° north declination, being at intervals of 5°.

The black points represent some of the stars of the constellation "Ursæ Minoris," of which the two brighter ones are the pole star near the centre and B Ursæ Minoris on the lower meridian near the declination circle of 75°. The smaller points represent the smaller stars which help to form the so-called "Little Dipper."

On FEB. 1ST *B* is almost exactly on the lower meridian at 6 P.M., and of course moves forward 15° every hour so that at 8 P.M. it is on the line marked MAR 1ST at 10 P.M. on line marked APL. 1ST at midnight on line MAY 1ST, and so on to line of AUG. 1ST at 6 A.M.

The star moves forward 1° app. each day so that on MAR. 1ST at 6 P.M. it is about on the line thus marked.

With a little practice the hour may be calculated by inspection on any clear night within 15 minutes and very often much closer.

SOME ADVENTURES ON THE ABITIBI.

E. V. Neelands, '00.

It was my good fortune last spring to be appointed as assistant on the surveying party in charge of Alex. Niven, O.L.S. Our work was to complete the boundary line between Nipissing and Algoma, about 180 miles in all, from Night Hawk Lake to the Moose River.

We left Temiscamingue on May 22nd, and after crossing a six-mile portage proceeded up the Montreal River in canoes. The current was swift and heavy, but by paddling, towing and poling, we reached the height of land after five days. Then, by utilizing a chain of small lakes, we arrived at Night Hawk Lake on June 5th, and commenced our work.

Nothing of moment occurred until we reached the Abitibi River about the middle of July, where we met our supply men, who had gone to Fort Abitibi for supplies. They also brought the mail, already a month and a half old, and which was the last we were to receive. They had lost one canoe descending the rapids, but everything else was safe.

Our supplies were to descend the Abitibi, which at this point is nearly parallel to the line, for about sixty miles, and were then to be packed into the main camp, a distance which the map showed to be about fifteen miles.

However, when we got opposite New Post, the point from which the supplies were expected, no one appeared. We ran the line on for about a week, in the hope of meeting our supply men ahead, till we were forced to stop for want of food. It was then decided to send eight men to look for New Post, a Hudson Bay fort, and the only place where supplies could be obtained within at least two weeks. The remaining men were to remain in camp until we returned.

About enough bread for two days was all that they could spare us. In addition to this, the position of New Post was very uncertain, the map, Ogilvie's report, and the latitude differing from each other by as much as twenty-two miles. Still, it seemed the only chance.

Our plan was to work back along the line twenty miles, and then turn west, and march out to the supposed site of the Fort. Owing to the lack of provisions, however, we were forced to modify this plan, turning west eight miles back. We left notes on all the mile-posts stating our plans, in case of the arrival of the supply men. We camped on the line that night, and the next day started west, and walked all day, fording and swimming rivers.

About night we heard the roar of a rapid ahead, and pushed on eagerly, thinking it must be the river, as, by our estimation, we had come fully fifteen miles. Imagine our disappointment when we saw, from the dark red water, that it was not the Abitibi.

It was too late to cross then, as it was already dark, so we camped on the bank that night. It was a gloomy situation; we had only one small loaf left among eight of us; we did not know where we were; and it was cold and raining.

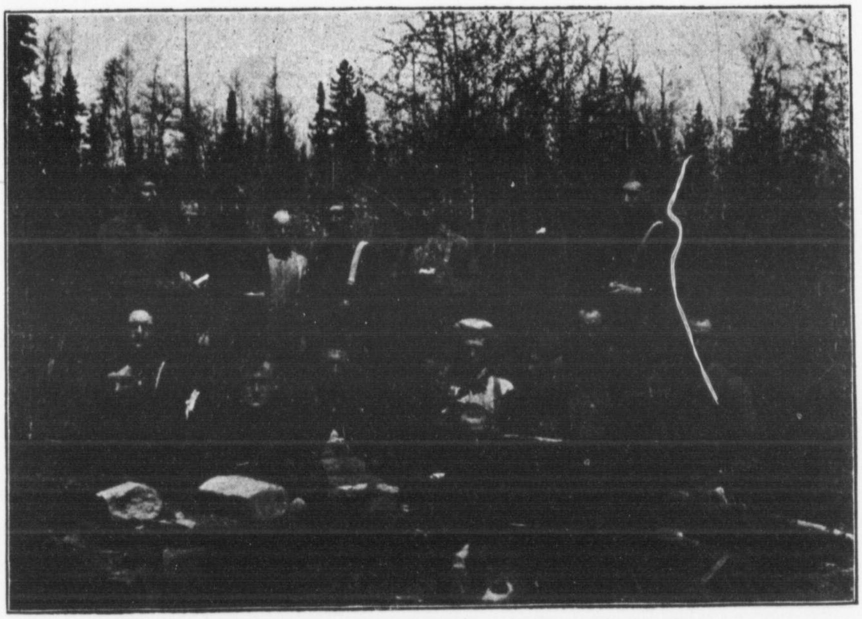
Next morning at daybreak we ate the last of our bread, and started to ford the river in the rapid; one of the men was already across, and the rest were in the river, when we heard a shout down stream, and presently a canoe came around the bend with one of our supply men, Toussaint Hunter, in it.

They had reached the line the same day that we left, and on reading one of our notes Toussaint had come back, travelling all night through the bush to head us off at the river. We learned from him that it was twenty-five miles to the Abitibi, instead of thirteen, and that we were not going in the right direction to reach the Fort, so his arrival was most opportune for us, as if he had been about five minutes later he would have missed us, and we would have starved in the bush.

After a delay of nearly ten days we were able to rejoin the remainder of the party on the line with the supplies.

From that time on the work was pushed steadily to a close. On October 1st we again crossed the Abitibi, and a few days later the Moose River, here over a mile wide on the line, pushing our work three and a half miles north of the latter.

On October 10th, after obtaining supplies from Moose Factory, the chief Hudson Bay post on the bay, we commenced our return journey, and found it even more difficult than we had anticipated. The current was so swift and heavy that we could seldom make more



Niven's Party.

Portaging.

than ten miles a day against it. In addition to this, we had to encounter a series of very bad rapids, one nine miles long, all of which had to be poled, as there was no portage cut.

After a week's hard struggle we reached New Post, sixty miles above the line; here we spent Sunday, the first night under a roof for nearly five months. Next week we worried our way on up the river, poling, towing, paddling against a current that never seemed to slacken. The hardest work came on Saturday, when we poled up the Long Sault Rapids, seven miles, through a storm of rain and sleet.

Next day the weather turned suddenly colder, and from Sunday till Thursday we worked our way on up stream in a continual snow storm. The snow now was very deep, and camping was a most elaborate process. It was necessary to go ashore about 4 p.m., in order to prepare for the coming night.

The work in the rapids was now particularly severe, as the spray from the icy water and the snow made it impossible to use a canoe pole for more than a few minutes at a time, while wading was almost unbearable. At night the canoes had to be thawed out over a fire, as each day snow and ice would accumulate on them till they were almost unrecognizable.

On Thursday morning we were congratulating ourselves that our troubles were almost over. "To-night," we said, "we'll get to the lake, and by noon Saturday we'll reach Fort Abitibi." But, as usually happened, our hopes were doomed to disappointment. When within about eight miles of the lake we were stopped by pack-ice, jammed in the river as far as we could see. We broke through it, however, with poles, but reached the lake only to find what was apparently a worse condition of affairs there, but on climbing the high bank we saw that the ice did not extend more than two miles at the most. We broke our way through this also, and reached the open lake that night, though too late to cross, as there was a heavy swell from the north, and our boat, a bark one, was leaking in every seam, being badly strained by the ice. We decided, therefore, to camp and make a desperate attempt to reach the Fort by the next night.

Imagine our disappointment when next morning we discovered that the lake was frozen over as far as we could see. It was impossible to walk, as the ice was too thin, yet it was too thick to break through in canoes. It was over 100 miles to the Fort by the shore, and this was through country so rough and snow so deep that we could not march more than ten miles a day. In addition to this several of the men were not in condition to undertake a trip of this kind, and we had only one day's provisions left.

Good fortune had not altogether abandoned us, though, for it happened that an Indian taking his winter supplies down the river had also been caught by the ice, and after some difficulty was induced to let us have a bag of flour and a smoked beaver. We also caught a few fish and two days later shot a cariboo.

By Tuesday the ice became solid enough to walk on, though not without considerable risk; but as our food supply was again becoming sadly reduced, we were forced to start. Two of our Indians left us here, under the pretence of catching fish, and following us later. The rest of the party abandoning the canoes, and everything except what was absolutely necessary, began the march for the Post. We took one canoe with us on a sleigh in case of meeting open water.

On the following day the weather turned so soft that it was impossible to use the ice, and two days later a warm south wind broke up the ice completely. By this time we were reduced to a slice of bread a meal, and more than half the men had nothing left for next day, and we were not yet half way to the Post.

That same afternoon we discovered an Indian "cache," containing some fish and flour. These we immediately appropriated, and also two old bark canoes which we found. The two Indians who had left us came up with one of the boats left behind, so that we now had enough to carry the whole party.

Next morning, notwithstanding a heavy swell, we again set out, each canoe paddling as hard as possible to get through. When still about twenty miles from it a heavy fog suddenly arose, so that we could not see 100 yards ahead. As no one in our boat knew the lake it was impossible to run, except by compass. We blundered on as well as we could till about 4 p.m., when we heard yelling close at hand through the fog, and heading for it we found an Indian shanty on the shore. They told us the way to the Post, and we again set out.

We had gone about seven or eight miles when it became so dark that it was impossible to go on, so we landed and boiled some tea, though we had no food. We stayed around our fire till about 1 p.m., when the fog having lifted somewhat we decided to try again.

A point about two miles ahead loomed up through the darkness, and we headed for it. We were eagerly discussing the prospect of a fine, hot meal in two or three hours, and counting what we should have, when we crashed into a piece of ice. For the moment we thought no harm was done, but as the canoe backed off we could feel her settling. We quickly threw over all her load, and paddled for the nearest shore. It was useless to make any attempt to stop the leak, the peculiar construction of the bark canoe made it impossible to see, the more so in the darkness, its position and nature.

When within about 200 yards of the shore, in spite of constant bailing, she went suddenly under, and left the six of us struggling in the icy water. Two of the men struck out for the shore, one with a waterproof bag, which acted as a support, and the other, an Indian, clinging to some paddles. The rest of us stayed with the boat, and after a hard struggle, succeeded in dragging it ashore. Here we found only one man, the Indian having never reached the shore. For some time we were too weak to move, but as soon as we were able we emptied the canoe, and by making two trips and getting in the stern and raising the damaged bow high out of the water, we managed to get back to our camp fire.

Here we passed a most miserable night, especially as a heavy snow storm came on, making it almost impossible to keep the fire alight, the more so as wood was scarce and we had no axe.

Next day we decided to walk the shore to the Post, but two miles brought us to a river that it was impossible to cross, as it was over two chains wide, deep and rapid. We then decided to go back to our camp fire, and next day try to reach the Indians' shanty that we had seen back on the shore. Next morning three of us started back, the others remaining in case any one came back to look for us. We struggled on all day through the bush, using a compass altogether, as it was still snowing, and we could not see the sun; sometimes so weak that we could only walk for a few minutes at a time. At last, when we had almost given up hope of reaching it, we saw smoke on a point about a mile away. The last mile was the hardest, and it took us what seemed hours to walk. At last we came to the clearing. An Indian was behind the house cutting wood. We shouted, and he dropped his axe; he could not speak English, but in broken Indian I explained the situation. He grunted sympathy, and took us at once into the house, and told the squaws to get us something. It was soon ready, and we started in like famished wolves. The menu was not elaborate, lumps of dough, fried in grease, but I never spent such a happy hour before.

Next morning the Indians went out and brought in the other two men, who were almost utterly exhausted, and had given up all hope.

While we stayed with the Indians they guarded themselves against loss by making us cut wood. After each meal they would take us to the edge of the clearing and point significantly to the trees, and then to the axes, and we would get to work, though we were still too weak to use them.

Finally, making a bargain with the Indian to give him certain goods when we reached the Fort, we set out taking him as guide. When nearly half way we met two of our men coming out to meet us; I went out on the ice to meet them. One was an Indian, a nephew of the drowned man. I said, "Toussaint is drowned." He said nothing, but after a few moments thought came up again, and said, "And so Toussaint is drowned? Yes. Well! By gosh!" and never referred to the subject again.

The three of us turned back to look for the body, while the others went on to the Post. We followed them next day, after a fruitless search.

We found the party busily engaged in making toboggans for our trip out, as the idea of canoeing was now altogether given up. Three days later, we again started south, every man with a toboggan, and taking one canoe on a sleigh. We had scarcely gone eight miles when the weather again turned soft, necessitating hauling the toboggans through the bush, a long, laborious feat, owing to the windfall prevailing along the banks.

We then crossed Upper Lake on the thin ice, not, however, without some of the party getting through. Here we came to a long stretch of open river, and again we were forced to take to the woods, the canoe taking the baggage. Fortunately, we discovered an old bark canoe, which we used to carry the toboggans, though it could only be kept afloat by constant bailing, and, even so, she sank twice suddenly, and left us to haul our load out.

Two days of this monotonous work brought us to Island Lake, where the same misfortune occurred that had so often happened before, the ice could neither be broken or walked on, and it took us three days to make eight miles over it. We then crossed the height of land, and reached the head of Long Lake.

After a vain attempt to raise an old Hudson Bay batteau, which was lying sunk here, we again started to walk the shore, abandoning our toboggans for the last time. Three days more brought us to the foot of the lake, and as we were almost out of provisions again we decided to leave everything and take to the bush, going south-west to Lake Temiscamingue.

Leaving everything except a little food we struck off through the woods, and on the second day came to the first signs of civilization, a road and an abandoned farm. The same night we reached the Indian village at the mouth of the Quinze. Here we got our first news of the outside world, and also our first meal in civilization—potatoes and other luxuries. We expected to take the steamboat next morning, but, unfortunately, during the night the lake was frozen over for several miles down, making it necessary for us to walk the lake twenty-five miles to Ville Marie, where, next morning, we caught the steamer Meteor for Gordon Creek and the south.

THE CONJUNCTION OF THE NINETEENTH AND TWENTIETH CENTURIES FROM AN ENGINEERING STANDPOINT.

By Charles T. Harvey, C.E.

President and Members of the Engineering Society of the School of Practical Science, Toronto.

We are at a notable point in the procession of numerals in the chronology of the Christian era when the figure "8" is not to appear in the third rank again until 900 years after this one. While the twentieth century will not literally commence for a score of months, yet, our calendar numerals will indicate a new century as arriving at the close of this year.

It is, therefore, not premature to review the preceding century in its relation to the advancement of the science of engineering, as well as to scan the probabilities in the same connection of the cycle soon to peep over the hills of history, like the morning sun rising in the east.

You are to be congratulated upon entering active professional life at by far the most interesting period of engineering achievements in the world's history, and when its physical welfare and material progress is controlled and guided by engineering talent, using the term in its broadest sense, to an extent never heretofore equalled.

NINETEENTH CENTURY EVOLUTION.

At the commencement of this century the civilized world's attention was mainly engrossed by those conducting military and naval warfare, Napoleon, Wellington and Nelson were then the most prominent directors of the world's energies in destructive operations.

But later on the functions of their class were eclipsed by those prominent in constructive undertakings, such as Fulton, Stephenson, Erickson and Roebling. All of these can be classed as Engineers, because they concentrated material qualities or forces for special objective purposes, whether in structural or mechanical development.

The extent to which Engineering has entered into the science of warfare is one of the marvels of this century. The fighting exploits of Kitchener on land, or of Dewey or of Sampson on the sea, is far more a record of engineering skill than of military courage.

What chance was there for the latter when facing machine guns?

Was not the engineering perfection of Dewey's ships and armament an essential element of his victory? Could Sampson have captured the escaping ships at Santiago if the engineers constructing or operating his cruisers had failed to do their part in a superior manner?

It is interesting to consider how the contestants in the famous sea-fights of antiquity would be surprised to learn that instead of encounters with battle axes and grappling hooks when their open war vessels clashed together, modern naval battles would be fought with miles of intervening space between the combatants, and the greatest endurance would be required of shovellers of coal into the engine furnaces (called "stokers"), who might not see a shot fired on either side until the victory was decided.

COMPARATIVE CENTENNIAL PROGRESS.

Have you ever considered that the century now closing has witnessed more improvement in the exterior conditions of human and social life than occurred in the sixty centuries preceding it?

Take the single but fundamental element of transit by land. There had been no essential change in that from the time that wheeled conveyance by animal traction was first mentioned in the Bible, when Joseph, the Viceroy of Egypt, sent waggons to Palestine to move his father Jacob and all his family belongings, up to the year 1829, when the first public exhibition of steam traction was made by Stephenson, with the famous engine Rocket, near Manchester, England, and the first locomotive railway was there opened for use the following year.

Yet this radical improvement is now eclipsed by the utilization of electricity, which has come into use for transit purposes within the life of the youngest here present.

It is hard to realize that within this century the first steamship crossed the ocean, the first cablegram vibrated beneath its depths, the first public telegram, "What has God wrought," flashed over conducting wires, or that wonders which would have paralyzed ancient wise men with awe, are now mere commonplace affairs with us, as for instance, that we can propel, illuminate, and heat a railway car by connection with a single minute wire, to say nothing of the horseless carriage which the last few months have seen introduced hereabouts.

An ingenious writer has recently undertaken to sum up the fundamentals of materialistic human progress in distinct centennial epochs.

He finds that the invention of alphabetic characters was the first, but the time of its introduction unknown. Next the system of numerals, also without date. With those exceptions he passes over fifty centuries failing to find any single improvement worthy of note, until he credits the fourteenth century of the Christian era with the discovery of the mariner's compass as its single achievement.

To the fifteenth he assigns the introduction of movable type by Guttenburg, although there is reason to infer that the Chinese had anticipated that by several centuries, but the European idea is the only one historically notable.

The seventeenth century he solely connects with the telescope, but it seems to me that magnifying lenses have not materially affected human conditions, and I would suggest that the introduction of explosives for engineering purposes was a greater event—the use of gunpowder for blasting rock dating from 1613.

With the eighteenth century he mentions only the steam engine, and in summing up says:

"We find only five inventions of the first rank in all preceding time, while in this nineteenth century alone we have 13, namely, (1) Railways, (2) Steamships, (3) Gas Lighting, (4) Friction Matches, (5) Telegraphs, (6) Telephones, (7) Electric Lighting, (8) Electric Railways, (9) Photographs, (10) Phonographs, (11) Antiseptics, (12) Anæsthetics, (13) Rontgen Rays."

ENGINEERING RETROSPECT.

The unexampled progress made in engineering works during this century, such as the Lake Superior and Suez Canals, suspension bridges, elevated railways, mammoth steamers and others too numerous to mention, together with the fundamental discoveries just referred to, are the outcome of a dominant spirit of peace pervading the earth, fostered by international exhibition of the results of peaceful pursuits, commencing with the first one in London in 1851-2, and reaching a climax in Chicago in 1892-3, causing a commingling of races, and of ideas never before seen on this orb

The spectacle of the vast army of the Czar of Russia being now largely engaged in building of railways, excavating of canals, and drainage of marshes under engineering supervision is a most suggestive one as in the direct line of converting "swords into plough shares, and spears into pruning hooks." Right here I will remark that when universal peace does eventually reign among the nations it will be largely due to the engineering skill which has already made war so destructive *and unromantic*, that educated humanity shrinks from it as never before. The "hill tribes" about Manilla recently faced the American machine guns, relying on bows and arrows, but the ignorance of centuries was destroyed in an hour, and the few survivors will become teachers of new truths, which their kind will heed, as never before!

SEISMIC PHENOMENA.

The century just closing has an unique record of seismic disturbances.

It is stated that it has witnessed 52 volcanic islands rise out of the sea, nineteen have since disappeared, and ten are now inhabited. The change in the earth's surface occurring at the Straits of Sunda a little over a decade since was the most serious yet recorded.

When a high range of mountains for a length of eighty miles disappear in the sea, and the volcanic pumice evolved in one eruption can be detected in the atmosphere on the other side of the globe for months afterwards, a total destruction of the world in the form we now see it seems to be quite possible on the same lines of unfathomed and unexplained energy.

TWENTIETH CENTURY PROBLEMS.

Turning towards the twentieth century we may eagerly enquire what can it bring to us as opportunities to add to the fundamentals of human progress so widely extended in the cycle now closing. Is the list exhausted? By no means. Two fields of prolific discovery can at once be named—Aerial navigation is one, which, permit me to predict, will become a practical factor in human conditions before many decades, and perhaps before one more has passed.

Utilizing tide energy is another of grand possibilities. The world is just waking up to the value of water powers in connection with electrical transmission, but compared with the aggregate energy of tides, they are quite overshadowed. The Province of Nova Scotia has few water powers owing to its topographical conditions, but its coast tides, particularly in the Bay of Fundy, could supply its own needs and leave a margin equal to all the steam power now used in the world ten times over.

And here let me say that no engineering prize, so far as fame is concerned, can excel that awaiting the discoverer of the best solution of either of these engineering problems, in which any of you can compete for success.

For your encouragement I will say that if other matters did not engross my own attention, and the means for experimenting were provided, I would unhesitatingly devote a few years to one of these topics, with full faith that a successful issue worthy of mention in marking a century's progress would result. If such sentiments can be entertained by one of my years, how much more by those endued with the fresh energies and the buoyant hopes of young men such as I see before me!

If any, however, prefer a purely mental and inductive line of investigation let them study seismic phenomena, and establish the data by which the energy producing earthquakes can be located, explained, estimated and forecasted, and the world will listen to any valuable deductions in that line because so directly interested. A seismometer is already provided in this vicinity to aid in such investigations.

Having thus glanced at these centuries from a world-wide standpoint, let us narrow our horizon to the country, or rather empire, in which we dwell.

BRITISH LIBERALITY.

You are to be congratulated upon coming forward into the arena of professional life under the protection of a Government the most just to the Engineering profession that the world has ever seen, and with a record in that respect of which you may well feel proud, for it is simply grand.

Let me relate one instance. In 1775 there was seen in London an awkward looking man about 40 years of age distributing cards in the seats of members of Parliament before the daily session commenced, which contained an appeal for the extension of his patent for the invention of steam engines, which was expiring just as he had it perfected sufficiently to secure a commerical success. The extension was opposed by manufacturers, who saw profit in using it, and they raised the cry of "No monopoly" When the members of Parliament understood the case, and that the distributor of those cards was the original inventor, James Watt by name, they promptly passed an Act extending the patent for twenty-four years, which insured the great inventor a competency for life, and when he died a monument was erected to his memory in Westminster Abbey, with an epitaph written by Lord Brougham, which denotes the highest level of national glory, and to which no other but England has yet attained, as the existence and uses of the famous Abbey attest.

The epitaph is worthy of your reverent attention, reading as follows:

NOT TO PERPETUATE A NAME
WHICH MUST ENDURE WHILE THE PEACEFUL ARTS FLOURISH
BUT TO SHOW
THAT MANKIND HAVE LEARNED TO HONOUR THOSE
WHO BEST DESERVE THEIR GRATITUDE
THE KING,
HIS MINISTERS, AND MANY OF THE NOBLES
AND COMMONERS OF THE REALM,
RAISED THIS MONUMENT TO
James Watt,
WHO DIRECTING THE FORCE OF AN ORIGINAL GENIUS
EARLY EXERCISED IN PHILOSOPHIC RESEARCH
TO THE IMPROVEMENT OF
THE STEAM ENGINE
ENLARGED THE RESOURCES OF HIS COUNTRY,
INCREASED THE POWER OF MAN,
AND ROSE TO AN EMINENT PLACE
AMONG THE MOST ILLUSTRIOUS FOLLOWERS OF SCIENCE,
AND THE REAL BENEFACTORS OF THE WORLD,
BORN AT GREENOCK, 1736.
DIED AT HEATHFIELD, IN STAFFORDSHIRE, 1819.

This tribute you will notice was tendered during this century, so prolific in achievements worthy of like perpetuation, and discloses one cause of such glorious results.

Another instance is recorded in connection with Robert Fulton, the renowned American pioneer of steamboat navigation, who went to London and submitted plans for torpedo boats to the British Government, for which it allowed liberally and paid promptly, in striking contrast with his own nation, which abused his confidence as to compensation for invaluable services later on. Its record in dealing with Erickson, whose genius greatly aided the re-union of the States by his invention of the first turreted warship, was still more discreditable.

Stephenson with his locomotive, Bessemer with his steel process, and many others with invaluable contributions to human progress, have found appreciation and protection under the "Union Jack," which you can rely upon for service of a similar kind when needed.

ONTARIO'S ENGINEERING CLIMAX.

Concentrating our attention on Canada as the eldest daughter of the Empire, and on Ontario as the Empire Province of the Dominion, with its great lake frontage on the south, and its salt sea coast on the north, constituting it a keystone of the trans-continental arch of confederated provinces, we find it has already within its borders the greatest engineering wonder of the world, and perhaps the most perfect example of national comity yet recorded.

I refer to the Dominion Canal at the outlet of Lake Superior in the District of Algoma and Province of Ontario. Its single lock is 900 feet long, 60 feet wide, and 20 feet deep. The lock gate machinery is operated by electricity which the attendant manipulates by a button arrangement which controls the valves and gates, and fills or empties the lock with perfect exactness. Here we have the spectacle of one person, whether man, woman or child, by a simple finger pressure causing the displacement of 1,080,000 cubic feet of water, weighing 32,690 net tons in less than five minutes!

This minimum of energy and maximum of effect stands unequalled in the world's history as an engineering triumph, and of it as an achievement of your chosen profession, within your own inheritance, you may well be proud.

The United States canal on the opposite side of the river is still larger in dimensions, but it is operated by water power controlled by hand leverage requiring more manipulating force, and hence, while equally efficient, does not furnish as perfect an example of the minimum of energy to obtain certain results as the other.

But another most charming feature is that both canals are free to the adjoining nations, and steamers sailing under either flag pass on one side or the other without question, as best suits the captain's convenience. It can be truly said that at this point the two greatest and richest nations of the earth come in closest, and yet freest, touch with each other, and that they severally owe their greatness and their wealth more to the engineering profession than to any other.

In singular contrast with this glorious engineering achievement is the condition of affairs on the northern boundary of this Province. There it possesses a coast line of several hundred miles on the second largest sea of the world, but without having instituted any improved means of access thereto, since possession was acquired in the seventeenth century.

Immense wealth in fish, minerals and forest products have remained unexplored and unutilized for centuries, when only separated from the central water-way of the great lakes of the continent by a zone of less than 300 miles wide.. The vacant space is now reduced to 250 miles by the advent of east and west railway facilities.

It is safe to say that a similar waste of natural resources is without precedent in the history of civilization. Various theories are advanced as to the cause, but perhaps the most plausible is that it has become the custom of the Government to rely for its revenue upon the sale of forestry products in the northern districts, the proceeds of which are expended at the seat of government, and in sustaining public institutions in the southern section of the Province, and that the northern region is regarded in Toronto as a farmer does his wood lot, which is left to the slow process of natures reproduction to offset limited use for special purposes.

But there are serious discounts in this policy. Desirable settlers avoid the unopened timber districts, and pass on to the western prairies, while fires devastate more or less territory every year.

NEW FORESTRY FOES.

A new element of destruction has lately appeared in two varieties of insect life, one of which attacks the tamarack timber, and the other the spruce, and threatens to ruin both, in latitudes where the more valuable pine does not grow, and there is less danger from fires.

Professor Bell reports that the tamarack groves in the vicinity of James' Bay, on the south-eastern side, have recently been largely killed by a species of worm, spreading over wide areas, and causing incalculable damage and waste, for which there is no remedy save speedy utilization. Your president, Mr. Carter, informs me that he noticed the devastation caused by this pest in large sections of the Moose River basin in his official explorations for the Provincial Government last season, and that the worm's scientific name is "Nematus'erichsonii."

NEW ENGINEERING OPPORTUNITIES.

The introduction of improved transit into these northern regions, and access to the Great Sea, will open up a sphere for engineering talent, which you may reasonably expect will give a wide range for the exercise of your professional abilities. Especially is such the case with regard to its being the natural highway to the great Mackenzie and Yukon valleys, where extensive demand must rapidly spring up for your services. This century ought not to pass without a commencement being made in that direction.

With this brief glance at your political and professional environment a few closing words will be devoted to your status as individuals, and to personal reminiscences connected with your profession.

PERSONAL SUGGESTIONS AND ILLUSTRATIONS.

The most wonderful feature of human life is what we term the human will. It can neither be seen, weighed or measured. Its existence can only be proven by its effects, which are as multiplied and varied as are the units of human existence. How any one who has considered its phenomena can doubt the existence and power of an origin for it in a creating will on a higher plane, where Deity itself, which we style God, dwells, I cannot comprehend, and hope that all of you will consider this subject with the attention which it deserves.

But to enable you to most advantageously use the will power with which you are severally endowed is what you, as students, are here for, and the ultimate value of your several existences will be determined by your use of such endowment.

The sublimest effects of which we can conceive, are caused by it, and the highest happiness we can know, is to look back at the close of life upon its having been used to the best advantage in the elevation of ourselves and our species towards the highest possibilities, in the material and spiritual world, for ascend as we may, there will be altitudes yet above us.

You have chosen a profession which calls for intense exercise of trained will power, as its functions are to re-arrange the material features of the earth to serve human purposes to a higher degree. The embankment of a railway, the prism of a canal, or the mechanism of a steam or electrical engine are triumphs of educated will power over matter.

ENGINEERING PROCLIVITIES.

Engineers of the highest class are born, not made. Technical education is helpful, but not determinative of the quality or strength of the will power which you need to best succeed in your profession. If I were to estimate your chances for eminence in it, I might not ask what technical works your are studying, but would enquire what class of books you liked best for reading, and what your amusements were.

These indicate the tendency of your will power, which may commence its development in boyhood, or even in childhood, on some fundamental principle of your profession, or of any other. Happy is the person who cultivates such manifestation of Deity in his nature, before he gets to technique.

About fifty years ago you might have seen a lad left to choose his own amusements, who selected a small watercourse, and without suggestion or attention from any one, proceeded to build over it a bridge made of laths placed in a new form of construction, and when after days of working in the muck he had it built on a good foundation, proceeded to cover it with an earth embankment, and not satisfied with its sustaining that, loaded a wheel-barrow with stones and set it on the centre of the span. The satisfaction of finding no deflection in the structure under extra pressure he deemed abundant compensation for days of hard work. Less than forty years later he had attained the unique engineering distinction of having a canal built by him out-classing all others on the globe, not only in lock dimensions but eventually in volume of transit tonnage, which occurred the same year—in the 80's—that a railway also originated by him, exceeded any other in number of passengers per mile transported over it. If you were to ask him how this distinction (probably never to be duplicated) was attained, he would tell you that he attributed it not to technical education, in which his opportunities were few, but to the choice he made in his amusements and reading.

Aside from scientific books, those of history and selected biography will prove the most useful to you. History shows you the effect of will power focused by, in, or on communities or nations. The first record in the series should be the Holy Scripture, as reaching to the remotest recorded time, and commencing with the sublimest sentence ever written, namely, "In the beginning God created the heavens and the earth."

As to biography, the first should be of the Nazarine carpenter's son, as the person who exercised will power to the highest degree ever attained in this life, and then the lives of those who developed it in your chosen profession in its widest application, afterwards, of those eminent in other spheres of life.

The facts thus to be learned are most salutory, as showing how others have surmounted difficulties far greater than any opposing your progress, and that the rewards of diligence, perseverance and discrimination generally come in due time.

NOTABLE BIOGRAPHIES.

Were I to name a few useful biographies I should begin with the life of James Watt, and continue with George and Robert Stephenson, Robert Fulton's Arkwright's, Telford's, Brassey's, Clinton's Morse's, Cornell's, Cooper's, Erickson's, Bessemer's, and so on to Edison, who is the latest marvel of will power, of whom it is probable that I bought newspapers as I passed over the railway where he as a lad was then selling the same. Of the influence of books and of observation on the will power, I will pause to mention two instances which greatly impressed me.

One was that of Hall, the Arctic explorer, who, when a journeyman engraver in Cincinnati, Ohio, read accounts of the mysterious fate of Sir John Franklin and determined to try to find traces of him.

Without money and without prestige to start with, his will power carried him to the wastes which Franklin traversed, and he brought back relics picked up where dropped by the great explorer, but his enthusiasm—which is but one name for will power—in Arctic explorations was communicated to the American Congress and to President Grant to such an extent that they made him a naval commander and placed a national vessel under his control by unprecedented special legislation. His name is indelibly connected with those Northern seas on the shores of which now reposes his body, in which his will performed feats that unless they were well attested would be deemed incredible.

He who now addresses you could tell about the influence of reading one of the biographies just mentioned which permeated his life and led to results hardly less improbable than those referred to.

The other instance is that of Bernard Pallissy, the Potter of France, who when following the profession of land surveyor, was so impressed by the sight of a specimen of glazed pottery that he devoted the best part of a lifetime to learning the secret of making it. He succeeded most marvellously. Read his life if you wish to be doubly impressed with the possibilities of will power, which in his case led one who started into active life without the advantages of early education to practically become the founder of the famous "French Academy," which ranks as the most learned organization in the world.

But why multiply mention when every eminently useful life—living as well as dead—is an illustration of this principle. Colonel Sir Casimir Gzowski, who departed this life from this City during the last year was an eminent example. Sir William Van Horne is another, while the Nova Scotia farmer boy of 1870, who is now President Schurman of Cornell University, and representing the United States in an extraordinary mission at Manilla is in the same line of eminent examples.

THREE EPOCH MAKERS.

It has been my good fortune to be on terms of intimacy with three epoch makers in the world's history. One was Thaddeus Fairbanks who established the first innovations in methods of weighing prevailing for over 5,000 years, by introducing the platform scale as an improvement upon the even balances, solely used before this century.

Another was Peter Cooper who built and operated the first locomotive on the Western hemisphere, and the third, Ezra Cornell, the founder of the famous University, who built the first telegraph line in the world, in connection with Congressional aid to Professor Morse.

I have heard the stories of these men's experiences from their own lips, and in every case their will power was exercised to the utmost before reaching success.

Thus far as to individuality. Now for a few remarks as to your profession and its environments.

THE IDEAL ENGINEER.

The ideal Engineer, the highest type of your profession, stands for stability of character in his work, which must be a reflection of like characteristics in himself. He will be tempted by shifty contractors or capitalists, but he must use the plumb line of integrity, and the square of equity in laying the foundation and rearing the superstructure of a bridge, or in making up the estimates of work done, or to be done.

If he attempts great achievements, he must expect great opposition, especially in innovations of a public nature.

Ezra Cornell spent an entire winter in endeavoring to gain consent in New York City to his erecting a telegraph line through it to Boston, and found opposition so strong that he had to go elsewhere, or starve. He then slept on chairs in his room because he could not spare money enough to pay for a bed. Read the speeches of those who opposed the introduction of railways into England, where you will find that the solicitor for a canal assured a Parliamentary Committee that he would prove that a canal boat could go faster with a load than Stephenson's "smoking machines." No more interesting bit of history can be found than the record of overcoming opposition to the introduction of the locomotive in England or the telegraph in the United States. It was in the former connection that the elder Stephenson, when a witness before a Parliamentary Committee was asked by an opposing lawyer, what would be the effect if his engine should encounter a cow on the track? "Bad for the "coo" was his reply.

THE ENGINEER AND CAPITAL.

Money is to the Engineer what air is to the lungs, and happy is he who has ample capital to back up his undertakings from start to finish.

The success of Watt was hardly more due to his inventive genius than to the financial ability and faith of Boulton his financier and partner.

The fame of Stephenson is shared by the capitalist known as the Quaker Pease, to whom a well-deserved statute was erected in Darlington, England, to commemorate his assistance as the financier of the great Engineer's railway enterprise. Other Engineers for the want of such financial aid have failed to attain possible success, as the speaker can testify.

I knew of a case where an Engineer had plans of vast utility which he needed $50,000 to launch in proper shape. He went to a certain financial magnate to solicit his aid. This individual then had exceeding ten millions in marketable assets of which over one million was cash in bank. He looked the matter over and took advice of third parties who discouraged the idea. He declined. The Engineer saw others occupy the field with capital that he could not obtain in time and clear many millions by the transaction. The next time they met the magnate referred to was in a lawyer's office where he was engaged in passing through bankruptcy, his ten millions having disappeared in stock speculations when the $50,000 might have made him famous as well as doubled his fortune.

This kind of disappointment is the rule rather than the exception in Engineering experience, because the number of aspirants to a prize must bear a relative proportion to the losers in the contest for it.

GOVERNMENTS, *in re* ENGINEERING TALENTS.

This is a theme which includes a large part of the progress of modern civilization, because it relates not only to governments directly, but to corporations which are the creations of governments, and can only exercise functions delegated by the latter.

Every country has its own methods of dealing with Engineers and their works, some of which are wise, and some otherwise. I will only select two examples. One is that of the Dominion of Canada with reference to railways, the other that of the State of New York in connection with its canal system.

Canada has more miles of railway per capita than any other people, and to this feature is due the fact that it has more influence in the world at large per capita than any other commonwealth.

It inaugurated at an early day a system of railway aid, municipal, provincial and federal, more liberal per capita than instanced elsewhere. While the same evolved abuses in some minor cases the total result was largely beneficial. The history of its great trans-continental (C. P. R.) railway is one of intense interest.

Commenced as a political necessity by the Government itself, as a composite system of part water-way and part railway, with a view to economy rather than comprehensiveness, it was a predestined commercial failure like the expenditures which from political influences are now being made upon the Trent Canal in Ontario. No administrative integrity or professional ability, could change the results when following out such lines.

Suddenly the Government policy was changed, and through the corporate agency of the Canadian Pacific Railway Company, the executive and engineering ability of Sir William Van Horne and Sir Sanford Fleming and their staffs were brought into full swing, with marvellous results which I need not describe. To secure these the Government acted with great liberality, turning over large sections of railway work it had already done, with twenty-five million acres of land, and as many dollars in money, as bonuses. That it was a master stroke of statesmanship is beyond question, and the statues of the master spirit then Premier at Ottawa, to be seen at the capitals and large cities of so many Provinces, is a proof of final popular approbation.

The money that the Dominion voted was expended in its own territory, the values thereby created are subject to control and taxation under its sovereign powers, and its gain irrespective of larger commercial advantages is positive and permanent.

THE CANALS OF NEW YORK.

The reverse of this policy is illustrated in the history of the Canal system of the State of New York.

This system at one time the most successful in the world, owed its existence to the will power of DeWitt Clinton, who met fierce opposition, but with the support of Peter Cooper, and others, he overcame all obstructions and saw the work completed in 1825 with an ovation, when for want of a telegraph line, intermediate placed cannon boomed the news of its opening from Buffalo to New York within an hour. He was elected Governor and was holding that office when he died in 1828.

The Canal from the Great Lakes to tide water proved a success beyond all anticipations. Its revenues soon paid back its cost, and in 1868 it was yielding a net revenue of over two millions annually. Some 15,000 boats were employed in its carrying trade, earning over nine millions of annual freight money, while it was an effective guard against railway combinations to raise freight rates unduly.

But there was one drawback, the use of steam power was not made available upon it, and this was a fundamental defect which impaired its usefulness from the start. Governor Clinton and Peter Cooper jointly endeavoured at an early date to solve the problem of the practical application of steam traction thereon, but without success.

CABLE TRACTION PROPOSED.

In 1868 an Engineer came forward with a new plan for that purpose which Peter Cooper at once said supplied the long-desired want. He signed and circulated a petition to the State Government asking that a speedy trial be made of it.

He said that if it had been shown to Governor Clinton or himself when the Canal was being built, it would have been made an adjunct of the same from the start.

The inventor was an Engineer of experience who offered to demonstrate its utility on a section of the Canal and establish a towage system which would double the boat speed and reduce the cost at least 33 per cent., without compelling any to use it, or interfere with the use of animal power in any respect. This practically doubled the capacity of the canal without costing the State one dollar of additional outlay and benefited the owners of boats in the same ratio by economy in time of transit. The Engineer asked the State to authorize the trial of a ten-mile section of the Canal equipped with the new method at private expense, but providing for an extension of the same for the entire length, if proposed savings were proven to result from its use.

The principle of the new method was cable traction but applied in a novel and peculiar manner upon which hinged entire success. Governor Clinton and Peter Cooper had themselves experimented with the same power but in a different form of application, which proved so objectionable that they gave up the idea and fell back on horse power. Hence when Mr. Cooper 40 years later endorsed the new method he spoke from experience in that line of Engineering.

A SHORT-SIGHTED GOVERNOR.

Had DeWitt Clinton been Governor the new system would have been adopted at once, but one of different mould was Governor (Fenton) in his place, who, although of unimpeachable private character was without mental grasp of large issues, lacking in will power and quite out of touch with Engineering problems. Under these conditions the opposition of the horse-towage combinations and other adverse influences blinded his mental vision from seeing the immense advantages for the State then within reach.

Mr. Cooper could not induce him to come out in favor of the Canal Improvement and the Legislation sessions of '68-9 passed by without action in that direction. The next election brought in the opposing party under the lead of the infamous Tweed, when no public measure stood any chance of State action except with corrupt influences behind it.

The Engineer withdrew his proposal, his improved plans were lost sight of, and the old system was continued. Thirty years have since passed and a review of results can now be made with relative accuracy.

On the new plan 75 stationary engines of suitable power with five men in attendance at a time, or ten per day on each, would have dispensed with the horses used by 15,000 boats averaging three each, and the same number of extra hands, with the result of 750 doing the work of 45,000 men and 45,000 horses, doubling the transit speed of the boats, at once reducing the cost to the boat owners 33 per cent., and then leaving abundant profit to the State and to private capital doing the towing. Distinguished citizens of the State took special interest in this subject, and one of them occupying the prominent position and life office of Clerk to the Court of Appeals (the highest in the State), published a pamphlet on the subject from which my data as to the number of Canal boats etcetera is obtained, a copy of which I have brought with me. He estimates that the saving to the State would at once amount to $2,666,000 per annum, as you can see on page 26—but events proved that his estimate was far too small.

The facilities on the Canal gradually became so poor that the State abolished its tolls in order to prevent disuse altogether.

The two millions of income was thus wiped out. Then the State resorted to direct taxation to maintain the Canal, the expense of which in the hands of politicians amounted to about two millions annually.

A few years since the statement was made, that prosperity would return to the Canal if it was enlarged at an expense of $9,000,000.

On a vote of the electors being taken, the measure was adopted, and the money spent with the result that the work is not completed, leaving the Canal it is publicly stated in worse condition than before, and $6,000,000 more is asked for. The usual charges of corruption and fraud are being bandied about, and general disgust engendered which it is not supposed that the Railway Corporations dislike to see approaching a crisis where the State may sell or give away the Canal which has so long stood as a bulwark against greedy combinations.

Meanwhile the boat owners have lost most of their capital and largely retired from the business. The alliance which the State might have had with the Steam Towing Company would have enabled it to manage the Canal very profitably and to have maintained its two millions of annual net income to this date. In a recent issue of a New York City paper (Mail & Express), several columns are devoted to a review of the Canal situation. It states that the number of boats is reduced to 2,300, of which only 1,117 are fit to carry grain, the majority of the remainder are old and rotten, few new ones are being built and tonnage has fallen off to such an extent that the outlook is extremely gloomy. The writer says that the system is fifty years behind the times, and hardly improved since the days of DeWitt Clinton. As matters now stand the State, has lost the difference between two millions net income and two millions outgo, or four millions per annum for thirty years, a total loss of 120 millions. Add loss of interest and of private boat equipment, also the $9,000,000 recently expended and the total easily foots up to $150,000,000 as the resulting loss to the State and its citizens from the want of will power in one of its Governors.

ENGINEERING ABILITY AS AN ELEMENT OF GOVERNMENTAL SUCCESS.

We are now in a position to draw a comparison between the management of affairs in the State of New York and the Dominion of Canada on certain engineering problems.

The State thirty years ago had a most valuable property earning four per cent. net on fifty millions. By neglect of Engineering talent when offered, it has lost a money equivalent for the canal or capital and one hundred millions with it.

Within that period the Dominion found itself with an uncompleted rail and water system on hand, in which it could easily have expended fifty millions and then had only a miserable failure, but invoking engineering talent, offering liberal inducements to private capital to become associated with it in transit affairs, a grand success has been achieved. It has a trans-continental railway system of over 4,000 miles, the stock of which (exceeding $120,000,000) is nearly at par, with four per cent. dividends being paid regularly thereon.

Young men when you pass a statue of Sir John A. Macdonald you can well afford to raise your hats to it, for his will power and appreciation of engineering ability averted a great disaster to Canada and its transit interests, while achieving a grand success in lieu thereof.

The State of New York under a low grade of executive ability started with a success, and ended with an enormous loss and scandalous failure from opposite Executive management.

ONTARIO'S PROBLEM.

Will Ontario profit by these examples?

Eminent citizens have memorialized her Government on the subject of opening up early access to Hudson's Bay. Will it respond? When such leading minds as Principal Grant of Queen's University, and Principal Parkin of Upper Canada College join with many foremost bankers, merchants and manufacturers of the Province in expressing the opinion that access to the great Northern Sea is the most important subject now before the Government, do they not in effect ask it to invite the Engineering profession to lead the way? Am I not right in assuming that it will respond to the full capacity of the opportunity?

I shall deem it a great honor to be associated with you in professional labors which will beyond doubt inaugurate a new era of prosperity for the Province and greatly benefit the entire Dominion. By taking the initiative in calling attention to the possibilities of easy transit between the waters forming Ontario's northern sea coast and the great Mackenzie and Yukon Basins I feel assured of being more or less identified with Canadian progress in a field where your profession will achieve some of its highest glories in the twentieth century.

Do not expect that so great an opportunity will open up without opposition. That would be contrary to all precedents in history.

The old game of starting rival routes to befog choice as to the best one, will be sure to come to the front. Sectional jealousies will be appealed to, and if these do not hold back the tide of progress, the "bug-bear" of increasing Provincial indebtedness will be borne aloft to frighten weak minds to the end that a prompt and liberal policy may be deferred, and the present opportunity lie buried or "laid up in a napkin" because of evil reports.

It is an interesting bit of history that when Governor Clinton had secured the approval of the New York Legislature to his plan of building the Erie Canal, the law which it passed was not effective until approved by a third power, since abolished, styled "The Council of Revision," composed mostly of Court Judges. The majority were opposed to the Canal Act, but when one of them in giving his reasons said that the State should hoard its money, and other resources to be ready for another war with England and invasion of Canada, Chancellor Kent said, "if that is what the money is wanted for I prefer to have it used for building a canal, and change my vote," which carried the measure. By such a narrow margin was opposition to that grand enterprise overcome, and based on objections which now appear as puerile as will some of those which you will hear in favor of letting Northern Ontario remain in a state of nature.

GREAT PRIZES AHEAD.

This Province has in extending transit facilities to Hudson Bay as great a prize in view as Governor Clinton foresaw in building the Erie Canal, only a railway instead of water transit is now called for.

With improved transit to those waters, avenues to remoter regions will soon need opening, and, in those beyond, splendid prizes are awaiting the engineering talent that I may be now addressing, of which I will name but two.

The wonderful Peace River upon which a full-sized Erie Canal boat loaded to six feet draught can pass for nearly 900 miles without artificial improvement, comes through the Rocky Mountains on a level, but with cliffs a mile high on either side. At the Eastern "foot hills" it plunges downwards 1,000 feet within ten miles.

That tremendous water power will be curbed and utilized ere long. Next barges of, say 500 tons burden will be taken by canal or inclined plane around it to and from the upper level. Is the young man now sitting before me who is to engineer these noble undertakings?

Within a short distance of Hudson Bay waters are those of the Gulf of Bothnia, four times as large as Lake Ontario, with abundance of fish life in its depths, but what of value along its shores no one knows. Some one will pioneer its exploration, and no doubt devise a method of utilization if marketable values exist thereabouts. Is the young man before me who will lead the way there?

A hundred other engineering problems of more or less magnitude in the great North and North-West wait upon coming educated "will powers" to search them out, and solve them during the near by century.

With the belief that your chosen profession will maintain its advanced position in the progress of human achievements in the twentieth century as in the nineteenth, and with the hope that those here present may be in the front ranks of its glorious phalanx I bid you *farewell!*

HINTS TO PROSPECTORS.

H. Roy Stovel.

The art of prospecting—for so it may correctly be called—cannot be summed up in the idea of simply going and finding gold or whatever one is after; but, on the contrary, involves the most precise calculations with regard to transportation, provisions, camping and the actual prospecting; and this, which is gained only after long experience, in turn exacts a clear foresight of all that is likely to take place.

Having decided on the locality in which the work is to be done, the first thought that naturally occurs is, How one may get there? Assuming that railroads and steamboats, if any, have done their part, there are still four ways of finishing the jounrey. Namely: by driving, riding, by boat or by the old reliable way, walking.

Sometimes one can combine two or three or all four methods, certainly the last way will always be in the program.

It would perhaps be as well first to give an idea of the weights of loads, that it is possible to transport by the different methods. For a light cart, the limit is about 750 lbs.; for a canoe with two men, about 500 lbs.; for a pack horse, from 200lbs. to 250 lbs., and by the last method, I would not advise a heavier load than 75 lbs.

Let us now see what provisions will be necessary, say for two men. It has been estimated that one man will, in one week, consume 14 lbs. of meat, 10 lbs. flour, 3 lbs. sugar, ½ lb. tea, and ½ lb. salt, making altogether a load of about 28 lbs. This of course can be augumented by other things such as beans, rice, meal, coffee, fruit (all kinds of evaporated), baking powder, canned milk and pepper. The rest of the indispensable equipment includes a nest of 3 tin pails, the largest holding about 1 gallon, a tea pot, a tent about 6ft. x 8 ft. ground area, a pair of blankets, a poll pick, small axe, gold pan (if prospecting for placer deposits), a butcher knife and sheath (a handy though not altogether necessary article), a knife, fork, spoon and tin cup, and some matches, which must be kept in a waterproof covering.

A tent will weigh in pounds, about 5, blankets 8, flour 10, meat 14, sugar 3, tea ½, salt ½, fruit ⅔, beans say 4. rice 1, meal 1, coffee ½, baking powder ½, milk 1, giving a total of 52 lbs. for one week, the weight of the pick and axe not being added, as these are usually carried in the hand.

A very good plan, if a horse or canoe can be used, is to take a large quantity of provisions as far as possible by that means, and at this furthest point establish a base of supplies from which to make trips of three or four days at a time with light packs. This enables one to stay out from town a much longer time.

Now let us take up the subject of camping. This is one which is very important to the prospector, because he can work harder and accomplish a great deal more when he is comfortable at night, and has the food kept in good condition, than where this is not the case.

In pitching camp one should, if possible, choose a spot where the ground is fairly level and where plenty of wood and water are handy, although sometimes it is by no means easy to find such a situation. I remember an occasion on which a party of three of us toiled up a steep stream all day long, and about 4 o'clock in the afternoon began to look for a level spot to pitch the tent; but such a place was not to be found. We kept on and on in hopes of seeing something better until about 5.30, when tired out and hungry we gave up the search and dropping our packs right where we were, began to dig a hole in the side hill in which to pitch the tent.

This was finished by dark and then the tent had to be set up by candle light. A hole was also dug for the fire place to keep the fire from rolling down hill.

I just mention this incident to give an idea of the difficulties a prospector will sometimes get into. Ever after we called that spot, "Camp Hole-in-the-Mud."

Having pitched our tent, we now decide upon the position the fire is to occupy; this depends mainly upon two things, the evenness of the ground and the wind. The most common situation is in front of the tent about 15 feet away, but if the smoke is liable to be blown into the tent it may be placed to one side, although smoke is a very

A Bit of the Rockies.

Taffy Camp, Howser Creek.

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good thing in mosquito time. On mountain streams the wind invariably blows in two directions, up and down stream, up in the day time and down at night; so one can be guided accordingly.

A word or two about cooking. Above all things take as much care with it as possible, endeavor to have everything well cooked and get as much variety as possible. If continually moving, take care not to cook too much for this causes waste by its having to be thrown away; cooked food, other than bread and bacon, being very awkward to carry in a pack.

Wash the dishes when through with them; it will not take long and it is necessary although a great many may not think so.

Regarding the actual prospecting, I will only speak of the four minerals most commonly looked for, namely, gold, silver, copper and lead. Gold occurs in two ways, free, and in combination with other minerals; free as placer gold, and in quartz veins free-milling, being combined with tellurium and often with silver and copper; but bear in mind that it is always where you find it.

Silver occurs native and in combination with lead in galena.

Copper occurs in the native state, also as copper glance, copper pyrites (distinguished from gold by its brittleness, and from iron pyrites by its deeper yellow colour).

Lead in the native state is rare. It occurs most commonly as the sulphide, galena, easily recognized by its crystalline form and steel grey color.

In searching for these minerals, the manner of procedure may be summed up as generally as follows:—

For gold, old river beds are thoroughly examined, also the sand in streams carefully panned.

For the other minerals the methods are the same. In hilly districts one finds what is called float, scattered over the surface of the land and consisting of pieces of rock matter usually quartz, containing the desired mineral.

In such cases these should be traced, if possible, to their source, after the following manner. If found in a stream or dry gulches in mountainous countries, one naturally infers that the float came from above; so walk up the lowest part of the gully or the bed of the stream, keeping a good look out for more of the same rock.

When no more is found, return to where the last piece rested and begin an examination of the banks on either side; if found again work up in the direction it appeared to come from until, after a careful search, the source is found, when a thorough examination of the lead should follow, tracing it as far as possible and uncovering it until its full width is known.

A day or two should be given up to this work and it will not be lost, but on the other hand may save a great deal of expense and disappointment later.

Decomposed rock should be well inspected, and also contacts between two different rock formations.

In selecting samples from the location, get as many as possible; but avoid the decomposed rock as it is seldom a fair average sample of the ore and is apt to be very misleading.

I will say nothing about staking out claims, other than that the greatest amount of land should be taken in the direction of the dip of the lead. Full directions for staking claims are given in the mining laws of the different countries.

I will conclude with a few necessary DON'TS.

Don't hurry over the ground.

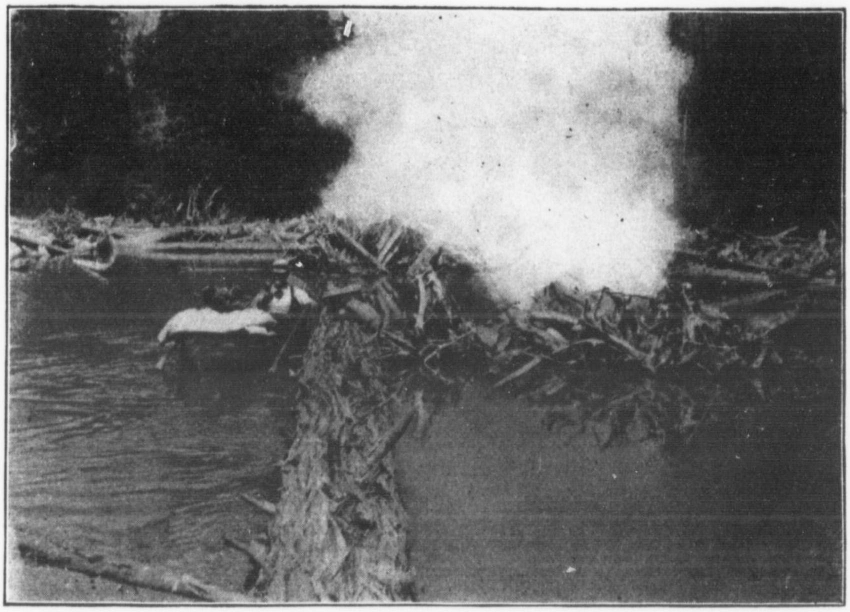
Don't go out alone if possible.

Don't overload yourself.

Don't exaggerate your find.

Don't fail to be cleanly as regards your person as health is the great consideration, and cleanliness is the great road to health.

Plenty of cold water is to be found. Don't be afraid of it.



Lunch—Mosquitoes Bad on Shore.

A Prospect in British Columbia.

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THE VALUE OF UNDEVELOPED MINERAL CLAIMS.

G. R. Mickle, B.A.

The full title of this paper should be the value of undeveloped or only slightly developed mining claims, these being taken in contradistinction to well developed claims or mines; since the words "developed" and "undeveloped," as applied to mining claims have no fixed meaning, each individual having his own idea as to what constitutes a well developed claim, I will first explain the meaning that is intended to be conveyed by these terms. A mine, for the purposes of this paper, I would define as a claim that has been so far developed that it is in the position to take out ore economically and continuously, so far as the underground workings are concerned. It will not, therefore, necessarily include buildings and machinery or roads; and by the words "in the position" it is understood that the mine has enough profits in sight to pay for the necessary buildings, roads, machinery, and leave a profit besides. A well developed claim is not so far advanced as a mine, but one which appears to have passed the critical stage, and has all the chances in its favour.

It will be seen that this definition is based rather on the results attained than on the work done. The mine is usually valued by the amount of net profits in sight, and the well developed claim by amount of profits in sight, plus some additional sum which is speculative.

To return now to the undeveloped claim, it is clear that as there is not enough profit in sight to pay for the expenses of development and the necessary equipment, the claim has possibly no value at all, and a more correct expression would be "the value of the chance of its becoming a mine"; and the object of this paper is to try and investigate the principles which should govern one in attempting to fix the "value of the chance." I propose to look at it from the standpoint of the engineer who is called on to advise with regard to the purchase of mining claims. Common sense will, of course, lead everyone to purchase as cheaply as possible, and be constantly on the alert for the rare opportunities of great bargains which may present themselves, but as the engineer is most frequently called on to investigate claims in districts where the excitement and rush at the time is directed, where capital insists on going, and competition among buyers arises, and where prices are consequently high, it is important, if he is to do business at all, that he should be able to form some idea as to the actual value of the chance in any particular case.

Before going further, in order to explain the meaning of the expression "value of the chance," let us take an example. Suppose, for instance, that it is possible in some way to determine the chance of any particular claim, and to estimate the cost of development, and the probable value of the claim when that amount is expended, let the chance be $\frac{1}{10}$ the amount to be expended $2,500, and the value of the claim $500,000. Then the value of the chance is $500,000 $\times \frac{1}{10}$ minus $25,000 and interest, or $25,000 less interest. That is, if one bought a large number of such claims at $25,000, he would come out exactly even, losing interest on money invested.

The question now naturally arises, is it possible to determine these factors with any degree of accuracy, or is the whole business of the purchase of claims as much a matter of chance as betting on a horse race, without having the slightest knowledge of the previous performances of a single horse in the race.

What is there now to guide one in forming an idea of the chance of any particular claim, and what factors of safety can be employed? First of all a careful examination, and noting of all there is to be seen on the surface. What values show and what appear to be the probabilities of permanency? Are the values uniform or erratic, and is the structure regular or not? Does a study of the rocks show any reason why the vein or deposit should be disturbed or terminated entirely? Two cases naturally arise, viz., that of a claim situated in an entirely new field and one in a district with a number of well developed mines. In the first case there is nothing to guide one but the information which can be obtained from the surface examination, and which may possibly be extremely indefinite. None of the three factors can be approximated, the chance especially being doubtful. One obvious safeguard is to put the chance very low, or, in other words, give only a small price; another, and probably better safeguard, is to take a working option for a year or more, paying only a small sum down, not over 5%, say, of the price asked, with heavy payments deferred, leaving a large proportion, say 50%, for final payment, keeping in mind the probability that unforeseen difficulties are almost certain to make the time required to test longer than the most careful estimate shows. Moreover, as the purchase of claims is acknowledged as risky, with the chances against any particular claim, in order to eliminate chance as much as possible it is necessary to invest in a large number, and consequently where the chance in favour of the claim is small the percentage of available capital invested in that claim, both on account of purchase and on development work, should be correspondingly small. If, for instance, the chance in favour of any particular claim is $\frac{1}{10}$, less than 10% of available capital should be put into the undertaking. Fortunately for buyers, the prices in entirely undeveloped districts are usually reasonable. Experience has shown that there are comparatively few districts or "mining camps" which have become continuously productive over any considerable period of time, and that many camps or districts attract attention for some time and then drop into oblivion, so that till extensive explorations have been carried out the future of any district is always doubtful; while this should never deter anyone from taking up properties in a new field, still the amount spent in testing such a property thoroughly will be large, and to keep the total expense down the price paid should be small or a long option secured. The most common cause of failure of veins or deposits is irregularity either in size or in case of gold ores especially, of value, so that, although there may be a number of places on the surface where valuable ore outcrops, and as it costs, comparatively speaking, nothing to search for the various rich spots, a false idea is often formed of the value of the deposit. When it comes to serious work, as exploring underground is excessively slow and expensive, the barren or low grade spots in between paybodies may take all the profit out of the undertaking. Consequently, till there are some deep workings in the neighbourhood which prove reasonable regularity and continuity no large sums should be paid for mining lands till they are fully developed, no matter how favourable the surface indications or outcroppings appear. Viewed in this light the prices of mining locations are, generally speaking, too high, and should not be given except under extremely liberal working options.

The second case, that of claims in well developed districts (by that is meant districts in which several claims have been worked to considerable depths, say 500 to 600 feet, with satisfactory results), here after a complete surface examination has been made of any claim, which we will say is satisfactory, indicating continuous or nearly continuous values over sufficient length of vein or area of deposit, then to determine "the value of the chance" it will be necessary to fix first of all the chance of its becoming a mine, basing this on a study of the underground workings and results elsewhere in the vicinity. The first point to be decided is, do the developed properties show an essentially erratic character either in values or structure, and is there any difference in the geological conditions at the well developed properties and the undeveloped one in question? The chance of success can vary widely from nearly unity, as in the case of say coal seams known to cover considerable areas and proved to be uniform or of known uniform reefs or veins, to some fraction, as in districts where uniformity and regularity is absent. As examples of the first, take China and the Transvaal. With regard to China, Baron Von Richthofar says, "The total area I estimate at 13,500 square miles, and throughout this extent no break in the continuity of the coal strata occurs." Mr. Kurita: "Over an area of 6,000 square miles there is an unbroken coal field. Every village or hamlet has its mine or mines." (Engineering and Mining Journal, April 23rd, 1898). For the Transvaal take the long unbroken stretches of heavily producing properties along the main reef series.

In determining this factor it should always be borne in mind that good mines are very rare, and the danger always in new districts is to rate the chance too high, and be possibly unconsciously influenced by the general enthusiasm which is apt to prevail, and by the opinion of local men, nearly all of whom are directly interested in one or more claims, and who are consequently not unbiased.

The second factor or probable cost of development would be based on study of amount of work found necessary to test other properties in the district. In the first place the probable number of feet of drifting or sinking and cost per foot, additional cost of roads and whatever machinery may be necessary. What amount of dead work must be done, such as tunnelling through barren rock, etc.

The third factor, i.e., the probable value when a certain amount has been expended on the claim would be estimated by consideration of size and value of ore bodies in the well developed claims in the vicinity, and how they compare with claims under consideration. By the "probable value" is meant not the nett profits on the product of the mine, which may take 10 or 20 years or more to extract, but the selling value at the end of a limited period of time, say two or three years, this is done in order not to complicate matters too much, and for the business reason that it is unwise to lock up money indefinitely in any enterprise, as better opportunities may present themselves at any time. Now, of these three factors which determine the vaule of our chance, the first is the most difficult to fix, and is the most likely to be put too high; the second should be possible to estimate fairly closely, and the third again within reasonable limits.

To cover the essential indefiniteness of the whole calculation use a liberal factor of safety, say two or three, i.e., do not pay more than one-half or one-third of the "value of the chance" calculated in way indicated, or else secure option on reasonable terms with heavy payments deferred to last. Assuming that this mode of reasoning is correct, we see that the prices of mining claims is generally too high, more especially is this the case with locations that are "stocked," and offered to the public at a relatively high sum for the whole property. Those buying only stock may happen to secure the fortunate one, as it would be easily possible to win by betting two to one that a coin tossed up will turn up "heads," but it does not prove that the purchase was any the less injudicious, and continuance in buying such stocks is as certain to lead to loss as repeated giving odds on "heads" turning up.

EXAMPLE.

Calculation to show value of claim which adjoins a claim of tested value—assuming that from observation taken on developed claim the vein should be found on claim in question.

The calculation, of course, being good for one particular district, and the figures based on a study of veins in the well developed mines.

The sources of failure are as follows:

1. Vein vanishes altogether or becomes too small to work.

2. Vein loses its value.

3. Through some serious change in strike, or some fault the vein misses new claim.

Putting the chance of success as influenced by first cause at $\frac{1}{2}$,

And as influenced by second at $\frac{3}{5}$.

And as influenced by third at $\frac{3}{4}$.

Then these are independent events, actual final chance = $\times \frac{3}{5} \times \frac{3}{4} = \frac{9}{40}$.

Now, assume, say $30,000 spent on claim, if successful, makes claim worth, say, x dollars (that is selling price at end of, say 18 months or two years).

Then the value of the claim at present, or the value of the chance is equal to $\frac{9}{40}$ x—$30,000 less interest. A case of this kind, as pointed out above, is risky, and the price paid for claim, together with cost of development, should amount to considerably less than 9-40 of purchasers available capital.

So far, in estimating the "value of the chance" of claims, only mining risks or risks controlled by nature have been considered, there is, however, another risk which will affect the value of claims, namely, what one might call the "industrial" risk, which comes into play in case of all mines, the product of which is not a staple article which can be produced in large quantities at the present time, and readily sold without waiting to fight its way. Such mines have, of course, the mining risk in addition to the industrial, and the final result would be that the "value of the chance" would be still further lowered, and large prices should never be paid for such claims. This class would include everything except coal, gold, silver, platinum, the precious stones and the common metals, which are consumed in very large quantities, and possibly some of the non-metallic salts. It has been assumed in all cases that the claims are within reasonable distance of transportation, with no especial difficulties in the way; it is obvious that any isolated deposit or vein containing a low value product, or one which cannot be concentrated readily on the spot up to a valuable one, and which is situated, to put an extreme case, say 100 miles from the nearest transportation with no apparent reason why shipping facilities should ever be better, would have no value.

THE HIGH PRESSURE STEAM BOILER.

E. Richards, '99.

In these days of fierce competition in the carrying trade on the Great Lakes, every effort is being made to increase the efficiency of the steamers, engaged in this trade, and one tendency has been toward the substitution of high boiler pressures for those in vogue at present. It is the purpose in this short paper to deal more particularly with the boilers to be used with these higher pressures.

It occurs to me, however, that it will be interesting and profitable to form an estimate of the actual, or probable, advantage to be derived from an increase of steam pressure, above that commonly used with the triple expansion engine. Let us suppose the case of the ideal engine, working in a Carnot's cycle, without loss, with an initial pressure of 168 pds. per sq. in. gauge pressure, the pressure commonly used in the triple expansion engine, and a final pressure of 26 in. vacuum, or about 2 pds. absolute pressure. The absolute temperatures, corresponding to these two pressures are 835° and 587° Fahr. respectively. The thermodynamic efficiency, in such an ideal or typical case, would be $\frac{835^\circ - 587^\circ}{{}^\circ 835} = 29.7\%$; the difference between the initial and final temperatures, divided by the absolute initial temperature, giving the percentage efficiency of the Carnot's cycle.

The ideal engine, using steam at 250 pds. per sq. in. gauge pressure, would have a corresponding efficiency of $\frac{867^\circ - 587^\circ}{867^\circ} = 32.3\%$

The higher pressure gives an efficiency 8.7 greater than the lower.

As to the comparison of the efficiencies of different types and pressures, probably the experiments of the British Admiralty Committee are the most exhaustive, embodying, as they do, the results of over five hundred trials of ninety-five ships. The trials were all over twelve hours' duration, under ordinary service condition, in all parts of the world, and with coal of ordinary quality. These trials have shown that about 90% of the theoretical gain, due to the use of increased steam pressure, has been realized in practice, and we are, therefore, safe in assuming an advance of efficiency of 8%, due to changing from a triple expansion engine using steam at 168 pds. to a quadruple using steam at 250 pds. pressure.

Now, as to a few of the considerations, that will influence us in the design or choice of the boiler, most suitable for this altered pressure. Rankine says, that the transmission of fire heat to water, varies as the square of the difference of temperature between the fire and the water. It is difficult to arrive at a thoroughly satisfactory conclusion on this point, as the result of several experiments seem to be somewhat contradictory. Then, it, also, is a question, whether a plate offers the same resistance, whether the transmitting medium be fire, heat or steam. Results show, that the temperature of the fire must be higher to maintain a given difference in temperature between the two sides of the plate, than in case of steam, but that the same quantity of heat is transmitted. This would indicate, that the resistance of the plates is the same, whatever the transmitting medium.

Mr. Bleckynden has made a series of experiments with plates of different thickness, and he finds that between certain limits, about 1⅛" and ½", that the transmission of heat varies inversely as the square root of the thickness, for any given difference of temperature, but that below ½", the tranmsission varies inversely as some higher root of the thickness. Fig. 1 gives the results of his work.

Dr. Kirk made a number of experiments with thick plates, and he tells us that one side became red hot, while the other side remained at 212°, the temperature of the water. He says that it would seem, that with plates above ⅛" in thickness, that the transmission of heat varies inversely as the thickness. Combining these results, we find that the transmission of heat varies as the square of the difference of temperature between the fire and the water, inversely as the thickness for thick plates, inversely as the square root of the thickness for medium plates, and inversely as the cube root of the thickness for thin plates.

With these results in view, we can ascertain what effect the rise in boiler pressure will have upon the transmisson of heat. We may assume the temperature of the gases on leaving the combustion chamber to be 1750° Fahr. The temperature of the water in the boiler at 168 pds. pressure is 374° Fahr., and 250 pds. pressure is 406° Fahr. Then for same thickness and condition of plates, we get

$$\frac{(1750^\circ-406^\circ)^2}{(1750^\circ-374^\circ)^2} = .49.$$

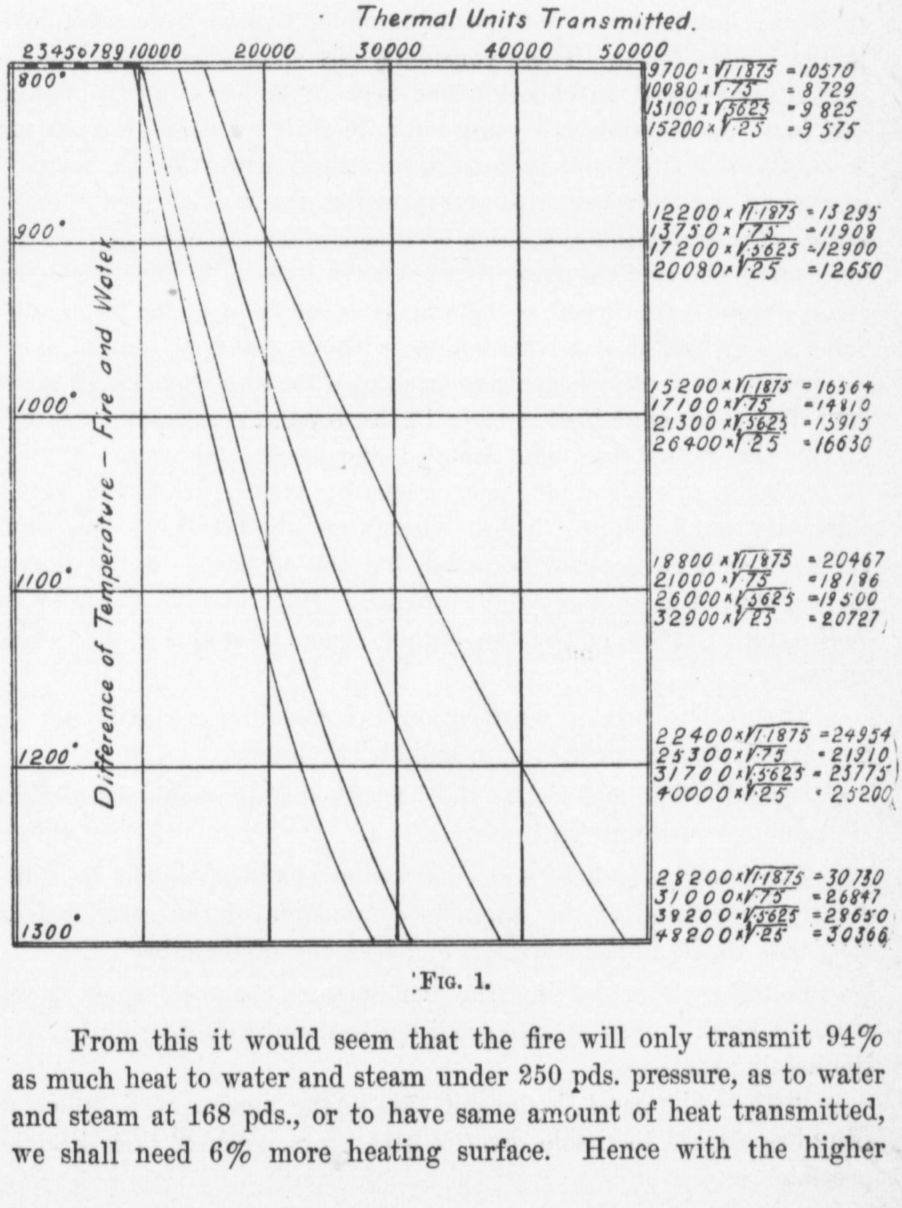

FIG. 1.

From this it would seem that the fire will only transmit 94% as much heat to water and steam under 250 pds. pressure, as to water and steam at 168 pds., or to have same amount of heat transmitted, we shall need 6% more heating surface. Hence with the higher boiler pressure in developing the same H.P. the grate area may be decreased 8%, or thereabouts, but practically no decrease can be made in the heating surface.

Undoubtedly, one of the most important considerations in the design or choice of a marine steam plant, is the space occupied, and the weight. Now, it is clearly apparent, that we cannot expect the quadruple engine to take up any less space than the triple expansion, so if any improvement is to be made along this line, we must look to the boilers for it. These considerations should influence the designer very largely in choosing one type of boilers. By decreasing the coal consumption, we shall both decrease expenses, in cutting down the coal bills, and increase the earning power of the boat, by increasing the carrying capacity resulting from a lessened bunker space. By decreasing the space occupied by and the weight of, the machinery, the earning power of the boat will again be increased. As far as weight is concerned, everything is in the favor of the water-tube boiler. The weight of Scotch boilers, without water, is from 25 to 30 lbs. per square foot of heating surface; of water-tube boilers, 12 to 20 lbs. The water contained is 12 to 15 lbs. for the Scotch, and 1.5 to 3 lbs. for the water-tube. The Scotch boiler has a total weight of from 37 to 50 lbs. to each square foot of heating surface, while the water-tube only weighs 13.5 to 23 lbs. The water-tube boiler has somewhat the advantage as to space occupied, but the advantage is not nearly so pronounced as in case of the weight. Other qualifications, to be looked for in a boiler for the higher steam pressure, would be as follows:—

First.—The cost of construction and installation should not be any greater that at present with cylindrical boilers.

Second.—The material of the heating surface should be as thin as possible, consistent with safety.

Third.—The furnace and combustion chamber should be sufficiently large to effect the complete combustion of the gases, before they pass to the heating surface, and lose any of their heat.

Fourth.—After leaving the combustion chamber, these gases should be well broken up into small streams, and well distributed over the heating surfaces.

Fifth.—The gases should not pass to the uptake until sufficient time has elapsed to enable them to give up as much of their heat as possible.

Sixth.—The construction should be such, that one can readily gain access to all parts for cleaning, examination and repairs and that all parts exposed to fire may be renewed without interfering, seriously, with the remainder of the boiler.

Seventh.—Its general arrangement should be such that mud and grease may collect somewhere at the bottom, out of the reach of the fire.

Eighth.—Should the supply of feed-water be interrupted, the boiler could steam for some time without the water lowering sufficiently to uncover any of the heating surfaces.

As to cost, the water-tube boiler proper is cheaper of construction, but when installation and royalties on patents are considered, the water-tube boiler costs just about the same as the cylindrical. The thickness of the material forming the heating surface is a very important consideration. We have already found, that the increased temperature of the water decreases the efficiency of the heating surfaces, and if we are also compelled to increase the thickness of the plates, or tubes, we shall still further decrease the efficiency. All things else being equal, we shall necessarily increase the thickness of circular furnaces, increase the thickness of flat stayed surfaces, or decrease the pitch of the stays, and increase the thickness of stay tubes, but plain tubes will not need to be increased in thickness, because they are now made sufficiently thick, hence a preference will be given the boiler in which as large a proportion of the heating surface as possible consists of plain tubes. As to size and arrangement of combustion chamber, too much consideration cannot be paid. If complete conbustion of furnace gases is not effected before they pass to the heating surfaces and lose a portion of their heat, much of the fuel will pass off into the up-take, never havin been burned at all. The ideal combustion chamber would be a large free space, immediately above the grate bars.

The distribution of the gases over the heating surfaces, and the time which they are in contact with the heating surfaces, affects the efficiency of the boiler very much. To secure a large efficiency, the water must extract as much heat as possible from the hot gases. Up to a certain limit, the gases must be as long a time as possible in passing over the heating surfaces, and they must also be well broken up into small currents, so that they may yield up their heat as readily as possible. The cylindrical return tubular boiler satisfies these demands splendidly, as long as the tubes are cleaned often. The tendency to choke up with deposited carbon, is manifestly much greater in the fire tube boiler than in the wàter-tube.

As to the sixth qualification, the cylindrical boiler may be readily examined and leaky tubes replaced easily; but, on the other hand, the strains due to the high pressure and temperature, will tend to shorten the life of the furnace and combustion chamber, and it will be apparent, that when the combustion chamber in a Scotch boiler gives out, the whole boiler may just as well be replaced, while with water-tube boilers, all parts exposed to the hottest portion of the fire may be readily replaced, not interfering with the remainder of the boiler.

As to the boiler's arrangement being such that mud and grease may collect out of the reach of the fire, neither type offers any advantage over the other, both furnishing good receptacles for deposits, away from the action of the fire.

As to the last qualification desired, the cylindrical, return tubular boiler offers a decided advantage. The Scotch boiler with six or eight inches of water over the crown sheet, will steam for thirty minutes without any danger to the soft plugs, while with the water-tube boiler, unless the water-tender watches his gauge continually, the water may be out of the gauge glasses, with the feed pump working, in an incredibly short time. It takes one person's attention almost constantly, to keep a satisfactory level in the marine water-tube boiler. This makes it necessary to have a feed supply on which the engineer in charge may depend at all times.

In a general comparison between water-tube and Scotch boilers, the former have relative advantages in considerations relating to safety from disastrous explosions, weight, suitability for high pressures, quickness of raising steam, which makes them highly desirable for war vessels, and ability to stand forcing. They have relative disadvantages in considerations relating to the general sensitiveness to variations in the circumstances under which they are working, and to the general feeling of uncertainty as to their durability and efficiency under conditions prevailing on deep water voyages.

From the owner's standpoint, the water-tube boiler possesses many advantages, which I believe will bring it into general use, but it has never yet been the favorite with the engineer in charge, because of this unfeeling of uncertainty as to its behaviour under all conditions, and because of the extra vigilance required on the part of the water-tender.

Marine architects and designing engineers seem to have considered the cylindrical boiler utterly unsuited for pressures exceeding 165 or 170 pds., and it seems certain that with a cylindrical boiler, a pressure of above this point is obtained only with great difficulties of construction. I have only heard of one boat on the lakes, or engaged in the coasting trade in the United States, which carries a pressure of over 200 pds. in Scotch boilers.

On the lakes, there are a considerable number of boats with water-tube boilers, carrying a pressure of 250 pds. or thereabouts, of these, two, the Northland, and Northwest, the magnificent, exclusively passenger steamers of the Northern Steamship Co. have each twenty-eight Belleville boilers. All the rest, as far as I know, have Babcock and Wilcox boilers.

For naval work, the British Admiralty has favored the Thornycroft for lighter boats, such as torpedo boats and destroyers, while, in the heavy vessels, the Belleville has been given the preference.

The Niclausse and Legrafel D'Allest boilers are used largely in the French Navy.

The Belleville has far outstripped all competitors in the Russian Navy.

NEELY'S FORMULA FOR THE STRENGTH OF WOODEN BEAMS.

By J. A. Duff, B.A.

There is no department of Engineering Science, in which greater progress has been made during recent years, than in Timber Physics. This progress is chiefly due to the work of the United States Division of Forestry, which, by means of liberal government appropriations, has been able to conduct under the direction of Mr. B. E. Fernow, Chief of the Division, a series of investigations on the properties of timber, that for scientific excellence and fruitful results stands unrivalled in the history of timber testing. The feature that distinguishes these from other tests on timber, and is at the same time the cause of their pre-eminent value both for commercial use and in the advancement of science, is that the greatest care was taken to record and correlate the chemical, physical and mechanical properties, and also the life history of each specimen. Every factor in the condition or history of a specimen that might have an influence on the mechanical properties was carefully observed, and the amount of that influence made the subject of special investigation. By systematically eliminating the effect of each variation, the true relative values were obtained, results apparently discordant were found to harmonize, and order was brought out of chaos.

An account of the investigations is contained in the circulars and bulletins of the U. S. Division of Forestry,* the most valuable publications in the English Language, on the subject of Timber Testing. A few paragraphs will be quoted to indicate their scope and purpose.

From the Preliminary Report (Bulletin No. 6, 1892):—"There is one important factor of difference between other materials of construction and timber. It is the factor of life. Life means variety, change, variability. Each individual differs from every other in its development, and each part of the individual differs from its other parts in structure, and hence in qualities. Each living tree of the

*For list of these publications see page 208.

same species, therefore, converted into building material offers a different problem as to its properties, especially its strength, and each stick taken from a different part of the tree shows different quality.

"This endless variability it is that has kept us in ignorance as to the capabilities of our timbers. While, by experience, we have learned that these differences exist, and even learned to find some of the relations between physical appearances, anatomical structure, and mechanical properties, the enormity of the enterprise has baffled investigators and deterred them from carrying on, in a systematic and comprehensive manner, such tests and examinations as would furnish us not only with reliable data as to the range of capacity of our timbers, but also as to the exact relation of their properties to their structure and physical condition.

"This investigation, the most comprehensive of the kind ever undertaken anywhere, in this country or in Europe, differs from all former attempts in similar direction in this, that it starts out with the fullest recognition of three facts:

(1) That in order to establish reliable data as to mechanical properties of our timbers, it is necessary to make a very large number of tests, by which the range as well as the average capabilities of the species is determined.

(2) That in order to enable us to make the most efficient practical application of the data thus obtained, it is necessary to know the physical and structural conditions of the test material, and bring these into relation with the best results.

(3) That in order, further, to deduce laws of relation between mechanical properties and the physical and structural conditions, as well as the conditions under which the material was produced, it is necessary to work on material the history of which is thoroughly known.

"Briefly, then, to solve the problems before us, it is necessary to make our tests on a large number of specimens of known origin, and known physical condition. While the tests in themselves appeal at once and first to the engineer, inasmuch as, by their great number, they will furnish more reliable data regarding the capabilities of the various timbers, the chief value and most important feature of the work lie in the attempt to relate the mechanical properties to the structure of the material, and to the conditions under which it was produced.

"We are not only concerned to know that a stick of this species of tree will bear a given load, but we want to be able to tell why this stick of the species will bear so much, and why the other stick of the same species will bear only half as much; why the timber grown in this locality is found generally superior to that of the same species grown in another locality, etc.

"When we have established such knowledge, then it will be possible for an engineer, not only to specify his timbers intelligently, but also to inspect them and to know whether or not they come up to his specifications."

And from *Circular No. 15.*

"The chief points of superiority of the data obtained in these investigations lie in: (1) Correct identification of the material, it being collected by a competent botanist in the woods; (2) Selection of representative trees with record of age, development, place and soil where grown, etc.; (3) Determination of moisture conditions and specific gravity, and record of position in the tree of the test pieces; (4) Large number of trees and of test pieces from each tree; (5) Employment of large and small sized test material from the same trees; (6) Uniformity of method for an unusually large number of tests.

"The entire work of the mechanical test series, carried on through nearly six years, intermittently, as funds were available, comprises so far 32 species, with 308 test trees, furnishing over 6,000 test pieces, supplying material for 45,336 tests in all, of which 16,767 were moisture and specific gravity determinations on the test material.

"In addition to the material for mechanical tests, about 20,000 pieces have been collected from 780 trees (including the 308 trees used in mechanical tests), for physical examination to determine structure, character of growth, specific gravity of green and dry wood, shrinkage, moisture conditions, and other properties and behavior.

"In addition to the regular series of tests, the results of which are recorded in the subjoined tables, special series to determine certain questions were planned and carried out in part, or to finish, adding 4,325 tests to the above number."

RESULTS.

As a result of these investigations, reliable strength values for the principal timbers of the Southern and Eastern States are now available.

Another and more valuable result is the establishment of general laws regarding the strength of timber, the most important of which may be stated as follows:—

1. A difference in strength values derived from a few specimens of the same kind of wood, up to 10 per cent. for coniferous woods, and to 15 per cent. for hard woods, cannot be considered a difference of practical importance; such differences cannot be relied upon as furnishing a criterion of the quality of the material.

2. The size of the test piece does not in itself influence strength values (except in columns, and in compression blocks shorter than cubes).

3. Small test pieces judiciously selected, furnish a better statement of average values of a species than tests on large beams and columns in large numbers.

4. A large series of tests on small pieces will give practically the same result as such a series on large beams and columns; hence there is no need of finding a co-efficient, with which to relate the results of the former to construction members.

5. The presence of moisture greatly reduces the stiffness and the compression and cross-breaking strength, but has very little influence on the tensile strength. Yard dried timber is about 50 per cent.; and house (or kiln) dried, 80 per cent. stronger than green or saturated timber. The manner of drying has no effect on the compression strength. The strength is reduced by the re-absorption of moisture to the same extent, as it is increased by drying.

6. The percentage of moisture being the same, the compression strength of conifers is proportional to the specific gravity.

7. The specific gravity of dry wood depends upon the ratio of summer to spring wood in the annual growth rings.

8. An inspection of the relative amount of summer wood furnishes the most delicate and accurate measure of differences in the specific gravity and strength, and is the surest criterion for ocular inspection of quality.

The influence of moisture and specific gravity on strength had been previously observed by Bauschinger, but the U. S. Forestry investigations established the laws by the authority of a very much larger number of tests.

NEELY'S FORMULA.

Finally, and most important of all, the relation worked out by Mr. S. T. Neely, which may be stated as follows:—

9. The extreme fibre stress of beams at elastic limit is equal to the compression-endwise strength of the material, and the strength of beams at rupture can be directly calculated from the compression-endwise strength; the relation of the compression-endwise strength to the breaking load of a beam may be expressed by a simple formula.

This relation is fully worked out in *Circular No. 18, 1898,* and is referred to by Mr. Fernow in the following terms:—

"When the writer, in 1891, organized the comprehensive work of timber physics in the Division of Forestry, planned several years before, he realized that the large series of data resulting from the many different kinds of tests, while necessary, would be difficult to handle and correlate; but he also foreshadowed the possibility of finding such a relation between the same as to reduce the number of tests necessary. This hope was expressed in the following sentence, in Bulletin 6, page 30, 1892, when discussing this line of work:

"'By and by it is expected that the number of tests necessary may be reduced considerably, when for each species the relation of the different exhibitions of strength can be sufficiently established, and perhaps a test for compression alone furnish sufficient data to compute the strength in other directions.'

"It is therefore with great gratification that the writer may now announce that the expectation then expressed is now realized.

"A careful study of the accumulated data by Mr. S. T. Neely, disclosed such a constant proportionality between the compression and cross-bending strength, that he was led to investigate the same more closely.

"His studies have enabled him to elucidate, not only the true position of the neutral plane in beams, which had hitherto been in doubt, but also to develop the formula for a practically correct correlation between compression and bending-strength, both at the elastic limit and at rupture. The results, we believe, will be of far-reaching importance, both to the science of wood and wood testing, and to the practice of using test data in designing structures.

"It would appear that the strength of a beam at the elastic limit—the only strength value in which the practitioner is interested when designing beams—is equal practically to the compression endwise strength of the material; that is to say, the compression strength is to be used for the factor f in the current beam formula,

$$W = \frac{2bh^2}{3l} f.$$

"We expect, finally, after further verification of the discovered correlation, that compression tests alone may suffice in future to determine all strength values of the material; that the designing of beams will be accomplished upon such data with much more confidence; that the factor of safety will be brought to a rational basis, and that greater economy in the use of wood will also be secured."

The following demonstration of Mr. Neely's formula is substantially the same as that given by him, the form being somewhat altered, and the notation changed to one that is more familiar to the members of our society.

RELATION OF COMPRESSION—ENDWISE STRENGTH TO BREAKING LOAD OF BEAM.

"In testing timber to obtain its various coefficients of strength, the test which is at once the simplest, most expedient, satisfactory, and reliable is the 'compression-endwise test,' which is made by crushing a specimen parallel to the fibres. All other tests are construing a specimen parallel to the fibres. All other tests are either mechanically less easily performed, or else, as in the case of cross bending, the stresses are complex, and the result coefficient can be expressed only by reliance upon a theoretical formula, the correctness of which is in doubt. It would, therefore, be of great practical value to find a relation between the cross-bending strength, the most important coefficient for the practitioner, and the compression strength, when the study of wood would not only be greatly simplified and cheapened, but the data could be applied with much greater satisfaction and safety."

THE ORDINARY THEORY OF THE BEAM

For the discussion of the relation of the internal stresses to the external load, assume the simple case of a beam of uniform rectangular cross-section, supported at each end, and loaded at the centre. The lower surface of the beam will become convex, and the upper concave, and the fibres at the lower side are extended, and at the upper side compressed. The surface which separates these two portions tions of the beam and which is neither extended nor compressed is called the *neutral surface.*

Let l = length of span.
h = depth of beam. .
b = breadth of beam.
E = Young's modulus of elasticity.
W = load at centre of beam.
Δ = deflection at centre of beam.
f = stress on extreme fibre.

Then, according to the theory of the beam in common use:—

$$f=\frac{3Wl}{2bh^2} \qquad (1)$$

$$\Delta=\frac{Wl^3}{4Ebh^3}=\frac{l^2f}{6Eh} \qquad (2)$$

This theory is founded upon the ordinary laws of statics, and the following hypotheses:—

1. A cross-section, which is plane before bending, remains plane after bending; the form and area of the cross-section is unaltered; the curvature of the beam is continuous.

2. The stresses are connected with the strains by Hooke's Law.

From the first of these hyphotheses is deduced the law that the strain of the fibre is proportional to the distance from the neutral axis. From the second that the stress is also proportional to the distance from the neutral axis, and that the neutral axis is at the centre of the beam (of rectangular cross-section).

They may be accepted as true, provided:—

(*a*) The beam is a "long" beam; i.e., the ratio of length to depth is large so that the shearing stresses may be neglected in comparison with the normal stresses.

(*b*) The extreme fibre stress does not exceed the elastic limit in tension or compression.

Within these limitations the theory is rational and consistent with the results of experiments in timber. Beyond these limits the theory fails, but the breaking load is still expressed by the same equation $W=\frac{2bh^2}{3z}f$ where f is not the actual stress on the extreme fibre, but what that stress *would be if* the theory were applicable beyond the elastic limit.

NEELY'S THEORY.

The considerations upon which Mr. Neely's theory is founded are:—

1. The first hypothesis of the ordinary theory is true for all loads up to rupture, and, therefore, the strain is, even at rupture, proportional to the distance from the neutral axis.

2. The second is true for any fibre on which the stress is within the elastic limit.

3. If the stress on any fibre exceeds the elastic limit, it is not proportional to the strain, and the position of the neutral axis is altered.

For stresses beyond the elastic limit the distribution of stress and the position of the neutral axis are determined from the following additional considerations:—

4. The tensile strength of timber is much greater than the compression-endwise strength. The elastic limit in either case is almost as great as the ultimate strength. Young's modulus is the same for both.

5. Wood tested in tension breaks suddenly as soon as the ultimate load is reached; tested in compression-endwise, it undergoes considerable distortion while sustaining the maximum load.

6. The elastic limit of a beam (shown on the load-deflection diagram, as the point where it ceases to be a straight line), is reached at the same time as the elastic limit of the extreme compression fibre.

7. A "long" beam will sustain an increasing load after the extreme compression fibre has been loaded to its ultimate strength; the compression fibres continue to be mashed down while the neutral plane is lowered, and the stress on the tension fibres increased until the beam "fails in tension."

8. The stress on any fibre *cannot* exceed the compression endwise strength.

9. "Finally and most important, it appears from (4) and (6), but especially from an examination of the several thousand test results on the several species of conifers made by the Division of Forestry that, *the extreme fibre stress at the elastic limit of a beam is practically identical with the compression endwise strength of the material.*

From these considerations it appears that after the stress in the extreme compression fibre reaches the elastic limit in compression (which is practically the ultimate compressive strength), the fibre strain continues to increase while the stress remains constant; the stress in each of the remaining compression fibres increases according to Hooke's Law, until each in succession reaches the elastic limit, after which it remains constant; at the same time the stresses on the tension side increase according to Hooke's Law (being within the elastic limit in tension), and the neutral axis shifts towards the tension side (so as to always preserve the equality of the total tensile and compressive stresses). Finally, when the ultimate strength of the extreme tension fibre is reached the beam suddenly "fails by tension."

Accordingly in the stress-strain diagram at rupture (Fig. 2).

If HK represents the cross-section of the beam.

MH the stress on the extreme compression fibre.

KL the stress on the extreme tension fibre.

NP the stress on last fibre to reach the elastic limit in com- limit in compression.

The line MN will be practically straight and vertical, NL will be straight and intersect HK in the neutral axis, and the stress-strain diagram will be composed of the rectangle $MNPH$ and the triangles NOP, and OLK. (The curvature of OL as indicated by the line ORL^1, where OL^1 is the actual stress on the extreme tension of fibre at rupture, is neglected).

On account of the proportionality of strain to distance from neutral axis, the vertical ordinate may represent (a) distance from neutral axis, or (b) the strain of the fibre. Accordingly HK represents not only the depth of the beam but also the total fibre strain or the sum of the amounts by which the extreme compression fibre is shortened and the extreme tension fibre lengthened. (The scale of strains in Fig. 2 is not the same as in Fig. 1.)

DEVELOPMENT OF FORMULA.

In the beam under consideration let the following quantities be observed and recorded:

Let h = depth of the beam,
b = breadth of the beam,
l = length of the beam,
W_e = load at elastic limit,
W = load at rupture,
Δ_e = deflection at elastic limit,
Δ_r = deflection at rupture,
E = Young's modulus of elasticity,
f_c = compression-endwise strength (from separate test).

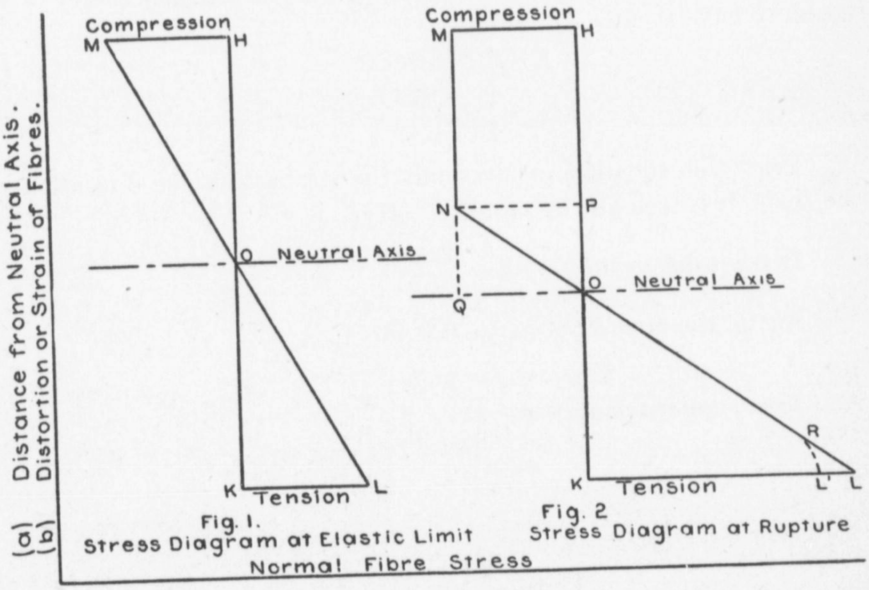

Fig. 1. Stress Diagram at Elastic Limit

Fig. 2 Stress Diagram at Rupture

By means of formula derived from the geometrical relations of the diagram (Fig. 2.) and the statical equations of equilibrium the following quantities can be calculated:

Let s_e = elongation or contraction of extreme fibre at elastic limit = OH in Fig 1.

s_t = elongation of extreme tension fibre at rupture = OK in Fig. 2.

s_c = contraction of extreme compression fibre at rupture = OH in Fig. 2.

y_t = distance of neutral plane at rupture from tension side of beam = OK in Fig. 2.

y_c = distance of neutral plane at rupture from that fibre on the compression side which has just reached the elastic limit = OP in Fig. 2.

f_e = elastic limit stress in compression-endwise = MH in Fig. 1, or NP in Fig. 2.

f_t = stress in extreme tension fibre at rupture = KL in Fig. 2.

T = total tensile stress on cross-section at rupture = triangle KLO.

C = total compression stress on cross-section at rupture = area $HMNO$.

$\bar{y}_t$ = distance of C. of G. of tension area from neutral axis at rupture.

$\bar{y}_c$ = distance of C. of G. of compression area from neutral axis at rupture.

M = moment of the internal stresses at rupture.

W' = theoretical breaking load (calculated by Neely's formula).

From the above considerations and from the ordinary theory of the beam we have at once

$$f_e = f_c \tag{1}$$

$$s_e = \frac{1}{E} f_e = \frac{6\Delta_e h}{l^2} \tag{2}$$

Since this equation involves only the strains and the dimensions of the beam, it is true also at rupture. (Hyp. 1.)

Hence total strain $= s_c + s_t = \dfrac{12\Delta_r h}{l^2}$

Again, the area KLO = area $HMNO$

$$\therefore \tfrac{1}{2} s_t f_t = s_c f_c - \tfrac{1}{2} s_e f_c$$

And from similar triangles

$$f_t = \frac{s_t}{s_e} f_c$$

$$\therefore \tfrac{1}{2}\frac{s_t^2}{s_e} f_c = s_c f_c - \tfrac{1}{2} s_e f_c$$

$$s_t^2 = 2 s_c s_e - s_e^2 = 2\left(\frac{12\Delta_r h}{l^2} - s_t\right) s_e - s_e^2$$

$$s_t^2 + 2 s_t s_e + s_e^2 = \frac{24\Delta_r h}{l^2} s_e = \frac{144\,\Delta_r \Delta_e h^2}{l^4}$$

$$\therefore s_t + s_e = 12\sqrt{\Delta_r \Delta_e} \cdot \frac{h}{l^2}$$

$$s_t = (2\sqrt{\Delta_r \Delta_e} - \Delta_e)\frac{6h}{l^2} \tag{3}$$

$$s_c = 12\Delta_r \frac{h}{l^2} - s_t = (2\Delta_r - 2\sqrt{\Delta_r \Delta_e} + \Delta_e)\frac{6h}{l^2} \tag{4}$$

$$f_t = \frac{s_t}{s_e} f_c = \frac{2\sqrt{\Delta_r \Delta_e} - \Delta_e}{\Delta_e} f_c = \left(2\sqrt{\frac{\Delta_r}{\Delta_e}} - 1\right) f_c \qquad (5)$$

$$y_t = \frac{s_t}{s_t + s_c} . h = \frac{2\sqrt{\Delta_e \Delta_r} - \Delta_e}{2\Delta_r} . h = \sqrt{\frac{\Delta_e}{\Delta_r}}\left(1 - \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\right) h \qquad (6)$$

$$y_c = \frac{s_c}{s_t + s_c} . h = \frac{\Delta_e}{2\Delta_r} . h \qquad (7)$$

$$C = T = \tfrac{1}{2} y_t f_t = \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\left(1 - \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\right)\left(2\sqrt{\frac{\Delta_r}{\Delta_e}} - 1\right) h f_c = \left(1 - \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\right)^2 h f_c \qquad (8)$$

$$\overline{y_t} = \tfrac{2}{3} y_t = \tfrac{2}{3}\sqrt{\frac{\Delta_e}{\Delta_r}}\left(1 - \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\right) h. \qquad (9)$$

$$\overline{y_c} = \frac{\tfrac{1}{2}(h - y_t) \times \text{Area } OQMH - \tfrac{1}{3} y_c \times \text{Area } OQN}{\text{Area } ONMH}.$$

$$= \frac{\tfrac{1}{2}(h - y_t)^2 - \tfrac{1}{6} y_c^2}{(h - y_t) - \tfrac{1}{2} y_c} = \tfrac{1}{2}\frac{(h - y_t)^2 - \tfrac{1}{4} y_c^2}{(h - y_t) - \tfrac{1}{2} y_c} \text{ nearly.}$$

$$= \tfrac{1}{2}\{h - y_t + \tfrac{1}{2} y_c\} = \tfrac{1}{2}\left\{1 - \sqrt{\frac{\Delta_e}{\Delta_r}}\left(1 - \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\right) + \tfrac{1}{4}\frac{\Delta_e}{\Delta_r}\right\} h$$

$$= \tfrac{1}{2}\left(1 - \sqrt{\frac{\Delta_e}{\Delta_r}} + \tfrac{3}{4}\frac{\Delta_e}{\Delta_r}\right) h \qquad (10)$$

$$\overline{y_t} + \overline{y_c} = \tfrac{2}{3} y_t + \tfrac{1}{2}(h - y_t) + \tfrac{1}{4} y_c = \tfrac{1}{2} h + \tfrac{1}{6} y_t + \tfrac{1}{4} y_c$$

$$= \left\{\tfrac{1}{2} + \tfrac{1}{6}\sqrt{\frac{\Delta_e}{\Delta_r}}\left(1 - \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\right) + \tfrac{1}{8}\frac{\Delta_e}{\Delta_r}\right\} h = \tfrac{1}{2}\left(1 + \tfrac{1}{3}\sqrt{\frac{\Delta_e}{\Delta_r}} + \tfrac{1}{12}\frac{\Delta_e}{\Delta_r}\right) h \qquad (11)$$

$$M = (C\overline{y_c} + T\overline{y_t}) b = (\overline{y_c} + \overline{y_t}) T . b.$$

$$= \tfrac{1}{2}\left(1 + \tfrac{1}{3}\sqrt{\frac{\Delta_e}{\Delta_r}} + \tfrac{1}{12}\frac{\Delta_e}{\Delta_r}\right)\left(1 - \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\right)^2 b h^2 f_c \qquad (12)$$

$$W' = \frac{4M}{l} = 2\left(1 + \tfrac{1}{3}\sqrt{\frac{\Delta_e}{\Delta_r}} + \tfrac{1}{12}\frac{\Delta_e}{\Delta_r}\right)\left(1 - \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\right)^2 \frac{bh^2}{l} f_c \qquad (13)$$

or $$W' = n\frac{bh^2}{l} f_c \qquad (13)$$

where n is a numerical co-efficient, $= 2\left(1 + \tfrac{1}{3}\sqrt{\frac{\Delta_e}{\Delta_r}} + \tfrac{1}{12}\frac{\Delta_e}{\Delta_r}\right)\left(1 - \tfrac{1}{2}\sqrt{\frac{\Delta_e}{\Delta_r}}\right)^2$

Unfortunately no tests have been made to study the application of these formula directly and in particular. The tests on beams made by the U. S. Division of Forestry were made for a different prepurpose, and Neely's theory was not worked out until after the present series of tests had been completed.

The following table exhibits the results of applying the formula to the data from these tests.

TABLE SHOWING RESULTS OBSERVED AND CALCULATED BY USUAL METHODS AND BY NEELY'S FORMULA.

Kind of Wood.	Original Number of Beam.	Data Observed and Calculated by Usual Methods. Compression Endwise Strength.	Dimensions in Inches. Length.	Depth.	Breadth.	Deflections in Inches. At Elastic Limit.	At Rupture.	Young's Modulus in 1,000 lbs. per square inch.	Loads in Pounds. At Elastic Limit.	At Rupture.	Results Calculated by Neely's Formula. Ratio of Deflections.	Numerical co-efficient in Equation 13.	Extreme Fibre Stress at Elastic Limit.	Stress in Extreme Tension Fibre at Rupture.	Theoretical Load at Rupture.
		f_c	l	h	b	Δe	Δv	E	W_e	W	$\frac{\Delta e}{\Delta r}$	n	f_e	f_t	W'
Short-leaf Pine......	12	*3,850*	192	11·87	7·87	1·02	3·10	1,711	13,000	**28,000**	·329	1·240	*3,380*	9,600	**27,600**
"	28	*3,590*	216	11·9	8·2	1·80	6·24	1,483	13,300	**23,500**	·287	1·290	*3,710*	9,800	**25,500**
"	9	*4,030*	192	12·0	8·0	1·50	6·16	1,630	19,000	**32,800**	·244	1·340	*4,750*	12,200	**32,400**
"	10	*3,900*	192	12·0	8·0	1·39	4·31	1,340	17,000	**29,400**	·325	1·244	*4,250*	9,800	**29,100**
"	13	*4,100*	192	12·1	8·10	1·36	4·06	1,540	17,000	**29,800**	·334	1·233	*4,130*	10,000	**31,200**
"	29	*4,450*	216	11·75	7·9	1·92	4·86	1,703	16,000	**24,500**	·395	1·168	*4,750*	9,700	**26,250**
"	33	*4,350*	216	12·06	8·0	1·48	3·36	2,017	16,000	**26,400**	·440	1·125	*4,460*	8,800	**26,370**
"	38	*4,500*	216	12·0	7·95	1·77	5·57	1,718	16,000	**27,240**	·318	1·228	*4,500*	11,400	**29,300**
Long-leaf Pine......	43	*5,300*	216	12·3	8·10	1·97	4·90	1,715	20,000	**33,550**	·402	1·160	*5,280*	11,400	**34,900**
White Pine	51	*3,330*	216	12·1	7·95	1·69	3·75	1,320	12,000	**18,700**	·450	1·110	*3,340*	6,600	**19,900**
Red Oak	3	*3,030*	192	12·0	8·0	1·50	7·94	1,646	9,000	**25,800**	·189	1·420	*2,250*	10,900	**25,800**
"	4	*4,460*	216	12·25	8·0	1·90	5·93	1,825	20,000	**31,500**	·320	1·250	*5,400*	11,300	**31,000**
"	8	*3,470*	216	12·25	8·37	1·71	6·70	1,485	14,000	**26,000**	·255	1·330	*3,610*	10,300	**26,800**

NOTE.—Columns of figures to be compared are in the same distinctive type.

An examination of the table shows the close correspondence between the actual breaking load of the beam and that calculated by means of Neely's Formula and also between the compression-endwise strength and the extreme fibre stress at elastic limit.

Comparing Neely's formula (equation 13) with the one in common use, we have for the value of the modulus of rupture—

$$f = \frac{3}{2}\, n\, f_c \qquad (14)$$

It follows from this equation that if the numerical coefficient n were constant, the modulus of rupture would be a constant multiple of the compression-endwise strength and consequently a satisfactory measure of quality. One objection to the use of the modulus of rupture is that it is a fictitious quantity, representing a stress which never does exist. A more serious practical objection is that it is not constant, varying not only with the content of moisture and other properties which exert an influence on the crushing and bending strength, but also with the ratio of length to depth of beam (even in "long" beams).

In the expression for the modulus of rupture (equation 14), the value of f_c should include all those variations which depend upon moisture, specific gravity, etc., and the numerical coefficient n should include those dependent on the proportions of the beam.

This is borne out by the values given in the above table which indicate that n varies with the proportions of the beam, decreasing as the ratio of length to depth is increased. The average value of n is 1.26 for the 4 short-leaf pine beams in which the ratio of length to depth is 16 and the average value of n is 1.20 for the 4 in which the ratio is 18. A similar decrease may be observed in the values of n for all the beams irrespective of species, but the number of tests is altogether too few to deduce any general law.

In order to derive the full benefit from Neely's theory as applied to the ultimate strength of beams, it will be necessary to establish the values of the numerical coefficient n for different materials and varying proportions.

It is not necessary, however, to establish these values in order to use Neely's formula for the load on a beam at the elastic limit —the load with which the practitioner is chiefly concerned—it being obtained at once from the equation

$$W_e = \frac{2bh^2}{3l} f_c$$

when the compression-endwise strength of the timber is known.

By referring the working stresses to the strength at the elastic limit instead of to the ultimate strength, a reliable system of strength values and factors of safety could be established, which would result in greater security and economy in the construction and use of timber beams.

PUBLICATIONS OF THE DIVISION OF FORESTRY.

The publications of the U. S. Division of Forestry so far issued as a result of the timber physics work are:

Bulletin 6. Timber Physics Part I., a preliminary statement of the scope and history of timber physics and of the methods pursued in these investigations. 4to, 57 pp. Price 10 cents.

Bulletin 8. Timber Physics Part II., being an exhaustive report of the results with Longleaf Pine. 4to, 92 pp. Out of print.

Bulletin 10. Timber—being a brief discussion of the characters and properties of wood in general, with a key and list to the commercial woods of the United States. 1895. 8vo, 88 pp. Price 10 cts.

Bulletin 12. Economical Designing of Timber Trestle Bridges, being an application of some of the results to practical problems. 8vo, 57 pp. Out of print.

Circulars 8 and 9, announcing the results of tests on bled and unbled Longleaf Pine.

Circular 12. Southern Pines, Mechanical and Physical Properties, giving a résumé of the results of 20,000 tests, and of an exhaustive physical examination of the four species under consideration. 4to, 12 pp.

Circular 15. Summary of Mechanical Tests on 32 species of American Woods. 4to, 12 pp.

Circular 18. Progress in Timber Physics—a résumé of results and discussion of Neely's Formula. 4to, 20 pp.

Circular 19. Progress in Timber Physics—mechanical and physical properties of the Bald Cypress. 4to, 24 pp.

These Bulletins and Circulars, together with other publications relating to Forestry, can be had at the prices noted by application to the Superintendent of Documents, Union Building, Washington, D.C., payment to be made by coin or postal note.

Where no prices are noted, a limited number of copies for free distribution is still on hand.

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Residue on sieve No. 100—0.08%.
Residue on sieve No. 200—1.003%.
Hot test—Perfect and sound.
Specific gravity—3.077.

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C.—One part Silica Cement, one part sand beween sieves No. 50 and 75, and four parts of standard stand, or one part of *B* to two parts of standard sand, *i.e.*, one part of cement to eleven parts of sand.

Tensile Strength.

——	AT 7 DAYS.	AT 14 DAYS.	AT 30 DAYS.	AT 90 DAYS.
	435	530	535	590
	450	555	550	600
A..................	460	585	550	620
	470	....	570	635
	470	....	585	....
Average	457	555	558	611
	180	235	290	355
	190	250	295	365
B..................	200	250	310	365
	226	270	350	405
	....	270	....	425
Average	199	255	311	385
	55	70	125	145
	55	75	140	155
C..................	60	80	150	155
	60	95	155	170
	65	95	....	175
Average	59	83	142.5	160

J. S. KORMANN.

OBITUARY NOTICE.

Colonel Sir Casimir Stanislaus Gzowski, K.C.M.G., one of the foremost engineers in Canada died at his residence, "The Hall," Bathurst Street, Toronto, on August 24th, 1898.

Descended from an ancient Polish family, his father, Stanislaus, Count Gzowski, was an officer in the Imperial Guard of Russia, stationed at St. Petersburg, where Sir Casimir was born in 1813. He was educated in a military college at Kremnitz, and in 1830 received a commission in the engineering branch of the Russian army. In the same year an insurrection broke out in Poland, and Sir Casimir left the Russian service to fight for the liberty of his countrymen. He served with distinction throughout the war, and after the Poles were finally overpowered, he was imprisoned for some months, and then exiled to the United States of America.

He landed in New York in 1833 with very little money, and not the slightest knowledge of the English language. He managed to support himself by teaching French, German and Italian, while he devoted himself to the study of law with the idea that by this means he could best acquire a knowledge of English.

After practicing law in Pennsylvania for a few years, he came to Toronto in 1841 and was an engineer in the Department of Public Works until 1846, when he left the Government employ and engaged in private practice. From 1850 to 1853 he was engineer of the Harbour Works at Montreal, and consulting engineer of the ship canal improvement between Montreal and Quebec. He then became chief engineer of the St. Lawrence and Atlantic Railway (now a portion of the Grand Trunk system), but soon resigned and entered into partnership with Sir A. T. Galt, the late Hon. L. H. Holton, and the late Sir David Macpherson for the construction of the Grand Trunk main line from Toronto to Sarnia.

On the completion of this contract, the firm of Gzowski and Macpherson was formed, which for many years carried on extensive railway building operations, amongst others the International Bridge over the Niagara River, which was completed in 1873, Sir Casimir being construction engineer. His skill in overcoming the engineering difficulties in this great work won him the admiration of the engineers of the world.

He was a member of the Institution of Civil Engineers, of the American Society of Civil Engineers and one of the founders and first President of the Canadian Society of Civil Engineers. He was first chairman of the Niagara Falls Park Commissioners, an officer of various financial institutions and President of the Corporation of Wycliffe College.

He took a deep interest in the Canadian Militia and was unceasing in his efforts for its improvement. In 1872 he was made Lieutenant-Colonel, in 1879 Colonel and honorary A.D.C. to the Queen. In 1890, in recognition of "valuable services rendered to the Dominion of Canada" he was created a K.C.M.G.

In 1896 he acted as Administrator of the Government of Ontario, during the absence through illness of Sir George Kirkpatrick.

Sir Casimir married, in 1839, Miss Maria Beebe, daughter of an eminent American physician, who survives him. His son, Mr. C. S. Gzowski, lives in Toronto, and his grandson C. S. Gzowski, jr., is on the engineering staff of the Canadian Pacific Railway.

INDEX TO THE FIRST TWELVE NUMBERS.