THE PORTLAND CEMENT INDUSTRY

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CEMENTS AND THEIR DEFINITIONS.

History records that the early Egyptians and Romans were familiar with a variety of mortars and mortar making materials. Remains of structures of those days show the use of mortar binders in what we would call masonry construction, and also a very extensive use of some kind of mortar in the form of stuccoes. That these early workers possessed no mean knowledge of mortars is perhaps best evidenced by the remarkable state of preservation even at this day of the many early examples of stucco.

There seems to be no evidence, however, that these early Greek, Roman, or Egyptian workers used a cement of the Portland type. Rather, these early cementing materials were common limes and plasters, very similar to those in use today.

Mortar binders may be conveniently considered in two broad classes - limes and cements. Falling between these classes are the hydraulic limes, so largely used in Northern and Central Europe. Cements, likewise, may be divided into two general classes - natural and portland cements. In addition to these are the variations known as puzzuolana, slag cement and iron cement, the last mentioned being best known in Germany.

Another way of dividing the cementing materials used in structural work is into two main classes - non-hydraulic and hydraulic. Non-hydraulic, as the name implies, will not set and harden under water; while hydraulic cements will harden in either air or water.

The following is a list of the structural cements of commercial importance:

Non-hydraulic (Gypsum plasters
(Common Lime

Hydraulic (Hydraulic Lime
(Grappier Cement
a by-product

(Puzzolan Cement
Natural Cement
Portland Cement
(Adulterated or modified
Portland Cement)

A more extended definition of some non-hydraulic and hydraulic cements follow:

PUZZOLANA is a cement of volcanic origin. Its name is derived from Puzzuoli, an Italian city near the base of Mount Vesuvius, where the ore vertices of puzzuolana were first discovered. The material, a volcanic ash, was pulverized and mixed with slaked lime and a small amount of sand to form a hydraulic mortar. Puzzuolana is a silicate of alumina in which the silica exists in a state easily attacked by caustic alkalies. Hence it readily combines with lime in mortar.

Puzzuolana may be produced artificially by burning certain kinds of clay. The natural material may frequently be improved by burning. In America, a cement called puzzolan has been manufactured for many years from lime and blast furnace slag. This is described later under "slag cement".

NATURAL CEMENT, as the name implies, is essentially formed by nature. Certain argillacious limestones containing various percentages of lime, silica and alumina are quarried and burned in their natural state in open lime kilns at comparative low temperatures. The resultant product when reduced to a fine powder is the natural cement of commerce.

The American Society for Testing Materials defines natural cement as follows:

"Natural cement is the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas."

To better illustrate what is meant by Natural Cement, a cement rock of the Lehigh district in Pennsylvania may be used as an example. This rock is of a laminated nature and even to the unaided eye, and much more so under the microscope, shows various layers or leaves of varying material. For practical purposes, it may happen that one of these small layers is lime, another alumina and another silica; or, there may be a large layer of lime, two layers of silica together and a small layer of alumina. This rock when calcined, either under high or low temperature, will not combine in all its parts or elements. Consequently, for purposes of comparison between natural and portland cement, it may be broadly stated that from twenty to twenty-five percent of

the natural cement is inert or not in combination. By taking the portions of silica and alumina that should combine properly with the lime, it will be found there are certain proportions in excess and therefore unconsumed. These natural cement rocks are burned at a comparatively low heat with coal, and the resulting material when drawn from the kiln is not very hard and can be reduced to fine powder with comparative ease.

Among the natural cements may be included the well known ones of the Rosendale, (New York), Potomac, (Maryland), Lehigh, (Pennsylvania), Akron, (New York), Louisville, (Kentucky), and Utica, (Illinois) districts. All of these cements have enjoyed a proper reputation and have been used in important work throughout the United States.

PORTLAND CEMENT is so named because the early product, when set, is said to have resembled in color a famous building stone on the Isle of Portland, England.

Portland cement is the product obtained by finely pulverizing the clinker resulting from the burning to incipient fusion of an intimate artificial mixture of finely ground calcareous and argillaceous materials.

The official definition of the American Society for Testing Materials is as follows:

"Portland cement is the product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination except water and calcined or uncalcined gypsum".

In general, the composition of portland cement is about twenty percent silica, ten percent alumina, plus ferric oxide, sixty-five percent of lime and five percent of other compounds. The required combination of the foregoing materials may be obtained by mixing limestone, chalks or marl with clay or shale or other argillaceous material as may be required to produce the proper balance of these ingredients. It is also made by adding limestone to blast furnace slag of low magnesia content. During burning, the combination of the lime and silica, alumina and iron oxide takes place. The product resulting from proper burning is called clinker. This consists of silicates, aluminates and ferrites of lime in certain definite proportions. The portland cement of commerce is the product resulting from grinding this clinker to a fine powder.

Richard K. Meade, in his book "Portland Cement" places materials under two general heads according to how the lime or silica and alumina predominate.

The following are his distinctions -

CALCAREOUS	ARGILLACEOUS
Limestone	Clay
Marl	Shale
Chalk	Slate
Alkali Waste	Blast Furnace Slag
	Cement Rock

In this classification Mr. Meade states that cement rock may be considered as either calcareous or argillaceous, but usually argillaceous. But in one section of the Lehigh

region the lime content is so high as to require an admixture of slate or clay.

Concerning distribution of materials, cement rock and limestone are found in the Lehigh District of Pennsylvania and in Northern Michigan. In the early days of portland cement manufacture in this country, Michigan, Ohio, Indiana and Central New York plants used marl and clay or shale. In more recent use, however, limestone has in many cases been substituted for marl. Throughout the country generally there are many deposits of limestone and shale or clay. In Indiana, Minnesota, Ohio and Pennsylvania a true portland cement is manufactured from blast furnace slag and limestone.

SLAG CEMENT, otherwise known as "puzzolan" cement is produced by the intimate mixture of slaked lime and granulated blast furnace slag. Both materials are pulverized before, during, or after mixing. Slag cement is not subjected to fire in kilns during the process of manufacture. It is inferior to portland cement in strength and other qualities. It found little market either in this country or abroad.

"EISEN" PORTLAND, or IRON CEMENT is made in Germany, where it enjoys a large demand. It is made by adding to true portland cement clinker, selected blast furnace slag in proportions varying from fifteen to twenty-five percent, then

grinding the resulting mixture to the finess required by the German Government specifications for portland cement.

SILICA SAND CEMENT is another type of mixed cement, where high grade silica sand or crushed granite is added to portland cement clinker in quantities varying from twenty to thirty percent, and the resulting mixture reduced to an impalable powder.

BLENDED CEMENT is a name that was given to cement which partook of the nature of puzzolan and portland cement. It was produced in California in connection with the construction of the Los Angeles Aqueduct, being made by regrinding portland cement with volcanic tuff. It was known locally as "tufa" cement.

COLLOR CEMENT began to attract attention about 1910. It was a patented product produced by slowly pouring molten blast furnace slag, when suitable for the purpose, or by pouring the molten material when fused directly for the purpose in a blast furnace, upon a rapidly revolving corrugated cylinder, which scattered it in finely distributed particles. While still in molten state, the particles came in contact with a spray of relatively small amount of weak solution of one or more of the soluble salts of alkaline earths, magnesium sulphate being generally used. The particles were then collected, cooled and ground to a fine powder. The resulting product differed materially from both portland and puzzolan cements.

PASSOW CEMENT is a slag cement manufactured under patents granted to Dr. Passow, one of the leading scientists of Germany, after whom it was named. Its production in America is described elsewhere.

DISCOVERY OF PORTLAND CEMENT.

The chronology of important events leading up to the discovery and manufacture of portland cement is given by Henry Reid, a distinguished English civil engineer and author of important works on cement, in his book "Portland Cement, Its Manufacture and Uses," published in London in 1877, as follows:-

1756 - John Sweaton, who sought a special cement for his own purposes.

1780 - Dr. Higgins, who was chiefly interested in stucco.

1796 - Parker, Important discovery of converting the nodules (septaria) found in London clay.

1810 - Edgar Dobbs. Contributed to the mechanical knowledge of the subject.

1818 - Vicat, John, Treusaart and St.Leger, foreign contributors to chemical knowledge.

1824 - Josephin Aspdin. Experiments revealed importance of high temperatures in kiln.

1826 - Sir C. M. Pasley. Conducted many important experiments.

1826 - Frost. The first to erect a factory near London for the manufacture of portland cement for construction purposes.

As will be seen from the above, credit for the discovery of portland cement is given to John Aspdin, an English brick layer of Leeds, who after experimenting since 1811, in 1824 took out a patent on an improved cement which he called portland cement because it resembled in color the Isle of Portland building stone.

In his early experiments Aspdin used hard limestones found near his plant, and struggled along for some time trying to make out of these and clays something which he thought would be a hydraulic cement. At this time he did not have quite the idea of portland cement, but he ultimately got it by burning his hard limestone at higher temperatures.

Other workers in the field of cement have endeavored to take away from Aspdin the credit for the discovery of portland cement. In 1911 when the discussion of the subject was revived in England and this country, nearly a century after Aspdin had obtained his patent, one, Isaac C. Johnson of England, who had long been prominent as a manufacturer of cement, and who was then well along in his 101st year, wrote to the editor of Cement Age, New York, claiming to be the "First manufacturer of a cement that would pass the tests of the exacting engineers of British and foreign governments". Johnson also says:-

"I grant that the name "portland" is due to Mr. Joseph Aspdin when he took out a patent in 1824, but which is no more like the cement that is made today than chalk is like cheese."

But in the Building News of London, there was published in 1880 an abstract of a statement prepared by Johnson in that year for G. R. Redgrave, British Chemist and author of "Calcareous Cements", from which the following extracts are taken:

Mr. Johnson states that about 1845 young Aspdin (William, son of Joseph) began work at Rotherhithe in connection with Messrs. Maudo and son on a small scale, and did sometimes make a strong cement, but owing to want of scientific method, the quality as respects strength and durability was not to be depended upon.

"I was at this time (about 1845) manager of the works of Messrs. White, at Wansombe, making only Roman cement, Keene's Plaster, and Frost's Cement."

"My employers, attracted by the flourish of trumpets that was then being made about the new cement, desired to be makers of it, and some steps were taken to join Aspdin in the enterprise, but no agreement could be come to, especially as I advised my employers to leave the matter to me, fully believing that I could work it out.

"As I said before, there were no sources of information to assist me, for although Aspdin had works, there was no possibility of finding out what he was doing, because the place was closely built in, with walls twenty feet high, and with no way into the works, except through the office."

"I am free to confess that if I could have got a clue in that direction I should have taken advantage of such an

opportunity, but as I have since learned, and from one of his later partners, that the process was so mystified that anyone might get on the wrong scent - for even the workmen knew nothing, considering that the virtue consisted in something Aspdin did with his own hands."

"Thus he had a kind of tray with several compartments, and in these he had powdered sulphate of copper, powdered limestone, and some other matters. When a layer of washed and dried slurry and the coke had been put into the kiln, he would go in and scatter some handfuls of these powders from time to time as the loading proceeded, so the whole thing was surrounded by mystery."

"What did I do? I obtained some of the cement that was in common use, and, although I had paid some attention to chemistry, I would not trust myself to analyse it, but took it to the most celebrated analyst of that day in London, and spent some two days with him. What do you think was the principal element according to him? Sixty percent of phosphate of lime! All right, thought I, I have it now. I laid all the neighboring butchers under contribution for bones, calcined them in the open air, creating a terrible nuisance by the smell, and made no end of mixtures with clay and other matters contained in the analysis, in different proportions and burnt to different degrees, and all without any good result."

Thus according to Johnson himself, Aspdin was a conspicuous figure in the cement world at the time - one whose secrets

others sought to discover.

IMPORTED PORTLAND CEMENT IN THE UNITED STATES.

A good trade soon sprang up in portland cement in England and on the continent. For a number of years before the first plant was started in the United States, foreign made cement had been imported in large quantities, shipping rates were negligible as cement made an ideal ballast for the clipper ships plying between Europe and America - ships that returned with the more profitable cargoes of wheat and cotton.

These importations in the United States are recorded as far back as 1865. The points of heaviest importations of foreign cements were New York, Philadelphia, Charleston, Savannah, New Orleans, Galveston, and some Pacific Coast ports. In the last case not only did Belgian, German and English cements come to the Pacific Coast as ballast for grain ships, but also cements from Japan and China.

As these ships had no regular sailing dates, and because they were sailing vessels, had no definitely known time of arrival, the successful marketing of foreign portland cement required far-seeing calculations. A ship would be loaded in London or Hamburg. Its actual arriving time was governed by the elements, and was a most uncertain factor. The cements would be consigned to various importers representing the manufacturers, and one importer might have a consignment of one brand and another importer an equally large lot of another brand, both on the same vessel. Thus it became a contest of wits to dispose of the cement promptly.

This had to be done to secure discharge from the ship at the earliest possible moment so as to avoid storage, demurrage and other unnecessary expenses. The result was that each importer was constantly endeavoring to secure orders for cargoes of cement that were to arrive at some unknown date, and when large shipments would arrive in a harbor on several vessels at approximately the same time, these representatives of foreign shippers were obliged to go to the builders exchange to find customers who would relieve them immediately of the shipments. Thus it can be seen that the business was an uncertain one as to profit and often entailed considerable loss.

The stories related by Robert W. Lesley of the early importers and their endeavors to secure orders makes interesting reading. These importers usually were of the country from which the cement was shipped. We have the contrast of the German, a military type, who controlled his office with discipline and accuracy, and the old type salesman, buoyant, jovous, hopeful and always a welcome visitor.

Mr. Robert M. Sinclair, a prominent figure in the cement industry at this time, now president of the Park Commission of Newark, has contributed the following interesting narration in debt. W. Lesley's book "History of the Portland Cement Industry in the United States":-

"My acquaintance with portland cement began in 1871, but previous to that time the firm of Hamill & Gillespie, 240 Front Street, New York, had been importing portland cement and Roman cement from England in small quantities, and I fancy were the actual pioneers. Their business was in English china clay, fire bricks, chalk, Fullers earth, and kindred articles, so it was quite fitting that they should import cement. Their call had, however, been more for Roman, than for portland cements and the former was placed first upon their sign as being the more important in their estimation. It is refreshing and very unusual in business annals in our country to find that this firm is still engaged in the same business at the same address."

"In 1871, I was a sort of lob-lolly boy for the firm of S. L. Merchant and Company, ship brokers, at 76 South Street, New York. They had shipping connections in London who occasionally loaded vessels with general cargo for New York, consigning the ships to Merchant & Company. It was during 1871 that they loaded the ship Indiana in London for New York, and being unable to obtain sufficient freight to make a full cargo, they put on 500 barrels of J. B. White & Brothers portland cement, consigning them to S. L. Merchant & Company with instructions to sell them as advantageously as possible, credit the ship with freight on them, and remit the proceeds to the London firm. Upon arrival of the ship, it was found that little was known of portland cement. There

were no brokers or commission houses through whom it could be sold - and so Mr. Merchant tried one clerk after another in his employ to get them to try to sell the cement to masons and contractors; but they got out of it upon one pretext or another. He finally got down to me at the bottom of the list and ordered me to get rid of the cement. When I found that I was expected to get $6.00 per barrel in competition with Rosendale cement selling at about $3.00, I felt that I was up against the impossible, especially as I had not the slightest knowledge of their comparative merits. But I was so fortunate as to come into contact with a more than ordinarily intelligent mason builder, Marc Eidlitz, who kept in touch with developments in building trades in Europe, and therefore knew something about Portland cement. He was desirous of trying some of it in work then under way. Through his advice and introduction, I was able to interest others in making small purchase, until finally the entire 500 barrels were sold, one sale I remember being to J. P. Wolfe & Brothers, Brooklyn dealers in building materials. I do not know whether that was the first Portland cement bought by New York dealers in building materials. The net returns for the 500 barrels must have been satisfactory to the London shippers as other shipments followed and in a short time C. L. Merchand and Company began importing on their own account."

"In the meantime, the New York Department of Docks, 1871-72 under the administration of George B. McClellan, Chief Engineer had perfected plans for building a bulkhead wall of portland

cement concrete on the North River, but found it impossible to obtain any dependable quantity of cement in the New York market. One of the Dock Commissioners had, as a neighbor, James Brand, a commission merchant having a London office, and the Department arranged with him to import the cement for them, paying him three percent commission. The brands imported were 'J. B. White & Brothers,' and 'Burham', made by the Burham Brick, Lime & Cement Company."

"John J. Schillinger at about the same time obtained a patent for a cement sidewalk made with an expansion joint, and learning of the Dock Department's arrangements with James Brand, he also arranged with Brand to import cement for him on a commission basis. Early in 1873, being dissatisfied with [illegible] Merchant & Company's business methods, I suggested to James Brand that he could build up a worth while business in importing cement for sale to the general trade, and he at once agreed me to manage that department of his business. We imported 'J. B. White & Brothers', 'Burnham', and 'I. C. B. & C.' (Knight, Bevan & Sturrs). The business grew rapidly and continuously profitable."

"During the first half of the decade 1870-80, my recollection is that only English cements were imported with the exception of a French cement brought from Boulogne by the Coignet Stone Company of Brooklyn for its own use. In those years the New York Department of Docks was practically the only buyer requiring that cement should be subject to test.

My recollection is that the tests were only two, namely, A tensile strength of 250 pounds per square inch after seven days when mixed neat, and that 75 percent should pass through a sieve having 2,500 meshes to the square inch. Captain W. J. Maclay, Asst. Engineer, supervised the tests made by the Department, and he probably did more than any one individual in those early years to raise the standards of quality in portland cement.

"In the early years, all importations came in sailing vessels, the cement being packed in barrels having a gross weight of 400 pounds. Almost every cargo had a portion damaged by water, owing to leaky ships. Occasionally the damage would amount to a large percentage of the entire cargo. Freight from London to New York, or Philadelphia ran from 35 to 40 cents per barrel, fluctuating according to amount of ship room available, occasionally dropping as low as 15 cents per barrel. Upon one occasion I brought a cargo of 5,000 barrels from Hamburg to New York for the nominal sum of one dollar.

"In 1876 or 1877 German cements began to appear, Dyckerhoff Alsen and Star (Stettin), and it was soon discovered that they were of better quality than the English cements, being finer ground and of greater tensile strength. There followed a gradual discrimination in their favor. When English manufacturers were informed of the superiority of German cements, they ridiculed the statements and declined to entertain the suggestion that they should institute similar improvements in

their own manufacture, saying with characteristic English manner that they were following exactly the same methods employed for the past thirty years, and they could see no reason for changing. The result was that the English cements ultimately were entirely supplanted in this country by German and Belgian brands, the former because of superior quality, the latter because of low price.

"During the first decade importation by steamer became necessary as the demand could not be supplied by sailing vessels alone, nor was their time of arrival sufficiently dependable. The Alsen Company was the only one so far as I know that attempted shipments in bags. A few shipments were made by steamer to New York in jute gunny bags containing 188 pounds of cement, two to the barrel, but they were too heavy to be conveniently handled and the experiment for general trade purposes was soon abandoned. However, the large quantity of Alsen cement used by the Florida East Coast Railway in building the viaduct toward Havana, was shipped in bags by steamer direct to Key West. In that case the cement went directly from the steamer to the work with the minimum of handling and the bags did not meet with serious objections, especially as they effected a considerable saving over cost of barrels.

"The Alsen Company was the only one, to my knowledge, to make the experiment of shipping cement in sheet iron drums. They were cheaper to make than a wooden barrel but being perfectly straight, without any bilge, they were awkward to

handle and were discontinued.

"During the decade 1890-1900 it became evident that imported portland cement would soon be supplanted by our home product, and manufacturers abroad were faced with the alternative of giving up their trade and good will in this country or building a plant in the United States. The Alsen Company decided to do the latter and on September 25, 1900, there was filed with the Secretary of State in New Jersey the certificate of incorporation of Alsen's American Portland Cement Works, with Heinrich Wessel as President; Heinrich Wulf, Vice-President; Herman Baasch, Treasurer; Robert S. Sinclair, Secretary.

"The incorporators were Heinrich Wessel, Herman Baasch, Heinrich Wulf, Arthur C. Babsen, and Robert S. Sinclair. Their mill was located on the Hudson River, six miles below the town of Catskill, their property immediately adjoining that of the already established Catskill Cement Company.

"Importations continued, however, in a small way until the war with Germany brought them to an end. My recollection is that importations of all brands never exceeded four million barrels in any one year."

In addition to the difficulties of shipment via vessels described by Mr. Sinclair was the difficulty of transportation by land to the interior. Railroad rates were high and the importer endeavored to get his shipments to land at a season that made the canals available for transportation. This, and the fact that the railroads were operating on

"gentlemen's agreements" prior to Interstate Commerce control, led to price wars in the rate field. Salesmen would go to large jobbers in the central and far west offering their materials "to arrive" to them. They were aided in this by the railroads giving through rates across the Atlantic.

Salesmen would frequently spend days with the prospective customer and a bond was formed between importer and distributor which the early American manufacturer found very lasting. Too, an enviable reputation was built up all over the country for various brands of foreign portland cement.

To sum up the history of the importations, and the difficulties connected therewith, Mr. Charles Keller, of the Western Lime & Cement Co., Milwaukee, writes as follows in the work of Mr. Lesley:-

"No longer do we have to hire experts to watch our Custom House clearances at New York or Baltimore or New Orleans and get all razzle-dazzled with ocean freights and custom duties and laws of 'general averages' and when an ocean-boat is lost at sea, not only lose our cement, but have to chip in and help pay for the boat.

"Whereat, in a fierce voice, I praise God that the days of imported portland cements have gone glimmering, and that the sales agents problems in handling cements now are insignificant compared to the tough old days that we have all outlived!

"All hail! American portland cements! All brands, all wills, everywhere, in the best country on earth! "

THE GROWTH OF THE PORTLAND CEMENT INDUSTRY IN THE UNITED STATES.

In writing of the growth of the portland cement industry in the United States the name of Robert W. Lesley stands forth as the manufacturer, organizer, salesman and one of the leading figures in the industry.

Mr. Lesley was born in Philadelphia, 1853 and his early education was in France, later at the Lawton School, Philadelphia. He entered the University of Pennsylvania in 1867, but left College to engage in business. Many years later, in 1908, the University graduated him with the degree A. M., as of the class of 1871. This was an unusual honor that made him a full alumnus of the University.

Mr. Lesley's early business career began in the office of the Public Ledger, Philadelphia, of which paper he finally became assistant editor. He studied law and was admitted to the bar in 1879. His early association with the pioneers of the cement industry, of which he was one, have been of great benefit to the industry. He has long been identified with many scientific and technical societies, and as a mark of honor and the esteem in which he has been held in the industry, he was elected to honorary membership in the Portland Cement Association in 1914.

In the history of the Association, he heads the list of presidents, being the first to serve in that capacity. His term of office covered the year 1903.

Mr. Lesley has written much of the cement industry and to his book on the early history of the portland cement indus-

try in the United States may be given credit for much of the material which appears in this chapter- most of that used being a direct quotation.

The history of an industry very properly begins with the account of its founder or founders. In compilation of the portland cement industry in the United States one is, to express it colloquially somewhat "up against it" to say who exactly is the founder in the United States, such as the British historians were in their attempt to identify the man the first manufactured portland cement.

When studying the natural cement industry in the Lehigh Valley, prior to the advent of portland cement into the United States, and of the men who had to do therewith we find David O. Saylor referred to as a leader. In dealing with the pioneers of the portland cement industry in the United States, Saylor again becomes prominent as one of the first and foremost in this field. In fact most authorities place him as the first manufacturer. He was a farm boy, who came into Allentown from the neighboring countryside. He began business in a small way and ultimately, in connection with Rohrig and Vollmer, purchased property on the Lehigh River above Coplay station on the Lehigh Valley Railroad where he started the manufacture of natural cement, known commercially as "Anchor Brand."

As one of the men who developed this business, it was but natural that the same imagination, courage and determination that brought successful development of these enterprises

into practical results should go on seeking further and wider fields. After several years of work in the small mill first built, Saylor, who had become familiar with the imported portland cement, was convinced that he could manufacture a similar article. His first idea was that he could take the natural rocks of the Lehigh district, burn them at high temperatures to incipient vitrification and by grinding the product make portland cement. The particular characteristics of the Lehigh rocks, which were high in lime, low in magnesia, and low in iron made this almost possible. The rocks were laminated and not crystalline like the other natural cement rocks found in many parts of the United States. They were, as stated, low in magnesia and iron content and in some of the layers nearly approached the composition of the English and German portland cements in the condition in which the slurry was put into the kilns for calcination.

The first results of the work in the field mentioned justified Saylor's expectations. The rock clinkered, the burned product resembled portland cement clinker, and when ground and made into briquettes gave results on the testing machine almost equal to the best imported brands. He naturally thought that he had solved the problem, and in 1871 applied for a patent which is as follows:

United States Patent Office,

David O. Saylor, of Allentown, Pennsylvania.
Improvement in the manufacture of cement.
Specification forming part of Letters Patent
No. 119,415, dated September 26, 1871.

To All Whom It May Concern:

Be it known that I, David O. Saylor, of Allentown, in the County of Lehigh, State of Pennsylvania, have invented a new and improved cement; and I do hereby declare that the following is a full, clear, and exact description thereof, which will enable others skilled in the art to make and use the same.

I have discovered that some kinds of the argillo-magnesian and also argillo-calcareous limestone found along the Appalachian range, containing more or less carbonate of lime, magnesia, alumina, silica, iron, salts, and alkalies adapted to the purpose, and which are now extensively used in the manufacturing of hydraulic cement, will make, when burned to a state of incipient vitrification, so as to be agglutinated, warped, or cracked, by contraction, and some burned to cinders, a very superior and heavy hydraulic cement, weighing from one hundred and ten pounds to one hundred and twenty pounds per bushel, and in every respect equal to the portland cement made in England and imported into this country.

The ordinary cement now in our market, such as Rosendale, Coplay, and other American brands are burned with the least possible degree of heat. The stone of calcination is arrested before it fuses or is contracted; should any of it do so it is thrown away as worthless. This cement weighs seventy to ninety pounds per bushel. I propose to burn this stone to the condition above indicated. After this calcination a selection is made and the pulverulent and scarified portions of the mass are

picked out and thrown away. The remainder is then passed through a crusher; then through a mill consisting of ordinary sand, or buhrstone. The manufactured material is then placed in a layer of from two to three feet thick over the floor of a cool shed and left exposed to the air for about four weeks before it is fit to use.

The stone which I use for the purpose contains the same ingredients as the composition used for making portland cement, and the products cannot be distinguished from each other except by treatment.

Having this described my invention, I claim as new and desire to secure by Letters Patent -

1. The process of making hydraulic cement from argillo-magnesian and argillo-calcareous limestone, substantially as herein specified and described.

2. As an improved article of manufacture, hydraulic cement produced from argillo-magnesian and argillo-calcareous limestone, substantially as herein specified and described.

David O. Saylor

Witnesses:

Edwin Albright
Augustus Weber

It will be noted that in one paragraph Mr. Saylor states that, "The stone which I use for the purpose contains the same ingredients as the composition used for making portland cement, and the products cannot be distinguished from each other except by treatment." This was a far-seeing and progressive step for-

ward in the pioneer days of the American portland cement industry. Saylor was constantly at his mill, always seeking to make more cement and cement of a better quality. He manufactured a considerable quantity of this new cement but due to irregularities in the laminae of the rock the material did not run regular and for long periods of time these tests of the cement showed that it would fail and disintegrate. As he had a large stock of the cement in his bins at these times, he was at his wits ends to know what to do with it. He put his brains to work however, had analyses made of his rock, found that the analysis of his manufactured material was nearly that of the portland cement of commerce, and without anything but his native ability to guide him, experimented again by grinding the raw rock into powder, made the powder into brick, built vertical dome kilns upon designs he procured from Portland, following the type then in use on the Medway and Thames, burned the brick in these kilns to clinker, and actually made portland cement.

It will be noted in connection with the account of Saylor's experiments that the date of the beginning of these was 1871. In view of the question which has risen in the writings of the historians of the portland cement industry, it is unfortunate that we do not know the date at which Saylor actually began to make a true portland cement. It will be noted later that others made a true portland cement about this time.

It was at about this time that a number of examinations were made in the Lehigh District by the Pennsylvania Geological Survey in connection with the iron deposits. The analyses

were made at Lehigh University by John W. Eckert, then a student at the college. After his graduation, he was employed by Mr. Saylor as a chemist and his assistant in the operating of the Coplay Cement Company. In addition to showing a marked executive ability, Eckert proved a most valuable assistant furnishing the technical knowledge so essential to Saylor's manufacturing ability. So far as recorded, Eckert's employment was the first scientific step in the new American industry. Shortly after Eckert entered the employ of the company, he examined the damaged material in their bins. As this had hardened and was now homogeneous and uniform, he suggested that it be burned a second time to clinker and ground. This was done with the result that the entire damaged content made an excellent portland cement.

In 1871, Thomas Millen and his two sons were engaged in the manufacture of cement sewer pipe, artificial stone, sidewalks, etc., at South Bend, Indiana. One of these sons, Duane Millen, at a meeting of the Portland Cement Association in Atlantic City in 1906, described in an after-dinner address the manner in which they became interested in portland cement. As it shows the initiativeness and resourcefulness of the early manufacturer, I will quote from this address.

The first car of portland cement brought into South Bend by the Millens cost them $9.12 a barrel. They often talked about portland cement but could not find out how it was made. One day, while Duane Millen was sitting in the office, a man entered and apologized for the intrusion by stating that he

had seen something in the yard which made him think of home. He explained that it was a pile of empty cement barrels with the old K. B. & S (Knight, Bevan & Sturge English cement) labels on them. He went on to say that he had worked for this company all of his life and to see the old barrels was like meeting someone from home. He asked Mr. Millen why he did not make his own cement, adding that he had seen plenty of marl near South Bend. The marl around the lakes at Notre Dame and the blue clay in the river bed were the materials to use, he said, but he could not tell how to use them, having worked continously in a single department in the English plant. He had heard of a book describing the process of manufacturing portland cement, but did not know where it could be obtained. Finally the Millens located the book through a Philadelphia house, which obtained it for them at a cost of $14. After studying the book the elder Millen would go out to Notre Dame Lakes and bring back two pails of marl in his buggy, and a pail of blue clay from the St. Joseph River. They were taken to the cement pipe shop where his son Duane would mix them with his hands and burn the mixture in a piece of sewer pipe. After burning the mixture, the clinker in the pipe, when any could be found, was ground in a coffee mill.

After six months of experiment and research the Millens felt that they knew all there was to know about making portland

cement; so they leased an old sawmill and built a kiln believed to be large enough to meet the entire cement requirements of the United States. It was twelve feet high by four feet in diameter. They continued building kilns each year until they had four, each twenty-four by six feet. In a few years demand far exceeded supply, the War Department alone taking virtually the entire output. Yearly contracts were made with the government for all the cement manufactured.

Another important early portland cement plant was that erected about 1875 by John K. Shinn, at Wampum, Pennsylvania. Some have claimed that it was in this plant the manufacture of American portland cement first took place.

After years of experiment, Mr. Shinn began, in 1874, to manufacture portland cement, but without entire success. Sometimes a good product would result and at other times the produce would be a failure. He finally advertised for an experienced cement maker and employed as such, William Pucell, of Cincinnati. A kiln was erected and from this Mr. Pucell succeeded in obtaining a portland cement of uniform quality. It was exhibited at the Centennial Exhibition held in Philadelphia in 1876, and the firm was awarded a gold medal by the United States Centennial Commission.

In the beginning at this plant, many primitive devices and methods were used to overcome the multitude of difficulties encountered. The grinding of the clinker was done by means of the stove up end of a heavy car axle suspended from a spring pole, the grinding taking place in a hollowed out flat rock.

is no apparatus for crushing limestone was available at Wampum, a carload of this material would be sent to Leetonia, Ohio, where it would be crushed at a foundry and sent to Newport, near Wampum, and taken to a sawmill in which the owner had rigged up a set of chopping buhrs. The crushed limestone was run through these buhrs and ground as fine as possible, and then brought back to Wampum for burning and grinding of the clinker as previously mentioned.

The earlier cement plants were not confined to the East alone. It was and is a fortunate thing that in the definition of portland cement that no specific requirements are given for the raw materials. This is because cement can be made from a variety of substances, permitting use of raw materials in various parts of the country instead of only a few localities.

Although this leeway is allowed in the selection of raw materials in the definition and now the cement must pass rigid specifications, these same allowances in the selection of materials, before the advent of modern testing methods, made for a great activity in the early days when the cement did not have to stand such rigid examinations.

Thus we find cement plants springing up in various parts of the country. Texas was among the pioneer states in portland cement manufacture, the first plant established there being the Alamo Portland and Roman Cement Company's works at San Antonio. This was established in 1879 by an incorporated company, one of the leaders being William Loyd, an Englishman who had some experience in cement making in his native country.

Among the early portland cement works was one established at Oregon City, Oregon in 1884. To show a condition which existed in many of these early plants where money was invested not too wisely, I quote from Mr. C. A. Newhall who, writing of this work in 1913, says:

"The plant was operated on this scale for a little over a year when it was decided to raise the capitalization of $50,000 and increase the capacity of the plant. But about this time the directors ordered a survey of the quarry, which showed that the rock was practically exhausted. They had been operating on a thin, saucer like body of stone standing on edge against a hill. The apparently inexhaustible mountain of stone was merely a thin veneer, so about 1890 the machinery was broken up and sold."

The Eagle Portland Cement Company was the first to operate in the Michigan field, which has later become a great cement manufacturing district. These works were at Kalamazoo, and the date of their establishment is debatable.

Mr. Lesley states that the plant was established in 1885, citing Mr. Dickinson, "who is familiar with the history of the company", who "states that the first date, 1885, is correct." In the 1916, Publication No. 24, Geological Series, Michigan Geological and Biological Survey, Mr. R. A. Smith, who writes of the Portland Cement Industry, says, "Apparently the first attempt in the United States to manufacture Portland cement was made at Kalamazoo, Michigan in 1872."

In this connection I have made inquiry from some of the

older residents of Kalamazoo, among them, relatives of Frederick Bush, who was the only local citizen among the founders of the plant. I find several who know that the plant was in operation prior to 1875 and who have shown me the location of the plant. One man, a Mr. Benj. Van Bochove, distinctly remembers that the plant was in operation in the spring of 1872. As this date was gotten from without any suggestion from me that the date was debatable, and he fixed the date from association with other events, I am inclined to believe there is considerable merit in the claim that this plant was the first plant in the United States.

A NEW ERA IN THE PORTLAND CEMENT INDUSTRY.

The competitors of the first American manufacturers of portland cement were as has been shown, the foreign cement makers and the American manufacturers of natural cement, whose product had the confidence of engineers and architects, and the further important advantage of familiarity in use. It is estimated that at the time the portland cement industry was first started in this country that the United States was probably using at least 2000,000 barrels of natural cement. Importations of portland cement must have been only a small fraction of this amount as the first authoritative figures on imports recorded in 1878 show only 92,000 barrels.

The following table shows that the American Manufacturers of Portland Cement had to overcome an established consumption

of competing products amounting to more than 2,000,000 barrels in 1878, and whose volumn showed rapid expansion before the American works could get fully under way.

Production of Natural and Portland Cements in The United States and Importations of Portland Cement in Periods of Five Years From 1878 to 1923, Inclusive -

Year	Natural Cement * (Barrels)	Imported Portland ** (Barrels)	Domestic Portland (Barrels)
1878	2,220,000 (Est)	92,000	28,000
1883	4,100,000	456,418	90,000
1888	6,253,295	1,835,504	350,000
1893	7,411,815	2,674,149	500,652
1898	8,418,924	1,152,861	5,692,284
1903	7,030,271	2,251,969	22,142,973
1908	1,686,862	842,121	55,072,612
1913	744,658	85,470	92,097,131
1918	452,966	305	71,081,663
1923***		1,678,636	137,460,258

* The peak of production in natural cement occurred in 1899, when the output was 9,868,179 barrels.

** Importations of portland cement reached high-water mark in 1895, when 2,997,595 barrels were brought in. Figures given for the more recent years include all kinds of cement imported but importations of cement other than portland are so small as to be practically a negligible factor.

*** United States Geological Survey figures for 1923 include in one total "masonry, natural, and puzzolan cements". The total shipments are given as 1,271,674 barrels.

As would be expected, the early American manufacturers followed very closely the English methods. These consisted of

grinding the raw materials wet, mixing them to as paste, and then drying, forming the mixture into bricks or balls, and charging them, usually by hand, into a verticle kiln for burning. After burning, the kilns were unloaded by hand and the clinker ground by some such primitive method as is mentioned in the fore-going chapter. This was an expensive process.

In England, labor was very cheap but fuel was expensive; in American, labor was expensive and fuel was cheap. Constant improvements were being made in this country in the methods used, in an endeavor to adjust the industry to the conditions of labor and fuel as they existed.

Among the most important and far reaching of these improvements, improvements which resulted in the growth of the industry by leaps and bounds was the introduction of the rotary kiln and modern grinding machinery.

The following account of the Rotary Kiln, probably the most revolutionizing of these improvements is described by R. A. Smith as follows:-

"The Ransome patents taken out in 1885 in Great Britain and in 1886 in the United States are the bases from which the modern rotary kiln have been developed. The modern rotary kiln consists essentially of a slightly inclined steel cylinder lined with fire brick and arranged to rotate. As the kiln rotates the raw mixture is fed into the upper end and travels slowly by gravity to the lower end where it falls out as a burned clinker. The fuel - gas, petroleum, or powdered coal,- is blown in at the lower end, the flame traversing the length of

the kiln.

"At South Bondont, New York, it was discovered that mixed and ground materials could be charged into the kilns without wetting, thus eliminating a step from the older process. The discovery that naturally wet materials,- marl and clay, could be successfully charged into the kilns without preliminary drying was made in 1891 at Montezuma, New York. Thus originated the two principal methods now in use, the dry process used with limestone or cement rock, and the wet process, with marl.

"The Ransome kiln was designed to use producer gas but petroleum was the fuel used in the first kiln successfully operated in the United States and was the principal fuel used for a number of years. In 1895, powdered coal was substituted for petroleum and was a very important step in the development of manufacturing practice. This is now the standard fuel used in this country, except in the regions where natural gas and petroleum abound.

"The next most important development in the rotary kiln was its increase in size, particularly in length. By 1903, the rotary kiln had been standardized to a length of 60 feet and, with dry materials; had a rated capacity of 200 barrels of cement per day. About this time the Edison plant demonstrated that a nominal lengthening of the kiln greatly increased its capacity and rapid lengthening began about 1905 until most of the kilns installed now are between 100 and 150 feet in length and there are now in use a considerable number over 150 feet, and a few from 225 to 250 feet in length. At present no standardization of the kiln is in sight. Some of the larger

kilns now in use have a capacity of over 800 barrels per day.

"The success of the rotary kiln is attested by the fact that foreign portland cement makers with cheap labor and high fuel costs have not been able to compete in American markets with the American manufacturers with cheap fuel and high labor costs."

Much could be said of the finished product of today - its characteristics, tests, etc. - and of the scientific and technical societies who have contributed in a great degree to the confidence with which it is used for a multitude of improvements which go to make our life of today worth living.

Of these societies perhaps the most far reaching effect has been that produced by the Portland Cement Association. The following chapter will be devoted to a short resume of this organization and its activities.

To properly appreciate the size of the industry today, a few of the high lights of the industry are given below, as of 1924.

A more intense heat is required to burn the material to clinker than is required to melt steel.

One of the largest kilns, set on end, would be as tall as a twenty story building. A touring car could run through it.

A medium sized kiln has foundations as heavy as for a ten story building.

The cement industry is the fourth largest manufacturing consumer of coal and the largest user of pulverized coal in the United States. In 1924 over 11,000,000 tons of coal were

consumed at the various plants, and about 7,500,000 tons of this were pulverized for burning in the kilns, and in a few cases in the dryers.

In addition to coal, the plants using other fuel in 1924 consumed more than 5,000,000 barrels of fuel oil and over 5,000,000,000 cubic feet of natural gas.

Over 17,000,000 pounds of dynamite and other high explosives were used in cement mill quarries in blasting loose the rock needed by the industry. Over 100,000 tons of rock were ground to flour-like fineness every day.

A large crusher may weigh 450,000 pounds - and crush 1,000 tons of rock an hour.

At least 78% of all portland cement must pass through a sieve having 40,000 holes to the square inch. This sieve is more closely woven than a fine quality of silk dress goods. It will hold water.

In one cement mill, it was found that the materials that go finally into a cement sack must be elevated 12 to 15 times to a height ranging from 80 to 90 feet. For every 376 pound barrel of cement produced this means enough power to lift a piano from the sidewalk to the thirty-second story of the Woolworth Building.

Over 2,000,000 lineal feet of belting were worn out and had to be replaced in American cement mills.

In power installed, the cement industry ranked tenth among all manufacturing industries of the country, according to the latest available United States Census figures.

Of the Census Bureau's 350 classifications of manufactured products, only two called for more power per dollar of selling price than cement.

The grease requirements of the cement industry would, in one year, supply over 335,000 high priced automobiles for a 5,000 mile trip. This would supply 3,800 taxicabs for thirty-one years.

The lubricating oil used in one year on cement machinery would operate over 54,000 taxicabs for a year, with each cab using one quart of oil per day. It would supply approximately 345,000 high priced automobiles for a 5,000 mile trip.

In other words, the cement industry in one year uses over 4,800,000 pounds of grease and 4,800,000 gallons of lubricating oil.

In one year of 37,000 miles of cloth 50 inches wide is used in making new sacks alone. This means that over 65,000 bales of cotton were used, enough to keep more than 3,500 looms busy every day for a year.

At the present time approximately 240,000,000 cloth sacks are required to meet the demands. Over 65,000,000 of these sacks do not come back to the manufacturer and have to be replaced each year.

Over 50,000,000 paper sacks are used in shipping cement each year.

THE PORTLAND CEMENT ASSOCIATION.

In 1902 a group of eastern cement manufacturers, intent as are all business men upon the money making side of their business and in establishing an American industry as against a firmly entrenched foreign competition, responded to a call for a meeting, issued by one of the number - Mr. B. F. Stradley, General Sales Agent of the Vulcanite Portland Cement Company - to discuss and find a solution, if possible, for "The present methods of handling the subject of sacks, which are almost universally unsatisfactory." Out of the meeting called to deal with this strictly commercial proposition grew the great scientific and altruistic organization now known as the Portland Cement Association.

There are probably few who have not at some time heard of the work of this Association. For convenience, it may be included in that large group commonly called "trade" associations. It is unfortunate, however, that many speak of the Portland Cement Association as a trade organization without further explanation. This causes frequent comparison of the Association with other groups of manufacturers, which, although in many instances similar, are quite different.

Fundamentally, the Portland Cement Association is a service organization. It is not incorporated and is not a commercial organization in any sense of the word. Membership is purely voluntary and its scheme of organization and policies is thoroughly democratic. Each member, without reference to size, has but one vote in helping to establish and promote its policies.

Having nothing to do with the manufacture, sale or distribution of cement, the Portland Cement Association can concern itself strictly with the educational research work for which it primarily exists.

The national headquarters of the Association are in Chicago. Recently the offices and laboratory have been moved into a new concrete building owned by the Association.

Some thirty district offices have been established in every part of the country. These are in the nature of service stations of the Association and have been established as needed by the growing demand for reliable information on the many applications of concrete made it imperative.

The national headquarters have been departmentized so that various classes of educational research work in the interest of concrete and its uses and the dissemination of the resulting information are done by these several departments.

The fund of information which the Portland Cement Association has accumulated is of almost inestimable value because of the research work done by the Structural Materials Research Laboratory, Chicago. This laboratory has been operated by, and in co-operation with the Lewis Institute. It is under the immediate charge of Duff A. Abrahms, one of the most prominent research workers in the country, whose studies are generally conceded pre-eminent. The extensive research and the resultant disclosures from the many years of experiments carried on in the Structural Materials Research Laboratory, have established as facts the valuable information which is the Portland

Cement Association's stock-in-trade, and which is furnished to those interested in making the most practical application. In no other laboratory in the world have there been, or are there being conducted, such numerous and exhaustive tests on the properties of cement and concrete, leading to a thorough understanding of these materials from the viewpoint of their adaptability to certain structural requirements.

The activities of the Association are extensive, but confined within the following limitations:

(1) Its aim is to increase the knowledge, utility, and use of portland cement through scientific investigation, public education, and associated promotion.

(2) It "sells" the idea "concrete for permanence"; in other words, the use of cement, not the commodity. Therefore it is not concerned in the brand of cement used.

(3) It performs only such functions as cannot well, if at all, be performed by its members individually.

(4) It undertakes only such activities as are for the common good and whose benefits when taken advantage of, accrue alike to all contributing members.

(5) Its conduct is jealously guarded and made to conform scrupulously in all respects to the highest concept of commercial morality and the strictest interpretation of the laws of the land.

To conform with these precepts makes it evidently impossible for the Association to engage in any attempt to solve individual manufacturing problems of its members except where

the nature of such problems is to invest them with common interest so that their solution would either benefit all alike or otherwise protect the whole industry against unfavorable reactions that likely would result from their neglect.

The Association, with its successful blending of the self-interested and altruistic interests of its members, is unique. It has no counterpart in American industrial history.

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