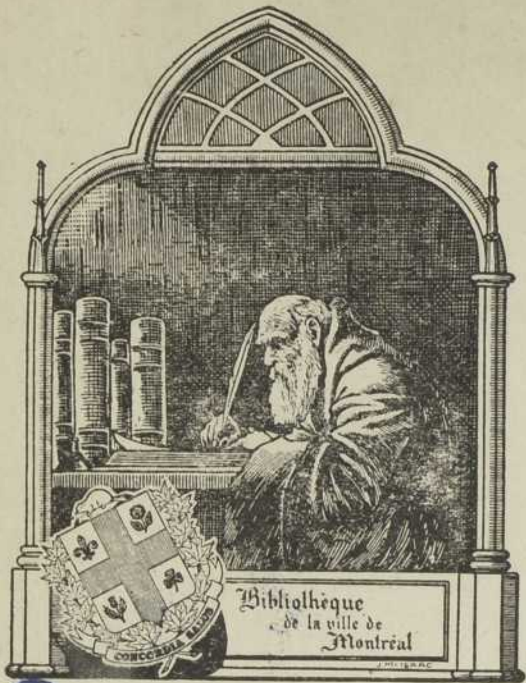
The Cement Industry in Canada


CONCORDIA SALUS
Bibliothèque
de la ville de
Montréal

Don

The Cement Industry in Canada

By A. C. Tagge

THIS little sketch of the CEMENT INDUSTRY IN CANADA grew out of a desire to make and preserve a record of the principal facts connected with the beginnings of what has grown to be one of our most important manufacturing industries. It was written primarily for those connected with the industry, but upon completion of the purely historical part it was thought it might be made of wider interest by including some general information as to the nature of cement, its origin, and the process of manufacture. The first three chapters were added for this purpose.

The information has been collected from many sources — Government records, private books and documents, and by correspondence or personal interview with men who were connected with the older companies. Considerable care has been taken to verify, in so far as possible, dates and principal facts, and it is believed that they will be found to be substantially correct.

The writer cannot make individual acknowledgment to the long list of those who have assisted by putting him in possession of information that it would have been difficult or impossible to obtain otherwise, but he wishes here to express his appreciation of the assistance so freely given.

A. C. TAGGE.

Montreal, March 12, 1924.

CONTENTS

Chapter I.

THE LIME-CEMENT FAMILY

ALL the cementing materials commonly used for structural purposes have some compound of lime as the principal constituent. To this group belong the various kinds of gypsum plaster, common lime, hydraulic lime, natural cement, puzzolan cement and Portland cement. The limes and plasters are not generally included in the term of cement, and in recent years Portland cement has so overshadowed all other cementing materials in the importance and variety of its applications, and has become so familiar to everyone, that it is commonly referred to simply as "cement." The cements are seldom used alone but are usually mixed with some other material, as with sand to form mortar, or with sand and crushed stone or gravel to form concrete.

While Portland cement is now by far the most important member of the lime-cement family, a brief consideration of the other members and their relations to one another will give a better understanding of what Portland cement is.

When gypsum, a hydrous calcium sulphate, is heated to a temperature of some 350° F., part of its water of crystallization is driven off and it is converted into "plaster of Paris," which, when water is added, takes up again an amount equal to what was driven off and rapidly hardens into its original form of gypsum. This is the basis of most of the plasters used for interior work.

When limestone, a more or less pure carbonate of lime or magnesia, is heated up to, and for some time maintained at, a temperature of about 800° F., the carbon dioxide contained is driven off and it is reduced to "quick lime." If water is poured upon a lump of this quick lime it is absorbed rapidly, the lime becomes very hot and breaks down into a fine, dry, white powder. This process is called "slaking," and the product is hydrated lime or "slaked lime." If more water is added a paste is formed, which, upon exposure to the air slowly hardens by the absorption of carbon dioxide, being thus converted again to the carbonate from which the lime was originally made. Ordinary lime mortar is made by mixing hydrated or slaked lime with sand and water in proper proportions. It is to be noted that carbon dioxide is necessary for the hardening of lime mortar, and that it will not, therefore, set or harden under water.

If the limestone from which the lime is made contains a certain small percentage of clay matter the product is very similar to ordinary quick lime, but slakes more slowly and has the property of hardening under water by the formation of silicates of lime or magnesia. From the fact that it will set under water it is known as "water lime" or "hydraulic lime."

If a larger proportion of clay matter is present in the limestone and the burning temperature is carried to a somewhat higher point, the product formed (known as clinker) will not slake upon the addition of water, and will not set unless first finely ground. After being pulverized it will, when water is added, set either in air or under water. This is a hydraulic cement as distinguished from a hydraulic lime, and is commonly known as "natural cement." The rock from which it is made is usually put into the kilns just as it comes from the quarry, and consequently cements made from different quarries, or even from different parts of the same quarry, may vary greatly in strength and value. Some of them are little better than hydraulic lime, while others approach Portland cement in strength and uniformity, and have sometimes been put on the market as "Natural Portland Cement."

Portland cement is made by heating to nearly the fusing point an accurately proportioned and intimately blended artificial mixture of some material containing a high percentage of lime with another material containing silica and alumina in proper quantity and proportion. The lime is usually furnished by limestone or marl, and the silica and alumina by clay or shale. The necessary proportions of these three ingredients are fixed within comparatively narrow limits, and the composition of the mixture must therefore be constantly watched and chemically regulated. It is to this careful proportioning of the raw materials and the higher temperature of burning that Portland cement owes its great advantage over natural cement in uniformity and strength.

The clinker, as it comes from the kiln, is a hard, black, granular substance that is not acted upon in any way by water, but when finely pulverized forms a gray powder that hardens rapidly when water is added. This hardening is brought about by the crystallization of the mineral compounds of which the cement is composed. Some of them crystallize rapidly, giving the mortar or concrete considerable hardness and strength within a few hours, but others act slowly and continue to form crystals, and thus add to the hardness and the strength, for several years, if the necessary water is available. The hardening of cement is not, therefore, a drying out process, but, on the contrary, involves the absorption of water as long as the process continues, and can be brought to its highest point only where the necessary water is furnished.

There is another class of hydraulic cements distinguished from the Portland and natural cements by the fact that the materials from which they are made are merely mixed and ground together, but are not heated, or "burned," after mixing. These are known as puzzolan cements, the name being derived from the material that the Romans mixed with lime for that purpose. Volcanic ash and similar materials suitable for this purpose are found in many parts of Italy and were used by mixing and grinding with lime to make what were probably the earliest hydraulic cements. Burnt clay and blast furnace slag act in much the same way, the latter being now used to make so-called slag cement.

Chapter II.

ORIGIN AND DEVELOPMENT OF THE INDUSTRY

LIME mortar and plaster similar to those used today are found in some of the oldest structures built by the Egyptians and the Greeks. In addition to lime the Romans used very extensively a puzzolan cement made by mixing lime with volcanic ash found in abundance on the slopes of Vesuvius and at other places in Italy. This produced a cement similar to our modern slag cement which, while a great improvement over ordinary lime, was far inferior to our modern Portland cements. There seems to have been no further improvement for many centuries in the making of mortar for structural purposes; in fact, the art of making the puzzolan cement used by the Romans appears to have been lost or neglected, as most of the masonry structures of the Middle Ages were built with lime mortar only.

It was not until the latter half of the eighteenth century that any distinct step in advance was made. In 1757 John Smeaton, an English engineer, conducted a series of experiments with mortar made from various limes then available in an effort to find one suitable for his purpose in building a lighthouse on the Eddystone rock, a dangerous craggy island off the coast of Cornwall, which was submerged at high tide. He found that, contrary to the opinion then generally held, the impure limes were the ones that would harden under water, and he succeeded in making a lime that suited his purpose by selecting from his quarry only those layers of stone containing a considerable quantity of clay. The lime thus produced slaked upon the addition of water and was, therefore, a hydraulic lime rather than a true hydraulic cement as now understood, but his experiments revealed for the first time why it was that some limes would harden under water and others would not, and thus pointed the way for further advance in the science of making cement. The results of Smeaton's experiments were not published until 1791, and it is significant that very shortly after this date the manufacture of natural cement was started both in England and France.

In 1796 Joseph Parker, of Kent, England, took out a patent for making what he styled "Roman cement" by burning, at a temperature higher than used for burning lime, certain concretions of lime and clay found along the coast. The product thus obtained did not slake upon the addition of water, but when finely ground would set in either air or water, and was, therefore, a true natural cement. Parker's cement soon became well known in England, and similar cements made in France and Germany were widely used on the Continent. The industry grew steadily and for the first half of the nineteenth century natural cement, or "Roman cement," as it was generally called, was the material commonly used in important masonry structures.

In 1810 Edgar Dobbs, of Southwick, England, obtained a patent for the manufacture of an "artificial Roman cement," by mixing lime and clay instead of using natural rock as was done by Parker. This patent foreshadows the invention of Portland cement in that it specifies an artificial mixture of the raw materials, but as the burning temperature was carried no higher than in Parker's kilns, the product was practically the same, and Dobbs produced only an "artificial natural cement."

The invention of Portland cement is usually credited to Joseph Aspdin, of Leeds, England, who in 1824 took out a patent covering the making of an improved cement to which he gave the name "Portland" because of its fancied resemblance, in appearance or quality, to the well-known building stone from the Isle of Portland. The process as described in his patent consisted of (1) making of quick lime from pure limestone; (2) mixing the lime with a definite quantity of clay and grinding the mixture in a wet state; (3) drying the ground mixture and breaking it up into pieces suitable for the kiln; (4) burning in a vertical kiln, and (5) pulverizing the clinker. Aspdin's patent says nothing about the necessity of a higher burning temperature than used by his predecessors, and his title to the invention has on that account been questioned. It is probable, however, that he knew of this necessity, as he began almost at once to produce a cement of superior quality at a factory that he built at Wakefield, near Leeds. He would, therefore, seem to be fairly entitled to the credit for not only the name, but the substance also. Aspdin and other members of his family continued in the business for many years, and in time the trade name "Portland Cement," by which their product was known, came to be generally applied to all cements of the class produced by them. The new material made its way slowly at first, as the natural cements were by that time favorably known and well established. Moreover, the quantity of cement used in those days was, when measured by our present standards, comparatively small, as it was employed only as mortar for laying up brick and stone, and not for mass concrete, which came as a later development. It was not until after 1850 that Portland cement began to figure prominently in the markets of England and Continental Europe.

In America the industry developed along similar lines but at somewhat later dates. The first natural cement was made in Madison County, N.Y., in 1818, for use in the construction of the Erie Canal. Suitable rock was soon found in other localities, and many plants were built within the next twenty or thirty years. The chief centres of the industry were the Rosendale district of New York, the Louisville district of Indiana and Kentucky, and the Lehigh Valley of Pennsylvania. The production of natural cement increased steadily till about 1890, when nearly 10,000,000 bbls. were produced in the United States and

Canada. For the next ten years the production remained about the same, but since that time has fallen off steadily until it is now less than 1,000,000 per year.

Although Portland cement had been gaining in popularity in Europe since about 1850, it was not until after 1870 that any attempt was made to manufacture it in America. The Eagle Portland Cement Co. built a small plant near Kalamazoo, Michigan, in 1872, to make cement from marl and clay, this being probably the first plant in America to make Portland cement. The product is reported to have been excellent, but the costs were so high that the enterprise was not a commercial success and manufacturing was discontinued after a few years' operation. In 1875 a plant at Wampun, Pennsylvania, started to produce Portland cement from limestone and clay, and about that time David O. Saylor, who had for some years been manufacturing natural cement, began the production of Portland cement at Coplay, Pennsylvania, by selecting and mixing different kinds of rock found in his quarries. Cement from Saylor's works and from Wampun were exhibited at the Centennial Exhibition in 1876, and are said to have compared favorably with the best imported cements. In 1880 the production was only about 40,000 bbls.; in 1890 it was about 350,000 bbls. Since that time it has increased at a marvelous rate, reaching, in 1923, the enormous total of more than 140,000,000 bbls. for the United States and Canada.

Chapter III.

MANUFACTURING PROCESSES

THE primitive manufacture of lime was a very simple operation. Limestone was quarried by hand and stacked up in a more or less cylindrical upright kiln, often built into the side of a hill for convenience in charging the stone into the top. An arch of large pieces was formed near the bottom to provide a firing chamber, and the coarse rock was piled above until the kiln was filled, care being taken to leave sufficient spaces between the pieces of rock to afford means of draft for combustion. A fire of wood or coal was then built under the arch and maintained until the rock was thoroughly calcined, when the fire was raked out and the burned lime drawn out through the firing chamber. Since the lime slaked down into a powder when water was added, no grinding was required.

The making of lime had not advanced much beyond this stage when natural cement appeared upon the scene, and, as it was a direct outgrowth of the lime industry, its manufacture was naturally carried on in much the same way. It was burned in kilns very similar to lime kilns, but a higher burning temperature was maintained, and, as a measure of economy, the fuel and the stone were usually mixed in the kiln, being put in in alternate layers. The principal difference in the process was due to the fact that the clinker from the cement kilns would not slake and had to be pulverized before it could be used. Millstones such as were then commonly used for grinding grain were used for this purpose, and for many years all the cement made was ground in this way.

The making of Portland cement added further steps to the process. Instead of putting the rock from the quarry directly into the kiln in large pieces, the two raw materials had to be thoroughly mixed in proper proportions. In order to get a uniform and intimate mixture it was necessary to reduce them to a finely divided state, which was done by slaking lime burned in the ordinary way and grinding it with the proper quantity of clay, enough water being added during the grinding to form a batter or slurry. Since the kilns would operate only when loaded with fairly large pieces, the wet mixture was run out into large settling basins, where it was allowed to dry, after which it was broken up into pieces of suitable size for the kiln. The burning temperature had to be carried to a much higher point than for natural cement, and the clinker formed was harder, but the equipment and process were practically the same in both cases. The operation was very wasteful of fuel, as double burning was required, one for the lime and another for the cement, and in both cases the kilns were cooled down after each burning and had to be heated up again, at the cost of additional fuel, when the next charge was ready for burning.

The clinker, as it came from the kiln, was broken up and sorted by hand, the thoroughly burned portions being passed on to the grinders, while the underburned parts were put aside for charging again into the kiln at the next firing.

The whole process was slow, laborious and inefficient, and greater economy in fuel and labor had to be attained before the industry could make much progress. Various improved types of kilns were tried with more or less success, and after some years of experimenting the practice settled down pretty generally to some kind of continuous kiln in which the raw material was fed in at the top, the burned clinker was drawn out at the bottom, and the fuel was introduced through chutes at about the middle. The air for combustion passed up through the clinker at the bottom, the air being thus pre-heated and the clinker cooled, and the hot gases from the combustion passed up through and calcined the raw material above. The more continuous operation gave greater output, and the more efficient utilization of the heat gave better fuel economy, but the labor cost was still high.

A further saving in fuel and labor was brought about in most of the newer plants by the use of chalk and river mud instead of limestone and clay. These materials being in a finely divided state could be thoroughly and uniformly mixed without the preliminary burning and grinding. They were simply dumped into large circular tanks where water was added and they were stirred by revolving paddles or harrows until all the lumps were broken up and a fine uniform slurry was produced, which was then prepared for the kilns as before.

No further advance of any marked importance was made until the invention of the rotary kiln. This appliance, which was destined to revolutionize the industry, was foreshadowed in several patents issued in England between 1877 and 1885, but did not attract much attention until 1885, when F. Ransome, an engineer of Surrey, erected a kiln of his design and put it into operation. His kiln consisted of a long iron cylinder lined with fire-brick and supported on rollers in such a way that it could be turned on its axis. It was set with one end slightly higher than the other, so that materials fed into the higher end would gradually work their way through to the lower end when the cylinder was revolved. The heat was furnished by a jet of gas introduced through an opening in a firing hood which closed the lower end, and the products of combustion swept through the kiln to a stack built at the higher end. When the kiln was in operation the mixed raw materials were fed into the upper end through a chute, and as they slowly made their way down through the kiln, the carbon dioxide was driven off and then, as they passed through the very hot portion near the lower end, they were combined chemically to form clinker, which dropped out of the lower end of the kiln through an opening in the bottom of the firing hood.

The first attempts to use the rotary kiln were not entirely successful, and it was some years before it was received with much favor by European manufacturers. In America, however, its progress was more rapid. Within two or three years after Ransome's first experiment it was tried at several places in the United States and Canada, and within a short time its development was brought to such a point that it rapidly displaced the older type of kiln. The rotary used today is a lineal descendant of Ransome's first kiln, the principal difference being in size. His kiln was five feet in diameter and twenty-six feet long, while present-day kilns are seldom less than ten feet in diameter and from one hundred and fifty to two hundred and fifty feet long. Much progress has been made also in details of construction and in operating procedure. The raw material is now fed into the kiln in either wet or dry condition, and powdered coal is commonly used for fuel, except in localities where oil or natural gas is cheaper.

The rapid displacement of the older kilns by the rotary was due to its many marked advantages, among the most important of which may be mentioned: its much greater capacity, its ability to use finely ground raw material in either wet or dry state, the more thorough burning and greater uniformity of its clinker, and the very great reduction in amount of labor required. From the standpoint of fuel economy, however, it was not as efficient as the best of the stationary kilns, this being mainly due to the large quantities of heat carried out of the front of the kiln by the red hot clinker and out of the stack by the hot gases.

Many efforts have been made to reduce these losses; some plants utilize heat from the clinker to pre-heat the air for combustion or to dry coal for the kilns; some utilize heat from the stack gases to dry rock or clay; and some, by passing the hot gases through specially designed boilers, are generating sufficient power for all their requirements, this being one of the most important developments in recent years.

While the rotary kiln has played a leading part in the remarkable growth that has taken place in the cement industry since its introduction, this growth would have been quite impossible except for corresponding developments in machinery for other parts of the process. In the days of the stationary kiln crude crushers followed by millstones reduced the materials to the required fineness, and shovels and wheelbarrows did the handling and conveying, but under the changed conditions these antiquated means were entirely inadequate, and better, more efficient equipment had to be devised. Wonderful developments have taken place within the last thirty years, especially in crushing and grinding machinery and in equipment for the mechanical handling of materials, with the result that in modern plants enormous quantities of materials are ground with a rapidity and efficiency unapproachable in the older days, and a continuous stream passes almost automatically through the various stages of the manufacturing process with a relatively small amount of manual labor.

We cannot here attempt more than a very

general description of the modern process of manufacture as carried on in the United States and Canada. The first requisite for the establishing of any factory is a supply of raw materials, and this is especially important in the cement industry, where the very large expenditure required to build a modern plant is warranted only where a cheap supply is insured sufficient for many years' operation. For this reason practically all plants have their own deposits of raw material, and, for economic reasons, are built close to them. Pure limestone, limestone containing more or less clay, marl, blast furnace slag, shale and clay are used in various combinations at different plants, but the majority use limestone and clay, and we shall confine our description to plants using these materials.

The getting out of the rock and clay and their delivery to the mill are very important parts of plant operation, but do not present any features peculiar to the industry. The rock is broken up and thrown down by blasting, loaded into cars by steam shovels, and hauled to the mill, where it is dumped into a large crusher. The clay is handled in much the same way, except that ordinarily it does not require blasting.

From this point the process consists of the following essential steps: (1), the reduction of both rock and clay to a very finely divided condition; (2), mixing them intimately in the proper proportions, usually during the grinding process; (3), the formation of clinker by heating this mixture to the requisite temperature in the kiln, and, (4), grinding the clinker to a very fine powder. In practice many distinct operations are required to carry the materials through these necessary steps, and great diversity of equipment and procedure is found at different plants, but the essentials remain the same for all.

In some plants the materials are ground dry and fed into the kilns as a fine, dry powder, while in others they are ground wet and fed into the kilns in the form of slurry. The former are known as "dry process," and the latter as "wet process" plants. Each has some advantages and the choice depends largely upon the nature of the raw materials and the cost of fuel. Where the dry process is used the materials have to be thoroughly dried before being ground, and for this purpose rotary dryers, similar in construction to rotary kilns, are used, the heat being supplied either by independently fired furnaces or by hot gases from the kiln stacks.

The formation of clinker requires a temperature of from 2400° to 2700° F., which is obtained by a jet of gas, oil or powdered coal blown into the front end of the kiln. Coal is now used at all plants except those located near natural gas or oil fields where those fuels can be obtained at a very low price. The preparation of the coal for the kilns introduces another set of operations, as it has to be thoroughly dried and then ground to a very fine powder before being blown into the kiln. The drying and grinding are done in much the same way as for rock and clay. It was the application of powdered coal that gave the rotary kiln its first commercial success, and the great development in the use of that form of fuel is to be credited almost entirely to the work done by the cement industry.

The crushing and grinding of large quantities of hard, abrasive material is one of the most difficult problems that the cement manufacturer has had to solve. The magnitude of it will be better appreciated when it is considered that a plant of fair size, producing, say, 4,000 bbls. of cement per day, uses from 900 to 1,000 tons of rock and from 200 to 300 tons of clay every day, in addition to which its kilns require some 200 tons of coal and it produces from 700 to 750 tons of clinker. All of these materials, a total of some 2,100 tons, must be reduced to such fineness that from 90 to 95% will pass through a screen having 10,000 meshes per square inch. The rock as it comes from the quarry contains many large pieces, some of them weighing a ton or more, and has first to be put through heavy crushers powerful enough to break up the largest pieces, then through smaller crushers, then through granulators which reduce it to about the fineness of sand, and finally through pulverizers, which bring it to the required fineness. The clinker comes from the kilns in sizes about like coarse gravel, and is usually reduced in two stages, that is, first by granulators and then by pulverizers. It is brittle, but extremely hard and abrasive, causing rapid wear on the machines used for its reduction. The coal crushes more easily than rock or clinker, but is difficult to pulverize on account of the fact that when in a finely divided state it acts as a lubricant on the grinding surfaces and thus retards pulverization. The clay, which is comparatively easy to grind, is usually put through the granulators and pulverizers with the rock.

In order to do this immense amount of work economically the manufacturer must have machines with large capacity, reasonable freedom from breakdown, low cost of maintenance and low power consumption. Efforts to meet these difficult requirements, and to combine them as far as possible in one machine, have led to a great variety of crushing and grinding machines. The preliminary crushing of coarse material is usually done by gyratory, jaw, or roll crushers. The granulation and fine grinding are done by various types of machines, the most commonly used of which may be divided into two general classes, the high speed centrifugal machines and the slower speed machine of the drum or barrel type. In the first class large steel balls or rolls are revolved at high speed inside of a heavy die ring against which they press by centrifugal force, thus grinding by a combination of crushing or rolling action. These machines are usually provided with screens against which the ground material is thrown by fans, the fine passing through the screens and the coarse falling back for further grinding. Machines of the second class consist essentially of heavily lined cylinders partly filled with metal balls or other grinding bodies and arranged to turn on the axis, so that material put into them is crushed and ground by the tumbling and rolling action of the grinding bodies. The proportions of the cylinders and the size of the grinding bodies depend upon the size of the material to be ground and the degree of fineness to which it is to be reduced. Granulators are usually short and of large diameter and loaded with heavy balls, while the pulverizers are longer, smaller in diameter and loaded with smaller grinding bodies. The granulators are usually provided with screens which return the coarse material to the drum for further grinding, but the fine grinders have no screens, the fineness being controlled by the rate at which the material is fed into the cylinder and the length of time it is subjected to the grinding action.

There is much difference of opinion and great diversity of practice among cement manufacturers regarding grinding machinery. Probably no general answer can be given to the question as to what kind is best, as cost of power, cost of repair parts, cost of labor, peculiarities of the material to be ground and other local conditions must all be taken into consideration before an intelligent choice can be made.

The rapid and efficient handling of large quantities of material, some of them hot and most of them hard and abrasive, is an important part of plant operation, as upon it depends the continuity of production. Elevators and conveyors of every type, traveling cranes, cableways, cars, and, in fact, nearly every kind of material handling equipment, find an application somewhere in the industry. The conditions under which it must operate and the nature of the materials handled make the wear and tear upon this class of machinery very severe, and the cost of maintenance, even with the best equipment, is necessarily high.

Comparatively little cement is used in the winter, and if the manufacturer is to keep his mill running steadily, which he must do to maintain his operating organization and produce economically, he must have large storehouses which can be filled in the winter and emptied during the next summer, when large quantities are required. The 4,000 bbl. plant that we have taken as an example will have storage bins for probably 500,000 bbls. The cement is stored in bulk in large bins so arranged that it can be drawn out at the bottom and carried by conveyors to the packing house when required. Practically all the Portland cement used in Canada and the United States is now put on the market in bags holding a quarter of a barrel each, which are filled and weighed by automatic machines and loaded directly into cars for shipment.

The various manufacturing operations, especially crushing, grinding and conveying, require large quantities of power, which is usually distributed electrically and applied to the individual machines by electric motors. The plant that we have taken as an illustration (4,000 bbls. per day) will require from 4,000 to 4,500 h.p., which must be distributed to possibly one hundred motors in different parts of the plant. Most of the plants in Canada, and some in the United States, purchase hydro-electric power, but the majority of plants in America still generate their own power in steam plants. Attempts were made some twenty years ago to utilize for power purposes the immense quantity of heat contained in the kiln gases by passing them through water tube boilers, but the efforts were not successful and the manufacturer continued to fire his boilers with coal, fuel oil or natural gas. Within the last six or seven years, however, the difficulties encountered in the first installations have been largely overcome, and many plants are now generating all their power from the heat that formerly escaped up the kiln stacks. This has resulted in a large saving of coal and a consequent reduction in the cost of power.

While the purely mechanical features of manufacture stand out most prominently, we must not lose sight of the fact that the production of Portland cement from its raw materials is a chemical process which requires careful supervision and constant control. The rock and clay must be mixed in proportions depending upon their chemical composition, and, as this is likely to vary from time to time, frequent analyses must be made before directions for mixing can be given. Samples are also taken and analyzed at various stages of manufacture in order to check the accuracy and sufficiency of the processes through which the materials are passed, and a final check is made by analyzing the finished cement. In addition to the chemical work required, many physical tests must be made. The fineness of the raw material fed to the kilns is carefully watched, the coal used in the kilns is tested for fineness and heating value; and the finished cement is tested for fineness, soundness, setting time and strength. A laboratory in charge of an experienced chemist and equipped for making the chemical and physical tests required, is, therefore, an essential part of every modern cement plant, and the result of the careful supervision given at all stages of manufacture is that Portland cement as now produced is of remarkable uniformity and may be depended upon to meet the requirements of standard specifications and to give excellent results if properly used.

CHAPTER IV.

THE BEGINNINGS IN CANADA.

LIMESTONES and dolomites containing sufficient clay matter to have hydraulic properties when burned, occur in many parts of Canada, and were utilized in very early days for making hydraulic lime and hydraulic cement. The production was usually on a small scale and for local use, and no official records exist regarding most of it. The first record of it in the reports of the Department of Mines mentions Major-General Baddley, R.E., as making hydraulic cement from the black limestone of Quebec in 1856, but it is certain that there was production at one or more places in Canada some years prior to that. Mr. Ruggles Wright was making lime and hydraulic cement at Hull some time between 1830 and 1840, the cement being made from a grey argillaceous magnesian limestone obtained on the south shore of the Ottawa River, about two miles above the present city of Ottawa. It was also made at an early date near the mouth of the Magdalen River, in the Gaspé Peninsula, in Argenteuil County, Quebec, and at Kingston and Thorold in Ontario. The works at Hull, Que., and Thorold, Ont., were operated for many years and their products were well and favorably known. All of the early plants were necessarily small and simple, the general process being to burn the rock in ordinary lime kilns, sort it out, and grind the thoroughly burned parts by buhr stones.

Small quantities of hydraulic cement were imported as early as 1860, but the domestic brands seem to have held their ground pretty well until about 1887, when imported Portland cement began to come into the market in considerable quantities, and, because of its superiority, gradually replaced the domestic hydraulic cements, forcing the manufacturers either to go out of business or to meet the competition by making Portland cement. Two of the manufacturers of natural cement, C. B. Wright & Sons, of Hull, Que., and the Napanee Cement Company, Limited, of Napanee, Ont., changed their mills and processes and put Portland cement on the market, the first reported to the Department of Mines being made by C. B. Wright & Sons in 1889. At about the same time two other plants were built to manufacture Portland cement;, the North American Chemical, Mining and Manufacturing Company of Canada, built at Shallow Lake, Ont., and Mr. Thomas M. Morgan at Longue Pointe, on the Island of Montreal.

The pioneer work on Portland cement in Canada was done at these four plants, and a brief account of their early operations and the development of the industry in their districts will be of interest.

Ottawa and Hull.—Philomen Wright settled in the Province of Quebec, where the city of Hull now stands, in 1799, being the first, or one of the first settlers in that district. His son, Ruggles Wright, started making lime and hydraulic cement at Hull some time between 1830 and 1840, the lime being made from rock quarried at Hull, and the cement from a dolomitic limestone found on the south side of the Ottawa River, about two miles above the present city of Ottawa. The cement rock was hauled across the Ottawa River on the ice during the winter, piled up, and later burned in ordinary "pot" kilns, after which the clinker was sorted out and ground by buhr stones. The cement was put up in bags of 100 lbs. each or in barrels of 300 lbs., and was sold at prices ranging from $1.50 to $2.50 per barrel.

Ruggles Wright carried on this business for many years, and his cement was widely used throughout Eastern Canada. In 1885 he was succeeded by his son, C. B. Wright, who, with his sons, continued the business under the name of C. B. Wright & Sons until 1893, when the name was changed to Wright & Co. Up to 1889 only natural cement was made, but English Portland had then begun to invade the Canadian market, and, in order to hold their business, Wright & Sons changed their plant and process, and began in that year to produce Portland cement. This plant was operated until 1900, when it was destroyed by a fire which wiped out a large part of the city of Hull. The cement plant was not rebuilt, but Wright & Co. have continued as manufacturers of lime and wall plaster, and as dealers in builders supplies. The present president of the company is Mr. Ruggles Wright, a great-grandson of the pioneer, Philomen Wright.

The process used by Wright & Sons to make Portland cement was as follows: Lime was made from the Hull limestone by burning in ordinary lime kilns, and was then slaked and mixed with the proper quantity of clay in a large tub with revolving arms and harrows, enough water being added to produce a slurry of the desired consistency. This slurry was then ground by granite mill stones and elevated to a large tank with an agitator, from which it was piped to the brick floors of drying chambers, heated by the hot gases from the kilns. Each firing of the kilns thus dried enough slurry for the succeeding charge. The dried slurry was broken up by shovels and loaded into the kilns in layers, alternating with layers of coke. There were six kilns, all 14 ft. high, four of them being 7 ft. in diameter and two of them 10 ft. The capacity of the plant was about 150 bbls. per day. The clinker grinding equipment consisted of three sets of French buhr stones and one Griffin mill.

Tests made in March, 1892, at the School of Practical Science, Toronto, showed the following tensile strengths for neat cement at the age of twenty-eight days:

"Rammed into moulds" (average of two tests)—580.25 lbs. per sq. in.

"Not rammed into moulds" (average of three tests)—457.20 lbs. per sq. in.

Napanee Mills and Marlbank — The first cement produced in this district was made from a hydraulic limestone found at Napanee Mills (now Strathcona), Ont., the business being started in 1867 under the name of Wright & Company by H. M. Wright, a lumber merchant of Napanee. There was at that time no railroad into Napanee Mills, so the clinker made by the kilns erected there was hauled six miles by wagons to Napanee, where it was ground by buhr stones and packed in wooden barrels. A cellar floor put in at Napanee Mills with this cement in 1873 is still in good condition.

In 1874 Geo. Lasher & Co. purchased the property and business and continued in a similar way until 1879, when they sold the grinding mill and cooperage at Napanee to the Napanee Cement Co., which was organized for that purpose by Mr. A. McNeil. Lasher & Co. continued to operate the quarry and kilns at Napanee Mills, and sold their clinker to the Napanee Cement Co., who ground it and packed it in barrels at Napanee. This arrangement was not very satisfactory, but was continued until 1885, during which time about 41,000 bbls. of cement were sold.

Upon the death of Mr. McNeil in 1885 the Rathbun Co., of Deseronto, acquired the stock of the Napanee Cement Co., and assumed control. They operated in the old way for two or three years, but by that time a Railway had been built through Napanee Mills and there was no longer any reason for hauling the clinker to Napanee. A new plant, consisting of kilns, grinding mills, and cooper shop, was erected at Napanee Mills in 1887, and went into operation in May, 1888. The kiln equipment consisted of three kilns of the continuous type, which were fired by wood, about one-half cord of soft wood being required per ton of clinker produced. This plant was operated until the close of 1891. During the six years that the Rathbun Company were producing natural cement they sold about 48,500 bbls.

The Rathbun Co. soon recognized the growing demand for a better product, Portland cement, which was coming in from England, was rapidly gaining favor with engineers and users, and they decided to meet the demand by making Portland in addition to, or in place of, natural cement. A new plant was built at Napanee Mills in 1891 to use marl and clay. The marl was brought by rail from Marlbank, a distance of about twenty-five miles, and the clay was obtained from a deposit near their plant.

Both the marl and clay were put into large stock piles near the mills, a sufficient quantity being stored during the summer to provide for winter operations. The marl was loaded from the storage piles into small cars and hauled by cable to the mixing department, and the clay was brought in from the storage by wheelbarrows. They were dumped into a wash mill, consisting of a concrete vat in which harrows revolved, suspended on chains from arms fastened to a central vertical shaft, a sufficient quantity of water being added to each batch to form a slurry which, when thoroughly mixed, passed through a grating to another tank containing agitators. The quantities required for the proper mix were determined by the chemist, and corrections were made by adding more or less clay in the wash mill. When the mix was correct the slurry was passed into a third tank, from which it was pumped to a tube mill loaded with small iron balls.

The slurry as it came from the tube mill contained about 50 per cent. water, and the next step in the process was to form it into bricks for use in the kilns. For this purpose it was passed through rotary dryers with a furnace at one end and a stack at the other. The product of these dryers was put through a pug mill similar to those used in brick-making, some of the undried slurry being added, if necessary, to bring the mixture to proper consistency. The material as it came from the pug mill was in the form of a thick paste, which came out onto an endless belt in the form of a ribbon, and was cut into pieces of convenient size by a man standing beside the belt. It was then taken off and loaded onto cars which were run into drying tunnels 4 ft. wide, 6 ft. high and 75 ft. long, which were heated by the hot gases from a large furnace. The cars were left in the tunnels until the bricks were thoroughly dry and were then pushed out and taken to the kiln department.

The first kiln installation consisted of three bottle kilns with a capacity of 400 barrels each per week. In 1894 two Dietsch kilns were built, and a year later two Aalborg kilns. The bottle kilns were fired with coke, but the Dietsch and

Aalborg kilns were fired with soft coal. When the Aalborg kilns were put into service the three bottle kilns were abandoned, and only the four Dietsch and Aalborgs operated thereafter. These four kilns gave a capacity of about 500 barrels per day.

The clinker was drawn from the kilns into dump cars and taken to the grinding mill, where it was put through a jaw crusher and buhr stones. Later on these were replaced by a ball mill and tube mill. From the grinding department the cement was taken to a large wooden stockhouse by means of bucket elevators and screw conveyors. Packing was done by hand in wooden barrels, paper bags, and cloth bags. The company made their own barrels at a cost of about 25c each. The prevailing labor rate at that time was 8c and 9c per hour during the winter months, and 9c to 11c during the summer.

This plant went into operation in December, 1891, and thereafter operations were confined almost exclusively to the manufacture of Portland cement. The cement used in the construction of the first power plant at Niagara Falls was manufactured at Strathcona.

In 1891 the English Portland Cement Company built a small mill at Marlbank to make Portland cement from marl and clay obtained from Lime Lake. This plant was put into operation in 1892, and continued until 1898.

In 1898 the Beaver Portland Cement Company purchased the plant and property of the English Portland Cement Company and remodelled the mill, installing, early in 1899, two 60 ft. rotary kilns, these being the first rotary kilns in that district.

In 1900 the Canadian Portland Cement Company, Limited, was formed and took over the plant and property of the Rathbun Company at Napanee Mills, and the plant and property of the Beaver Portland Cement Company at Marlbank. The plant at Marlbank was enlarged and improved in 1903, four new kilns 6 ft. by 4½ ft. by 95 ft. being installed, together with additional grinding machinery. When these improvements were completed, and the enlarged mill put into operation, the plant at Napanee Mills (then called Strathcona) was shut down (1904) and never operated again. Operations were continued at Marlbank by the Canadian Portland Cement Company until the property was taken over by the Canada Cement Company, Limited, in 1909. The Marlbank plant was operated by the Canada Cement Company until 1914. It has since been dismantled.

Shallow Lake—The following account of the early operations at Shallow Lake is given by Mr. R. P. Butchart, now President of the British Columbia Portland Cement Company, Limited, Victoria, B.C.:

"Early in the year 1888 Mr. R. J. Doyle, of Owen Sound, Ont., extended an invitation to Mr. John Corbet, Mr. Wm. Robinson and myself to meet him at his office and discuss the formation of a company to manufacture Portland cement from marl and clay, which materials were to be found in a lake known as Shallow Lake, owned by Mr. Doyle, and located in the Township of Keppel, county of Grey, about nine miles from Owen Sound. At this meeting Mr. Doyle submitted samples of marl and clay taken from the lake, together with several small cubes of cement which he had made from a mixture of marl and clay, and burned in a coal stove. The cubes did not show that the raw material would make a good grade of Portland cement, but from the analyses of the marl and clay which Mr. Doyle had obtained, when compared with the analyses of English chalk and Thames mud as given in Gilmore's work on Portland Cement, which Mr. Doyle showed us, it was obvious that this marl and clay would make a high grade Portland cement.

"At this meeting Mr. Doyle informed us that, in his opinion, it would be impossible to secure sufficient heat in a coal stove to calcine cement, and suggested that we should subscribe sufficient funds to build a small furnace and make further tests of the material. This we did, and, after many failures to produce a good grade of cement, we advertised for a man who understood the manufacture of Portland cement, and were fortunate in securing Mr. Wm. McKay of Ottawa, who had exhibited a sample of Portland cement made from materials found near Ottawa, at the Centennial Exhibition in Philadelphia in 1876.

"Mr. McKay, after looking over our work, advised that in his opinion the furnace we had used would not give us a temperature sufficiently high to produce a good quality cement, and under his directions another furnace was built. The first batch of cement Mr. McKay turned out of this furnace had a tensile strength of over 400 lbs. per square inch. This assured us that the raw materials were suitable, and we decided to incorporate a company to build a mill at Shallow Lake. This company, the North American Chemical, Mining & Manufacturing Company, Limited, was incorporated April 16, 1888, with a capital of $100,000, the directors being Mr. R. J. Doyle, Mr. R. P. Butchart, Mr. Wm. Robinson, Mr. John Corbet and Mr. H. B. Harrison. Up to this time less than 800,000 barrels of Portland cement had been made on the American continent.

"About this time we learned that the manufacture of cement in England was to be revolutionized by a kiln called the rotary kiln, the invention of a Mr. Ransome, and that these kilns were being made in England by the well-known firm of Ransome & Sims. In July, 1888, Mr. Robinson was sent to England to investigate the kilns, and, if they were found satisfactory, to purchase one. The information he obtained in England was favorable, and he therefore bought a kiln, which arrived at Shallow Lake in the latter part of 1888 or the early part of 1889.

"Mr. Robinson was made manager of the company, and at once proceeded with the building of the plant. Mr. Doyle took a great interest in the company and really dominated the situation. He had read a couple of works on the manufacture of Portland cement, and declared that he was going to 'show the English how to make Portland cement.' Our equipment consisted of, first, a wash mill made locally, the raw material being first weighed, then dumped into this mill, then going to buhr stones, then on to a sheet iron pan about 24 ft. by 60 ft., under which there were several fireplaces in which wood was burned to dry the slurry. From the pan the dry slurry was conveyed to a disintegrator, and from this disintegrator to a pan, from which it was wormed into the rotary kiln. From the rotary kiln the clinker went through steel rolls to buhr stones, where it was ground into cement.

Our rotary kiln was 5 ft. in diameter by 25 ft. long, lined with fire-brick, with three fire-brick ledges lengthwise of the kiln, equal distance apart. These ledges were for the purpose of bringing the material to the top and dropping it through the heat. We first used producer gas made from wood but found that we could secure a temperature of only 1500° F. Then we tried gas from coal, but this was not satisfactory. Afterward we found fuel oil would give us all the heat we desired, but it required only a day or two to first burn off the projecting fire-brick ledges, and then burn holes through the fire-brick, necessitating a shut-down for repairs. Very shortly we found that our rotary kiln was a failure. Compared with the rotary kilns of today, some of which are 10 ft. to 11 ft. in diameter and 240 ft. long, our kiln, the first used on the American continent, was certainly a pigmy.

"The net result of our operations up to that time was that we had produced several hundred barrels of very badly underburned cement and about seventy-five barrels of inferior Portland cement, and we had on our hands a plant which in every respect was unsuitable. Litigation with Mr. Doyle as to the terms on which we had acquired the raw material also added to our troubles, but this was later decided in our favor.

"My brother, D. M. Butchart, and myself had by far the largest interest in the concern, and it seemed up to us to either suffer the shareholders to make a total loss or endeavor to reorganize the company and secure added capital to build a suitable plant. With unbounded faith that the material was suitable and that Portland cement could be made at a cost to compete with the imported article, I decided on the latter course and to devote the whole of my time to the reconstruction of the company.

After such a dismal failure of our first efforts I was up against a difficult situation. In order to secure further capital it was necessary for me to show my good faith in the enterprise by subscribing for more stock, and every dollar I could scrape together was used for this purpose. Finally, aided by some of my colleagues, I was successful in securing a sufficient capital to warrant a commencing.

In June, 1892, we reorganized the company, forming the Owen Sound Portland Cement Company, Limited, with H. B. Harrison as President; R. P. Butchart, Vice-President and Managing Director, and John Corbet as Secretary. I went to

England and secured a competent superintendent to take charge of the erection and operation of the plant, a miller and a burner, and all the necessary machinery; and secured plans of what is known in England as the Batchelor Kiln. This is a round kiln, dome covered, with a drying chamber connected and extending about 80 ft. by 20 ft. wide to a chimney, the waste heat from the kiln passing through this chamber and drying the slurry. This slurry was afterward loaded into the kiln and burned with coke, first a layer of wood, then a layer of coke on which was dumped a layer of dried slurry, then coke and more slurry until the kiln was loaded. When the kiln was burned, requiring about 28 hours, the burned clinker, about 100 barrels to a kiln, was conveyed to a crusher, then passed through steel rolls, then through buhr stones, from which the finished cement was conveyed to bins. These Batchelor kilns we used for several years. They gave excellent results, although not so economical in operation as the rotary kilns, which kilns, 6 ft. by 60 ft., we adopted in 1901, shortly after they had, in the Lehigh district, Pennsylvania, been proved a commercial success.

"With the introduction of the rotary kiln came the changing of our grinding machinery. The old buhr stones were discarded for ball and tube mills. Learning that a company in Germany was securing superior results from kilns 100 ft. long, I went to Germany and found that a considerably larger output and a consequent saving in fuel could be effected by using 100 ft. kilns. The kilns being used there at the time were 6 ft. x 100 ft. carried on three roller bearings. Upon my return we ordered from the Bonnet Company of Canton, Ohio, four 7 ft. x 100 ft. kilns to be carried on two roller bearings. One of these kilns was installed at Shallow Lake in 1903, and three of them at Lakefield, Ont., where we had recently built another mill with 60 ft. kilns. These were the first 100 ft. kilns to be used on this continent.

"Undoubtedly the mill at Shallow Lake produced the first Portland cement manufactured in a commercial way in Canada, but I am not sure if a mill built by the Rathbun Company at Napanee Mills, Ont., did not have Portland cement manufactured there on the market shortly before the Shallow Lake product reached the market. Unquestionably the honor of the promotion of the first company in Canada to manufacture Portland cement remains with Mr. R. J. Doyle, of Owen Sound, Ont.

"For the first few years the securing of a market for our cement was somewhat difficult. The Government refused to use it for canal work and other public works. The city of Toronto, largely owing to the patriotism of the then city engineer, Mr. Rust, and his assistant, Mr. L. Yeomans, who was employed by the city to test cement and other materials, gave us great encouragement, and this aided materially in getting our cement into other cities and towns in Ontario, where we could compete with foreign cement.

"In the early days we had our troubles with many engineers and architects, but on the other hand, many were sympathetic and helpful in introducing our product.

"Indicative of what we were up against, the market refused to accept our cement in sacks. They had been accustomed to receive Portland cement in wooden barrels with half round hoops, and it was several years before we could persuade them that the cement we shipped in half barrel and quarter barrel sacks was really Portland cement. It was not until 1897 that we could persuade the Government to use our cement and take delivery in sacks.

"Some of the first cement we made was used in Owen Sound. A certain contracting firm had taken a contract to lay sewer pipe. The town engineer, happening on the job while the contractor was at work, and seeing that Shallow Lake cement was being used, said: 'I specified that you were to use Portland cement on this job.' The contractor replied, "Well, I am using Portland cement.' The engineer said, 'You are not using Portland cement; that blankety-blank stuff never saw Portland.' A few months afterward the same engineer bicycled out to our works and told me that he had been asked to read a paper at an engineers meeting which was to be held shortly, and that he had decided to read a treatise on Portland cement.

In October, 1895, the late Mr. J. M. Kilbourn and his son, Mr. Geo. S. Kilbourn, of Owen Sound, bought into the Owen Sound Portland Cement Company, both taking a considerable interest in the concern."

This plant was taken over by the Canada Cement Company, Limited, in 1909, and was operated until 1914. It has since been dismantled.

The Island of Montreal—In 1886 Mr. Thos. M. Morgan had an office and laboratory on St. James Street, Montreal, where he was engaged in the business of analytical and consulting chemist. Mr. Morgan and an old friend, Mr. J. Mowat Reid, had for some time been talking of the possibilities and opportunities in the manufacture of Portland cement. Mr. Morgan had studied up the chemical and technical part of the subject, and Mr. Reid had looked into the market and commercial possibilities. In 1886 they decided that the subject was worth going into seriously, and Mr. Morgan made a visit to New York, where he gathered all the information he could get on cement and cement-making, and visited a number of plants in the eastern States, where lime, plaster of Paris, and cement were being manufactured. Upon his return to Montreal he and Mr. Reid started a search for suitable material in a good commercial location. They examined a number of materials and deposits between Montreal and Toronto, and went so far as to enter into negotiations for a property near Trenton. These negotiations, however, fell through, and there was no immediate result. This work occupied the greater part of the year 1887.

At about this time a warehouse of Messrs. B. & S. H. Thompson, on the water front at Montreal, containing several thousand barrels of White's (English) cement, was destroyed by fire, the cement being soaked with water and hardened so as to be considered worthless. Mr. Morgan conceived the idea that this cement might be restored in quality by re-burning and re-grinding, and after some experimental work in his laboratory, became convinced that this was feasible. He and Mr. Reid thereupon entered upon a contract to clear the hardened cement from the cellar of the warehouse, and for this purpose they rented, in the spring of 1888, a building on Wellington Street in which they erected a kiln and grinding machinery. The hardened cement was reburned, re-ground, and sold at $2.05 per barrel, being apparently satisfactory to the users.

Before this work was completed Mr. Morgan and Mr. Reid dissolved partnership in 1888, Mr. Morgan continuing the work that they had undertaken. Mr. Reid had interested some local capitalists in a plan to erect a plant for the manufacture of Portland cement at Pointe Claire, on the Island of Montreal, where it was proposed to use limestone and clay found there. A small plant with vertical kilns was erected and some Portland cement was made, but the operation was not a success and was discontinued after a short time.

In the meantime Mr. Morgan had been continuing his search for a suitable material, and in the latter part of 1888 he decided that material found at Longue Pointe, on the Island of Montreal, would make a good quality of Portland cement. In March, 1889, he entered into an agreement with the Town Council of Longue Pointe to erect a plant for the manufacture of

Portland cement near that town, in consideration for which he was to receive a bonus of $2,000.00 and exemption from taxation for a period of twenty-five years. During the summer of 1889 he erected a plant on the bank of the river at Longue Pointe, and began production and shipment of Portland cement early in 1890.

The material used was an argillaceous limestone mixed with a small quantity of shale or clay that was found on the surface and in the seams between the layers of rock. The quarry was located some half mile back from the river, and the rock was loaded into cars and brought down to the plant, where is was put through a jaw crusher, then through a "cracker," then through French buhr stones. The finely ground rock was mixed with clay or shale in a pug mill, a sufficient quantity of water being added to make a plastic mixture. As the mixture thus formed was squeezed out of the pug mill it was cut up into lumps and put on cars, which were then run into a drying house heated by exhaust from the engines that furnished power for the plant, the steam being conducted around the walls and under the drying house in 1-inch pipes. When the material was sufficiently dried the cars were run onto a hoist which elevated them to one of the loading platforms for the vertical kilns. There were two bottle kilns about 60 ft. high, with a diameter of about 12 ft. at the largest part and about 6 ft. at the top. These kilns had doors at two levels, with a charging platform at each level. The dried material was dumped from the cars onto the platforms and shovelled into the kilns in layers alternating with layers of gas coke, from 90 to 100 lbs. of coke being required for each barrel of clinker produced. After burning for two to three days the charge was allowed to cool, and was then drawn from the bottom of the kilns, sorted out, and ground through crackers and French buhr stones. The production of the two kilns was from 100 to 150 barrels per day.

The hard burned material was ground to make the first quality cement, which was known as "Crescent Brand Portland Cement," and was packed in barrels of 375 lbs. gross; the slightly underburned material was ground and after being seasoned for two or three months, was sold in barrels of 300 lbs. gross under the name of "Star Brand." The Star Brand was of lower strength than the Crescent Brand and was quicker setting, but was preferred by some users for certain classes of work. The Crescent brand was officially registered in the Department of Agriculture, Canada, on November 7, 1890, the design being a typical barrel label with red background and bearing the words "Crescent Brand Portland Cement" in white letters, also a white crescent on the red background.

The method of grinding rock was troublesome and expensive, and Mr. Morgan decided to build a new raw grinding mill with a different type of machinery. This mill, which was put in operation early in 1897, was built near the quarry, about one-half mile back from the river front, and contained "tumbler" mills 6 ft. in diameter by 5 ft. long for the preliminary grinding, and tube mills for the fine grinding. The material from the tumblers was passed over screens, the fine material being taken to the tube mills and the coarse being returned to the tumblers. The tumblers, which were of Mr. Morgan's own design, were somewhat similar to ball mills, having stepped steel grinding plates and perforations in the shell to let the ground material out, but no balls were used, the rock being put into the mills in large pieces, which served the purpose of balls.

In 1899 Mr. Morgan installed a 6 ft. by 60 ft. rotary kiln into which the powdered raw material was fed in a dry state, this being the first dry rock process rotary kiln in Canada. The kiln was fired by producer gas, the producer being placed in a pit directly in front of the kiln. This part of the plant, containing the rotary kiln and the new grinding machinery, was destroyed by fire in 1900 but was immediately rebuilt, with the addition of a second kiln and the installation of larger and improved grinding machinery. When the reconstructed plant was put into operation in January, 1901, the vertical kilns and the old plant near the river were shut down and were never operated again. The cement produced was of excellent quality and found a ready market in the city of Montreal.

Operations were continued at this plant until 1907, when the plant and property were sold to the Vulcan Portland Cement Company, Limited, who erected a 2,000 barrel plant with four 125 ft. kilns, kominuters and tube mills for grinding, and separate motor drives for all the heavier machinery. This plant was taken over in 1909 by the Canada Cement Company, Limited, by whom it was operated until 1914. Since that time it has been shut down owing to lack of demand for its product.

Chapter V.

THE MARL BOOM IN ONTARIO

THE years 1898 to 1905 were the boom years in cement plant promotion and building in Canada. In 1889, the year in which Portland cement was first produced in Canada, the total consumption was 122,273 bbls., practically all of which was imported. During the next ten years the consumption increased steadily until in 1889 it was 626,916 bbls., of which 371,550, or about 60 per cent., was imported.

The steadily increasing demand together with the large proportion supplied by imports offered a tempting field for expansion of the domestic industry; furthermore, a number of marl plants in Canada and the United States had been in successful operation for several years, and were reported to be making large profits. These facts were taken advantage of by over-enthusiastic, and in some cases unscrupulous, promoters, and led to great activity in the building of new plants.

Central Ontario, which has large quantities of marl underlying the numerous small lakes in that region, was a favorable field for promotion. Many small towns saw development and prosperity ahead if they could only induce someone to build a cement plant to utilize the marl and clay they were fortunate enough to have close at hand. In some cases enterprising and successful local business men saw what seemed to them an excellent opportunity to benefit their community, and at the same time to make some money for themselves and their friends, by forming a company to manufacture cement. Such companies were usually capitalized at too low a figure, and found before they got into operation that they not only had no working capital, but were in debt for their plant. In other cases companies were formed by promoters who were more interested in the immediate profits of promotion than in the ultimate success of the enterprise. These companies were usually capitalized at too high a figure, and the financing done in such a way that they found themselves burdened with capital charges which they were unable to meet.

In the rush to get in early, or to get ahead of some threatened neighboring competition, properties were hastily and superficially examined by some "expert" who hoped to get a job if the deal went through, but would get only a meagre fee, or perhaps nothing at all, if it did not go through. In some cases local influence, a bonus, or a tax exemption led to the location of a plant where sound business judgment would never have placed it. The result was that some plants were badly located, others found that their raw materials were of poor quality or insufficient in quantity, and most of them found that the margin between cost and selling price was far different from what they had been led to expect.

By the end of 1905 the producing capacity of Canadian plants was about 3,500,000 bbls. per year. The consumption for that year was 2,265,-249 bbls., but only 1,346,548 bbls. was of domestic manufacture. The trouble was that about 80 per cent. of the producing capacity was in Ontario, where it could not successfully compete with imported cement for the markets of Quebec, the Maritime Provinces or British Columbia. Canadian manufacturers could produce 50 per cent. more cement than the country used, but could sell only about 40 per cent. of their capacity, and much of this had to be sold at prices forced down by ruinous competition to a point below cost of production. A few of the stronger, better located or better managed companies were able to survive these conditions, but for most of them the result was inevitable failure.

Eleven companies built marl mills in Ontario during this period and only three of them, the Hanover Portland Cement Co., Ltd., the Lakefield Portland Cement Co., Ltd., and the Ontario Portland Cement Co., Ltd., escaped a more or less disastrous end.

The Hanover Portland Cement Co., Ltd., the oldest of this group, built a plant at Hanover in 1898 to use marl and clay found near by. This company started in a small way with one upright kiln, but the plant was enlarged and improved as the business grew, and finally three 7 ft. by 100 ft. rotary kilns took the place of the upright kilns. This plant was operated on marl up to a few years ago, being the last one to so operate in Canada.

Low capitalization and careful, conservative management enabled this company to continue its operations under conditions that were fatal to most of its competitors. Rock brought in by rail from a quarry near Walkerton is now used instead of marl.

The Lakefield Portland Cement Company, Limited, built a plant at Lakefield, Ont., in 1901, using marl obtained from Buckley's Lake nearby and clay brought in from Drummond Siding, a distance of about ten miles. The first installation consisted of three 6 ft. by 60 ft. rotary kilns, with wash mills and tube mills for grinding raw material, and ball mills and tube mills for grinding clinker. In 1903 three more kilns were added, these being 7 ft. diameter by 100 ft. long, and two or three years later three more kilns of the same size were added. The power for operating the plant was supplied by two hydro-electric plants owned by the company on the Otonabee River. This plant was built and operated by the Butchart, Kilbourn and Bravender interests, who had for some years successfully operated the plant at Shallow Lake. The plant and property were taken over in 1909 by the Canada Cement Company, Limited, by whom it was operated until 1914, since which time business conditions have not warranted its operation. It is now being entirely reconstructed for a capacity of 3,000 bbls. per day, using limestone and shale obtained a short distance from the plant, and will be put into operation when its product is required.

The Ontario Portland Cement Co., Ltd., built a marl plant with five 6 ft. by 70 ft. rotary kilns at Blue Lake, Ont., and operated with more or less success for a number of years, but finally shut down its plant in the early years of the war, when its operations were no longer profitable. It has recently done some new financing and has started the construction of a plant near Beachville, Ont., where it will use limestone and clay by the wet process.

The less successful companies were:

Imperial Portland Cement Co., Ltd., Owen Sound.

Grey & Bruce Portland Cement Co., Ltd., Owen Sound.

The Sun Portland Cement Co., Ltd., Owen Sound. This company was later reorganized as the Doric Portland Cement Co., Ltd., and was later merged with Grey & Bruce under the name of Union Portland Cement Co., Limited.

Colonial Portland Cement Co., Ltd., Wiarton, Ont. Name later changed to Crown Portland Cement Co., Ltd.

Maple Leaf Portland Cement Co., Ltd., Atwood.

Raven Lake Portland Cement Co., Ltd., Raven Lake. Name later changed to Kirkfield Portland Cement Co., Ltd.

Superior Portland Cement Co., Ltd., Orangeville.

National Portland Cement Co., Ltd., Durham.

All of these plants were built to use marl and clay. All of them except the Imperial (which changed later) were equipped from the start with rotary kilns. Some put their slurry directly into the kilns, and others first put it through separately fired rotary dryers. Some were built close to their marl beds, and others had to bring their raw material several miles by rail. The nominal capacities ranged from 300 to 1,500 barrels per day.

Some were failures from the start, but most of them struggled along for years, hoping for better times, or managing by reorganization and new financing to keep out of the hands of a receiver. Eventually they all ceased operations, and most of them have been dismantled. In nearly all cases the original investors lost all they had put into the venture.

Chapter VI.

FURTHER DEVELOPMENT IN ONTARIO AND QUEBEC

THE Morgan plant at Longue Pointe, Que., was the first in Canada to make cement from rock by the rotary kiln dry process. This was in 1899. For the next four or five years marl plants were the fashion, and little attention was given to rock. Beginning with 1905 the rock plants became an important factor in the situation, and since that time the development has been almost entirely along that line, the use of marl gradually losing ground and finally disappearing altogether. In 1922 no cement was made from marl in Canada.

In 1903 two companies started construction work, the Belleville Portland Cement Company, Limited, and the International Portland Cement Company, Limited. Both completed and put their plants into operation at about the same time in the spring of 1905.

The Belleville Portland Cement Company, Limited, built at Pointe Ann, on the Bay of Quinte, near Belleville, Ont., to use limestone and clay, both found close to the mill site. They installed eight 7 ft. by 5½ ft. by 60 ft. rotary kilns, each discharging directly into a 5 ft. x 30 ft. rotary cooler placed below and in front of the kiln. The rock and clay were crushed and dried before mixing, and then ground by ball mills and tube mills. The clinker was ground by kominuters and tube mills. Coal was brought in either by rail or by water and, after passing through rotary dryers, was ground by Fuller mills.

An interesting feature of this plant was the installation of waste heat boilers back of the kilns. One standard Babcock & Wilcox boiler of five hundred horse power rating was installed for each pair of kilns, and each boiler was connected to a vertical tube Green economizer in two sections of 216 tubes each. They were also provided with grates for coal firing, if necessary. The accumulation of dust in the gas passages was greater than was anticipated, especially in the economizers, which, unfortunately, were so located between the kilns that cleaning was very hot and difficult work. The interruptions and delays due to accumulation of dust, together with the cost of removing it, were so serious that, after about eight months' trial, the waste heat feature was abandoned and the boilers were thereafter fired by coal.

Mr. A. Ansley was president of the company, Mr. J. W. McNab was managing director, and Prof. R. C. Carpenter, of Cornell University, was consulting engineer.

The plant was taken over by the Canada Cement Company, Limited, in 1909, and extensive changes made, especially in the equipment and arrangement of the grinding departments. Hydro-electric power was substituted for steam in 1911. The plant has been idle since 1914, but is held in readiness to operate when required.

The International Portland Cement Company, Limited, built at Hull, Que., just across the river from Ottawa. The plant was located where large deposits of limestone and blue clay come together, and both materials were brought to the plant by suspended cableways. The kiln installation consisted of eight 7 ft. by 6 ft by 60 ft. kilns, with provision for two more. The rock and clay, after crushing and drying, were ground by ball mills and tube mills, the mix being made between the ball mills and the tube mills. The clinker also was ground by ball mills and tube mills. The coal was dried by hot air taken from the clinker pits and then ground by rolls and tube mills. Hydro-electric power was obtained from the Ottawa & Hull Power and Manufacturing Company, which had a plant at the Chaudiere Falls on the Ottawa River, only about two miles distant from the cement plant. All of the principal heavier machines were driven by individual motors.

The plant was enlarged in 1908 by the addition of more grinding machinery and additional storage capacity for clinker and cement.

Mr. W. F. Cowham was president of the company, Mr. J. S. Irwin, managing director, and Mr. C. A. Irwin, secretary-treasurer.

In 1909 the plant was taken over by the Canada Cement Company, Limited, by whom two additional kilns were installed and another cement stock house built. This plant also was shut down in 1914 on account of conditions brought about by the war, but will be started again as soon as business conditions warrant.

In 1907 four companies started construction work on new plants, the Lakefield Portland Cement Company, the Vulcan Portland Cement Company, Limited, the Lehigh Portland Cement Company and the Canadian Portland Cement Company, Limited. These plants were all completed and put into operation in 1908.

The Lakefield Portland Cement Company built on the north side of the St. Lawrence River, just beyond the eastern limit of the city of Montreal, the property extending back about a mile and a half from the water front and affording means of water transportation as well as connection to steam and electric railways.

The raw material used was a heavy bedded, argillaceous limestone, to which only small quantities of clay or siliceous volcanic rock had to be added, all of these materials being found close to the mill site. The kiln installation consisted of four 8 ft. x 110 ft. kilns with rotary coolers. The grinding of both raw materials and clinker was done by ball mills and tube mills. Hydro-electric power for the operation of the plant was obtained from Shawinigan Falls.

The company was controlled, and the plant built, by the same interests that had for many years operated the plant at Shallow Lake, and had, more recently, built plants at Lakefield, Ont., and Calgary, Alta. Mr. J. M. Kilbourn was president, Mr. R. P. Butchart and Mr. W. H. E. Bravender were vice-presidents.

The plant was taken over in 1909 by the Canada Cement Company, Limited, and extensive alterations and additions have since been made. The kiln equipment now consists of four 8 ft. by 110 ft., four 8 ft. by 125 ft., and nine 9½ ft. by 8½ ft. by 150 ft., making this the largest plant in Canada. Ball mills, kominuters and tube mills are used for grinding.

The most notable features about it are: the coal unloading and handling plant on the river front, the store-houses for cement, clinker, and gypsum, and the large packing and shipping capacities. The coal is unloaded from lake or ocean steamers, and put into storage or into cars by a cable-operated travelling bridge some 460 ft. long with four ton grab-buckets. The storage space will accommodate over 150,000 tons. Six concrete cement stock houses have a combined storage capacity of 1,250,000 barrels; two clinker storages will hold about 450,000 barrels, and the gypsum storages about 18,000 tons. There are seventeen cement-loading tracks, upon which over one hundred empty cars can be placed for loading without any further switching service. The large coal and gypsum storages are to carry the plant over the closed season of navigation, and the large cement stock houses and shipping facilities are necessitated by the long winter season and comparatively short shipping season.

The Vulcan Portland Cement Company, Limited, built on the property at Longue Pointe, Montreal, where Mr. Thos. Morgan had operated a cement plant for some eighteen years. The Vulcan Company was owned by the Warren-Burnham Company, of New York, who had for some years owned and operated the Virginia Portland Cement Company at Fordwick, Va. The installation consisted of four 7½ ft. by 125 ft. rotary kilns, with kominuters and tube mills for grinding both raw materials and clinker. The raw materials used were the same as at the Lakefield plant above described. Hydro-electric power was obtained from Shawinigan Falls.

This plant was taken over by the Canada Cement Company, Limited, in 1909 and operated until 1914, since which time it has been closed on account of lack of demand for its product.

The Lehigh Portland Cement Company of Allentown, Pa., built at Pointe Ann, about a mile east of the plant of the Belleville Portland Cement Company, Limited. Limestone and clay were used, both being found on the property. The installation consisted of six 7½ ft. by 125 ft. kilns, kominuters and tube mills for grinding raw materials, Griffin mills and tube mills for grinding clinker, and Griffin mills for coal. A concrete dock provided means of water shipments. Steam power was used, one engine for the raw grinding department, one for the clinker grinding, one for the kilns, and two others with direct connected generators provided electric current for induction motors in more distant parts of the plant.

The plant was taken over by the Canada Cement Company in 1909. In 1911 hydro-electric power from the Trent Valley was substituted for steam power. The plant has since been enlarged by the installation of three more kilns, and by additions to and changes in the grinding departments.

The Canadian Portland Cement Company, Limited, who had for many years operated the marl plant at Marlbank, built a new plant at Port Colborne, Ont., near the Lake Erie entrance to the Welland Canal, to use limestone and clay found on the property. The installation consisted of two 8½ ft. by 150 ft. kilns, with kominuters and tube mills for grinding both raw materials and clinker. Hydro-electric power was obtained from Niagara Falls, about ten miles distant. A dock on the canal bank afforded facilities for water shipments.

The plant was taken over by the Canada Cement Company, Limited, in 1909, and the capacity increased by the addition of two 9½ ft. by 8½ ft. by 150 ft. kilns, and more crushing, drying and grinding equipment, and more stock house capacity.

Up to 1912 all the rock plants operating in Ontario were running on the dry process. In that year the St. Mary's Portland Cement Company, Limited, put into operation at St. Mary's, Ont., a plant with two 8 ft. by 160 ft. kilns operating on wet process, using rock and clay found near the mill site. The raw materials were ground by kominuters and tube mills, and the clinker and coal by Fuller mills. Brick-lined rotary coolers below, and in front of, the kilns served to preheat air going into the kilns. The plant was operated by electric power purchased from the Hydro-Electric Power Commission of Ontario.

In 1917 a third kiln was put into operation and additions and changes made in the grinding equipment. In 1921 a reinforced concrete building was erected for office and laboratory, and an exceptionally complete equipment for chemical and physical testing was installed.

The name of the company has been changed to the St. Mary's Cement Company, Limited. The officials are Mr. Geo. H. Gooderham, President; Mr. Alfred Rogers, Vice-President; Mr. John G. Lind, General Manager.

Chapter VII.

THE WEST

UP to 1894 no cement was manufactured in the western provinces of Canada. The British Columbia market was supplied by imports, mostly from England, and the small amount used in what are now the Prairie Provinces was brought from Ontario or from the United States.

Many deposits of limestone and shale are found in the mountains of British Columbia and western Alberta; limestone is found also in the lake region north of Winnipeg, and there are large quantities of clay in that vicinity. There are also near Winnipeg several beds of calcareous shale which have been used for making natural cement. The great stretch of prairie country extending for nearly a thousand miles from Winnipeg to the Rocky Mountains has, however, no materials suitable for making cement, and the development of the industry has been confined to three regions—western British Columbia, western Alberta, and the southern part of Manitoba. Four plants have been built in British Columbia, four in Alberta, and three (counting two for natural cement) in Manitoba.

The Canadian Pacific Railway Co. was the first to attempt to manufacture cement in British

Columbia. About the year 1891 this company started the replacement, on a large scale, of the original wooden structures on the mountain section of its line, using in this work large quantities of masonry. The cement required was very costly, as it was all brought from England in sailing vessels which had to make the long, slow trip around Cape Horn.

In an effort to reduce this cost the company decided to investigate the possibility of making cement at or near Vancouver, and for this purpose brought out from the Isle of Wight an experienced cement maker and chemist, who, after examining various materials available, made a favorable report, and, in 1893, was commissioned to build a small plant on a site selected on the water front at Vancouver. Limestone was brought by barge from Texeda Island, about forty miles north-west of Vancouver, clay by rail from a cutting about thirty miles east, and coal by barge from the Dunsmuir mines on Vancouver Island. The limestone was burned in simple kilns and then mixed with clay and water to form a slurry which was dried on a floor of iron plates with fires underneath. The dried slurry was burned in upright kilns and the clinker was ground by buhr stones. The cement is said to have been of excellent quality and was used in thousands of yards of masonry which is still in good condition.

The Canadian Pacific Railway Co. operated the plant for four or five years, and then leased it to a Mr. Fisher, who operated it for two or three years longer. It was not, however, a commercial success, and was shut down and dismantled some twenty years ago.

The first rotary kiln plant in British Columbia was built on Vancouver Island by the Vancouver Portland Cement Company, Limited. This company, which was organized in 1904 with Mr. E. R. Wood as president, and Mr. R. P. Butchart as managing director, built on a rock and clay property on the shores of Tod Inlet, near Victoria. The plant was completed and put into operation in February, 1905, with one kiln 7 ft. by 70 ft. operating on dry process, and with ball mills and tube mills for grinding. Coal was used for burning. In the first year of operation about 75,000 barrels was produced and sold, and another kiln was installed to take care of the increasing demand. By 1911 the installation had grown to five kilns, and over 400,000 barrels of cement were sold. In 1916 the process was changed from dry to wet, the kiln equipment for the wet process being one 10 ft. by 9 ft. by 170 ft., two 9 ft. by 7½ ft. by 150 ft., and one 8 ft. by 125 ft.

In 1912 the Associated Cement Company (Canada) Limited, of London, Eng., built a mill at Bamberton, about four miles from the Vancouver Company's plant. The kiln installation consisted of two 8 ft. 9 in. by 185 ft. kilns operating on wet process. The raw materials were limestone and clay, and coal was used for burning. Manufacturing operations were started in 1913.

In 1916 the interests owning the Vancouver and the Associated plants united under the name of the British Columbia Cement Company, Limited, with Mr. R. P. Butchart as president and managing director. The demand was not sufficient to take the output of both plants, so the Bamberton plant was shut down. The Tod Inlet plant was operated until 1922, when it, in turn, was shut down and the Bamberton plant was put into operation. The company expects to operate both plants again as soon as the market for their product warrants so doing.

One other company built a plant in British Columbia, but it had a short and unfortunate career. In 1912 the British Columbia Portland Cement Company, Limited, built near Princeton, B.C., to use limestone and clay found nearby. One 8 ft. by 125 ft. kiln was installed, and the plant was put in operation in 1913, but trouble soon developed, as the limestone was found to be present in the quarry only in streaks, and four or five tons of rock had to be quarried and handled to obtain one ton suitable for making cement. There was practically no local demand for cement, and the distance to markets, together with the high cost of production, made the venture a failure from the start. The company went into liquidation in 1914, and the plant has been sold and dismantled. This company had no connection with the present British Columbia Cement Company, Limited, of Victoria.

The first plants in Alberta were built in 1906 and 1907 by the Alberta Portland Cement Company, Limited, and the Western Canada Cement & Coal Company, Limited.

The Alberta Portland Cement Company built in the city of Calgary, installing three 7½ ft. by 100 ft. kilns, with ball mills and tube mills for grinding. Limestone was brought in by rail from The Gap, about 60 miles west in the mountains, and shale from Sandstone, about 20 miles south, where the company operated also a brick plant. The dry process was used, with coal for burning, and a steam power plant supplied electric power for the operation of motors throughout the plant.

The Western Canada Cement & Coal Company, Limited, built at Exshaw, in the Rocky Mountains, about 60 miles west of Calgary, installing six 7 ft. by 6 ft. by 80 ft. kilns, with ball mills and tube mills for grinding. Limestone was obtained close to the plant, and shale was brought in by rail from Kananaskis, a distance of about three miles. The dry process was used, with coal for burning. The plant was operated throughout by electric motors, the current being supplied from a steam power plant. The coal for boilers and kilns was obtained from Alberta and British Columbia mines.

The Calgary and Exshaw properties and plants were acquired by the Canada Cement Company, Limited, in 1909 and 1910. The steam power plants at both mills were shut down in 1913 by the purchase of electric power from the Calgary Power Company, who had just put into operation a hydro-electric plant at the Horseshoe

Falls on the Bow River, about five miles east of Exshaw.

The Calgary plant was shut down at the end of 1914 and has since been dismantled, the machinery being transferred to other plants of the Canada Cement Company, Limited.

The Exshaw plant was enlarged in 1913 by the installation of three 9½ ft. by 8½ ft. by 150 ft. kilns in place of three of the 80 ft. kilns, and by additional crushing and grinding machinery, but market conditions since 1914 have been such that it has been operated to only about one-quarter of its capacity.

In 1909 the Rocky Mountains Cement Company, Limited, built a dry process plant at Blairmore, Alberta, with one 8 ft. by 100 ft. kiln. A second kiln was added about two years later. Limestone and shale were obtained close to the plant, and coal for kilns and power was obtained from mines only about a mile distant. The venture was not a success, and the company became involved in financial difficulties which finally compelled them to discontinue operations. The plant was purchased by the Canada Cement Company, Limited, in 1919, but the demand for cement in that district has not yet been sufficient to warrant putting it into operation.

The only marl plant that has been built in western Canada was erected in 1912 by the Edmonton Portland Cement Company, Limited. The plant was built near large deposits of marl and clay at Marlboro, about 140 miles west of Edmonton. Three 8 ft. by 140 ft. kilns were installed, with ball mills and tube mills for grinding, and the plant was put into operation in 1913. Coal was used for burning, and power was supplied from a steam power plant. The marl supply proved unsatisfactory and a change was made to dry process in 1917, limestone being brought in by rail from the mountains to the west and clay obtained near the plant. At the same time the company was reorganized and the name changed to the Edmonton Cement Company, Limited, with Mr. A. McDonald of Winnipeg as president. The name has recently been changed to the Marlboro Cement Company. The plant has operated for only a small portion of the time for several years past.

In the fall of 1913 the Canada Cement Company, Limited, acquired limestone properties near Crow's Nest, Alberta, and clay properties near Medicine Hat, Alberta, where it was proposed to build a wet process plant with three 10 ft. by 240 ft. kilns. Natural gas, which is found in abundance in that district, was to be used for both kilns and power. The work of construction was well under way in the summer of 1914, when the changed prospects brought about by the breaking out of the war made it advisable to suspend operations, and conditions in that territory have not yet warranted resumption of the work.

The industry in Manitoba started with the production of natural cement. Beds of calcareous shale, of a composition suitable for making natural cement, outcrop in several places in the Pembina Hills, southwest of Winnipeg, and have been utilized for that purpose since early in the nineteen hundreds.

The first plant was built by the Manitoba Union Mining Company at Arnold, Manitoba, some seventy miles from Winnipeg, where the shale occurs in horizontal beds about twenty feet thick, at the bottom of a hill. A tunnel was driven into the side of the hill, and the shale was delivered by wheelbarrows in an inclined elevator, which carried it to a charging platform near the top of a vertical kiln made of steel plates and lined with fire-brick. Lignite coal used was brought in by rail on a track that ran along the top of the hill on about the same elevation as the top of the kiln, and was taken over a trestle in wheelbarrows to the charging floor. The clinker, after being sorted, was put through a small crusher, and then through a Griffin mill, and the cement was elevated to the packing house alongside the railway track. This company discontinued operations some years ago.

In 1906 the Commercial Cement Company, Limited, started the manufacture of natural cement at Babcock, Man., only a few miles distant from the plant at Arnold. The shale used was of the same character and was worked in a similar way. The initial installation had two vertical kilns 11 ft. in diameter by 40 ft. high; two others have since been added, bringing the capacity of the plant up to about 500 bbls. per day. The clinker is put through a crusher and rolls, and finished in 5 ft. by 22 ft. tube mills. The cement is shipped in sacks containing 87½ lbs.

This is the only company now making natural cement in Canada.

In 1911 the Canada Cement Company, Limited, built a clinker storage, a grinding mill, and a cement stock house at Tuxedo, Man., about nine miles southwest of Winnipeg. Clinker, made at one of the company's plants near Belleville, Ont., was shipped by water to Fort William and thence by rail to Tuxedo. The plant was operated by electric power purchased from the Winnipeg Electric Company. After operating in this way for about two years, the plant was completed by the installation of four 10 ft. by 150 ft. kilns, together with the necessary drying and raw grinding equipment. Limestone was brought by rail from Steep Rock, 145 miles north of Winnipeg, on the east shore of Lake Manitoba, where a quarry was opened and a crushing plant erected. Clay was obtained close to the plant at Tuxedo. The kilns were operated on dry process, with coal for burning. Conditions resulting from the war, which came on shortly after the completed plant was put into operation, so curtailed the demand for cement in the West that the plant has never been operated up to half its capacity.

Chapter VIII.

THE CANADA CEMENT COMPANY, LIMITED

IN 1909 the Canada Cement Company, Limited, was formed by a combination of the interests owning ten of the mills then operating in Canada, and the following plants came into its possession:

QUEBEC.

Montreal—Lakefield Portland Cement Co.
Vulcan Portland Cement Co., Ltd.
Hull—International Portland Cement Co., Ltd.

ONTARIO

Belleville—Lehigh Portland Cement Co.
Belleville Portland Cement Co., Ltd.
Lakefield—Lakefield Portland Cement Co., Ltd.
Marlbank—Canadian Portland Cement Co., Ltd.
Port Colborne—Canadian Portland Cement Co., Ltd.
Shallow Lake—Owen Sound Portland Cement Co., Ltd.

ALBERTA

Calgary—Alberta Portland Cement Co., Ltd.

At later dates two other plants in Alberta were purchased:

Exshaw—Western Canada Cement & Coal Co., Ltd.
Blairmore—Rocky Mountain Portland Cement Co., Ltd.

A plant was also built near Winnipeg, Man., and properties were acquired near Medicine Hat, Alta., and Moncton, N.B., upon which it is planned to build plants when conditions warrant.

Chapter IX.

PUZZOLAN CEMENT

CEMENT of the puzzolan class has been produced at only one place in Canada. In 1905 the Sydney Cement Company started making cement from blast furnace slag and lime, at Sydney, Nova Scotia. The slag was obtained from the Dominion Steel Co., under contract, and the lime was at first purchased, but was later on made by the Cement Co. in a kiln erected for that purpose. These materials were mixed and ground without any burning and the product was therefore a true puzzolan cement.

The chemical composition of the slag as it came from the furnaces averaged about as follows:

SiO_2 — 33 to 34%
Al_2O_3 — 12 to 13%
Fe_2O_3 —0.3 to 0.5%
CaO — 49 to 51%
MgO — 3 to 4%
S. — 2 to 2.5%

The sulphur content was considerably reduced by the granulating and drying.

The manufacturing process was simple. The slag, after being granulated by water as it came from the furnaces, was put through dryers and then through rolls. The lime was then added, and the mixture was ground to required fineness in tube mills. The plant, which had a capacity of about 500 bbls. per day, was operated by steam power.

The cement was slower setting and lower in strength than Portland cement, but gave satisfactory results for many kinds of work. It was used extensively for construction work at the plants of the Dominion Iron & Steel Co., and by municipalities and contractors in the vicinity of Sydney. For a time a plant for making cement brick was operated in conjunction with the cement plant, but the business was not profitable and was discontinued after a few years.

The plant was shut down shortly after the beginning of the war and was not operated again until 1920, when it was purchased by the Dominion Iron & Steel Co., by whom it has since been operated for short periods to supply cement for the owners' requirements.

TABLE I.

CONSUMPTION OF PORTLAND CEMENT IN CANADA

Year	Barrels	Year	Barrels	Year	Barrels
1887	102,750	1900	663,942	1913	8,913,014
1888	122,402	1901	872,966	1914	7,270,502
1889	122,273	1902	1,141,548	1915	5,709,222
1890	207,017	1903	1,401,419	1916	5,379,674
1891	186,361	1904	1,694,988	1917	4,768,488
1892	216,454	1905	2,265,249	1918	3,591,481
1893	261,416	1906	2,785,609	1919	4,831,817
1894	259,326	1907	3,109,533	1920	5,849,276
1895	258,356	1908	3,134,338	1921	5,519,357
1896	282,792	1909	4,196,671	1922	6,505,513
1897	330,640	1910	5,103,285	1923	7,087,337*
1898	469,672	1911	6,309,717		
1899	626,916	1912	8,568,224		

* Estimated.

TABLE II.

ORIGIN OF PORTLAND CEMENT USED IN CANADA

Year	Barrels used	Made in Canada	Imported	% imported
1889	122,273	....	122,273	100.00
1890	207,017	14,695	192,322	92.9
1895	258,356	62,075	196,281	76.0
1900	663,942	292,124	371,818	56.0
1905	2,265,249	1,346,548	918,701	40.5
1910	5,103,285	4,753,975	349,310	6.8
1915	5,709,222	5,680,937	28,285	.48
1920	5,849,276	5,816,313	32,963	.56
1921	5,519,357	5,507,309	12,048	.22
1922	6,505,513	6,475,013	30,500	.46
1923	7,087,337*	7,072,705*	14,632*	.20

* Estimated.

Chapter X.

STATISTICS

THIRTY-FIVE years ago, in 1889, the consumption of Portland cement in Canada was 122,273 bbls., all of which was imported. Domestic Portland cement first appeared in the market in 1890, with sales of 14,695 bbls. The growth of consumption and domestic production since that time are shown by the figures given in the tables on the following pages.

Table I shows the quantity used each year for the past thirty-seven years. It will be noted that the high point was reached in 1913 and the low point of the war years in 1918. Since 1918 there has been an irregular recovery, but the amount used in 1923 is still more than 20% below that for 1913.

Table II shows the growth of domestic manufacture and the reduction of imports. Since 1915 the imports have averaged less than one-half of one per cent. of the cement used.

Table III shows the per capita consumption. The peak was reached in 1913 with 1,173 bbls. per capita. 1913 was not, however, a normal year, and it is doubtful if this rate could have been maintained even if the war had not intervened. The low point of the war years was

TABLE III.

CONSUMPTION OF CEMENT PER CAPITA IN CANADA

Year	Population	Bbls. Cement Used	Bbls. Used Per Capita
1881	4,324,810	....	...
1891	4,833,239	186,361	.038
1901	5,371,315	872,966	.162
1911	7,206,643	6,309,717	.875
1913	7,600,000*	8,913,014	1.173
1918	8,200,000*	3,591,481	.438
1921	8,788,483	5,519,357	.628
1922	8,900,000*	6,505,513	.731
1923	9,000,000*	7,087,337*	.787

* Estimated.

TABLE IV.

CAPACITY AND CONSUMPTION

	Reported Annual Plant Capacity—300 days run	Cement Used—Including Imports Bbls.	% of capacity
1908	6,525,000	3,134,338	48.0
1909	7,350,000	4,196,671	57.1
1910	7,650,000	5,103,285	66.7
1911	8,640,000	6,309,717	73.0
1912	12,480,000	8,568,224	68.6
1913	13,020,000	8,913,014	68.4
1914	14,190,000	7,270,502	51.2
1915	14,250,000	5,709,222	40.0
1916	13,860,000	5,379,674	38.8
1917	14,040,000	4,768,488	33.9
1918	14,340,000	3,591,481	25.0
1919	14,070,000	4,831,817	34.3
1920	13,245,000	5,849,276	44.1
1921	13,305,000	5,519,357	41.5
1922	13,245,000	6,505,513	49.1
1923	12,795,000	7,087,337	55.4

reached in 1918, with only .438 bbls. per capita. The consumption for 1923 was .787 bbls., still considerably below that of 1911, which may be taken as a normal pre-war year.

Table IV gives a comparison between consumption and plant capacities. The capacities given are based on three hundred days operation per year, and might be increased by from 10 to 20%. It will be seen that at no time during the past sixteen years has the domestic consumption reached 75% of the producing capacity, and that at present Canada could undoubtedly produce twice as much cement as she uses.

Unfortunately, there is very little chance to dispose of the surplus by export. The duty on cement entering the United States pretty effectually closes that market, and the higher freight rates to the West Indies, South America and South Africa put Canadian producers at a serious disadvantage as compared with European manufacturers. The total exports for the past five years have been:

1919	177,506 bbls.	1921	242,345 bbls.
1920	846,960 bbls.	1922	425,137 bbls.
1923	480,575 bbls.		

The present export business, therefore, amounts to something less than 4% of the producing capacity of Canada's mills, or enough to keep them running for about two weeks. Under present conditions there does not seem to be much reason to hope for any material increase in this business.

The question is often asked as to the quantity of cement used in various classes of work. Reliable statistics on this point are very difficult to obtain, but the best figures available indicate that for the ten years from 1913 to 1922 inclusive the following percentages of the total consumption went into the classes of work indicated: Public Works—Federal, Provincial and municipal—including highways, about 15%; large private undertakings, including railways, about 30%; miscellaneous small work, about 55%. For the past two or three years the quantity used in public works and highways has been somewhat greater and the quantity used in large private undertakings has been somewhat less than the percentages given above. The small user, however, holds his place steadily as the chief consumer of cement.