HISTORY OF THE PORTLAND CEMENT INDUSTRY IN THE UNITED STATES

CHAPTER I

CEMENTS AND THEIR DEFINITION

Cementing Materials Known Since the Dawn of History

History records that the early Romans and Egyptians 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.

General Classes in which Cementing Materials Fall

Mortar binders may conveniently be considered in two broad classes—limes and cements. Falling between these classes are hydraulic limes, so largely used in western 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.

Essential Difference Between Natural and Portland Cement

The main difference between natural and portland cement is that the former is a direct product of rocks as found in nature, burned usually in open kilns, while portland cement is a scientifically controlled product, made from properly proportioned calcareous and argillaceous materials. When these materials are burned in kilns and artificially proportioned, a chemically combined material called clinker is the result. Natural cement is burned at a lower temperature than required to produce portland cement clinker; but in both cases, after burning, the materials are ground into a fine powder, which is the cement of commerce.

More extended definitions of some cements follow:

PUZZUOLANA is a cement of volcanic origin. Its name is derived from Puzzuoli, an Italian city near the base of Mount Vesuvius, where the properties of puzzuolana were first discovered. The Romans used this cement extensively in their hydraulic works. The material was pulverized and mixed with slaked lime and a small amount of sand to form 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 the mortar.

Trass, a volcanic material found in Germany and Holland, and arenes, a sand found in France, were used in the same manner.

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. It is described later under "Slag Cement."

NATURAL CEMENT, as the name implies, is essentially formed by nature. Certain argillaceous limestones containing various percentages of lime, silica and alumina are quarried and burned in their natural state in open lime kilns at comparatively 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 elements or parts. Consequently, for purposes of comparison between natural and portland cement, it may be broadly stated that from 20 to 25 per cent 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 uncombined. 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 clinker

This mill at Williamsville, New York, built in 1824, supplied natural cement for the construction of the original locks on the Erie Canal at Lockport, New York.

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 addition subsequent to calcination except water and calcined or uncalcined gypsum.

Essential Composition of Portland Cement

In general, the composition of portland cement is about 20 per cent silica, 10 per cent alumina, plus ferric oxide, 65 per cent of lime and 5 per cent 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 materials, or by taking a cement rock in which all ingredients are present in nearly the proper proportions, then adding limestone or 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.

The fact that there is considerable variety of raw materials entering into portland cement manufacture has resulted in a classification of materials. Richard K. Meade, in his well known 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 the author 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. 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 mechanical 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 prepared by adding to true portland cement clinker, selected blast furnace slag in proportions varying from 15 to 25 per cent, then grinding the resulting mixture to the fineness 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 20 to 30 per cent, and the resulting mixture reduced to an impalpable powder.

BLENDED CEMENT is a name that was given to cement which partook of the natures 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.

COLLOS 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 a 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.

Note: The reader who is interested in pursuing a more detailed technical discussion of some of the cements mentioned in the foregoing, as well as cement manufacture in its broader aspect, will find much of interest in the following books:

"Calcareous Cements," by Redgrave and Spackman, published by Charles Griffin & Co., 1905. This book gives an unusually complete account of the early history of cements and also a very satisfactory treatment of numerous types of cement other than portland.

"Portland Cement," by R. K. Meade, Chemical Publishing Co., Easton, Pa., 1911. Based largely on American practice; probably the best general treatment which has been published in this country.

"Cement," by Bertram Blount, published by Longmans, Green & Co., London, 1920. Reflects modern English practice and theories.

"Portland Cement," by Arthur C. Davis, published by John Falconer, Dublin, 1922. This book deals with English practice in the manufacture of portland cement.

"Cements, Limes and Plasters," by Edwin C. Eckel, published by John Wiley & Sons, New York, 1922. This publication deals with raw materials, their manufacture and properties.

Note: For information concerning the more technical features of portland cement, see also papers on this subject published by Geophysical Laboratory, Washington, U. S. Bureau of Standards, Association of German Portland Cement Manufacturers and periodical literature.

Bibliography on Lime, Cement and Concrete

The following list of old, rare and out-of-print books on lime, cement and concrete, has been compiled by the Structural Materials Research Laboratory, Lewis Institute, Chicago, and are now in the library of the Structural Materials Research Laboratory.

It is probable that the more important libraries in various large cities throughout the country contain some, if not all, of these publications:

Date of Original Publication	
50 (?) B.C.	"Architecture," by P. Vitruvius; translated from Latin by Joseph Gwilt (John Weale, London, 1860).
50 (?) B.C.	"The Ten Books on Architecture," by Vitruvius; translated by Morris H. Morgan (Harvard University Press, Cambridge, 1914).
1774	"Practical Essay on a Cement and Artificial Stone," by M. Loriot; translated from French (T. Cadell, London).
1776	"Treatise on Building in Water," by G. Semple (J. A. Husband, Dublin).
1780	"Essays on Cements," by Bry Higgins; bound with essay of M. Loriot, (T. Cadell, London).
1791	"Narrative of the Building of the Edystone Lighthouse," by John Smeaton; 2d Edition, London, 1813. Book IV gives an account of experiments, manufacture, and use of "water cements." (Longman, Hurst, Rees, Orme and Brown.)
1818	"Practical and Scientific Treatise on Calcareous Mortars and Cements, Artificial and Natural," by Louis J. Vicat; translated from French by John T. Smith (John Weale, London, 1837; property of Lewis Institute).
1838	"Observations on Limes, Calcareous Cements, Mortars, Stuccos and Concrete," by C. W. Pasley (John Weale, London).
1868	"Practical Treatise on Manufacture of Portland Cement," by Henry Reid (E. and F. N. Spon, New York).
1868	"The Practical Manufacture of Portland Cement," by A. Lipowitz; translated from German by W. F. Reid (E. and F. N. Spon, New York; bound with Reid's book above).
1870	"Practical Treatise on Limes, Hydraulic Cements, and Mortars," by Q. A. Gillmore; 3d Edition, 1870; also 11th Edition, 1896 (D. Van Nostrand, New York).
1871	"Practical Treatise on Coignet Beton and Other Artificial Stone," by Q. A. Gillmore (D. Van Nostrand, New York).
1877	"Science and Art of Manufacture of Portland Cement," by Henry Reid (E. and F. N. Spon, New York).
1887	"Experimental Researches on the Constitution of Hydraulic Mortars," by H. LeChatelier; translated from the French by Joseph Mack (McGraw Publishing Company, New York, 1905).
1888	"Notes on Compressive Resistance of Freestone, Brick Piers, Hydraulic Cements, Mortars and Concretes," by Q. A. Gillmore (J. Wiley and Sons, New York).
1893	"Manual on Lime and Cement," by A. H. Heath (E. and F. N. Spon, New York).

Date of Original Publication

1894-5 "Commission des Methodes d'Essai des Matériaux de Construction," Tome I, "Documents Generaux;" Tome IV, Sec. B. "Matériaux de Construction autres que les Métaux" (J. Rothschild, Paris).

1896 "Digest of Physical Tests," Quarterly Journal; 2 volumes published (property of Lewis Institute), (Riehle, Philadelphia).

1897 "Chimie Appliquée a l'Art de l'Ingenieur;" Part I—Analyse Chimique des Matériaux de Construction, by Durand-Claye and Derome; Part II—Etude Spéciale des Matériaux d'Agregation des Maconneries, by Rens Feret. (Libraire Polytechnique.)

1898 "Materials of Construction," by J. B. Johnson, 4th Edition; also 5th Edition, revised by Withey and Aston, 1919 (J. Wiley and Sons, New York).

1898 "American Cements," by Uriah Cummings (Rogers and Manson, Boston).

1899 "Treatise on Masonry Construction," by I. O. Baker, 9th Edition revised and partially rewritten, 1903. Also 10th Edition rewritten and enlarged, 1909 (J. Wiley and Sons, New York).

1901 "Communications Présentées devant le Congrés International des Methodes d'Essaie les Matériaux de Construction;" Tome II, Part 2, Non Metallic Materials (Dunod, Paris).

1904 "Manufacture of Hydraulic Cements," by Albert V. Bleininger (4th Series, Bull. 3 Geological Survey of Ohio).

1905 "Report on Brickwork Tests, Conducted by a Sub-Committee of the Science Standing Committee of the Royal Institute of British Architects" (Royal Institute of British Architects, London).

1905 "Calcareous Cements; Their Nature, Manufacture, and Uses," by Redgrave and Spackman; 2d Edition (C. Griffin, London).

1906 "Der Portlandzement," by Oskar Schmidt (Konrad Wittwer, Stuttgart, Germany).

1906 "Etude Experimentale du Ciment Armé," by Rene Feret (Gauthier-Villars, Paris).

1909 "Manual Théorique et Pratique du Constructeur en Ciment Armé," by De Tedesco and Forestier, including "Le Calcul des Arcs," by Henry Lossier (Library Polytechnique, Paris).

1909 "Concrete-Steel Construction" (Der Eisenbetonbau), by Emil Mörsch; translation from Third (1908) German Edition, by E. P. Goodrich (Engineering News Publishing Company, New York).

1909 "Reinforced Concrete in Europe," by Albert Ladd Colby (Chemical Publishing Company, Easton, Pa.).

In addition to the literature listed, the following serial publications on cement, concrete and related subjects are in the library of the Structural Materials Research Laboratory, Chicago:

American Society for Testing Materials
- Proceedings v. 1-23 (1899-date)
- Miscellaneous preprints

International Association for Testing Materials
- Bulletins and Proc. (English edition, 1906-1914)

American Association of Cement Users
- Proceedings v.1-9 (1905-1913)

American Concrete Institute
  Journal (1914-1915)
  Proceedings, v.12-date (1916-date)
University of Illinois Engineering Experiment Station
  Bulletins 1-138, Circulars 1-10 (1904-date)
University of Wisconsin
  Bulletins relating to cement and concrete (1907-date)
Iowa State College Engineering Experiment Station
  Bulletins relating to cement, concrete, and brick (1903-date)
University of Missouri Engineering Experiment Station
  Bulletins relating to cement and concrete (1911-date)
University of Minnesota
  Studies in engineering relating to cement and concrete (1915-date)
American Ceramic Society
  Transactions, v.1-18 (1899-1917)
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Cement Age (Jan., 1904-June, 1912)
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  Concrete (July, 1915-date)
American Society of Civil Engineers
  Transactions, v. 56-74 (1906-1911); v. 84-86 (1921-date)
  Proceedings. Papers relating to concrete and reinforced concrete. (1904-1910)
Association of American Portland Cement Manufacturers
  Bulletins 1-23 and miscellaneous papers (1904-1909)
  Proceedings (1914-1915)
Portland Cement Association
  Proceedings (1916-date)
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National Research Council
  Bulletins and Circulars
The Concrete Institute (London)
  Transactions and Notes, v. 1-9 (1909-1921)
Mitteilungen aus dem Materialprüfungsamt zu Berlin-Lichterfelde West (formerly Mitteilungen aus den Königlichen Technischen Versuchsanstalten zu Berlin):
  Miscellaneous Bulletins (1886-1919)
Imperial Earthquake Investigation Committee:
  Bulletins
U. S. Government Publications:
  Bureau of Standards:
    Technologic Papers relating to cement and concrete
    Circulars relating to cement and concrete
    Annual Reports (1912-1922, except 1914, 1920)
  Geological Survey:
    Bulletins on cement, concrete, etc. (1904-date)
  Department of Agriculture:
    Bulletins on cement, concrete, etc. (1907-date)
    Public Roads, v. 1-4 (May, 1918-Dec., 1921)
  Reclamation Service:
    Annual Reports (1912-1920, except 1917, 1918)
    Reclamation Record; various issues

Panama Canal:
- Annual Reports (1912-date, except 1915, 1916)

Bureau of Mines:
- Miscellaneous bulletins

Public Works of the Navy:
- Bulletins 27-33 (1917-date)

Philippine Bureau of Science:
- Papers on cement, concrete, etc. (1908-date)

Inventive Minds of All Ages Interested in Cementing Materials

The subject of cementing materials seems to have attracted the attention of studious and inventive minds in all ages. Vitruvius, who in the early days of Rome, wrote much about mortars, had a great deal to say about lime and its uses, but it was ages afterward when a French inventor

Ruins of one of the earliest cement kilns built in this country, that of the Thomas Millen plant at South Bend, Indiana.

petitioned his king to grant a patent for the use of quicklime in mortar as distinguished from the old method whereby lime and sand were slaked together and permitted to remain in pits for many months before use.

Early Writings of Vicat

L. J. Vicat, a distinguished French engineer and author of numerous technical works, was practically the first within comparatively modern times to go into the complexities and variations in lime and its uses. In 1818, he published a book which was translated by Captain J. T. Smith under the title "A Practical and Scientific Treatise on Calcareous Mortars and Cements, Artificial and Natural," and published in London in 1837. It has ever since been regarded as a classic on the subject. Vicat's remarkable book shows how extended and thorough had been his research, and due to his investigations, especially of hydraulic limes, much of that known about cement today had its origin in this early work. Though published more than a century ago, the book seems quite modern. Vicat classified calcareous materials and defined the various kinds of lime they furnished. His study of clays was equally comprehensive. He described the qualities of different materials used with lime in the manufacture of mortars or calcareous cements. His research included observation as to the action of various substances upon mortars, and comparisons between mortars of ancient and modern times. In a chapter on natural cement, he made the following prophecy:

> That which is in England very improperly termed Roman cement is nothing more than a natural cement resulting from a slight calcination of a calcareous mineral, containing about 31 per cent of ochreous clay and a few hundredths of carbonate of magnesia and manganese. A very great consumption of this cement takes place in London, but its use will infallibly become restricted in proportion as the mortars of eminently hydraulic lime shall become better known and in consequence better appreciated.

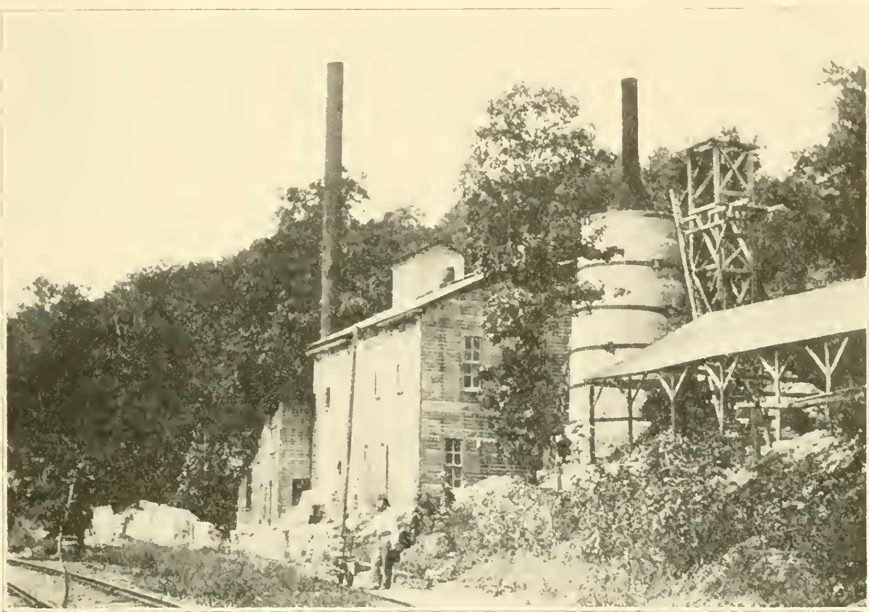
Vicat had followed up the discovery of John Smeaton, of Edystone fame, as to the advantage of clay in natural limestone to make such limestone hydraulic. This was accomplished by mixing rich lime with varying percentages of clay, to which Vicat refers in his book when he says: "We have no longer, therefore, to attend to laboratory experiments, but indeed, to a new art very nearly arrived at perfection." This new art, described in 1818, was what has now become the art of making portland cement, although Vicat did not describe it by that name, nor did he in his early experiments arrive at the results which he subsequently obtained.

Dr. Bry Higgins Among Early Investigators and Writers

Perhaps few, if any, writers among those who recorded their studies of cements and mortars, surpassed Dr. Bry Higgins. In 1780, he published a book under the title "Experiments and Observations Made with a View of Improving the Art of Composing and Applying Calcareous Cements, etc." Dr. Higgins regarded the subject of greatest importance, since he realized that "the strength and duration of our most useful and expensive buildings depend chiefly on the goodness of the cement with which they are constructed." He referred to his coworkers in this field as artists and gave much credit to a certain Dr. Black, who also appears to have been a student in this field of research.

Dr. Higgins found human nature in his day not much different from that of today. On the subject of fire resistive building construction, he says:

> The public are indebted to Mr. Hartley for the experimental proofs he has given to the efficacy of his method of securing houses from fire; and to Lord Mahon for those judicious and expensive experiments by which he has shewn that a calcareous incrustation answers the purpose of Mr. Hartley's art. I am afraid that their good intentions will be frustrated by the indifference of men to distant or improbable evils, and their dislike to any immediate expense which affords no extemporary convenience or ornament.



Said to be the first cement mill in Illinois, located at Deer Park near LaSalle. The modern successors to this humble beginning in cement manufacture are not far from this spot.

CHAPTER II

AMONG THE PIONEERS IN NATURAL CEMENT

Edystone Lighthouse Impelled Research for Better Hydraulic Mortar

In 1756, John Smeaton, who in 1791 described his experiments when writing of the construction of the Edystone Lighthouse, developed the thought which led to the discovery of the ingredients of hydraulic mortar. He laid down the principle that the hydraulic properties of a limestone depend not, as had been formerly supposed, upon color or texture, but upon the percentage of clay entering into its chemical composition. Announcement of this discovery naturally directed examination on the part of engineers and others, of various limestones and other materials found throughout England.

Almost contemporaneous with Smeaton's publication was the patent granted Joseph Parker, who claimed to make Parker's Cement out of certain stones or argillaceous products. This patent he followed up in 1796 by a second one for the use of nodules, or "noddles," of clay which he found along the Kentish coast of England. Later on the name of Roman Cement was given to this product, which commanded quite a large sale in England.

Almost simultaneous with the work of Parker, but still following Smeaton's discovery, one Lesage, connected with the French army, found similar noddles at Boulogne, from which he made good quick setting cement along in 1796. Chemically speaking, all of these were natural cements and analyzed very nearly alike—about 45 per cent of lime to 30 per cent of silica and alumina.

Established Reputation of Natural Cement Impeded Progress of Portland Cement

As a sidelight of cement history, it may be mentioned briefly here that in the face of the greater cost of producing portland cement, the reputation of the English natural cements was so great that for several years following the establishment of portland cement works, the natural product commanded a higher price; and for quite a time it seemed as though the manufacture of natural cement would endure to such an extent as to block the development of the then new portland cement industry.

Transportation Developments Forced Attention to Cement

The early history of the United States shows that necessity was frequently the mother of invention. Where construction grew on the basis of the people's needs and the materials came from what was ready at hand, it was most natural that we should have wooden buildings, pavements, sewer boxes, plank roads and, in general, a widespread use of lumber because of its ready availability. The progressive development of our resources naturally made better methods of transportation essential. The development of the country beyond the Alleghenies, the growth of the western part of New York State, the establishment of communities along the Great Lakes, made better means of transport essential between the seacoast and inland communities.

During this period, say from 1800 to 1820, methods of transportation were both primitive and limited. The practicability of steamship navigation had been demonstrated, but had not become available. Railroad building did not start until 1837. Horse-drawn wagons over the roughest of roads were practically the only means of intercommunication.

Canal Development Required Watertight Masonry

Canals had become an old institution in Europe and with the impelling force of necessity, engineering and financial minds in the United States turned to canals as the solution of the then pressing transportation needs of this country. Canals necessarily involve problems dealing with water and masonry. There must be locks, bridges over small streams, aqueducts to carry the canal over valleys, and all of these involve water-resisting mortar. From these needs resulted the early discovery of natural cement in the United States.

Erie Canal Responsible for Discovery of Natural Cement Rock in United States

The building of the Erie Canal, which was started in 1817, was not only the greatest of early transportation projects in this country in which cement played a most important part, but led to the discovery of natural cement rock in the United States. According to the best authorities available, this discovery was made in 1818 by Canvas White near Fayetteville, Onondaga County, New York. Mr. White took out a patent which was later sold by him to the State of New York for $10,000. State control of this patent finally resulted in removal of all manufacturing restrictions under the White process.

Richard K. Meade, in his book already referred to, quotes a county history which states that Mr. White made his discovery near Chittenango, Madison County, New York, and that after experimenting with the rock, applied to the state for the exclusive right to manufacture for twenty years. This right the state declined to grant, but gave Mr. White $20,000 in recognition of his valuable discovery. Thus do "authorities" cloud the facts. For the cement used in such large quantities on the canal, White received about 20 cents a bushel.

Under the administration of DeWitt Clinton as Governor of New York, work on the Erie Canal proceeded rapidly from the Hudson River to Lake Erie. Other sections of the United States were clamoring for canals. The Richmond and Allegheny Canal, extending from the James River to the Allegheny Mountains; the Chesapeake and Ohio Canal, from Baltimore to the headwaters of the Potomac; the Lehigh and the Pennsylvania State Canals in Pennsylvania; the Great Canal around the Falls of the Ohio at Louisville, Kentucky, and canals started in the vicinity of Chicago, all were dependent upon hydraulic cement, as each required water-resisting mortar for safety and permanence. It is evident that the development of the canal system of the United States in the early days therefore went hand in hand with the development of the American Natural Cement Industry.

It is a matter of history that the Rosendale, Akron and Howes Cave cement districts in New York; the Lehigh Valley cement district in Pennsylvania; the Cumberland, Round Top and Shepherdstown districts in Maryland and West Virginia; the Balcony Falls district in Virginia; the Louisville cement district near Louisville, Kentucky; the Milwaukee district in Wisconsin, and the Utica district in Illinois, were practically all discovered and brought into being through the need of cement mortar for the construction of our artificial inland waterways. Also, as in Europe, where, in the early days of cement manufacture, canals and waterways were the thoroughfares of transportation to market, so in this country similar methods were part of the history of the development of the cement industry. Out of this fact grew the employment of the wooden barrel, tight against moisture, as a shipping container. It was more than half a century after the discovery of natural cement in this country and the advent of railroads as a superior means of transportation, that it was discovered that the cotton sack and paper bag were equally good shipping containers.

The pioneers who had the courage to build these early cement mills and produce a new article of commerce were men of keen foresight and strong business purposes. In the group that developed the Rosendale district on the Hudson near Rondout, New York, were men of the highest type in business ability and integrity.

Personalities in the Early History of Natural Cement Manufacture

Among the earlier companies was the Lawrence Cement Company, which manufactured the Hoffman Brand. Its officers included Watson H.

Lawrence, Warren Ackerman, Dr. Woodward and M. Albert Scull. This company was one of the large producers in its day. The order and old-time business methods that pervaded its offices and the fair dealing which stamped every one of its transactions were proverbial among those who dealt with Rosendale cement in the early days.

Harry Brigham and S. D. Coykendall were two well known pioneer manufacturers identified with a group of mills known as the Hudson River Company near Rondout. Mr. Brigham was known as a distributor; Coykendall as an owner of barge and steamship lines and a pioneer in railroading in the Catskills. Coykendall started the manufacture of portland cement in the early days of the cement industry in this country but gave it up, holding until the day of his death a belief in a permanent market for Rosendale natural cement.

The Newark and Rosendale Company was another large concern in Newark, owned principally by the Tompkins family and associates. One of the younger Tompkins was Dock Commissioner in New York and for many years held high positions in business circles.

Another of the bright lights in the Rosendale field was Wm. N. Beach, a handsome, gray mustached, physically fit type of New York business man, keen, alert, wise in the handling of his mills and plants and a man who made many friends.

Among those in the strictly scientific or engineering side of cement manufacture in the early days was F. O. Norton, manufacturer of the Norton Brand. Mr. Norton was a member of the American Society of Civil Engineers and prominently associated with the foremost bridge, canal and railroad builders of his time. Perhaps more credit is due to him than any of the other early group for putting Rosendale cement, especially the Norton brand, in the front ranks of favor by the engineering profession. It is related of Mr. Norton that when the Lehigh cements first began to make their way into the New York market and endeavor to have a specification made by the engineering societies for all natural cements, he was against any specification on the ground that his cement was the best. "But," said the Lehigh manufacturers, "if we don't get a specification, how can we get into the market?" "Well," said Mr. Norton, "when I have sold all the cement my mill can make, you may have your chance to sell yours."

The Howes Cave Association, organized in 1869 and subsequently consolidated with the Howes Cave Lime & Cement Company, was among the early manufacturers of natural cement. These merged concerns finally became the present Helderberg Cement Company. The Howes Cave Lime & Cement Company made natural or Rosendale brands, known as "Ramsey's Cement," "Rose's Cement," and "Howes Cave Cement." The manufacture of natural cement continued after the Helder-

This view of a present-day cement plant indicates that even moderate-sized plants, as plants go today, conduct manufacturing operations on a large scale.

berg Company was incorporated, or until 1905. Maximum production reached about 10,000 barrels per month.

F. W. Kelley, at this writing President of the Helderberg Company, has supplied the following facts concerning the original company:

> Joseph Ramsey, an attorney and State Senator, who afterward became president of the Albany & Susquehanna Railroad, which is now a part of the Delaware & Hudson system, established the Howes Cave Association. A letter to him from Professor James Hall, who made the first geological survey of the state, covering the occurrence and outcrop of water-lime rock at Howes Cave, is still in existence.
>
> Natural cement was made from water-lime outcropping on the hill at this point in a layer about seven feet thick. The rock was mined and broken up by hammers in pieces weighing in some cases as much as twenty pounds. It was then charged in layers about a foot thick with alternate layers of coke, and sometimes anthracite coal, in vertical kilns having an inside diameter of eight or ten feet, the kilns being built of masonry and lined with fire-brick. At the bottom of the kiln was a sheet iron hopper having grate bars which could be withdrawn as the charge of calcined rock was drawn from the bottom of the kiln. The burned rock was separated and the under-burned and over-burned pieces extracted, while the properly burned material was passed through rotary crackers and then ground between Esopus mill stones to about 50-mesh fineness. One mill was operated by water power and the other by steam power.
>
> Charles H. Ramsey, son of Joseph H. Ramsey, operated the plant of the Howes Cave Association and was one of the first officers of the Helderberg Cement Company. About 1884 he became interested in the possibility of making portland cement from the Howes Cave materials, with the result described elsewhere in this history.

Hiram Snyder, who handled the New York and Rosendale brands, is well and favorably remembered, and unlike many of his Rosendale associates, went into the sales end of the rapidly growing portland cement industry as a part of the Lehigh Portland Cement Company organization.

In western New York there was another group of manufacturers of natural cement. These were possibly more aggressive and venturesome than their rivals in the eastern part of the state. The Bennetts, who had a large plant at one end of Main Street, Buffalo, did an enormous business in the western part of the state. After having excavated their cement rock from nearly a square half-mile of territory, they went out of business, disposing of the land with the cellars excavated for house construction to would-be builders of small homes in the rapidly growing city. That was a sample of the type of men in the Western New York group of manufacturers. A survivor, Lesley J. Bennett, recalls interesting facts connected with the natural cement works in that vicinity known as the Williamsville Cement Plant, which was in operation until about thirty years ago. Mr. Bennett treasures a photograph of the plant taken about twenty-five years ago, showing the mill on the bank of a creek and such interesting details as the old wooden water-wheel and the stone kilns. This mill was built to furnish cement for the Erie Canal locks at Lockport. Mr. Bennett says that, beginning with the Buffalo cement mill's quarry at the north end of

Buffalo, and running through the Williamsville district, the ledge contains fossils, called "Eurypterus," which are found only in the lower Silurian Age. It is said that the only other places in which these fossil remains have been discovered are Genesee Falls, near Rochester, New York, and on an island in the Black Sea off the coast of Russia. These fossil remains vary from a few inches to six feet in length and embrace some forty or fifty varieties. Owing to their rarity, the Smithsonian Institution has collected several hundred specimens. German universities have also collected some of these specimens, having paid as much as from $200 to $300 for each specimen.

There were two cement plants at Akron, New York. One of these was headed by Uriah Cummings, a man intensely interested in his business and its development, and the author of a book which is referred to later.

The other plant near Akron, included among its owners, Daniel S. Lockwood, a leading lawyer of Buffalo, an associate of President Grover Cleveland, and a man of widely recognized legal and business ability. During the days of the Wilson Bill, when it was proposed to reduce the duty on cement and admit it to this country under the free list, it was "Dan" Lockwood who served those having tariff matters in charge in the interest of the industry and assisted in having the duty retained.

There were a few cement mills in Ohio, at New Lisbon and elsewhere, but the first big cement center west of Buffalo was at Louisville, Kentucky. Many plants congregated near the Falls of the Ohio, near Louisville and across the river at Jeffersonville, Indiana. John Hulme of Philadelphia and James B. Speed of Louisville were owners of the principal plants in that district. They were foremost in the introduction of new machinery, the development of new methods, and in opening new markets. On their death they left enviable reputations with their associates in the industry. John Hulme left no successor, but the Speed interests came into the hands of William S. Speed, son of the original owner, who, in turn, is making new and bigger successes not only in the manufacture of portland cement, but of "Brix-cement," a revived natural cement.

Under modern methods in the Lehigh district of Pennsylvania, the Coplay Cement Company was a pioneer, although many years before its establishment (about 1850), a small mill was started on the Lehigh Canal at Siegfrieds Bridge, under the ownership of General J. K. Siegfried. It was the outgrowth of this natural cement plant at Coplay that led to the first successful portland cement plant in the United States. David O. Saylor came from the farm to Allentown, Pennsylvania, and associated himself with Adam Woolever and Esias Rehrig. Saylor became interested along with Christian Knauss, a farmer near Whitehall, just above Coplay, in cement rock along the line of the Lehigh River and Lehigh Valley Railroad. Mr. Woolever had the reputation of being a leading politician in Allentown and Mr. Rehrig, the County Clerk or Recorder of Deeds, backed Saylor to see what could be done with the material discovered. Saylor, tall, stout, red faced, with a long beard, Rehrig of dark complexion, dark beard and hair, of the same strong physical type, and Woolever, another of like characteristics—these three clear-cut, decided and positive men started to work at their problems by burning the rocks in a little cook stove in Rehrig's office or in Saylor's house. They found that the material would make cement. They secured capital and put up their works at Coplay and from this start they ultimately developed into not only the original producers of portland cement in this country, but owners of one of the large mills in the Lehigh district.

General Siegfried, on the other side of the river, put up a small mill, and through his political connections did a large business on state work and state canals.

Farther to the south, in the Potomac Valley, at Round Top, Maryland, the Waters family, farmers and country storekeepers, erected a cement plant which was very successful and which supplied cement to the Chesapeake & Ohio Canal and to the Washington, D. C., market. At Cumberland, Maryland, another group of men, which included Slack and Gephardt, developed the Cumberland Cement Company, which also found its market along the canal. In West Virginia, on the Potomac River, below Round Top, there was the Shepherdstown works under the control of Blunt. This plant came into its growth after the canal construction days had well passed. Later the Cedar Cliff plant, near Cumberland, was built.

The Lochers of Virginia, some of whom became noted contractors throughout the country, developed the Balcony Falls works in Virginia. The Richmond and Allegheny Canal, so far as masonry is concerned, stands as a testimonial to their success as manufacturers.

The Milwaukee works began with the discovery and manufacture of natural cement by J. R. Berthelet, Sr., whose adventure is described elsewhere. One of the owners of the Milwaukee works was William Plankington, prominent also in the grain and meat-packing industries. All of these plants produced cement of excellent quality and reputation.

At Utica, Illinois, was a plant owned by the Clark family. Reference to the long and successful operation of this plant appears elsewhere.

On the Pacific coast, a bed of hydraulic limestone was opened up in 1863 at Vallejo, and kilns were built near Benicia. Importations on the coast impeded the development of this plant, but production finally reached 100 barrels a day.

In 1881, natural cement rock was discovered at Canon City, Colorado. Experiments were conducted by M. Megrue, and in 1882 a plant

Twenty years ago quarrying was all done by hand, from drilling the rock to moving the cars. Today, the well-drill, steam shovel and steam train do it much more efficiently and economically.

When rock was loaded by hand, each piece had to be sledged into "one-man" size; consequently, quarry outputs were low. Today, one steam or electric shovel does the work of dozens of men.

was built at Denver. In that year about 100 barrels of cement were made and the following year the first entire kiln of cement was turned out.

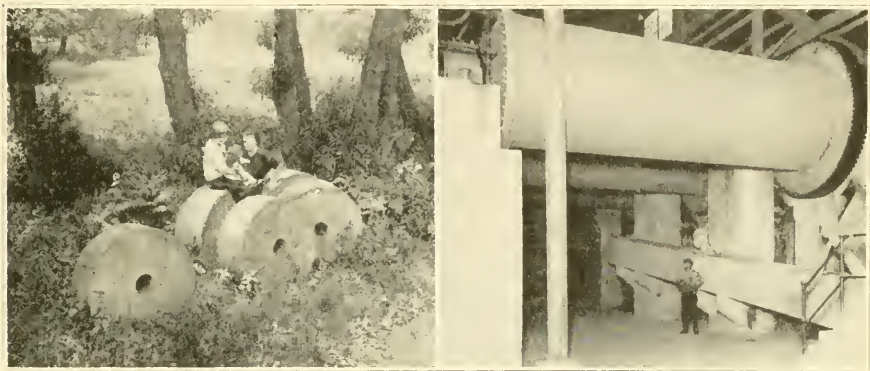
Early Literature on the Natural Cement Industry in the United States

Two books stand out preeminent in dealing with the natural cement industry in this country, namely, that of Uriah Cummings, already referred to, and that of General Quincy A. Gillmore on "Limes, Hydraulic Cements, and Mortars," published originally in 1863 and put through many editions since. General Gillmore was recognized as a man of remarkable scientific attainments, as a government engineer who was largely interested in the use of Rosendale cement in the New York territory, and from his investigations into the Rosendale district spread his inquiries into natural cement plants all over the United States.

Many of the Early Natural Cements Distinguished for Quality

Those who have been in the habit of regarding the old natural cements as of no value and as having been completely superseded by portland cement will find much that is instructive in General Gillmore's book. They will also be surprised at the deserved prestige which early natural cements won. The description of tests and details of the use made of some of the old natural cements on such work as the East River Bridge, government fortifications and other types of construction along the Atlantic coast makes interesting reading.

Considered from the standpoint of output, the Rosendale natural cement district in Ulster County, New York, surpassed all others. Its



In the early days, millstones like these were used to grind and crush the raw material. Tube mills do the work today, the charge of steel balls in one of these mills often weighing as much as a steel freight car.

The modern crusher, to the right, crushes thousands of tons of rock a day, some of the rocks being larger than the ancient apparatus to the left.

remarkable development was due to the excellence of its product and to cheap transportation to New York City and other points on the Hudson River.

The prosperity of the Rosendale industry endured until portland cement had practically supplanted the natural product. A government report in 1896 stated that of all of the natural cements then produced in fifteen states, about half came from New York and nearly all of this from the Rosendale district, with its fifteen plants operated by twelve companies.

How Rosendale Cement Was Named

According to General Gillmore, the Rosendale cement deposits were so named because the stone was first discovered in the township of Rosendale, and were confined chiefly to a narrow belt scarcely a mile wide, following the northwestern base of the Shawangunk Mountains along the line of the Delaware and Hudson Canal in the valley of Rondout Creek.

As described by General Gillmore, the beds occupied "every conceivable inclination to the horizon, being sometimes vertical, seldom on a level, and ordinarily dipping at a greater or less degree either to the northwest or to the southwest. The entire face of the country in this region exhibits unmistakable evidences of having been subjected to a succession of remarkable upheavings. * * * * * * The useful effect of these upheavings has been to develop into accessible and convenient positions a vast amount of cement stone that would otherwise have been buried beyond the practicable reach of ordinary mechanical skill."

Various Early Companies Described by Gillmore

Works referred to by Gillmore were those of the Ogden Company and Delafield & Baxter (formerly Ogden & Delafield) at High Falls; the Newark Lime and Cement Manufacturing Company on the Hudson River, at the mouth of Rondout Creek; the Lawrence Cement Company, manufacturers of the Hoffman brand, above Whiteport; the Newark and Rosendale Company at Whiteport; the Rosendale Cement Company, manufacturing the Lawrence brand at Lawrenceville; the Ogden Rosendale Cement Company, High Falls; the works of N. Bruce, at Bruceville, near High Falls; Martin and Clearwater, on the Delaware and Hudson Canal, a few miles from Rondout; Hudson River Cement Company, with quarries five miles from Rondout and mills in Jersey City; Maguire, Crane & Company, a few miles from Rondout; the Lawrenceville Cement Manufacturing Company, Lawrenceville; and Rosendale and Kingston Cement Company, Flatbush.

From descriptions of works it is learned that one company had "seventeen cylindrical (vertical) kilns, * * * * * and the mill driven by steam power, containing five 'crackers' and eleven run of stone of two and a half feet in diameter, and two run of four and a half feet in diameter. Four of the crackers and five run of stone can grind 800 barrels of cement per day."

The interesting fact to be gathered from writings of Gillmore, Cummings and others is that these cements were essential to the development and construction of the canal systems of the United States and were dependent for their power in many cases upon the waters from the canal itself. Further than this, their storehouses and shipping facilities were on the canal or on the adjacent river, transportation being governed by water conditions.

Early Mill Practice

As to the mill construction of these plants, it may be mentioned that all the kilns, with possibly a very few exceptions, were stone vertical kilns of various heights and diameters into which the raw cement rock was loaded at the top with layers of coal and, in turn, drawn from the bottom into cars which conducted the material to the plant itself. In many cases plant construction was such that the "coffee mill" crushers, which tore apart in the initial step the calcined rocks coming from the kiln, were located on the upper floor of the mill and necessitated tracks on which small cars drawn by wire ropes were conveyed from the drawing floor in front of the kiln to the "coffee mill" crushers. So general was this practice that when a cement manufacturer in later times started to build a plant with crushers on the ground opposite the drawing floor of the kiln, and the crushed material was conveyed in short bucket elevators to the mill stones, the entire neighborhood predicted that the plant would never operate because it did not have an inclined railway from the kiln floor to the crushers, then generally located at the top of the mill.

The other governing factor in early mill construction was that the grinding was performed by old-fashioned buhr stones, or sand stones of the same general type. All these stones required constant dressing, and when one entered a cement mill in those days, he was greeted with a merry chorus of clinking mill picks playing on the hard stones, which required constant redressing at heavy expense.

The So-called Louisville District and Its Extensive Development

The second largest field was that developed near Louisville, Kentucky. The quality of the cement was excellent and its distribution in time covered a wide territory which ranged from Ontario to Florida and from the Atlantic to the Rocky Mountains.

In 1905 a newspaper article referred to the passing of the Louisville cement industry, stating that many of the towns formerly dependent upon the natural cement mills for their prosperity were dead.

The manufacture of Louisville natural cement began in 1829, the year of discovery. John Hulme & Company established works near Louisville, Kentucky, the cement being used in the construction of the Louisville and Portland Canal. For a long time manufacture from the original quarry continued, the cement being sold under the brand of "J. Hulme Star." Mortar made from this cement could be seen in a portion of the original

Every week or ten days one of these old vertical kilns would produce enough clinker to make about 200 barrels of cement, nearly equaling the four-hour output of a modern rotary kiln.

canal wall that remained after a period of sixty years. It was almost as hard as the limestone in the masonry walls, showing no effects of time.

The Hulme mill enjoyed a monopoly of the cement business for many years. The company was without a competitor until 1854, when W. F. Beach erected a mill on the Ohio River, opposite Louisville. After a few years, however, this mill closed down and was finally destroyed by floods.

In 1866, Dexter Belknap, having ascertained that the quality of Louisville cement was excellent, and being impressed with the many advantages to be obtained by the manufacture of cement on some railroad line, built the first cement mill located on a railroad in Indiana. He had traced for some miles north of the Ohio River the strata of rock exposed in the bottom of the river, and located his plant on the J. M. & I. Railroad at a point called Belknaps, so named in his honor. He organized what was known as the Falls City Cement Company. Manufacture began with a capacity of 200 barrels a day, and in 1892 output was 2,700 barrels daily.

The success of this company encouraged others to seek the advantages of railroad transportation, and in a few years other mills were built. These included the Sabin & Gilmore works, erected in 1867, about eight miles north of Louisville, but finally dismantled.

Prior to 1868 the mills along the railroad were comparatively small. In 1871 the Louisville Cement Company built the Speed Mill at Speeds, Indiana, with a capacity of 700 barrels per day. This mill was operated for a long time, capacity increasing to 4,000 barrels per day. It was known as the largest cement mill in the world. Other important mills were those of Bondurant & Todd, known as the Black Diamond; the works of W. P, Hahn, erected in 1869; the plant of the Falls City Cement Company. erected in 1870.

With characteristic enterprise, the Louisville manufacturers built with reference to future demand instead of current requirements. Business was prosperous, and as time went on additional mills were built, these including the Ohio Valley Cement Company works, near Cementville, Indiana, in 1881; the Kentucky & Indiana Cement Company plant, near Watson, Indiana, in 1887; and the Clark County Cement Company plant, in 1890. Works were also established at Hausdale, Charlestown, and Sellersburg, Indiana, in 1891 and 1892, respectively.

From the single mill of small output erected in 1829 by John Hulme, the number of plants in this locality had increased to eighteen by 1892, having an annual production of a little over 2,000,000 barrels. The production of the entire country in 1892 was a little more than 8,000,000 barrels.

Louisville cement was used in practically all the great engineering works of the time within reach of this field, these including important bridges, water-works, tunnels, locks, dams, street foundations, pavements and sewers.

Natural Cement in the Lehigh Valley District

Third in importance was the Lehigh Valley district, in Pennsylvania. The history of the natural cement industry in the Lehigh Valley district is closely intertwined with that of the portland cement industry. It began with the construction of the Lehigh Coal & Navigation Company's canal along the banks of the Lehigh River from the coal regions to Easton. The first plant established was at Siegfried, Pennsylvania, where General Siegfried, to whom reference has been made, and who afterwards became prominent in public life in Pennsylvania, built a small plant a short distance back from the canal and river. This cement was largely used in the construction of the canal.

On the opposite side of the river, above Coplay station, there was a large hill along the Lehigh Valley Railroad. The face of this hill as exposed by railroad cuts, showed rock similar to that found near the Siegfried works. This led some of the residents to investigate cement-making properties of the material. Among them was the farmer Knauss, to whom reference has been made. He purchased some of the land and endeavored to interest others in it. This property in later years produced some natural, as well as portland cement, and, after the destruction by fire of a small works erected on it, the location became the first works of the Atlas Portland Cement Company. Above this was another small works, known as the Hercules Company, which also made a small amount of natural cement, its site now being that of the Whitehall Portland Cement Company works.

The early developer, however, of the natural cement industry in the Lehigh district was the Coplay Cement Company, the owners of which at that time were David O. Saylor, Esias Rehrig, and Adam Woolever. These men believed that natural cement could be made of the rocks just above Coplay station on the Lehigh Valley Railroad, so they took the material to Allentown, where they lived, and, as previously mentioned, they spent evenings in the house of one of them trying it out in a cook stove, and finally in a kiln they had built. It is related that some of the product was taken down to a flour mill nearby and ground, a characteristic proceeding in the early days of experiment. This cement was known commercially as "Anchor Brand," and in the seventies was largely used for many important works. The Girard Avenue Bridge, and other railway bridges in Philadelphia which carried most of the traffic to the Centennial Exposition of 1876, were built with this cement. After Saylor had perfected the manufacture of portland cement at these works, an addition of portland cement clinker to the natural cement was made, and out of this a mixed cement known as "Improved Anchor" was produced and found large sale.

The Siegfried works had a checkered career, passing through the management of Hugh N. Camp & Sons, of New York, the American Cement Company, A. B. Bonneville and the Allen Cement Company, finally coming into the ownership of the Lawrence Cement Company. In its early days this plant produced natural cement in large quantities. Later an "Improved Shield," a mixed cement, and "Shield," a natural cement, were produced there by the Lawrence Cement Company, the present owners.

The success of these natural cement works in the Lehigh district caused those who in later days were seeking to establish themselves in that field—where in the eighties portland cement was beginning to be manufactured—to search for cement rock of some general character out of which both natural and portland could be produced. This led to the establishment of the American Cement Company, originally the American Improved Cements Company, whose works were on the line of the Ironton Railroad about two miles back of the Coplay Cement Company and up a small valley leading from Coplay to the iron ore beds at Ironton. This plant introduced the manufacture of "Union" natural cement and "Improved Union" mixed cement at an early day and became large producers of cements which found a market in all the eastern states. They were used on many important engineering works—railroads, dams, bridges, etc. The Johnstown (Pennsylvania) Bridge, celebrated as having withstood the great flood, was built of natural "Union Cement."

Early Natural Cement Works in Maryland and Virginia

Along the Chesapeake and Ohio Canal a number of natural cement works were located. Those at Round Top, about three miles above Hancock, Maryland, and at Cumberland, Maryland, were the principal ones and the pioneers in this field. Both of these plants were located near the canal and the Potomac River, the former plant deriving its motive power from the discharge of the water of the canal into the river. These two companies were largely engaged in supplying cement to the works along the canal, to bridges over the Potomac River, and to Government works in Washington, Baltimore, and Northern Virginia and Maryland. Both made excellent cement, some of which, in Government tests, showed results for long-time periods in sand mortars almost approaching some of the early tests of portland cement under similar conditions.

Another works at Shepherdstown, Virginia, started later. This differed from the other two in that its rock was more highly magnesian than that of the other plants, which had a rather remarkable material for cement making purposes. This company also found a large market for its material in Government work in the District of Columbia and vicinity.

The laying of asphalt pavements in the District of Columbia under the Shepherd and following administrations, provided a large market for all the cements of the Potomac region. Many miles of pavements in Washington, D. C., are laid upon concrete foundations containing natural cement produced in the district mentioned.

In later years a small works which ran for a short period was started at Cedar Cliff, near Cumberland, Maryland.

Of these plants the one at Round Top was the most famous, cement rock having been discovered there in 1837 by A. B. McFarlan, contractor on the Chesapeake & Ohio Canal. The closing down of this plant was announced in 1906.

Milwaukee, Wisconsin, the Center of Natural Cement Manufacturing Activity

Milwaukee, Wisconsin, also became the center of a group of natural cement mills whose founding, as in other cases, was preceded by an accidental discovery of natural cement rock; and, as happened elsewhere, the humble cook stove played an important role. In the early seventies the City of Milwaukee was building a bridge across the Milwaukee River. At that time J. R. Berthelet, Sr., was engaged in the manufacture of cement sewer pipe in Milwaukee. He used Louisville cement, and made frequent visits to that great cement region. There he became familiar with the nature of cement rock and methods of cement manufacture. As a maker of sewer pipe, Mr. Berthelet had occasion to hold frequent consultations at the office of the Milwaukee City Engineer. During one of these visits he noticed samples of rock taken from the bed of the Milwaukee River,

In the early days, cement was stored in bins in this and similar buildings until it was shipped to the consumer in barrels.

where caisson construction had been necessary. Because of its resemblance to the Louisville natural cement rock the specimens aroused his curiosity. Taking samples to his home he burned them in the cook stove. Upon reducing them to powder with a mortar and pestle, he was surprised and pleased to find that he had made a natural cement.

Mr. Berthelet interested a number of intimate friends in plans to exploit the material. Careful test of the rock was made from samples procured throughout the entire area of visible deposit. Samples were sent to all the leading geologists and chemists in the country, their reports bearing out Mr. Berthelet's conclusions as to the adaptability of the rock to the manufacture of natural cement. The Milwaukee Cement Company was formed and land on both sides of the river was acquired, the tract extending nearly a mile and a half to the north of the city. Works were erected, and on June 16, 1876, the first barrel of Milwaukee hydraulic cement was manufactured. Output began with about 200 barrels per day, which gradually increased until in 1888 the daily capacity of the two mills owned by the Milwaukee Cement Company was 4,000 barrels.

The first officers of the Milwaukee Cement Company, which was incorporated in 1875, were J. R. Berthelet, Sr., President; George H. Paul, Vice President; John Johnston, Treasurer; Henry Berthelet and Chas. H. Orton, Directors. In 1876, J. R. Berthelet, Jr., resigned his position with the U. S. Engineer's Office, District of Milwaukee, and joined the company as superintendent of manufacture and in charge of construction, in which capacity he served for over thirty years.

About 1890, the Cream City Cement Company was organized, and erected a small mill on the Milwaukee River in the vicinity of the Milwaukee Cement Company's plant. The Cream City Company manufactured under the brand of "Cream City" cement, but after a time the plant ceased to operate.

A few years later another Wisconsin cement company was organized under the name of the Consolidated Cement Company. A mill was built on the shore of Lake Michigan, north of Milwaukee, where an outcropping of natural cement rock was available. Owing to excessive cost of manufacture, the venture was not a success financially, and after a few years was discontinued.

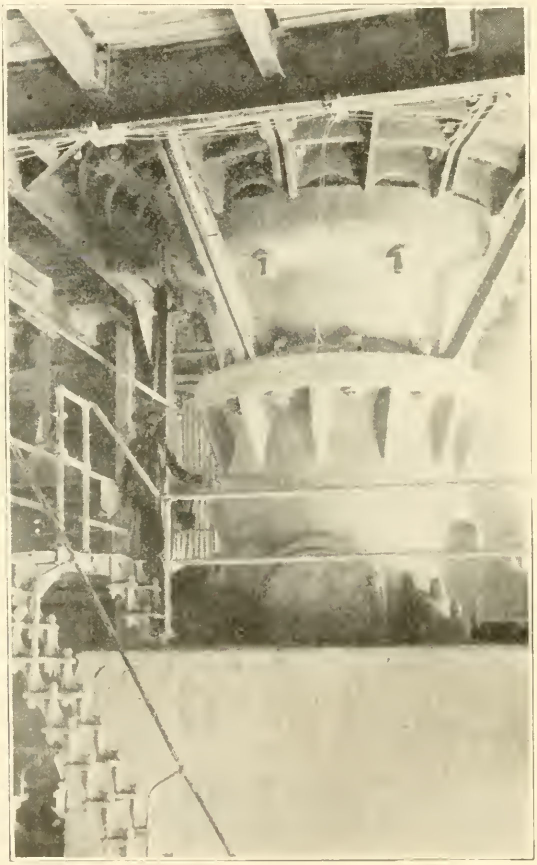
The advent of the rotary kiln was followed by rapid development of the portland cement industry and a corresponding decline in the natural cement industry. The Milwaukee district began to feel the effects of the change as early as 1905, and in 1909 the Milwaukee Cement Company ceased to manufacture natural cement.

Early Natural Cement Developments in Minnesota, Michigan and Illinois

Among the early natural cement centers was Mankato, Minnesota. Works were established there in 1883, and the locality has been identified with the industry since that time. Of the first Mankato plant, Cummings says that it was of stone and presented a fine and substantial appearance. He adds that the cement rock was of the very best quality, the manufactured product obtaining a strong foothold in the markets of the Northwest, where it was extensively used in municipal, railway and miscellaneous construction throughout several states. Cummings says that the mortar from this cement became exceedingly hard and stone-like in character, whether above or below water, and withstood to a remarkable degree the effect of alternate freezing and thawing. In 1901 the Mankato cement works had a capacity of 1,200 barrels per day.

Among the well-known manufacturers was Patrick Carney, who died some years ago. The Carney Cement Company is still operating at Mankato, with H. E. Carney, a son, as president.

It is said that an attempt to manufacture natural cement was made at Trowbridge Dam, on Thunder Bay River, seven miles northwest of



Rock crushers nowadays weigh as much as 450,000 pounds, or equal to the weight of three steel Pullman cars.

Alpena, Michigan, in 1866. Wood was used for fuel. Owing to the poor quality of the material the enterprise was not successful.

Some of the southern and western plants survived long after many in the east had been abandoned. For example, N. J. Cary, of Utica, Illinois, until recently actively interested in cement, wrote as follows on June 25, 1920:

> In 1838, the late Hon. James Clark, of Utica, La Salle County, Illinois, commenced the manufacture of hydraulic cement here, where it was used in the construction of the Illinois and Michigan Canal, and the works have been in continuous operation from that time to this. During this period they turned out many million barrels of cement, the most prosperous time in that industry being from 1880 to 1906. Of late years the industry has been almost entirely superseded by the portland cement industry. Utica cement is still manufactured here, however, although on a smaller scale. The Utica Hydraulic Cement Company succeeded Mr. Clark in the manufacture of cement in 1883, and still continues its manufacture.

While the greater part of this chapter relates to large and important natural cement regions and the use of the product in canals and large engineering works, successful manufacture on a small scale was sometimes undertaken to supply local demand for cement. Kensington, Connecticut, had a plant of this character, which manufactured for many years, and it was said the cement made there showed marked superiority in stucco work. Expensive land transportation prevented it from coming into competition with the Rosendale cements. The Kensington rock was discovered in 1826.

Uriah Cummings Traces History of Natural Cement Industry

In his book published in 1898 under the title of "American Cements," the late Uriah Cummings, long prominently identified with the cement industry, gives an exceedingly valuable and comprehensive history of the natural cement industry. The book contains much that would have been lost save for his indefatigable industry in collecting and publishing important facts. He relates many interesting incidents connected with the early production of natural cement in the United States. As an instance, he says that a clergyman, Rev. Charles W. Howard, of Charleston, South Carolina, discovered cement rock in 1850 in Cement, Georgia, and associated with him in an analysis of the rock was the distinguished chemist, St. Julien Ravenel, of Charleston, intimate friend of Professor Agassiz. Howard and his son manufactured cement until the breaking out of the Civil War. In 1867 Col. George H. Waring, of Savannah, Georgia, took over the plant, which operated as the Howard Hydraulic Cement Company. Concerning the quality of this cement, which was very superior, plaster made from it and applied by Dr. Ravenel to the exterior of his house on the Charleston Battery in 1852 remained unimpaired until long after the sandstone lintels of the windows had disintegrated. The plaster was still intact in 1898.

Of these old natural cements, Cummings says no other country in the world had cement rocks which compared favorably in any sense with those so well distributed throughout the United States.

In 1895 he contributed the chapter on natural cement appearing in the United States Geological Survey Report. Writing of European sources of supply he says:

> No experienced cement manufacturer in America would undertake to produce a rock cement from such a mixture of clays, shales, marls, nodules, limestones and cement stones. * * * * * Contrasting these materials with our own massive cement-rock deposits, we find that we have immense beds of cement rock, absolutely free from any extraneous substances, perfectly pure and clean, with layer upon layer extending thousands of feet without an appreciable variation in the proportion of ingredients. Cement-rock quarries are worked in this country decade after decade without the necessity of rejecting a pound of the material, and the analyses taken during successive years show no marked change whatever in the constituent parts. Had England and France possessed such cement-rock formations as are so well distributed throughout this country, it is extremely doubtful if the production of artificial cement would have been resorted to. Under such circumstances there would have been no occasion for it.

The following table gives the more important discoveries and uses of American natural cements in chronological order:

DISCOVERY AND EARLY USES OF NATURAL CEMENT IN THE UNITED STATES

YEAR	LOCALITY	CONSTRUCTION
1818	Fayetteville, N. Y.	Erie Canal
1824	Williamsville, N. Y.	Erie Canal
1826	Kensington, Conn.	Miscellaneous
1828	Rosendale, N. Y.	Delaware and Hudson Canal
1829	Louisville, Ky.	Louisville and Portland Canal
1831	Williamsport, Pa.	Muncy and Lock Haven (Pa.) Canal
1836	Cumberland, Md.	Miscellaneous
1837	Round Top, Md.	Chesapeake and Ohio Canal
1838	Utica, Ill.	Illinois and Michigan Canal
1839	Akron, N. Y.	Miscellaneous
1848	Balcony Falls, Va.	Miscellaneous
1850	Siegfried's Bridge, Pa.	Easton and Mauch Chunk Canal
1850	Cement, Ga.	Miscellaneous
1863	Vallejo, Calif.	Miscellaneous
1867	Fort Scott, Kans.	Miscellaneous
1869	La Salle, Ill.	Miscellaneous
1869	Howe's Cave, N. Y.	Miscellaneous
1874	Buffalo, N. Y.	Miscellaneous
1875	Milwaukee, Wis.	Miscellaneous
1881	Canon City, Colo.	Miscellaneous
1883	Mankato, Minn.	Miscellaneous

The consumption of some of the cements whose uses are designated in the above list as "miscellaneous" was very large, construction including many important engineering works other than canals.

The status of the several natural cement districts at the time maximum production was at hand is shown by the following table, published in 1898, at which time something like 100 works conducted by 70 different firms or companies were operating in 14 states. While the total in the production column differs slightly from that appearing in the large official table covering all cements, published elsewhere, it is sufficiently close to show that the figures are substantially correct.

PRODUCTION OF NATURAL ROCK CEMENT DISTRICTS IN 1898

District	Number Concerns	Barrels Produced	Per Cent of Total
Rosendale, Ulster County, New York	15	3,500,000	41.9
Louisville, Kentucky and Indiana	15	1,750,000	20.9
Lehigh Valley, Pennsylvania	6	750,000	8.97
Erie County, New York	4	550,000	6.59
Illinois	2	550,000	6.57
Milwaukee, Wisconsin	1	475,000	5.68
Maryland and West Virginia	5	275,000	3.28
Schoharie and Onondaga District, N. Y.	10	200,000	2.39
Kansas	2	140,000	1.68
Minnesota	2	85,000	1.02
Ohio	3	35,000	0.42
Virginia	3	20,000	0.24
Georgia	1	15,000	0.18
Texas	1	15,000	0.18
Total	70	8,360,000	100.00

Natural cement production in America from the time the rock was discovered by White in 1818, is given in the table on page 72 in conjunction with portland and puzzolan cements. For the figures on early production tribute is again due Uriah Cummings. For thirty years he worked assiduously in collecting, sifting and compiling data not then considered by the Government sufficiently important to record, and to him alone is the country indebted for the only reliable early natural cement statistics extant.

Mr. Cummings, who was born at Akron, New York, in 1833, subsequently removed to Stamford, Connecticut, where he died on November 11, 1910. At the time of his death he was president of the Cummings Cement Company of Akron. He was an authority on many questions relating to cement and concrete, and for years had charge of Government investigations relating thereto. He was a frequent contributor to technical magazines and other publications on scientific subjects, and the inventor of a great many successful mechanical devices. Aside from technical matter, he wrote tales, both historical and fanciful, dealing chiefly with the Indians of western New York, in whom he was greatly interested. His life represented a long period of industry and usefulness.

CHAPTER III

DISCOVERY OF PORTLAND CEMENT

England the Birthplace of Portland Cement

Portland cement originated in England. Before its discovery, extensive manufacture and use of natural cements prevailed in England. Many were attempting to improve these natural cements and numerous patents were granted. In an account of the development of the natural cement industry up to about 1818, 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, says:

> All experiments up to this period (1818) apparently aimed only at the obtainment of a resulting product from the kiln which should, in its leading characteristics, approach the quality of lime fresh burnt. Instead of driving the mixture to the point of vitrifaction, all operations were so conducted as to studiously avoid such a result, and when, by accident, this occurred, the pieces so hardened were carefully rejected as worthless.

Early Experiments of Aspdin

This avoidance of vitrifaction, as described by Reid, was getting away from portland cement. But in 1824 Joseph Aspdin, an English bricklayer who had been experimenting since 1811, took out a patent on an improved cement which he called portland cement because it resembled in color the Isle of Portland building stone. This was his second patent, the first covering specifications for "An Improvement in the Modes of Producing an Artificial Stone," which patent was practically the first scientific description of an artificial portland cement.

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 a portland cement, but he ultimately got it by burning his hard limestone at higher temperatures.

About 1845, there were two strong factions at work in England. On one side was John Bazley White, who was making Roman and Frost's Cements, the latter a lightly calcined artificial cement. On the other side was William Aspdin, son of Joseph Aspdin, making portland cement, who, after securing some financial backing, came down to the Thames district and used the soft clay and chalks found there for the manufacture of his product, and ultimately formed the firm of Robbins, Aspdin & Company.

Concerning preceding experiments and patents of others and the patent obtained by Aspdin, Reid writes as follows:

> While all these patentees and other experimenters in England, France and Germany were simply seeking, and indeed were apparently satisfied with an artificial hydraulic lime, Aspdin went beyond, and gave the grand finish to the whole by his discovery of the increased temperature of the kiln, and consequent high specific gravity of the cement, now no longer regarded as a simple hydraulic lime.

This would seem to prove that Aspdin was the first to discover portland cement, but further along Reid makes finer distinctions. He says it is difficult to attribute to any one of the numerous experimenters the credit of inventing portland cement, but adds:

> We find differences, however, in the value of the assistance rendered at the various stages of progress, and Aspdin, although the least distinguished of all of them persevered in bringing to our knowledge the importance and, indeed, necessity, of a high temperature in the kiln.

The story of the discovery of portland cement might be dismissed with the foregoing account were it not for the fact that discussion of the subject was revived in England and in this country in 1911, nearly a century after Aspdin obtained his patent. In June of that year, 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.

Dr. William Michaelis, Sr., in a review of the subject published in Tonindustrie Zeitung of March 24, 1905, gives great credit to Johnson as having "placed the child, so long weakly and helpless, on its feet," and says:

> The communications of this eye-witness (Johnson) and an exhaustive study of English technical literature, especially of that of the first half of the last century, have now led to the certainty that the contention that J. Aspdin was the discoverer of portland cement cannot be maintained.

Old newspapers, circulars, and advertisements reveal incidents relating to the early manufacture of portland cement in England that are full of human interest. The same jealous rivalries that marked the beginning of the industry in the United States prevailed in England, and concerning the Aspdins—Joseph, who invented a cement called portland in 1824, and his son, William, who also became a manufacturer—simple justice demands recording the fact that they kept their competitors guessing and on the jump. Even Isaac C. Johnson becomes a most entertaining witness in support of this statement. 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 engineer and author of "Calcareous Cements," from which the following extracts are taken:

Mr. Johnson states that about 1845 young Aspdin

—began work at Rotherhithe in connection with Messrs. Maude & 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.

Swinging hammers in the hammer mill batter the rock from the crushers into pieces small enough for the preliminary grinders. The impact sounds like machine-gun fire.

I was at this time (about 1845) manager of the works of Messrs. White, at Swanscombe, making only the 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 some 20 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 then 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 analyze it, but I 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 per cent 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. Johnson goes on to describe subsequent experiments which led to the production of a good portland cement.

Another interesting fact is that in 1851, when the first of the great expositions was held, there were shown samples of portland cement, and Pasley—who was the grandfather of all the ideas concerning hydraulic limes—for the first time knew that Aspdin had taken out a patent in 1824 on what he himself had written about in 1820.

Engineering records in England contain many accounts of experiments with natural and portland cements in the early fifties. The great controversy that had been going on between the exponents of these rival cements ended in a victory for portland cement. Natural cement was eventually driven to the wall and the portland cement business became a thriving industry in England.

Having presented impartially the recorded claims of those who aspired to the honor of having invented portland cement, it would be remiss not to refer more fully to John Smeaton, the first to rediscover the source of hydraulicity in limestone, and who, in this earlier field of endeavor, was the greatest figure of his time.

Dr. Michaelis' publication of 1869 says:

A century had elapsed since the celebrated Smeaton completed the building of the Edystone Lighthouse. Not only to sailors, but to the whole human race, is this lighthouse a token of useful work, a light in a dark night. In a scientific point of view it has illuminated the darkness of almost two thousand years. The errors which descended to us from the Romans, and which were even made by such an excellent author as Belidor, were dispersed. The Edystone Lighthouse is the foundation upon which our knowledge of hydraulic mortars has been erected, and it is the chief pillar of modern architecture. Smeaton freed us from the fetters of tradition by showing us that the purest and hardest limestone is not the best, at least for hydraulic purposes, and that the cause of hydraulicity must be sought for in the argillaceous admixture.

Contemporaneous with the early technical research of British engineers and cement manufacturers was advanced thought along other lines, which we, in this day, are likely to regard as altogether modern. As an illustration, there is found in Reid's book the following paragraph relating to workingmen:

> Before entering on the discussion of the various cement-making materials, we are desirous of calling attention to the desirability of inculcation in the minds of the operatives the advantage, if not the necessity, of acquiring something more than a simple external or surface knowledge of the materials passing through his hands, and in the conversion of which he plays so important a part. * * * * * Is it creditable in this age of intelligence that the operative cement maker while dealing with the simplest of minerals should exert only mechanically the aid required of him, and continue debarred by his ignorance from appreciating the nature of these materials and the original sources from which they are derived. * * * * * Hard work is made harder when pursued without interest. It is the wearisome, uncongenial task that ultimately breaks down the most elastic mind.

This philosophy, which has a thoroughly practical as well as an altruistic side, was proclaimed nearly half a century ago.

The chronology of important events leading up to the discovery and manufacture of portland cement is given by Reid as follows:

1756—John Smeaton, 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 the 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—Joseph Aspdin. Experiments revealed importance of high temperatures in kiln.

1826—Sir C. W. Pasley. Conducted many important experiments.

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

The manufacture of portland cement found its way to Belgium, where Edward Fewer, who had married a daughter of Joseph Aspdin, started its manufacture near Antwerp.

Other countries gradually took up its manufacture, the first plant in Germany being the Lossius & Dellbruck plant, established in 1855, near Stettin. France also started the production of portland cement, there being at Boulogne, one of the largest works in Europe.

The manufacture of portland cement in Europe grew rapidly. European producers began to find numerous new uses for their material in sidewalks, buildings, artistic construction, docks, etc.; and engineers, familiar with world problems, soon began to realize the enormous possibilities that the development of this new material for building construction possessed. Consequently, along in the early eighties, Europe began exporting portland cement to North and South America and to other parts of the world.

CHAPTER IV

IMPORTED PORTLAND CEMENT IN THE UNITED STATES

Influence of Post-Civil War on Growth of Portland Cement Industry

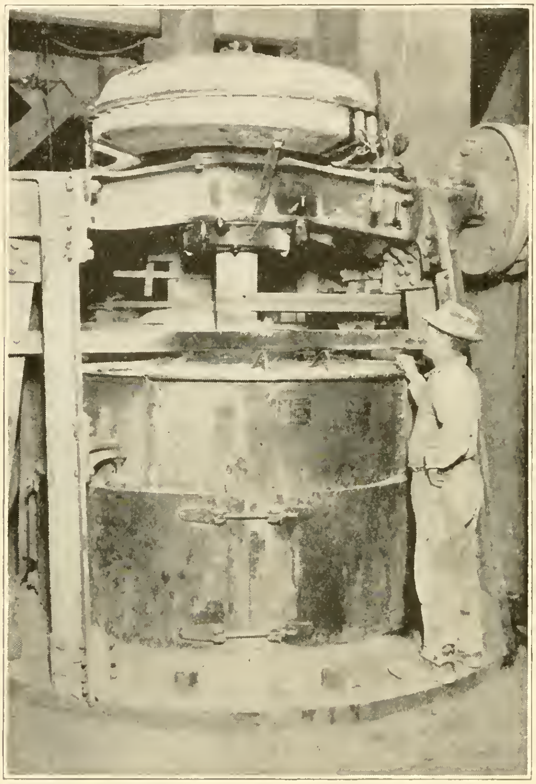
With the development of the United States after the Civil War, construction began to grow rapidly. The building of the great railroads to the Pacific had developed large territory and produced great wealth.

After the Jay Cooke panic of 1873, the country began to realize the financial benefits of reconstruction and of the commercial development that took place in the early eighties. It was but natural, therefore, that in the desire for more substantial buildings of greater height and larger foundations, in the desire for bigger and stronger bridges, in the wish for better and more permanent sidewalks and roads, and better work generally along artistic lines, that the engineer and the constructor should turn to the uses of portland cement in Europe, and that they should seek to obtain a wider use of it in this country.

There had been some importations of portland cement in the United States recorded as far back as 1868, but the quantity was insignificant and little was known of this then comparatively new cement and its manufacture. The interested student of the material in this country had at the time but a single book of reference in the English language, namely, the work of Henry Reid, published in London, in 1868. Engineers and builders were practically dependent for such information as could be had on portland cement upon papers of Grant on the London sewerage system, Bamber on various engineering work in England. Beyond this there was only an occasional paragraph in the technical press telling what could be done with portland cement.

As time went on, however, the reputation of portland cement abroad continued to increase through its growing use in the construction of docks, public works, miscellaneous buildings, sidewalks, etc. Through engineering publications and the practical knowledge of engineers acquired in Europe and who came to this country to engage in various engineering enterprises, the reputation and fame of portland cement spread among American engineers and builders.

Interest was further increased by the rapid development going on in the United States following the readjustment period after the Civil War. In the construction field this was marked by more pretentious buildings, which meant structures of greater height and therefore requiring larger foundations, intensive programs of city street improvement, which included street paving and sidewalks. The well-known paving contractors of the time, among whom were Filbert and Drehman of Philadelphia, the Stewart Granolithic Organization of New York, Cranford of Washington, D. C., and a large number of their followers, who had begun to build concrete sidewalks, demanded portland cement for the purpose, because of the reputation which it had already gained as a superior product. There was also a large demand from Germany, where it was used for concrete floors in breweries.



The centrifugal type of grinding mill uses great swinging rollers, rotating rapidly, to crush the material between them and the outer die.

In 1878 importations of portland cement totaled 92,000 barrels. From this they grew to 106,000 in 1879, to 187,000 in 1880, and by 1885 to 554,000 barrels. In 1888, which marked the end of a ten-year period, importations were 1,835,504 barrels.

Importations of Portland Cement Often Came as Ballast

With these figures in mind, it is a matter of considerable interest in connection with the history of the American portland cement industry to describe the methods by which this large importation was handled. In those early years the usual cargo ship was a wooden sailing vessel. Barques or full rigged ships were generally employed. These had no auxiliary power, and when sailing without regular cargo required ballast of sand, stone or other material to stabilize the ship. These vessels differed entirely from the liners which carried expensive cargoes from Europe, and which, being constructed of steel or iron, had compartments that were filled with water ballast when necessary and discharged when taking on cargo. The vessels in the cement-carrying trade were of the type known as tramp cargo ships. In most cases they came to the United States to get export cargoes of grain or cotton. Such cargoes paid high revenue. Instead of non-paying ballast (as there was little inbound paying cargo to this country) they took on cement or other heavy material. The result was that freight from European ports to this country on cement was very low. In some cases the American consignee was not only able to get his cement brought across the Atlantic free of charge but was actually paid by the ship as high as ten cents a barrel for the unloading of it. This occurred at times when the outgoing grain paid such good rates that the tramp ship, in order to take advantage of the market, was obliged to get the cargo she had carried over discharged rapidly, even if necessary to pay for unloading.

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 material 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 shipments to arrive, and when an excess of material would reach the harbor on several vessels at the same time, they had to go on the building material exchange and find customers who would take it off their hands at the earliest possible moment. The business was uncertain as to possible profit and sometimes entailed considerable loss.

Among the Early Importers

In the early days James Brand, a keen Scotchman, was the importer of the best English brands, such as "Knight," "Bevan & Sturge," "Burham" and other cements of high reputation. Brand was straightforward in his dealings and rigid in his ideals of business methods. His office was a model of old-time business methods, accuracy, promptness and care.

He dealt not only in portland cement, but was also an importer of hatters' furs, asphalt, and other commodities. In later years, he became one of the original stockholders in the American Cement Company, at Egypt, Pennsylvania.

Another large importer was Howard Fleming, who handled the "J. B. White" brand, and later several German cements. Buoyant, joyous, hopeful, Fleming was always a welcome visitor and had a large following among buyers.

Sinclair & Babson was another firm of importers. Robert S. Sinclair of this firm was a graduate of Mr. Brand's office, where he had charge of the cement importing department. This firm represented for many years the great Alsen Company of Germany. Its trading extended all over the United States, as its cement was high in favor of leading engineers. Later, when the Alsen Company decided to build an American plant on the Hudson River, near Catskill, New York, Mr. Sinclair was associated with the company in its management. At this writing he is president of the Park Commission of Newark, and has contributed the following interesting narration:

My acquaintance with portland cement began in 1871, but previous to that time the firm of Hammill & Gillespie, 240 Front Street, New York, had been importing portland 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 & 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 Asiana 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 about 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 try to get rid of the cement. When I found that I was expected to get $6 per barrel in competition with Rosendale cement selling at about $2, 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 soon 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 purchases, until finally the entire 500 barrels were sold, one sale I remember being to W. T. Klots & Brother, 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 S. L. Merchant & 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 5 per cent commission. The brands imported were "J. B. White & Brothers," and "Burham," made by The Burham Brick, Lime & Cement Company.

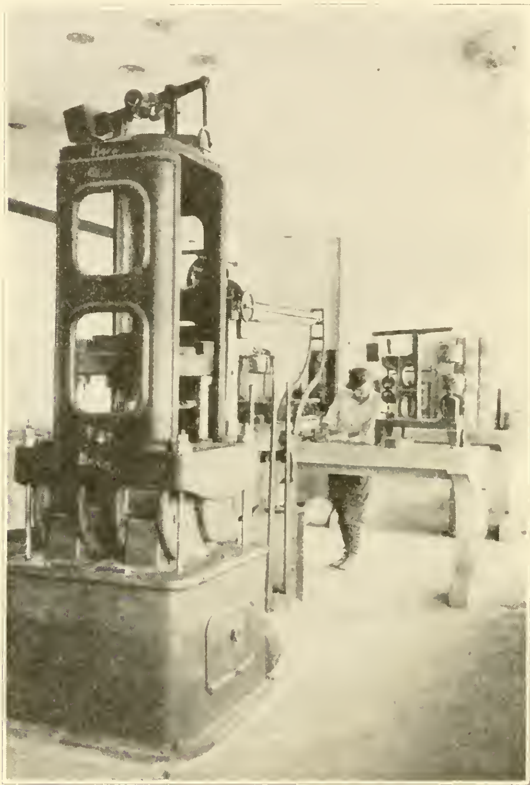
John J. Schillinger at about the same time obtained a patent for a cement sidewalk made with an expansion joint, and learning of the Dock Department's arrangement with James Brand, he also arranged with Brand to import cement for him on a commission basis. Early in 1873, being dissatisfied with S. L. 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 engaged me to manage that department of his business. We imported "J. B. White & Brothers," "Burnham" and "K. B. & S." (Knight, Bevan & Sturge). The business grew rapidly and was 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 per cent should pass through a sieve having 2,500 meshes to the square inch. Captain W. W. Maclay, Assistant Engineer, supervised the tests made by the Department, and he probably did more than any one individual in those early years to raise the standard 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 25 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 3,000 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 statement 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.



Interior of a cement plant physical laboratory. Men are at work here, night and day, testing samples of the raw materials and the finished product.

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 26, 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.

Emile Thiele, a tall, slim, military type of German, controlled the importation of the well-known Dyckerhoff and other German brands, the Hilton English brand, and several Belgian cements. Thiele's office, as well as Mr. Thiele himself, conveyed the impression of German military discipline and accuracy. Dependable, systematic, careful marketing was evident to every visitor, and Thiele had representatives devoted to him personally in all the large cities of the country. Today he is living in New York the life of the successful retired business man.

Batjer & Meyerstein also had a large business, as did Charles J. Stevens, who represented the Brooks-Shoobridge English cement.

A very important figure in the importing business, though possibly he might better be classed as an exporter, was Charles Zunz, whose headquarters were in Brussels. He was a merchant prince with trade all over the world, dealing in cement, steel, plate glass and other Belgian products, and importing into his own country grain, oils and other materials from the United States and South America. His dealings were marked by unfailing courtesy and high sense of business honor. He was characterized by his broad view as a merchant, his willingness to take a loss, and his desire, in every case, to protect his customers and deal fairly with them. Of him Charles Weiler, of the Western Lime & Cement Company, Milwaukee, writes as follows:

> He was an ideal salesman, speaking a very precise English, and neither eager nor argumentative over portland cement problems, so that I found it a pleasure to deal with him. I at once called upon him and found, for the first time, that he was a very important plate glass manufacturer, having a large office with about fifty or sixty clerks, every one of them able to speak three or more languages. Mr. Zunz represented cement only as a small side issue, and this evidently accounted for his indifferent attitude in trying to make cement sales in America. After a pleasant hour's talk he volunteered to show me the beautiful Parliament Building opposite the King's Palace, across the park, explaining that Parliament was not in session, and, as a stranger, I would be denied admission. I noticed that the armed guards bowed deferentially to Mr. Zunz as he piloted me through halls and splendid rooms; but the reason was not evident until we entered the small and richly beautiful Senate Chamber—equivalent to the House of Lords in London, as it was reserved for the titled nobility. Then he stopped in front of a conspicuous blue-velvet arm-chair, and quietly said: "This is my seat." I glanced at the polished plate on the chair arm and saw that it read "Le Baron Charles Zunz." At the hotel later I learned that he was one of the wealthiest men in Belgium and a Peer of the Realm. He was also a kindly, pleasant, democratic, plain citizen, and an honor to the Portland Cement Industry.

An interesting recollection of many years' dealing with all of these importers is how much they were governed in their methods by the manners and customs of European business men. In many cases the letters that went out of their office were hand-written by the principals, being copied in old-fashioned letter books. The typewriter had great difficulty in finding its way into the offices of these great importing concerns. The efficiency engineer would have had the door shut in his face, but the efficiency was there without the interposition of the engineer. All their work was done with accuracy and dispatch, and an unfailing sense of responsibility seemed to permeate the atmosphere of their offices, while courtesy in conversation and willingness to assist the customer were marked characteristics of all business houses of that "old school."

Of later growth was the firm of Dickinson Brothers & King, composed of William and John Dickinson, of Chicago, and Jerome A. King, the latter trained in James Brand's office. This firm, of whom some are still engaged in the manufacture of portland cement and plaster in this country, was an active business concern for many years, and marked the combining of the importing interests in the two great centers of cement distribution, namely, New York and Chicago. William Dickinson's cheery greetings, his friendliness and business acumen made friends for him everywhere; while King, with his long apprenticeship in importation, was most successful at his end of the line.

William Dickinson was actively interested in the sale of the first portland cement used in the Middle West. His story follows and is most interesting with respect to other facts:

In 1873 I was working for the Empire Warehouse Company on Market Street, Chicago, doing a general warehousing business and also acting as agents of a line of steamboats plying between Montreal and Chicago.

In the summer of that year the Montreal managers of the steamboat line running weekly between Montreal and Chicago, for which we were the Chicago agents, advised us that the boat leaving there being light of cargo, they had purchased for the account of the steamer 250 barrels of portland cement which they wanted us to sell on arrival. There had never been any portland cement in the West up to that date. After canvassing the situation, we were unable to get anybody to purchase it. Later on we called on John V. Farwell, of John V. Farwell Company, wholesale dry goods, and he stated that he had just returned from England where he had seen portland cement used in large quantities and knew all about it. As he intended soon to erect a building in which he would like to use some cement, he was very glad to purchase it. This was the first cement used in the Middle West. Subsequent shipments were received and met with incre asing demand. The first sale in a country town was to John Allen, of Rockford, Illinois. He purchased it on the guarantee that a sidewalk laid with it in September would be in good condition in the following spring. If so, then to be paid for. Allen did a good piece of work, the sidewalk was a success, and led to other sales in that city.

Thus, with a very small beginning, trade gained rapidly year by year. The concrete conduits for cable car lines in the large cities began to consume thousands of barrels in their construction, and there were dealers in various parts of the West who gradually began to purchase portland cement of us. Notable among them were Cutler & Gilbert, Duluth; L. J. Pettit, Milwaukee; Saunders & Matthews, St. Paul; Thorne & Hunkins, St. Louis; C. A. Brockett, Kansas City; the Sunderland Brothers, Omaha; McPhee & McGinnity, and Hallock & Howard, of Denver.

In 1890 to 1892, importations of foreign cement into the United States had reached a maximum of about 3,000,000 barrels a year. The arrangements for importations of cement were the same as in many other articles. The freight room had to be engaged at the beginning of the year for monthly shipments of given quantities through the year, and cement purchased to fill the space was contracted for at the same time. This made the business quite complicated as supplies had to arrive at regular intervals in order to make the business anything like permanent. All contracts had to be based upon the regular delivery of the material, and thus the non-arrival of ships at stated periods caused great difficulty in keeping contracts supplied.

Inland Transportation Had Its Difficulties

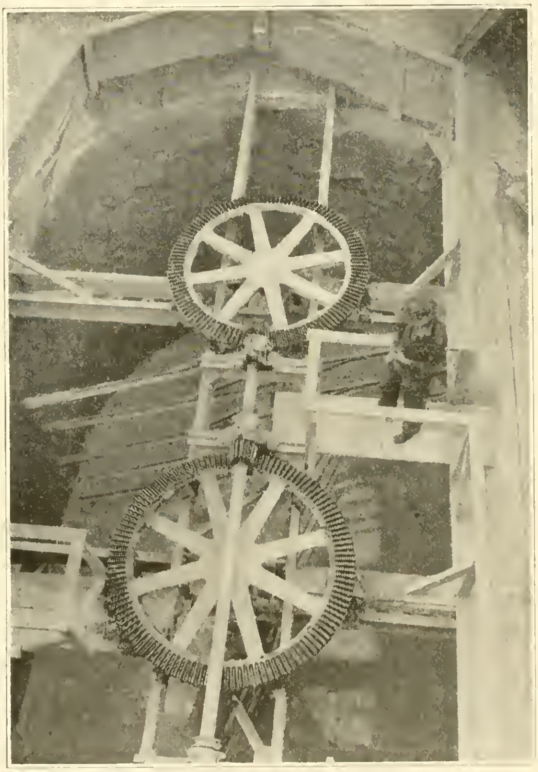
Cement, as is well known, is a heavy article, and as it was sold at reasonably low figures it can readily be understood that in those early days the transportation of portland cement cargoes to the various points throughout the country was a serious matter. Railroad rates from the coast to the Ohio and Mississippi Rivers and the Central West were high and the object of the importer was to get his cement into New York in the summer season so that he would be able to avail himself of canal transportation to western markets at low rates. This necessitated the closest management in directing imports, and the greatest cooperation between the importer and the canal and lake lines of transportation. Railroad wars were also prone to exist prior to the days of "gentlemen's agreements" and Interstate Commerce control. It was a well-known fact that many railroads, in order to get this heavy body of freight, would cut rates and make figures based upon through transportation across the Atlantic, in order to secure an advantage over competing railroads. Salesmen representing the importers would go through the central and far West offering their materials "to arrive" to the large jobbers and distributors of cement in the great cities.

Salesmanship of this type was a friendly relation. The salesman would sometimes spend several days with his prospective customer in order to effect a sale and the bonds formed between the importer and his distributor were difficult to disturb and were usually lasting. Facilities had to be provided with these great distributors to take up large stocks of cement which might come in at untimely periods, and which had to be stored and carried. These were in some cases necessary at the lake steamship terminals. Banking facilities had to be provided to finance the importers and pay the freight on materials casually arriving from time to time in sailing vessels. The whole business was one requiring concentrated personal attention. It also established close friendships between importers and distributors, and led to the upbuilding of an enviable reputation all over the country for various brands of foreign portland cement. Such a reputation with successful merchandising, accompanied by the conservatism of the great engineers, built up for the high-grade English, Belgian, German and French cements, proved most difficult to assail when the manufacture of portland cement began in the United States.

The first use of this foreign material, as already stated, was largely in sidewalks, a new use in this country, but one in which bad material would rapidly show itself, whereas good material not only added to the attractiveness of the work but made permanent the improvement under way.

Superior Merit of Portland Cement Begins to Attract Attention

Specifications for massive foundations for important bridges and buildings began to call for portland cement. Construction in winter, where portland cement stood the hardships of weather better than natural cement, was another field where engineers demanded the foreign article. In all construction the reputation of the engineer was at stake in the use of this higher-priced material, especially in cases of greater risk.



In "wet process" plants, water is added at the time of the first grinding operation. When this mixture, or "slurry," is fed to the kilns, it has the consistency of thick soup.

Owing to the difficulty of overcoming the early preference for foreign portland cement, the first manufacturers of the domestic product learned to look upon the United States as a large importer of cement and the market almost exclusively confined to the foreign brands.

This production of the late eighties was running somewhere about 100,000 barrels a year. The fact that Johnson & Wilson, who were selling Saylor's Cement and were clever merchants in their difficult field, and Lesley & Trinkle, who were first distributors of Saylor's Cement in Philadelphia, and later general agents for Giant Cement, had a hard time to make an impression upon the market, disclosed a situation practically controlled by the foreign cements.

There was a Builders' Exchange in New York where the dealers from New York and the adjacent territory assembled daily. In this market the representatives of the American cements just mentioned had to fight their way to get orders. New York was essentially a market for the foreign portland because it was there with the minimum of freight; but in western markets the American product began slowly to make its way because of slight advantages in price. New York was in most cases a closed book, so much so that Robert W. Lesley, in seeking to bring his American cement in competition with the successful importers who met him on the Exchange, soon acquired the title of "Crazy Lesley" by which name he passed on the Exchange until in later days the "arrival" of the American Portland Cement Industry enabled him to remove the adjective from his name.

To sum up the history of the importations, and the difficulties connected therewith, Mr. Weiler, previously mentioned, said:

> 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 customs 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 cement now are insignificant compared to the tough old days that we have all outlived!
>
> All hail! American portland cements! All brands, all mills, everywhere, in the best country on earth!

CHAPTER V

THE PORTLAND CEMENT INDUSTRY IN THE UNITED STATES

How the reputation of portland cement in Europe was first established through its use by the London Sewerage Department reached and impressed America, was described in the preceding chapter. As far back as 1865 portland cement was imported into this country and was used in a limited way for sidewalks and for the more difficult types of engineering work. Imports were small and there being but little knowledge of it, prices were high and the business limited. Rapidly, however, attention was called to the material by the steady growth of imports and its general adaptability to American engineering requirements. American ingenuity, always ready to seek new outlets for its labor and capital, naturally soon began studying the manufacture of portland cement.

Pioneers in the Portland Cement Industry in the United States

The history of an industry very properly begins with some account of its founder or founders. In the compilation of data covering the portland cement industry in the United States, the author finds himself somewhat in the position of the historians of the British industry who essayed to determine the identity of the man who first manufactured portland cement.

Among the pioneer manufacturers of portland cement in this country were David O. Saylor, Allentown, Pennsylvania; Thomas Millen, South Bend, Indiana, and John K. Shinn, Wampum, Pennsylvania.

David O. Saylor the First Successful Manufacturer

In the chapter on natural cements, a description was given of the early development of the natural cement industry in the Lehigh Valley, and of the men who had to do therewith. Of these David O. Saylor was referred to as a leader. In dealing with the pioneers of the portland cement industry in the United States, Saylor again becomes prominent as the first and foremost in this field. 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 Rehrig and Woolever, 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."

Saylor's Early Experimentation

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 experiments 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 vitrifaction 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 other parts of the United States. They were, as stated, low in magnesia and iron content and in some of the layers did nearly approach the composition of the English and German portland cements in the condition in which the "slurry," or raw mix, was put into the kilns for calcination.

The first results of the work in the field mentioned justified Saylor's expectations. The rock did clinker, the burned product did resemble 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:

Saylor's Patent

UNITED STATES PATENT OFFICE

David O. Saylor, of Allentown, Pennsylvania.

Improvement in the Manufacture of Cement.

Specification forming part of Letters Patent No. 119,413, 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, silica, alumina, 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 vitrifaction, 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 stage 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 thus 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:

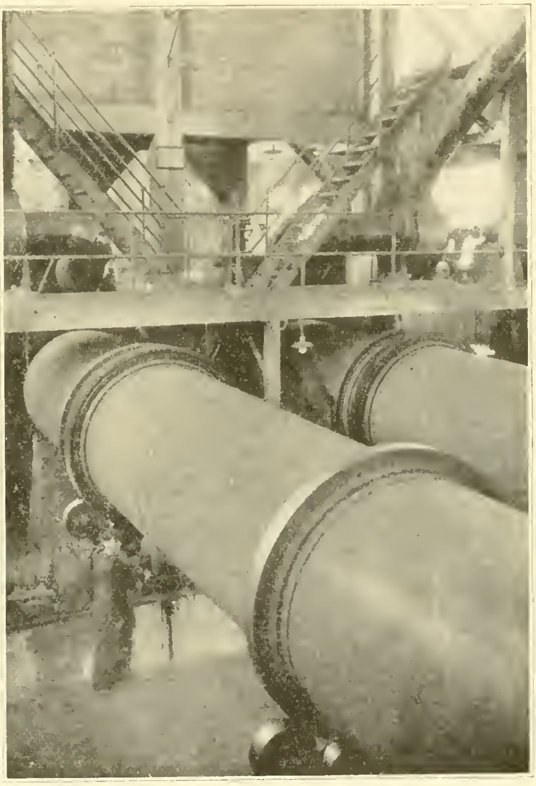
Edwin Albright

Augustus Weber

It will be noted that in one paragraph he 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 certainly was a progressive and far-reaching step in the pioneer days of the American portland cement industry. Saylor, full of vigor and energy, was constantly at the mill, always seeking to make more cement and cement of better quality. He manufactured a large quantity of his new product, but suddenly found that he was doomed to disappointment, for the material, owing to irregularities in the laminae of the rock, was not homogeneous and at long periods the briquettes, pats and works made with the cement all began to fail and disintegrate. At that time he had a large stock of this cement in his bins and was driven to his wits ends to know what to do with it. He put his brains to work, 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 England, following the type then in use on the Medway and Thames, burned the brick therein to clinker, and actually made portland cement.

Pennsylvania Geological Survey Investigates Lehigh District Cement Making Materials

At about that time the Pennsylvania Geological Survey had made a number of examinations into the limestones of the Lehigh District to determine their quality for use in iron making in connection with the rich hematite iron ore of the Ironton region, just back of the Lehigh River at Hokendanqua and Coplay. While the geological surveys were made by the engineer of the state, the analyses were made at Lehigh University by John W. Eckert, then a student at that college. Immediately after his graduation Mr. Eckert was selected by Mr. Saylor as his chemist and assistant in the operating of the Coplay Cement Company. Eckert, a typical Lehigh County youngster, full of resources and ability, was a most valuable assistant to Saylor in his work, furnishing the technical knowledge that Saylor's manufacturing experience required. He had also marked executive ability. It is believed that his employment as a chemist was the first step in scientific progress in the portland cement industry in the United States. After Eckert entered the employ of the company he came to look at the bins of damaged cement which Saylor then had on hand. Taking lumps of the material, which had by this time hardened in the bins, he suggested that the material, originally in the form of powder and now homogeneous and uniform, could, by burning it a second time to clinker, be ground and made available. The result was that the entire contents of the bins were ground and burned in the way suggested, with excellent portland cement as the result.



In "dry process" plants, moisture in the raw material is evaporated in rotary dryers.

The combined efforts of these two men were very important to the industry in its early days, as the chemical knowledge of Eckert threw new light upon the material in the quarry and enabled the composition to be kept regular and uniform, with the result that the manufactured product was portland cement of the best quality.

In the sale of the Coplay Company cements, Saylor had associated with him the firm of Johnson & Wilson, of New York, who have already been mentioned, and who made successful progress in the introduction of American portland cement. Saylor was also associated with the firm of Lesley & Trinkle, of Philadelphia, of which Robert W. Lesley was a member, and which likewise was most energetic in the development and sale of the natural and portland cements made by the Coplay Company. John W. Trinkle of this firm was popular with all the large contractors and a most successful salesman.

Growth of Saylor's Cement Business

Under the name of "Saylor's Portland Cement" the material described by the foregoing patent found a sale all over the United States on engineering work of the largest kind, and received an award at the Centennial Exhibition, in Philadelphia in 1876. In December of the same year General Gillmore, then of the U. S. Engineer's Office, New York, recommended Saylor's portland cement as entirely trustworthy, and in 1878 the government specified it for the Eads jetties at the mouth of the Mississippi. Some years after the jetties were completed Major Eads spoke of it as portland cement of the best quality.

Through the firm of Lesley & Trinkle, which in 1874 began the shipment of natural cement in bulk to tidewater from the Cumberland cement works, the Coplay Cement Company was induced to do the same thing with its natural and portland cements; and for many years both Johnson & Wilson and Lesley & Trinkle had large packing houses in Jersey City and Philadelphia respectively, to which the cement was brought in bulk from the mills and there repacked in second-hand barrels which had come from the Rosendale and other mills shipping by water and which, therefore, had no means of getting the barrels back. These barrels, then a waste product, were bought up at low prices, and in times of shortage were supplemented by second-hand barrels from other sources available in the two cities.

The Coplay Cement Company was a close and compact organization composed of Saylor, Rehrig and Woolever, the owners, with Balliet, formerly a cashier in a bank in Allentown, as treasurer, and Eckert as superintendent. With the two firms of sales agents, they were quick to realize the importance of the industry that had been started, and for a number of years conducted without much competition a very successful and prosperous business, which played an important part in the development of the industry in this country.

Thus early records appear to substantiate the claim that Saylor was the first American manufacturer to patent and produce on a commercial scale a product corresponding to the imported portland cement.

How Millen Began

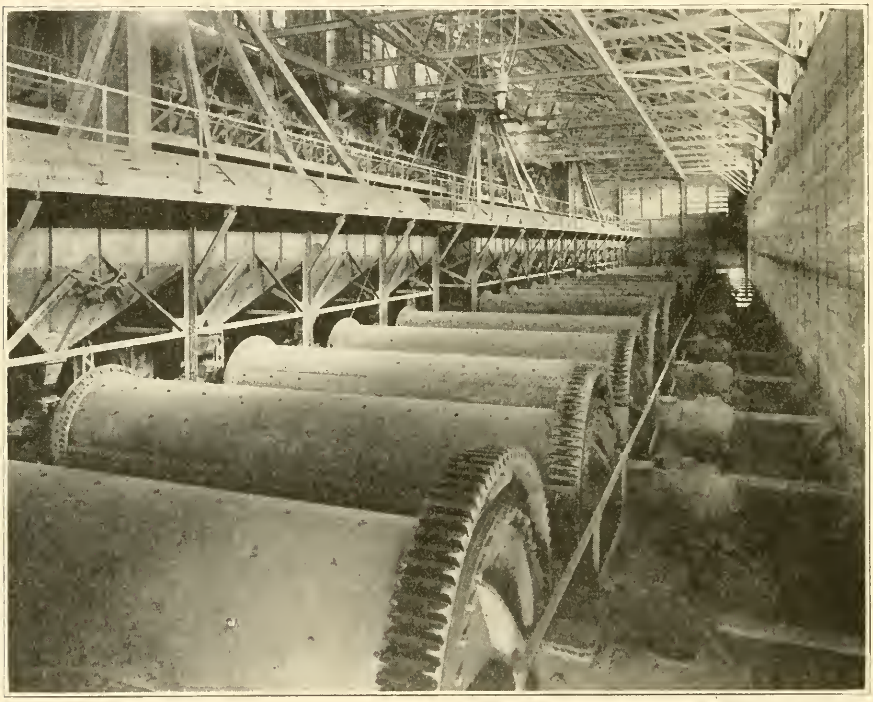
In 1871, Thomas Millen and his two sons were engaged in the manufacture of cement sewer pipe, artificial stone, sidewalks, etc., at South Bend, Indiana. How they became interested in portland cement was the subject of an entertaining after-dinner address delivered by Duane Millen, one of the sons, at a meeting of the Portland Cement Association in Atlantic City in 1906.

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 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 continuously 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 12 feet high by 4 feet in diameter. They continued building kilns each year until they had four, each 24 by 6 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.

In 1886, Duane Millen built works at Warner, New York, later known as the Empire Portland Cement Works, which was operated in conjunction with the old South Bend plant. In 1891, the Millens sold both plants and two years later engaged in manufacture at Wayland, New York.

Thomas Millen, who was born at Camillus, New York, died at his home in Syracuse on January 27, 1907, aged 75 years. Prior to going to



A battery of rotating steel cylinders loaded with steel balls do much of the fine grinding in modern cement plants. These grinders have superseded the millstones used in the early days.

South Bend, Indiana, where he began the manufacture of portland cement as described, Mr. Millen was a member of the firm of M. G. Field & Company, which conducted a stone and sewer pipe plant in Syracuse.

The ruins of the old Millen kilns as they appear on page 9 show the primitive character of these initial undertakings when compared with the modern cement plant. Their crumbling walls with grass-grown approaches have passed into the realm of things historic, but insofar as the requirements of that early period were concerned, they were quite as important as the cement mill of today.

The Work of John K. Shinn

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.

Before the manufacture of portland cement began at Wampum, the Wampum Mining & Manufacturing Company was in operation there. John K. Shinn was secretary and treasurer of the company, which was succeeded by the National Cement Company and later by the Crescent Portland Cement Company. After years of experiment, Mr. Shinn began, in 1874, to manufacture portland cement, but without entire success. Sometimes a good product would be produced and at other times failure would result. He advertised for an experienced cement maker and finally employed William Pucall, of Cincinnati. Mr. Pucall worked earnestly, putting in days and nights at a stretch. He erected a kiln, or furnace, with which he 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. Associated with Mr. Shinn at the time were W. P. Shinn, president of the company, and Joseph Shinn, superintendent.

In the beginning many difficulties were encountered and the methods employed were very primitive. For example, in the reduction of clinker a groove conforming to the outline of a box was cut in a flat rock and into this was fitted the box in which the burnt clinker was placed and pounded, or pulverized. This was done by means of a heavy car axle with the end stove up, the axle suspended from a spring pole such as is used in drilling small wells. This crude process preceded the use of modern mills. Having no apparatus for crushing or grinding limestone, a carload of material would be sent to Leetonia, Ohio, where it would be crushed and sent back to Newport, near Wampum, and taken to a sawmill in which the owner had rigged up a set of chopping buhrs. The limestone was run through these buhrs and ground as fine as possible, and then brought down to Wampum.

Under Mr. Shinn's plans, Mr. Pucall built a square kiln of fire brick, six or seven feet outside measurement and about eight feet high, the walls about a foot thick. The chimney was at one side of the top and a firebox was placed at the bottom of the kiln. The lime was mixed in certain proportions with a blue clay found nearby. The clay and limestone, finely ground, were mixed together wet. This mixture was shaped in fire brick molds, the material being taken to a brick yard for that purpose, where the bricks were dried on a hot floor. They were then brought back and placed in the kiln with alternate layers of coke, and burned. After burning, the brick were shipped to Cunningham's foundry in Newcastle, Pennsylvania, where they were ground on a set of buhr stones.

On November 1, 1878, Mr. Shinn, whose residence was given as Newcastle, Lawrence County, Pennsylvania, took out a patent on an improved method of burning lime and cement by means of a mechanical device designed to inject a forced draft into the lower part of the kiln. In the first or burning stage, combustion was promoted thereby and later cooling of the kiln contents expedited.

The Old Alamo Works

Texas was among the pioneer states in portland cement manufacture, the first plant established there being the Alamo Portland and Roman Cement

Original kilns used by the Alamo Cement Company, San Antonio, Texas, now a Mexican Village in Brackenridge Park in that city.

Company's works at San Antonio. The following interesting history of this company was contributed by C. Baumberger, president of the San Antonio Portland Cement Company:

In 1879 William Loyd, an Englishman who had had some experience in cement making in his native country, was hunting in the northern limits of San Antonio when he came across the rock quarries belonging to the city. There he found a blue argillaceous limestone which he believed was cement rock. At the suggestion of W. C. Peters, engineer, and one of the proprietors of the Alamo Ice Company, a specimen of the rock was submitted to George H. Kalteyer, who had been an assistant in the laboratory of Dr. Frisenius, of Wiesbaden, Germany, the latter having been employed in the late sixties to investigate cements for the German government. Mr. Kalteyer made an analysis of the rock and pronounced it natural cement rock, containing about the correct proportions of lime and clay to make a true portland cement. Thereupon Mr. Loyd and W. R. Freeman, a hydraulic engineer and designer of several waterworks in Texas, conducted experiments in the way of burning. With the financial and technical assistance of Mr. Kalteyer they organized a company for the manufacture of hydraulic cements, and on January 15, 1880, the Alamo Portland and Roman Cement Company was incorporated. The capital stock of the company was only $3,100, divided into 124 shares with par value of $25 per share. The city was forbidden by its charter to sell the quarries, so the company leased them for a period of five years. The original incor-

A municipal sunken garden and Japanese lily pond in Brackenridge Park, San Antonio, Texas, originally a quarry attached to a cement plant. From this quarry, in 1879, the first material was taken and manufactured into portland cement in this district. Note the chimney of the Schoefer kiln in the left background.

porators were William Loyd, George H. Kalteyer, B. J. Mauermann, F. V. Weise, and W. E. Jones; Messrs. Kalteyer, Mauermann and Loyd being elected president, secretary and superintendent, respectively.

The mill was a timber affair and quite small. The equipment consisted of a small Blake jaw crusher, a pair of rolls and a vertical French buhr mill. A small slide-valve engine, whose fly-wheel had wooden spokes and a rim of cast iron, furnished the power. The plant had a capacity of about ten barrels per day, the company endeavoring to follow European practice by grinding to a fineness of 5 per cent residue on a No. 50 cloth. All the cement was bolted and the rejection from the bolt sent back to the buhr mill. Fuel was hauled to the mill and the finished product hauled back to the city, the plant being three miles from the nearest railroad. The mill was a three-story affair. Seasoning took place on the two upper floors, where the cement was spread in layers of six to nine inches. It was then stored in wooden bins on the first floor. Tests for soundness were pretty much as in this day, but nothing was known about the boiling test, the cold water test being used to determine soundness. The result was an occasional shipment of "green cement." The mill was adjacent to the county poor house and the promoters of the enterprise were encouraged by their friends with the suggestion that when they got through they "wouldn't have far to go."

Burning consisted of the customary practice of that day, namely, alternate layers of fuel and rock, coke being used as fuel. It required about a week to burn a kiln, production amounting to about 120 barrels of cement. The product was hand-picked. That portion which had clinkered was classed as portland cement and the balance was used for making natural cement, called Roman cement. Lime burning and the sale of building stone aided the company to a precarious existence. The business expanded, however, and at the close of 1881 extensions were made and another kiln was installed. The capital stock was increased to $10,000 and the company charter amended to read Alamo Cement Company. When sales finally reached about a thousand barrels per year enthusiasm supplanted anxiety, the company feeling that it was among the largest cement producers of the world. For Roman cement the company received about $18 per ton, and $22.50 per ton for portland cement in bulk. The cement was packed in the "Stark A Seamless" cotton bags, for which an extra charge of twenty cents each was made, and in billing the cement the following printed slip was attached:

Sacks—Sacks containing cement will be charged for at . . . . cents each, but if returned in good order inside of . . . . days from date of invoice, at our office or works, free of expense, we will refund four-fifths of the price charged.

Alamo Cement Co.

The kilns used for burning cement were also used for burning lime. Cement burning was an occasional operation, the sale of lime and building stone being the chief business of the company.

It was difficult to introduce the new product, and in self-defense the company went into sidewalk construction to show the utility of cement for this purpose. Newly-laid walks would be covered with planks, ostensibly for purposes of protection, which enabled the company to make secret inspections to determine the stability of their product. A proud day in the history of the company marked the receipt of a high testimonial from General Q. A. Gillmore concerning the good quality of Alamo cement. Matters progressed, and in 1889 the facilities of the plant were materially increased. Eventually a rotary kiln was purchased, powdered coal being used for fuel. In 1901, when oil was discovered in Texas, it was substituted for coal as fuel. By 1908 demand for cement had so increased that the old mill was inadequate to meet the situation, and finally the company was incorporated as the San Antonio Portland Cement Company, and erected a new plant of much larger capacity.

Mr. Kalteyer, who was so prominently identified with the early history of the company, was taken ill during a visit to Europe, and upon his return died under an operation, in Philadelphia, on August 4, 1897. Plans for improvements acquired by him while abroad were carried out by Mr. Baumberger.

Mr. Baumberger entered the employ of the original company in 1880 as a bookkeeper, subsequently becoming manager, secretary, and, in 1897, president of the company.

The original quarries and factory site of the old Alamo Company have been converted by the city into public gardens, which now constitute one of the chief attractions of San Antonio.

In these days of restricted hours of labor and time-and-over-time perquisites, it is interesting in the way of personal reminiscence to state that Mr. Baumberger received as bookkeeper of the company a salary of $10 per month. The office of the company was in a drug store, from the proprietors of which he received the additional munificent compensation of $30 a month for keeping books. He also made collections and handled the cash, frequently covering afoot the three miles between the office and mill.

American Cement Company Among the Pioneers

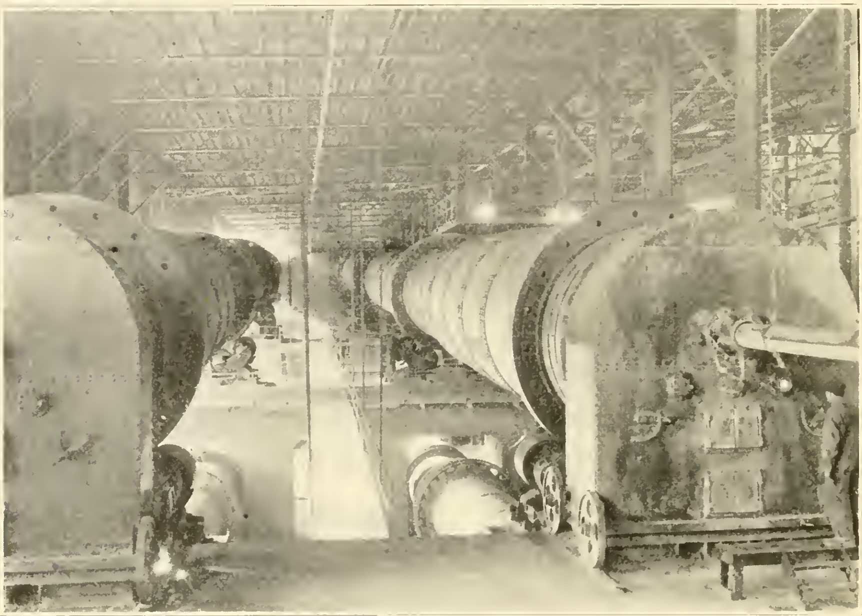
Another pioneer Eastern plant was that of the American Improved Cements Company, later on the American Cement Company, with works at Egypt, Pennsylvania. Robert W. Lesley was one of the founders of this company. The story of his initiation into the mysteries of cement manufacture and the subsequent development of his company is told in his own words:

In 1874 John W. Trinkle and I were clerks in the advertising office of the Philadelphia Public Ledger. Among my duties was the collection of accounts from the stationers who sold the paper to their customers, and in that way I became quite familiar with "Stratena" and similar cements used for sticking together porcelain, wood, and like materials.

In the summer of that year my mother, Mrs. James Lesley, was visiting her brother, Dr. Thomson, near Cumberland, Maryland. She wrote me from there that my uncle had financial interests at stake in a Cumberland cement works threatened with failure, and asked whether I could sell some of their cement, which their Baltimore agent was unable to take on contracts he had made. With the courage of youth and the supposed knowledge I had of cement, I at once wrote her to send some on and I would take care of it.

Time passed, and a few weeks later I received a bill of lading from the Clyde Line of steamships advising me that 200 barrels of cement were on hand at their dock at the foot of Market Street and **had to be removed within twenty-four hours**, and that $176 freight charges **must be paid that day**. This was a knock-out blow to my finances and to my idea of being a dealer in "sticky" cement. I went to the dock, looked at the 200 nice new barrels, and saw there more cement in a single minute than I have seen since in a career covering the sale of many millions of barrels.

Persuading the savings bank where I had my small capital to waive the ten-days' notice, I was able to pay the freight and through the assistance of a contractor, whose office rent I also collected, I was able to move the material to his yard on Broad Street, Philadelphia. These details having been disposed of, and having secured information from the manufacturers as to what cement was and what it could be used for, I opened my heart to Trinkle, who was my senior in the office, and a confidant, and told him of my distress and trouble. Trinkle, who had a large vocabulary, promptly asked me: "What the hell is cement?" I replied that it was used for building. "Can it be used on bridges?" asked Trinkle. "Yes," I said. He then explained that a political friend of his had been instrumental in securing for a contractor the large bridge over the Schuylkill



Rotary kilns such as these are as long as a twenty-story building is tall and, in use, weigh as much as the Twentieth Century Limited. Below are the clinker coolers.

River at Callowhill Street, and he thought he could help us. I said: "All right, whatever we get you get half." A letter of introduction from the politician to the contractor enabled me to sell 10,000 barrels the second day we were in business, and the sale was due to the fact that we introduced a new method, that of bringing the cement in bulk from the mills and getting the contractor to give us back the empty barrels for nothing, which enabled us to sell under the price of Rosendale cement, brought down in barrels from the Hudson River.

Thus was formed the cement firm of Lesley & Trinkle, in which, with the modesty of youth, I made myself the senior partner.

We brought many thousands of barrels of cement from Cumberland on this and other contracts, but when the freights were advanced we had to seek other manufacturers and found a good and substantial friend and backer in Saylor, of the Coplay Cement Company, from whom we later bought many hundreds of thousands of barrels. Here, too, we employed the same method of handling cement, bringing it down in bulk to our packing house and putting it into second-hand barrels, and then delivering it on the job.

This connection led to our first experience with American portland cement, when we began to handle in a small way Saylor's portland, though before that time we had received several shipments of foreign portland through James Brand, of New York. My recollection of those early days—and I am sure Trinkle's was the same—was that of two young men working about eight or nine hours a day for the Public Ledger and then working seven or eight hours a day more in the cement business, seeing customers by night, going to our packing house and storehouse, then at Front and Noble Streets, in the early morning, and then meeting again at lunch for a discussion of our business and its many problems.

Whenever opportunity offered I read Henry Reid's celebrated book on portland cement, which, fortunately, came to hand for review while I was on the Ledger staff. This great work was not only helpful but a stimulus to the novice, and I went through it again and again, acquiring a great deal of practical information and avoiding many mistakes in after years. Incidentally, this was the book that inspired Millen in his early efforts at South Bend, Indiana.

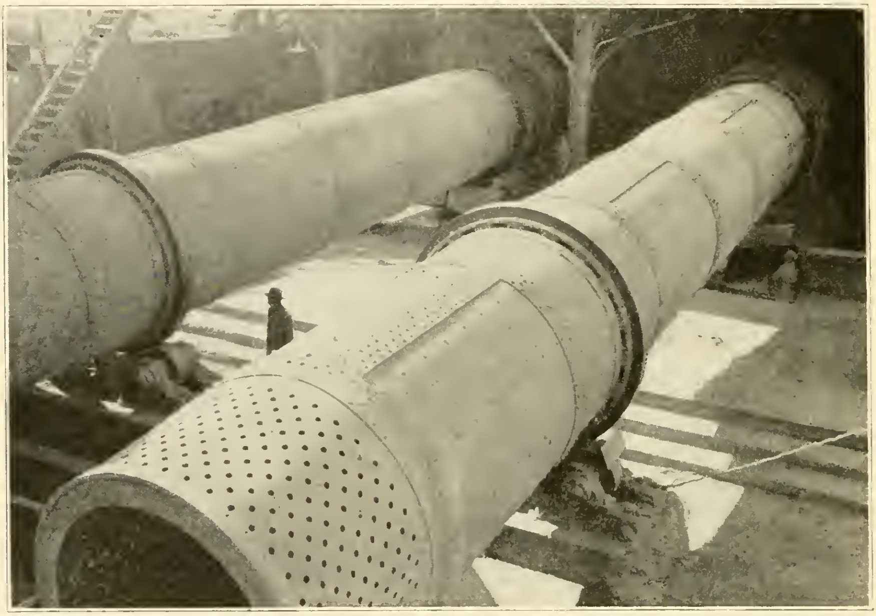
In those days our principal competitors were the great Philadelphia firms of Samuel H. French & Company, still active in the sale of cement, and J. Campbell Harris & Company, who had large plaster mills at Delaware and Fairmount Avenues. Our office was around the corner, at Front and Noble Streets, and we had many scraps with Mr. Harris over purchases and sales and over customers that we both sought.

When J. Campbell Harris decided to go out of business in the early eighties, he sent for us and told us that he had selected us to go on with his business, then one of the largest in Philadelphia. We explained that we had no money, but he was set in his determination, and finally, on a shoestring deposit of a thousand-dollar government bond, we leased his property and purchased his stock, agreeing to pay for it as we took it and to maintain always the deposit of $1,000 intact in his hands. The result of this was to give us a large standing in the trade and to supplement the good will that we had already earned among the contractors of Philadelphia and vicinity. Our natural cement trade increased largely, as we were thus enabled to store large quantities of Rosendale cement which arrived at the dock by water, and were enabled to broaden our importation of the foreign portland cement, which was then establishing a trade in this country.

About this time, through my association with government officers and contractors in Washington, I became acquainted with E. J. DeSmedt, who was then the inspector of asphalts and cements for the District of Columbia, and who was also running the Laboratory of the District, on 4½ Street, Washington. DeSmedt, a Belgian, was a scientist in asphalts and limestones, and a trained chemist. At that time I was connected with the Cumberland Portland Cement Company and became interested in some inventions that DeSmedt had worked out to make slow-setting natural cement at the Cumberland works.

Later on DeSmedt, who was familiar with tars and oils through his connection with the asphalt industry, invented a process for manufacturing portland cement whereby great economies were to be effected. The method of manufacturing in Europe was to take the mixture of clay and chalk and permit it to settle in backs or vats until, by evaporation and decantation, it became dry enough to handle. This material was then put around the stacks of the vertical intermittent kilns and permitted to dry, and finally was put in the kilns in layers with coal. Desire to avoid this expensive way of making cement and to save on the labor was the moving element in DeSmedt's invention. The great difficulty in all the American enterprises seemed to be getting the raw material into powder, then into paste, then into bricks or blocks, then putting it into the kiln, all with sufficient economy in view of the much higher cost of labor in this country than in Europe. Consequently, DeSmedt's patent, which was for the mixing of liquid hydro-carbons with the paste, was a step in advance. In this way a slurry was made which, when compressed into balls or eggs, could at once be put into the kiln, dispensing with many of the intermittent steps of drying, thus saving much labor and money.

I made a number of experiments in a small kiln with the process above described, making the mixes with my own hands, manipulating the material to be made into briquettes until holes were burned in my fingers by the lime content, and finally succeeded in making what stood the test of portland cement.



After the white-hot clinker leaves the rotary kilns it is generally passed through smaller rotating cylinders to cool.

Following these experiments, which I thought had solved the problem, I got John W. Eckert, of the Coplay works, to test in a small 10-foot kiln, a charge of bricks made with liquid hydro-carbon, to determine the value of the process. The result was a failure, for instead of finding powdered clinker when we opened the kiln in the morning, we found that the bricks had squashed and softened and instead of cement clinker there was a mass of choked bricks and dust where the draft of the kiln had been unable to penetrate and proper burning had not been possible.

This led to an invention for making the material in a solid state whereby it could be handled easily and the proper draft in the kiln secured.

By the purchase of the Loiseau patents and the Loiseau press, which had been used in making artificial coal at the dock of the Reading Railroad in Philadelphia, a method was secured by which hard lumps of cement-making material mixed with liquid hydro-carbon in the shape of small eggs were manufactured at the rate of 100 tons a day and delivered automatically from the machine to the kiln. This apparatus was originally erected in a building in the back of the warehouses at Fairmount and Delaware Avenues, and all stone was brought down from the Coplay Plant and from other quarries in the Lehigh District. For many months the manufacture of portland cement was conducted by means of these eggettes, which were subsequently calcined in a small kiln and ground to impalpable powder. This cement proved successful commercially, in a small way, and shortly thereafter it was determined to build a plant.

I started out on various explorations, both geographical and geological, going first up the Schuylkill Valley to Reading on foot with a well-known geologist, but found no available material with the proper economic possibilities. I walked over the region between Bedford and Cumberland, but turned it down on account of the geographic location with reference to markets. Finally I walked from Campbell Hall, New York, down the Delaware to Martins Creek, Pennsylvania. At that time there was no bridge and no railroad connection across the Delaware River, and going over in a small row boat, I started to walk from Martins Creek through Bangor, Bath, Nazareth and Northampton to the Lehigh River at Coplay, following the great belt of cement rock which stretched between the points described. My bottle of acid, my sample hammer, and my pack of samples were practically all the baggage I could carry.

I recollect distinctly that as my purpose was to secure a rock out of which we could make natural cement, then most largely in demand, and by adding lime to it to make portland cement, I did not take any rocks that had such a high lime content as to make great effervescence when acid was applied.

As a result of this trip I secured plans of many properties, options on some, and finally located at Egypt, on the line of the Ironton Railroad, upon rock which seemed to form the back door to the Coplay Cement Works, the front door of which was on the Lehigh River, above Coplay. As I look back I realize that my desire to secure material that would make both natural and portland cements led me to neglect the opportunity to make hundreds of thousands of dollars, for among the properties that were turned down because of high lime content were the great quarries now operated by the Alpha Portland Cement Company at Martins Creek, those at Bath, operated by the Bath Portland Cement Company, and those at Nazareth, operated by the Dexter Portland Cement Company.

In Philadelphia we had, as our superintendent, a stubby, fat, little Englishman, who claimed to have made cement in England at a place called Grimsby, and who was very vain and self-sufficient, making us all feel very ignorant when we talked to him, with his accumulated wisdom, though his experience carried no real scientific knowledge. With his assistance we erected a plant at Egypt, Pa., to make portland cement under the DeSmedt, Willcox, Lesley, and other patents. We erected our press roll with which we made the eggettes, ground the raw material on buhr stones, carried the eggettes by elevators up to the kiln, loaded the kiln with intermittent layers of coke and eggettes, and ground the clinker upon buhr stones again. The process was largely based upon a by-product, namely, coal tar and pitch, which were used as the liquid hydro-carbon and binder for the eggettes. The gas works of Philadelphia, then making gas with coal, permitted millions of gallons of this tar to go to waste each year, and it was possible to buy the material almost for the cost of barreling and loading it. The process was used by gas companies generally, but about that time the Lowe process of making water gas came into common use, being much more economical than the coal gas process, and we were left without our binder, and had to turn to the process then used at Saylor's works, which consisted of many acres of drying floors where the bricks cut from the paste were piled against heating pipes around the closed rooms in which the drying floors were situated.

It was not long after manufacture had started that winter came, and as the plant kept on running the stock sheets showed considerable portland cement on hand for delivery in the early spring, but when orders were sent up the cement was not forthcoming. Finally I went to the mill and demanded to see the bins where the portland cement was stated to be, and found that they were largely filled with natural cement but veneered on the top and front with portland cement powder. When I asked the English superintendent where the portland cement was that he had reported on hand, his only answer was, "And did ye think I et it?" He was soon decapitated and John W. Eckert, then superintendent, reorganized the whole establishment, building new kilns and putting it all on a solid and substantial basis.

The original company which built the works was organized in 1883, and called the American Improved Cements Company, and my father-in-law, James M. Willcox, of Philadelphia, was the president. It was later on changed to the American Cement Company and is now the Giant Portland Cement Company.

An Early Oregon Plant

Among the early portland cement works with an interesting history was one established at Oregon City, Oregon, in 1884. According to early accounts the factory was designed and managed by a Mr. Middleton. He was regarded as something of a genius, for his plant was built along plans that did not come into general use, even in the older cement plants in the East, until ten years later.

C. A. Newhall, writing of this works in 1913, describes it as follows:

The raw material, a cement rock from southern Oregon, was ground in pebble mills and the raw mix burned in a gas-fired rotary kiln. The resulting clinker was ground to cement in a pebble mill. The gas was made for the most part from Australian coal, though local coal was used to some extent. Power was derived from the falls of the Willamette, just above the plant. The output of this pioneer plant was over 100 barrels per day of true portland cement. The product was in great demand and was superior in quality to the imported portland cement. It was used in sidewalks and curb work and in making artificial stone.

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 the hill. The apparently inexhaustible mountain of stone was merely a thin veneer, so about 1890 the machinery was broken up and sold.

The First Michigan Mill

The Eagle Portland Cement Company was the first to operate in the Michigan field, which later became a great cement manufacturing district. The Eagle works were established at Kalamazoo in 1885. Some authorities fix the beginning of manufacture at this plant as early as 1872, a year after Saylor obtained his patent for portland cement, but William Dickinson, who is familiar with the history of the company, states that the first date, 1885, is correct. The founders of the plant included George L. Dunlap, Perry H. Smith, T. B. Blackstone, W. H. Schimpferman and Samuel Keith, of Chicago, and Frederick Bush, of Kalamazoo. According to Mr. Dickinson, marl and clay were obtained about two miles north of Kalamazoo. The materials were mixed in a pug mill and formed into bricks, which were burned with alternate layers of coke. Two days were required for burning and a like time for the cooling of the kiln and contents. About a third of the product, and sometimes more, was too lightly burned to make good cement, thus curtailing output, but such as was properly burned made cement of good quality, which found ready sale at about $5 per barrel. At the first annual meeting of the company the superintendent reported considerable cement on hand and all bills paid, so that the company considered it a conservative step to declare a ten per cent dividend. It transpired, however, that the stock on hand was much smaller than reported and that cost of manufacture had exceeded the price of the cement. The stockholders were disgusted as well as dumbfounded by these revelations and closed the mill, which soon thereafter was destroyed by fire.

Early Manufacture in New York

In the Rosendale district a number of men undertook to make portland cement out of Fullers earth and lime under patents of C. F. Dunderdale. Works were erected, but it was found the cost was so far out of proportion to the price that could be realized, that these works, which were established in 1876-77, were finally abandoned. So were other works subsequently established under the name of the Walkill Portland Cement Company, in the same district, and the National Cement Company, established by S. D. Coykendall.

"Buffalo Portland Cement" of which small quantities were manufactured from 1878 to 1885, resulted from the discoveries and patents of Uriah Cummings and L. J. Bennett, who were connected with these works, and who found by selecting the over-burned material from the common cement kilns of the Buffalo Cement Company, that a material resembling portland cement could be made. The rock, however, was largely magnesian, and for this reason no great quantities of portland cement were manufactured.

A New England Plant

The Cobb Lime Company, an important producer of lime at Rockland, Maine, started works in 1879 to produce portland cement, but owing to the high price of fuel the product was too costly for commercial success and this plant shut down after a short period of manufacture.

From the foregoing it may be seen that out of the several pioneer works started in this country from the time Saylor began, up to and including 1885, a large percentage were failures, and the situation did not offer a very encouraging outlook to the investor. At this period foreign portland cement had the market almost exclusively and there seemed little likelihood of growth for the American portland cement industry, the American output in 1881 being approximately 60,000 barrels as compared with importations of about 221,000 barrels.

Development in the Lehigh District

The Lehigh district in Pennsylvania not only witnessed the founding of the industry, but soon became the great portland cement producing center of the United States. In 1890, the Lehigh mills produced 60 per cent of the total output of the United States. The percentage declined the three following years, reaching 44.9 per cent in 1893, when an upward trend began, culminating in the highest point in 1897, when the Lehigh district's share of the country's total output was 74.8 per cent. Thereafter a gradual decline set in, the percentage in 1923 being 25.9 per cent.

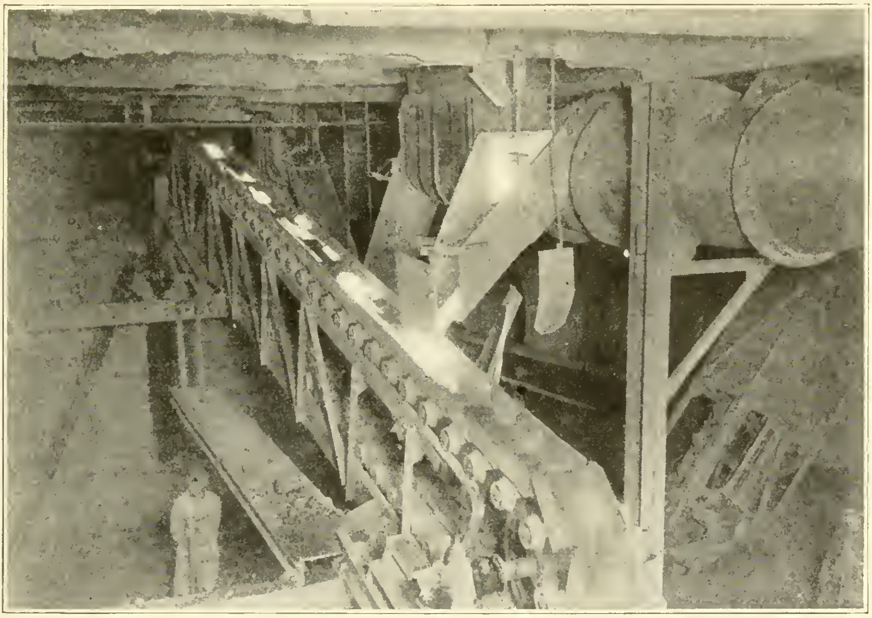
PORTLAND CEMENT PRODUCED IN THE LEHIGH DISTRICT AND IN THE UNITED STATES, 1890-1923

Year	Lehigh District (barrels)	United States (barrels)	Percentage made in Lehigh District	Year	Lehigh District (barrels)	United States (barrels)	Percentage made in Lehigh District
1890	201,000	335,500	60.0	1907	24,417,686	48,785,390	50.0
1891	248,500	454,813	54.7	1908	20,200,387	51,072,612	39.6
1892	280,840	547,440	51.3	1909	24,246,706	64,991,431	37.3
1893	265,317	590,652	44.9	1910	26,315,359	76,549,951	34.4
1894	485,329	798,757	60.8	1911	25,972,108	78,528,637	33.1
1895	634,276	990,324	64.0	1912	24,762,083	82,438,096	30.0
1896	1,048,154	1,543,023	68.1	1913	27,139,601	92,097,131	29.5
1897	2,002,059	2,677,775	74.8	1914	24,614,933	88,230,170	27.9
1898	2,674,304	3,692,284	72.4	1915	24,876,442	85,914,907	29.0
1899	4,110,132	5,652,266	72.7	1916	24,105,381	91,521,198	26.3
1900	6,153,629	8,482,020	72.6	1917	24,423,507	92,814,202	26.3
1901	8,595,340	12,711,225	67.7	1918	19,701,820	71,081,663	27.7
1902	10,829,922	17,230,644	62.8	1919	22,747,956	80,777,935	28.161
1903	12,324,922	22,342,973	55.2	1920	25,417,804	100,023,245	25.412
1904	14,211,039	26,505,881	53.7	1921	25,571,726	98,842,049	25.8
1905	17,368,687	35,246,812	49.3	1922	31,195,617	114,789,984	27.1
1906	22,784,613	46,463,424	49.0	1923	35,721,751	137,460,238	25.9

Thus in the early development of this great industry we find veritable romance, if romance ever attached to any phase of America's commercial and industrial progress. The country had its great captains of industry and finance when the Saylors, Millens and Shinns were experimenting. But they were concerned in railroads, iron, lumber and coal, or in the exploitation of land. Not one of them seemed to realize the great potential value of the work of the pioneers in the portland cement industry. The latter, like Fitch with his steamboat, labored in remote places with crude materials; and that one of the largest and most important industries in the world, something calling for exact scientific procedure, should have been founded by men who, in some cases, had only hammers, cook stoves and coffee mills for experimental purposes, is one of the most remarkable and interesting of the many remarkable happenings in the industrial development of the United States.

The Increasing Ascendancy of Domestic Portland Cements

The competitors of the first American manufacturers of portland cement were the foreign portland cement makers and the American manufacturers of natural cements, whose products had the confidence of engi-



White-hot clinker dropping from the kilns onto the conveyor to the cooling cylinders.

neers and architects, and the further important advantage of familiarity in use. In 1871, the year Saylor took out his patent, the country was probably using at least 2,000,000 barrels of natural cement. Importations of portland cement must have been far below the American production of natural cement, as the first authoritative figures on imports recorded in 1878 show only 92,000 barrels. Therefore, it is safe to say that the first American manufacturers of portland cement had to overcome an established consumption of competing products amounting to more than 2,000-000 barrels, whose volume showed rapid expansion before the American works could get fully under way.

It may be well to present here statistics covering in concise form the history of the struggle for supremacy between American portland cement and its two competitors. The following table, which is confined to periods of five years, gives a sufficiently comprehensive survey of the field from 1878 to 1923. The first reliable statistics on portland cement production appeared in 1878.

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	250,000
1893	7,411,815	2,674,149	590,652
1898	8,418,924	1,152,861	3,692,284
1903	7,030,271	2,251,969	22,342,973
1908	1,686,862	842,121	55,072,612
1913	744,658	85,470	92,097,131
1918	432,966	305	71,081,663
1923***		1,678,636	137,460,238

*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 2,997,395 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.

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

It will be seen from the foregoing table that while the importation and use of foreign portland cement was a serious obstacle at the very beginning of the portland cement industry in America, the actual consumption of all foreign brands seems absurdly small in the face of subsequent production by American mills.

As the history of the portland cement industry proceeds, it will be convenient to have for reference a compact but complete tabular statement covering the production of portland, natural and puzzolan cements from the time manufacture of each began in the United States. From this table full data may be readily obtained, and immediately following is a second table giving average factory prices of portland cement for the same period of time. In conjunction with these tables are two showing production of portland cement in 1922 and 1923 by states and by commercial districts.

The United States Geological Survey records covering the prices of portland cement group the years 1870 to 1880, inclusive, at $3 per barrel for the average factory price. From that time up to and including 1923 the average factory prices per barrel in bulk were as follows:

AVERAGE FACTORY PRICE PER BARREL IN BULK OF PORTLAND CEMENT, 1870-1923

1870-1880	$3.00	1897	$1.61	1911	$ .844
1881	2.50	1898	1.62	1912	.813
1882	2.25	1899	1.43	1913	1.005
1883	2.15	1900	1.09	1914	.927
1884	2.10	1901	.99	1915	.860
1885-1888	1.95	1902	1.21	1916	1.103
1889	1.67	1903	1.24	1917	1.354
1890	2.09	1904	.88	1918	1.598
1891	2.13	1905	.94	1919	1.71
1892	2.11	1906	1.13	1920	2.02
1893	1.96	1907	1.11	1921	1.89
1894	1.73	1908	.85	1922	1.76
1895	1.60	1909	.813	1923	1.90
1896	1.57	1910	.891		

PORTLAND CEMENT PRODUCED IN THE UNITED STATES, 1922 AND 1923, BY STATES

State	Active Plants		Production Quantity (barrels)	
	1922	1923	1922	1923
Alabama	3	5	2,290,884	3,497,256
California	9	9	8,711,515	11,001,910
Illinois	4	4	6,407,129	7,147,906
Iowa	4	5	4,272,432	5,732,470
Kansas	7	7	4,634,287	6,025,657
Michigan	12	14	6,243,805	7,619,792
Missouri	5	5	6,170,633	7,305,997
New York	9	9	5,922,706	6,990,174
Ohio	5	6	2,835,243	4,188,755
Pennsylvania	22	22	33,276,093	38,157,482
Texas	5	5	3,628,756	4,178,895
Washington	4	4	1,942,781	2,105,711
Other States a	29	31	28,453,720	33,508,233
	118	126	114,789,984	137,460,238

a Colorado, Georgia, Indiana, Kentucky, Maryland, Minnesota, Montana, Nebraska, New Jersey, Oklahoma, Oregon, Tennessee, Utah, Virginia and West Virginia.

PORTLAND CEMENT PRODUCED IN THE UNITED STATES, 1922 AND 1923, BY DISTRICTS

Commercial District	Active Plants		Production Quantity (barrels)	
	1922	1923	1922	1923
Eastern Pennsylvania, New Jersey and Maryland	22	22	31,195,617	35,721,751
New York	9	9	5,922,706	6,990,174
Ohio, Western Pennsylvania and West Virginia	10	11	10,753,301	13,495,799
Michigan	12	14	6,243,805	7,619,792
Illinois, Indiana and Kentucky	10	10	17,998,914	21,193,666
Virginia, Tennessee, Alabama and Georgia	8	11	5,954,043	7,908,846
Eastern Missouri, Iowa and Minnesota	9	10	11,392,552	14,037,099
Western Missouri, Nebraska, Kansas and Oklahoma	11	11	8,025,720	9,779,034
Texas	5	5	3,628,756	4,178,895
Colorado and Utah	5	5	2,020,784	2,427,971
California	9	9	8,711,515	11,001,910
Oregon, Washington and Montana	8	9	2,942,271	3,105,301
	118	126	114,789,984	137,460,238

PRINCIPAL HYDRAULIC CEMENTS PRODUCED IN THE UNITED STATES, 1818-1923

Year	Natural Cement		Portland Cement		Puzzolan Cement		Total	
	Quantity (barrels)	Value	Quantity (barrels)	Value	Quantity (barrels)	Value	Quantity (barrels)	Value
1818-1829	300,000	$ 246,000	...	...	...	...	300,000	$ 246,000
1830-1839	1,000,000	850,000	...	...	...	...	1,000,000	850,000
1840-1849	4,250,000	3,612,500	...	...	...	...	4,250,000	3,612,500
1850-1859	11,000,000	9,350,000	...	...	...	...	11,000,000	9,350,000
1860-1869	16,420,000	13,957,000	...	...	...	...	16,420,000	13,957,000
1870-1879	22,000,000	18,700,000	82,000	$ 246,000	...	...	22,082,000	18,946,000
1880	2,030,943	1,726,707	42,000	126,000	...	...	2,072,943	1,852,707
1881	2,440,000	2,379,000	60,000	150,000	...	...	2,500,000	2,529,000
1882	3,165,000	3,481,500	85,000	191,250	...	...	3,250,000	3,672,750
1883	4,100,000	4,100,000	90,000	193,500	...	...	4,190,000	4,293,500
1884	3,900,000	3,510,000	100,000	210,000	...	...	4,000,000	3,720,000
1885	4,000,000	3,200,000	150,000	292,500	...	...	4,150,000	3,492,500
1886	4,350,000	3,697,500	150,000	292,500	...	...	4,500,000	3,990,000
1887	6,692,744	5,186,877	250,000	487,500	...	...	6,942,744	5,674,377
1888	6,253,295	4,533,639	250,000	487,500	...	...	6,503,295	5,021,139
1889	6,531,876	4,702,951	300,000	500,000	...	...	6,831,876	5,202,951
1890	7,441,116	3,822,501	335,500	704,050	...	...	7,776,616	4,526,551
1891a	7,767,979	3,671,147	454,813	967,679	...	...	8,222,792	4,638,826
1892	8,211,181	3,991,455	547,440	1,152,600	...	...	8,758,621	5,144,055
1893	7,411,815	3,251,757	590,652	1,158,138	...	...	8,002,467	4,409,895
1894	7,563,488	3,635,731	798,757	1,383,473	...	...	8,362,245	5,019,204
1895	7,741,077	3,895,424	990,324	1,586,830	...	...	8,731,401	5,482,254
1896	7,970,450	4,049,202	1,543,023	2,424,011	12,265	$ 12,250	9,525,738	6,485,463
1897	8,311,688	3,862,392	2,677,775	4,315,891	48,329	48,500	11,037,792	8,226,783
1898	8,418,924	3,888,728	3,692,284	5,970,773	233,000	198,050	12,344,208	10,057,551
1899	9,868,179	4,814,771	5,652,266	8,074,371	335,000	268,000	15,855,445	13,157,142
1900	8,383,519	3,728,848	8,482,020	9,280,525	365,611	274,208	17,231,150	13,283,581
1901	7,084,823	3,056,278	12,711,225	12,532,360	272,689	198,151	20,068,737	15,786,789
1902	8,044,305	4,076,630	17,230,644	20,864,078	478,555	425,672	25,753,504	25,366,380
1903	7,030,271	3,675,520	22,342,973	27,713,319	525,896	542,502	29,899,140	31,931,341
1904	4,866,331	2,450,150	26,505,881	23,355,119	303,045	226,651	31,675,257	26,031,920
1905	4,473,049	2,413,052	35,246,812	33,245,867	382,447	272,614	40,102,308	35,931,533
1906	4,055,797	2,423,170	46,463,424	52,466,186	481,224	412,921	51,000,445	55,302,277
1907	2,887,700	1,467,302	48,785,390	53,992,551	557,252	443,998	52,230,342	55,903,851
1908	1,686,862	834,509	51,072,612	43,547,679	151,451	95,468	52,910,925	44,477,656

PRINCIPAL HYDRAULIC CEMENTS PRODUCED IN THE UNITED STATES, 1818-1923—Continued

Year	Natural Cement		Portland Cement		Puzzolan Cement		Total	
	Quantity (barrels)	Value	Quantity (barrels)	Value	Quantity (barrels)	Value	Quantity (barrels)	Value
1909	1,537,638	$ 652,756	64,991,431	$ 52,858,354	160,646	$ 99,443	66,689,715	$ 53,610,563
1910	1,139,239	483,006	76,549,951	68,205,800	95,951	63,286	77,785,141	68,752,092
1911	926,091	378,533	78,528,637	66,248,817	93,230	77,786	79,547,958	66,705,136
1912	821,231	367,222	82,438,096	67,016,928	91,864	77,363	83,351,191	67,461,513
1913	744,658	345,889	92,097,131	92,557,617	107,313	97,663	92,949,102	93,001,169
1914	751,285	351,370	88,230,170	81,789,368	68,311	63,358	89,049,766	82,204,096
1915	750,863	358,627	85,914,907	73,886,820	42,678	39,801	86,708,448	74,285,248
1916	b 842,137	b 430,874	91,521,198	100,947,881	c	c	92,363,335	101,378,755
1917	b 639,456	b 435,370	92,814,202	125,670,430	c	c	93,453,658	126,105,800
1918	b 432,966	b 401,341	71,081,663	113,730,661	c	c	71,514,629	114,132,002
1919	b 528,589	b 583,554	80,777,935	138,130,269	c	c	81,306,524	138,713,823
1920	b 767,481	1,150,890	100,023,245	202,046,955	c	c	100,790,726	203,197,845
1921	b 539,402	b 897,025	95,507,147	180,778,415	c	c	96,046,549	181,675,440
1922	b 889,428	b 1,293,598	117,701,216	207,170,430	c	c	118,590,644	208,464,028
1923	b 1,271,674	b 1,947,352	135,912,118	257,684,424	c	c	137,183,792	259,631,776
	b 240,234,550	b$ 156,319,648	1,641,771,862	$2,136,635,419	4,806,757	$3,937,695	1,886,813,169	$2,296,892,762

a The figures for 1890 and previous years are estimates made at the close of each year and are believed to be substantially correct. For years since 1890 the official figures are based on practically complete returns from all producers.
b Includes puzzolan cement.
c Included with natural cement.

Early American Made Portland Cement Often Sold Under Foreign Labels

The commercial introduction of American portland cement was no easy task for the pioneers in the industry. Prejudice against the American product in the early days was so uncompromising that some of the large distributors of foreign portland cement throughout the country actually insisted that American manufacturers should have the names of special

Great piles of clinker are held in reserve at most cement plants. Being impervious to the elements, it is stored until needed. Then it is ground, gypsum added, and sacked.

brands of English, German and Belgian portland cements placed on the barrels when shipped into some of the western and southern markets; however, this continued but a short time, for gradually the extraordinary quality and valuable characteristics of American portland cement made themselves felt in the markets of the country.

In a paper on the Manufacture of Cement delivered before the International Engineering Congress in 1904, Robert W. Lesley said:

> The first portland cement made in America involved a great cost of labor and could not be offered at prices very much below the foreign article, and as the cement in a building costing a million dollars represented but a small percentage of the total cost of the structure, and the difference between the prices of foreign and domestic portland

cements being, in turn, but a very small percentage of the total cost of the cement, it was almost impossible to convince engineers and architects that American portland cement should be used. By slow degrees the prejudice in favor of the imported cement was overcome.

Importance of Patents Covering Early Processes

In seeking to improve methods of manufacture, each of the works established when the industry was just struggling for a footing was based upon patents of one type or another. It is almost axiomatic that while a patent does not give a man or an industry a right to exist, it does give a right to show a right to exist. This seems to have been exemplified in the portland cement industry, and the works that are shown to have survived the struggles of the early days are those whose founders and owners possessed initiative and sturdy intellectual attributes. While these qualities would intrinsically have made for success under ordinary conditions, in this case the inventors were, as stated, merely given the right to show their right to exist by patents, and they distinctly made good in the development of the industries placed in their hands.

It was not until 1890, or thereabouts, that any great progress was made in combating the paramount influence of the foreign portland cement in the American market. The figures of the United States Geological Survey appearing on a preceding page indicate the growth of the industry from 1880 to 1890, and show how slowly it progressed. The following complete table of imports covering the period named shows how firmly intrenched in the United States were the foreign manufacturers:

FOREIGN CEMENT IMPORTED FOR CONSUMPTION, 1878-1923, IN BARRELS OF 380 POUNDS

1878	92,000	1893	2,674,149	1908	842,121
1879	106,000	1894	2,638,107	1909	433,888
1880	187,000	1895	2,997,395	1910	306,863
1881	221,000	1896	2,989,597	1911	164,670
1882	370,406	1897	2,090,924	1912	68,503
1883	456,418	1898	1,152,861	1913	85,470
1884	585,768	1899	2,108,388	1914	120,906
1885	554,396	1900	2,386,683	1915	42,218
1886	915,255	1901	939,330	1916	1,836
1887	1,514,095	1902	1,963,023	1917	2,323
1888	1,835,504	1903	2,251,969	1918	305
1889	1,740,356	1904	968,409	1919	8,931
1890	1,940,186	1905	896,845	1920	524,604
1891	2,988,313	1906	2,273,493	1921	122,322
1892	2,440,654	1907	2,033,438	1922	323,823
				1923	1,678,636
				Total	51,039,381

Concerning the status of the American portland cement industry in 1890-91, S. B. Newberry, in the United States Geological Survey report, says there were 17 plants whose geographical distribution and annual production were as follows:

PORTLAND CEMENT WORKS AND PRODUCTION IN 1890-1891

District	No. of Works	1890		1891	
		Barrels	Value	Barrels	Value
California, San Diego	1	....	....	5,000	$ 15,000
Colorado, Denver	1	12,500	$ 40,000	12,500	40,000
Dakota, Yankton	1	....	....	31,813	71,579
Indiana, South Bend	1	15,000	36,000	15,000	36,000
New York, Onondaga County, Buffalo, etc	5	65,000	140,000	87,000	290,000
Ohio, Bellefontaine and Columbus	2	22,000	49,000	35,000	82,000
Pennsylvania, Lehigh and Lawrence counties	6	221,000	439,050	268,500	532,850

CHAPTER VI

OTHER CEMENTS

The world's demand for mortars, especially mortars of higher strength, had constantly increased with the greater size of buildings and the necessity for larger, stronger bridges, aqueducts, dams, roads, and other engineering structures. It was but natural therefore that inventors and engineers should seek mortar-making materials other than the natural and portland cements then known and so generally used.

The results of this trend were several types of cements, some of which have been referred to briefly in a preceding chapter.

Puzzolan Cement

The first and most important of these cements was that described in all books on cement as "puzzolan" and "slag" cement. "Puzzolan" is a term applied to a compound of silica and alumina which, when mixed with slaked lime and made into mortar, has the property of hardening under water. There are several classes of material which have this quality, such as "trass," "tufa," "arenes," and the well-known "puzzuolana" found in the southern part of Italy.

"Slag" cement is, however, by far the most important of the puzzolan cements. It is the product obtained by mixing powdered slaked lime and finely pulverized blast furnace slag. In this material the hydraulic ingredients are not burned with the lime, but are present in the cement in a mechanical mixture only.

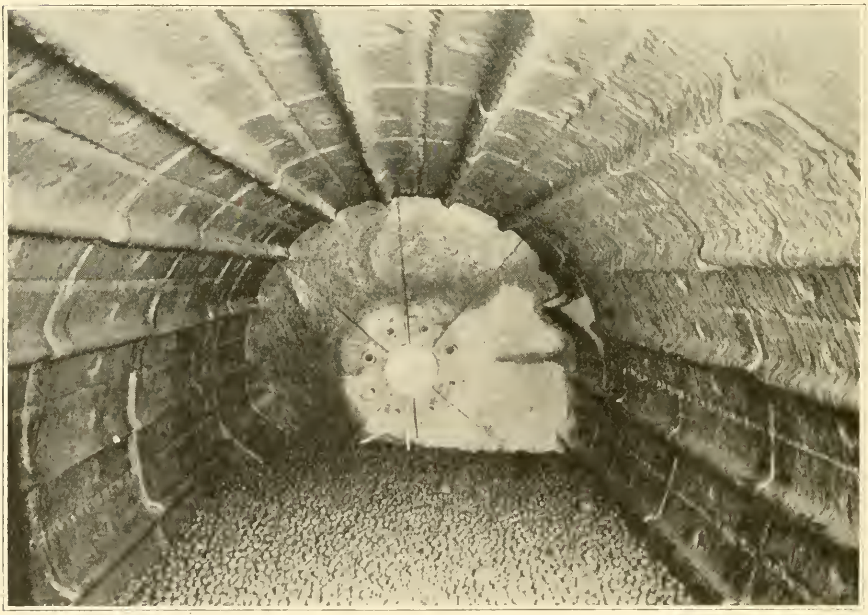
This cement originated in Germany and was manufactured in Westphalia as far back as 1863. The process employed was described by W. Lurmann before the Technical Society at Osnabruck in January, 1867. Many improvements on the original process were made by German inventors between 1863 and 1900, and owing to the desire of German iron manufacturers to find an outlet for their slag, the production of this cement became quite general in Germany. Large quantities were being made about 1885, but in a United States Consular Report dated July 3, 1895, it is stated that of about fifty slag cement works in Germany in 1890, only two were then in operation. The French writer Candlot, referring to this industry about 1900, states that no new works had been built in Switzerland, and that in Belgium but one remained, while in France there were but three.

On February 5, 1895, Jasper Whiting, of Chicago, Illinois, applied for a patent which was granted to him on August 20, 1895, the claims of which are as follows:

> 1. The method of manufacturing cement from slags which consists in chilling molten slag in water, drying and grinding the product, and adding thereto caustic soda or its equivalent in a dry state.
> 2. The method of manufacturing cement from slags which consists in chilling molten slag in water as it comes from the furnace, drying and grinding the slag, and adding thereto slaked lime and caustic soda both in a dry state and in the proportions substantially as set forth.
> 3. A cement composed of blast furnace or other slag in a dry pulverized form and caustic soda in a dry state, in substantially the proportions set forth.
> 4. A cement composed of blast furnace or other slag in a dry pulverized form and caustic soda and slaked lime in a dry state and substantially in the proportions set forth.

The general purpose of this invention as stated by him was that:

> The presence of caustic soda renders the resulting cement much stronger and quicker setting and by varying its proportions a cement of any desired quality can be obtained.



Tons of steel balls in the interior of a tube mill pulverize the materials to a powder finer than flour.

Under this patent, which was the result of experiments conducted by Mr. Whiting for nearly two years, a plant for the manufacture of cement was established at the North Works of the Illinois Steel Company, in Chicago. Later this plant was greatly enlarged and the output increased. The material was marketed under the name of "Steel Portland Cement," and was largely used for important works of all kinds throughout the South and West.

The Brier Hill Iron & Coal Company, of Youngstown, Ohio, took out a license under the Whiting process, and from 1898 to 1910 manufactured cement under the patent, calling it "Brier Hill Portland Cement."

Considerable discussion arose as to whether this particular cement properly came under the definition of "Portland Cement" and the manufacturers of the latter very naturally sought to exclude the "Steel Portland Cement" from works where portland cement or high-grade American portland cement was specified. Numerous cases of this kind occurred in Baltimore. In the letting of city contracts in 1900, the issue was raised, and again in the same year a government board of engineers was appointed to investigate the question of whether "Steel Portland Cement" could be accepted and used in the United States lock at Plaquemine, Louisiana, where high grade American portland cement was specifically required, as being within the meaning of the Government specification of February 16, 1898, for the construction of the Plaquemine Lock.

The investigation continued for some time, and the testimony and conclusions cited in the report of the engineers form an admirable summary of the status of puzzolan or slag cements. The conclusion of the report was that the cement sold by the Illinois Steel Company under the name of "Steel Portland Cement" should be classified under the generic name of puzzolana cement and under the specific name of slag cement and could not be classified as a portland cement.

As a historical fact, and possibly as a business fact, this adverse report was one of the most advantageous things that ever occurred to a great manufacturing concern such as the Illinois Steel Company, which about that time had become a part of the United States Steel Corporation. Undaunted and undismayed by this adverse decision, which to a less courageous set of men would have meant the end of a then successful business, E. J. Buffington, the president of the Illinois Steel Company, Edward M. Hagar, then general sales agent of the Cement Department, and others connected with that concern, and the United States Steel Corporation, immediately set about to make a true portland cement with the material produced from the steel works. Taking specially selected slags, they added to them limestone in the requisite amount to bring the content of the mixture, when calcined, to the proportion of normal portland cements as then required under existing specifications for that material, and by grinding this mixture to impalpable powder and putting it through rotary kilns, produced clinker similar to that produced under ordinary portland cement processes of manufacture which, when ground, made a true portland cement that for years has held its own in the market as one of highest quality.

Passow and Colloseus Cements

Under this general type, though made without admixture of lime, are the Passow and Colloseus cements, also mentioned in a previous chapter. Each of them has an American history, though brief.

The Passow patents were the result of studies of Dr. Passow, one of the leading scientists in Germany. The process was used in Germany in a number of works, and for a brief time the cement was manufactured on a very limited scale in this country.

The Colloseus patents were brought to this country by Vavasour Earle, of England, and Dr. Susskind, of Germany, who endeavored to enlist capital in the process. That they attached high value to their patents

Throughout the entire process of portland cement manufacture the materials are under the watchful eye of the chemist.

was shown during a dramatic meeting they had sought with the Board of Directors of the North American Portland Cement Company. Panic was thrown into the souls of the American manufacturers when Susskind, being asked what the price of the invention was, said: "A million!" One of the directors present asked: "A million dollars?" "No," Susskind replied, "a million pounds." Thereupon the Americans, in a fainting condition, retired for deliberation. The result was that a commission consisting of Dr. Clifford Richardson, the well-known chemist and scientist, and

Robert W. Lesley, cement manufacturer, was appointed to visit Europe and investigate the process. This they did, finally reporting against its practicability.

Subsequently William R. Warren and associates bought a small works in Buffalo and started manufacturing Colloseus cement, but without achieving very satisfactory results.

Iron Cement

This material was produced as specially adapted to salt water construction, and for a time small quantities were brought into the United States, but none was manufactured here. The invention was that of Dr. Michaelis, the distinguished German chemist, and the cement was manufactured by the Krupps at their great steel works in Essen.

Silica Sand Cement

In 1893, a patent was issued to Verner Frederik Lassoe Smidth, of Copenhagen, Denmark, for "a new and useful improvement in cement called 'Sand Cement'." The claim was as follows: "The improved cement herein described consists of a dry ground mixture of ordinary cement and sand, gravel, or other filling material, substantially as set forth." The object of the invention was stated to be to grind a filling material with the ordinary cements of commerce and to produce, when portland cement was used, a new kind of cement by which a mortar is obtained that has all the good properties of cement mortar but is just as cheap, if not cheaper than the ordinary lime mortars.

Mr. Smidth was the head of the well-known engineering firm of F. L. Smidth & Company, of Copenhagen, with offices throughout the world, and stood high in his profession. At his works in Malmö, Sweden, and also at the Aalborg Portland Cement Works in Denmark, many experiments were made with this material, and considerable quantities were produced. In many cases excellent results were shown in tests and great economy found, while in other cases the results were not so satisfactory, especially when very lean mixtures were made.

As early as 1893, Danish engineers came to this country to introduce the cement, and while, as above stated, varying results were obtained by those who tested it, no commercial success in the introduction of the process was made, and it was not until somewhere about 1905 or 1906, when a serious shortage of cement occurred in this country, that the manufacture of this cement began on Long Island, near New York, where the Standard Silica Cement Company established a works with quite an output.

Contemporaneously with this, Sears Humbert & Company, dealers in cement in Chicago, established a similar plant in that city under the title of Calumet Cement Company. Neither of these plants achieved permanent success and ultimately the process was abandoned.

Blended Cement

Blended cement was somewhat like puzzolan and portland cements. It was used extensively in California during the construction of the Los Angeles Aqueduct. A volcanic tuff, known locally as "tufa" cement,

The portland cement industry is the fourth largest manufacturing consumer of coal, although oil and gas are used to some extent. An unfailing supply of fuel is absolutely essential to successful cement plant operation.

was ground with portland cement. In 1910 about 95,000 barrels were produced, the value being $1.50 to $1.60 per barrel. The output of this cement in 1912 reached a little over two hundred thousand barrels, valued at $1.50 per barrel.

CHAPTER VII

LEADING PIONEER COMPANIES IN PORTLAND CEMENT MANUFACTURE

As has been stated in mentioning those who were pioneers in the industry, D. O. Saylor's works at Coplay, operating under the name of the Coplay Cement Company, had achieved commercial success by 1890.

On the Ironton Railroad, back of Saylor's plant, was the American Cement Company, described by Robert W. Lesley in the story of his early connection with the industry.

Between Whitehall station on the Lehigh Valley Railroad, and Coplay station to the east of it, there was a high bluff of cement rock. The tracks of the Lehigh Valley Railroad ran along the property, and just beyond them was the Lehigh River. On the other side of the river, at Whitehall, was the Lehigh Coal & Navigation Company's canal.

Just as the American Cement Company, rather than make new experiments, had settled back of the Coplay works, using practically the same rock, so, too, this attractive bluff along the Lehigh could not remain long unused. Bonneville, already mentioned, was active in developing along this frontage, and at one time there were two mills, one at Whitehall, that of the United States Cement Company, in which S. B. Wellington was largely interested, and another immediately beyond Saylor's works, which was operated for a time and subsequently became the first plant of the Atlas Portland Cement Company, then known as the Keystone Company. All these works were in operation, making both natural and portland cement—much natural and little portland.

In the early days of all of them, and this is true also of the Keystone Company, the manager of each plant would go to his works in doubt as to whether he or the sheriff would be the first to take charge. Those were "parlous times" for all who had to do with manufacturing at that period.

The United States mill was subsequently bought, and became the Whitehall Company. The Bonneville Cement Company was also one of the early producers. The Keystone Cement Company, predecessor of the Atlas Portland Cement Company, started operations in 1889, and under the Navarros was the first concern to use the rotary kiln in the Lehigh district, initial experiments with the rotary kiln having taken place in the Rosendale district, New York, in 1886, as is described elsewhere by A. de Navarro. In 1892, according to F. H. Lewis, the Atlas Portland Cement

Company succeeded in burning portland cement clinker at Coplay in rotary kilns with crude oil, which then cost about a cent per gallon. Mr. Lewis says: "It burned cement clinker very readily; its calorific value was high, and it took only ten to twelve gallons of oil to burn a barrel of cement. At the time and under the prevailing conditions, it was a success. For the first time rotary kilns were functioning readily, and they made then, as they do now, an interesting and impressive spectacle of chemistry applied on a large scale to industrial uses."

Across the river from Whitehall, at Siegfried Bridge, was the old Allen mill which General Siegfried established for making natural cement for the Lehigh Canal locks; and nearby was an old paint mill using the red ores for making paint for iron construction and similar types of work. Later on the Allen mill was turned into a portland cement plant, and the Ackermans, of New York, who had been connected with the Rock Lock Cement Company, Lawrence, and other cement companies in the Rosendale region, established portland cement works in the old paint mill, and later on acquired the old Allen plant. Four generations of the Ackerman family have been in the cement business and representatives of the present generation are still successfully operating the large cement company at Siegfried Bridge, making the well-known "Dragon" portland cement.

Whenever David O. Saylor had occasion to go to New York over the Central Railroad of New Jersey or the Lehigh Valley Railroad, he noticed in the railroad cuts large bodies of rock similar to the rock he was using on the banks of the Lehigh River, near Coplay station. For many years he kept this knowledge to himself, and the property below Easton remained undeveloped, while Saylor and his associates were building up their business at Coplay. Others, however, friends and associates of Saylor, and men also interested in the development of the other mills around about Coplay and Whitehall, noticed these rocks, and Thomas D. Whittaker, of Philadelphia, a successful manufacturer of cotton goods, became interested in property near Phillipsburg, New Jersey, where, after the success of the Atlas Portland Cement Company with rotary kilns, and the American Cement Company with Griffin mills, he established, in 1892, a small rotary kiln plant using fuel oil at Bonneville Station (now Alpha), New Jersey. Associated with him was George E. Bartol, the founder of the Philadelphia Bourse, who later became an important figure in the industry around Easton and Nazareth. This plant proved successful almost from the start, having excellent selling facilities in Boston, New York and Philadelphia, and succeeded in obtaining much large and important work.

After the establishment of this plant, Bonneville, who was always interested in starting new concerns, succeeded in inducing Dr. Filbert of the well-known Vulcanite Paving Company, and his associates, Messrs. Lober, Widener and Elkins of Philadelphia, to join with him in the building of works near the old Whittaker plant, now the Alpha Portland Cement Company's plant. This project was started by what is now known as the Vulcanite Portland Cement Company, today a large and successful company under the presidency of John B. Lober, who is among the most popular and able of the many able men in the portland cement industry.

The discovery of cement rock back of Coplay station by the American Cement Company resulted in the building of a number of other plants by that corporation, and also led to investigation of the cement resources of the hills in the back country between Egypt and Ironton. As a result, the Lehigh Portland Cement Company of Allentown, Pennsylvania, was established in 1897 by Colonel Harry C. Trexler and Edward M. Young on land near Ormrod. These two men have been associated as President and Vice President of the Lehigh Portland Cement Company since its incorporation, and have seen the small works then established expand to sixteen plants with an annual capacity of 16,000,000 barrels of cement, the output of works situated in all parts of the United States from Pennsylvania to the state of Washington. In the cooperation of these two men, courage and business ability joined hands, and with Charles Matcham, formerly of the Whittaker Company, as superintendent, and his father-in-law, Mr. Ormrod, as wise counsellor, Trexler and Young laid the foundation of what has become one of the greatest organizations of its kind in the country. Since that time other mills have been established in Pennsylvania by the Lehigh Portland Cement Company, which now has one mill at West Coplay, three at Ormrod, and a very large mill at Fogelsville.

It was not long before an attempt to manufacture portland cement from rock took place in New York. Manufacturers there encountered the same difficulties experienced by the Pennsylvania cement makers.

The founder and first president of the Glens Falls Portland Cement Company, Glens Falls, New York, was Captain W. W. Maclay, assistant engineer of the New York Department of Docks, who, as stated by Robert S. Sinclair in a previous chapter, supervised the department tests of cement and did more than any other individual to raise the standard of the product.

The Glens Falls Portland Cement Company, which was organized in 1893 with a capital of $48,000, estimated as sufficient to erect a plant capable of producing a hundred barrels of cement a day, undertook to manufacture cement, but without results, and in 1894 the capital was increased and two Schoefer kilns were erected with machinery to prepare the materials and reduce the clinker. How the company finally mastered the problems of successful manufacture is described elsewhere in detail by George F. Bayle, now president of the Glens Falls Company.

In the chapter on "Natural Cement" the founding and operation of the Howes Cave Association was described by F. W. Kelley, President of the Helderberg Cement Company, successor of the Howes Cave Association. It was stated that Charles H. Ramsey, who operated the Howes Cave Association plant, became interested in portland cement about 1884. Mr. Kelley contributed the following additional facts:

For years hard gray limestone had been taken from the cliffs at this place for building purposes. The same material had been manufactured into lime in kilns operated by the Howes Cave Lime & Cement Company, and had also been crushed and shipped as crushed stone. Howes Cave, a long narrow cavern eroded by water action in the hard limestone formation lying over and considerably above the water line, contained large deposits of very finely divided and highly silicious clay. It was from these materials Mr. Ramsey sought to make portland cement. His efforts continued through the eighties and until the experimental plant was built in 1898.

Mr. Ramsey first sought to make portland cement from marl deposits found in local bogs, the marl being combined with cave clay, and later by combining the finely-pulverized limestone with the clay. Prof. Schaefer, of Cornell, made a number of tests for Mr. Ramsey, and George Brown, a Scotchman who died about a year later, spent six months at Howes Cave in 1894, taking samples of marl and clay from fields and from the cave in an endeavor to burn clinker. Melvin Herron, foreman in the natural cement plant, carried on experiments for Mr. Ramsey in 1891-94, and later Prof. R. C. Carpenter assisted in the final experiments which led to the establishment of the present plant.

Mr. Ramsey built a vertical kiln of fire brick about 2 feet inside diameter, 5 feet outside diameter, and about 6 feet high, for use in his experiments about 1895-96. The hard limestone was sometimes pulverized by hand and sometimes in a pan mill about 3 feet in diameter. This pan mill also ground the samples of cement from the clinker which was obtained, and strength and setting tests of the product were then made in the testing laboratory of the natural cement plant. At the time, there was no chemist attached to this laboratory although Mr. Ramsey possessed considerable knowledge of the chemistry of cement. The raw material used in this experimental kiln was wet sufficiently to be made into the form of balls, and when dried these were placed in the kiln with alternate layers of coke. Compressed air from the line which supplied the drills in the natural cement mine was used to give the necessary temperature after the fuel in the kiln had been well started.

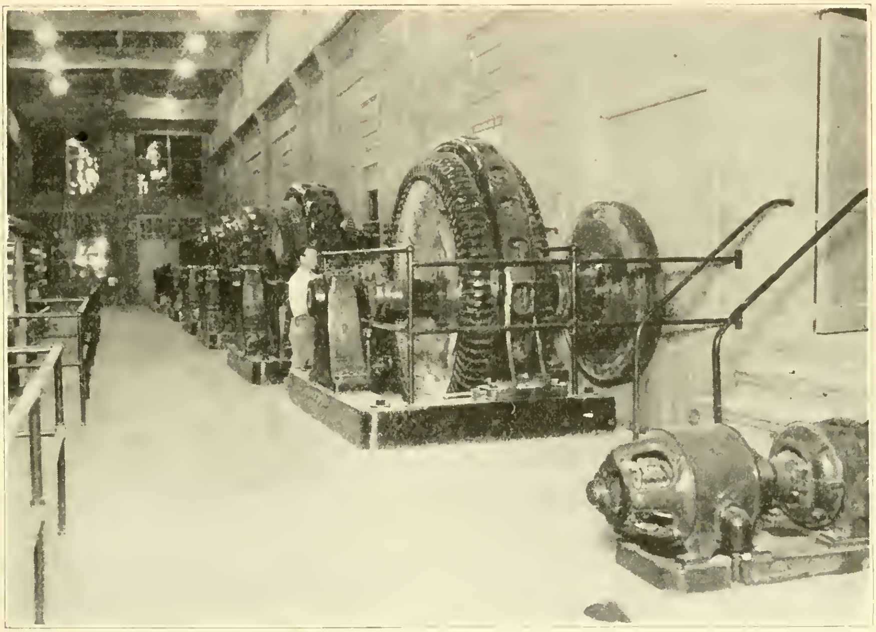
Having demonstrated what could be made from the raw materials at hand, Mr. Ramsey secured sufficient capital to build a small experimental plant, including two 5½-foot by 50-foot Mosser kilns, a 4-foot by 40-foot Mosser drier, a small Farrel jaw crusher, a Bonnet ball mill and Bonnet tube mill, three thirty-inch Griffin mills, and a No. 12 Smidth tube mill. The dry process was tried for a time with bad results, so the wet process was soon installed and continued to date. It was probably the first plant in this country to use the wet process with hard materials.

Oil was first used for kiln fuel, but pulverized coal was soon substituted. In studying the use of pulverized coal, Prof. Carpenter undertook experiments which resulted in a patent on coal burning in rotary boilers. These experiments took place between 1898 and about 1902.

In building the larger plant which followed the successful experimental plant in 1900, alternating current induction motors were used throughout to supply power, and it is believed that this plant was the first cement plant so equipped.

The corporate existence of the Helderberg Cement Company began in 1898, with T. H. Dumary as president. Mr. Dumary was succeeded by F. W. Kelley, who became associated with the company in 1900, having charge of the erection and development of the enlarged plant.

With the growing output of American portland cement and a constantly growing demand, it was idle to suppose that American ingenuity and American capital would permit the field of manufacturing to be confined to the Lehigh district, though that territory was the home of the first works and had materials of unique character and quality for cement



The cement industry ranks tenth among the country's industries in point of total power capacity. The motors shown here operate two-compartment grinding mills.

making. It was already known that the Millens, who were among the pioneers, had used clay and marl at South Bend, Indiana, and the Eagle Portland Cement Company, at Kalamazoo, Michigan, had, in a small way, used similar materials. Consequently, when attention was attracted to the portland cement industry for the reasons above stated, many minds were turned to these old methods and materials. This led to the discovery and the use of marl and clay in many other states, but principally in New York and Ohio. In South Dakota chalk was used. Mills were established to manufacture from marl and clay in these several states and processes were pretty much alike, though varying somewhat in detail. Later the Michigan field was developed.

Concerning the preparation of raw materials, the late S. B. Newberry, writing in 1892, said that while the English wet method gave a perfect mixture, it was quite out of the question in this country, owing to the labor required and the cost of drying out the very wet slurry obtained by the foreign method. In America the available materials were chiefly shell-marl and clay, both usually in a very wet condition. The semi-wet process was followed almost everywhere. It consisted in charging the materials in a wet state into large iron pans provided with heavy rolls or edge-runners. In these the plastic materials were thoroughly blended. The mixture as it issued from the pans was molded directly into bricks, dried and burned. In one or two cases the brick-making was omitted and the wet mixture spread out to dry on floors heated by steam pipes. It was then cut up into blocks with spades, as commonly the practice in England.

Michigan Marl Plants

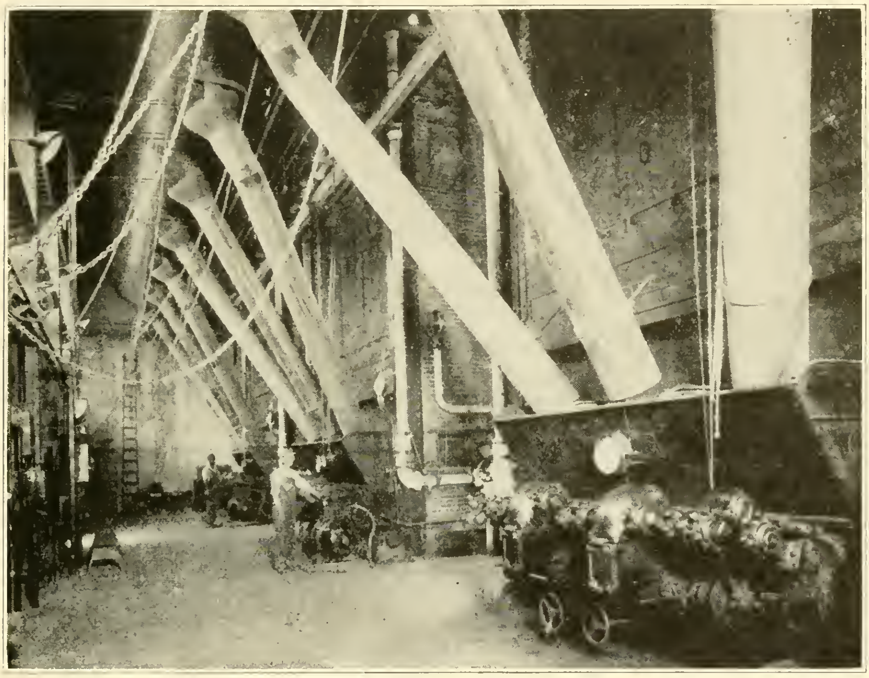
Michigan contained the most promising of all the marl fields in the United States. The history of the industry in that state begins with the pioneer Eagle plant, erected near Kalamazoo in 1885. This plant, whose brief existence has been mentioned, had no successors for a decade or more. Then came the Bronson Portland Cement Company, Bronson, incorporated in 1897, with J. F. Townsend as President. The following year the Peerless Portland Cement Company, Union City, and the Michigan Portland Cement Company, Coldwater, entered the field. L. M. Wing was President and H. S. Bossett, Vice President of the Michigan company, which, in 1902, became the Wolverine Portland Cement Company. The present Michigan Portland Cement Company, of Chelsea* was organized in 1911, the plant occupying the site of the Homer C. Millen works erected in 1903.

That there was an abundance of marl in Michigan had been known for many years, owing to its value as a fertilizer. The United States Geological Survey records of 1900 state that single beds of marl, 100 to 300 acres in area and with an average depth of 20 feet or more, are not rare. The marl is of two well-defined varieties, white and gray, although there is no sharp distinction between them. The purest deposits of white marl are described as being white and fine as wheat flour.

The development of the industry in Michigan was very rapid after the Bronson and Peerless companies began operation. In May, 1901, ten mills were producing cement and six others were in process of construction. The mills then running were provided with nineteen dome kilns and sixty-six rotary kilns, but not all of the latter were then in operation. The capital stock of all the Michigan portland cement companies then organized was about $25,000,000 and their estimated capacity approximately 8,600,000 barrels per year.

*Plant leased to State of Michigan in 1923; destroyed by fire 1924.

In writing of the Michigan industry in 1901, Israel C. Russell says, that "one of the pleasing conditions observed by the writer during his visits to the several portland cement factories now in operation or being built in Michigan is the manifest ready adaptability of their managers to new conditions, their readiness to adopt new and improved methods, their skill in modifying or reconstructing familiar types of machinery, and



The boiler room of a typical large cement plant helps to generate power equal to the needs of a city of 100,000 people.

their ability to originate and apply new ideas. This healthful condition of the industry, as well as the abundance of raw material, facilities for transportation, excellence of the finished product, increasing demand, etc., insures its permanence and ultimate success."

In the treatment of raw materials, processes were as described above, but an economy was introduced at the Bronson works. The material was prepared in the regular wet way, but the slurry, containing from 50 to 60 per cent of water was introduced directly into the kiln by a pump. This offered new possibilities in manufacture by the wet process through the substitution of rotary for vertical kilns. The Bronson process might be described as a combination of European and American practice. In the preparation of raw materials the methods were like the best European practice by the wet or humid way, while in burning, the distinctly American practice was represented by the use of the rotary kiln. The marl and clay were first mixed, ground wet, and then run into dosage tanks, where the composition of the slurry was determined.

At the Michigan Portland Cement Company's plant at Coldwater, erected in 1898, blue clay and marl were handled in the wet way and pumped into rotary kilns as slurry containing an average of 50 per cent of water. The kilns were 6 feet in diameter and 60 feet long. Crude petroleum was used as fuel.

In 1899, the Omega Portland Cement Company was incorporated and established a plant north of Jonesville, Michigan. Operations began in 1901 with Frank M. Stewart as President of the company, Dr. W. H. Sawyer, Vice President, Charles F. Wade, Secretary-Treasurer and General Manager, and George H. Sharp, General Superintendent. The company used the wet process, obtaining marl from its own bed immediately adjacent to the plant and clay from Millbury, Ohio. The plant was equipped with six kilns, 6 by 60 feet, and pulverized coal was used for fuel. Bonnot pulverizers were used in clinker grinding. The capacity of the plant was 1,000 to 1,250 barrels per day. The plant operated successfully up to about 1912, showing a profit each year. Around 1912 the price of cement became and continued so abnormally low that in 1914 the company was forced to cease operations.

Other Michigan portland cement companies were rapidly established. Among the earlier concerns were the Alpena, Newaygo and Peninsular Companies, also established in 1899; the Detroit, Egyptian, Elk Rapids, Great Northern, Standard, Three Rivers, Zenith and Wabash Companies, established in 1900; the Clare, Farwell, German, Lupton, Pyramid and Twentieth Century Companies, established in 1901, and the Hecla Company, incorporated in 1905.

Among the men prominently identified with the early history of the cement industry in Michigan, was John W. Boardman, father of John W. Boardman, Jr., Vice President of the Huron and Wyandotte Cement Companies. The elder Boardman was long and actively identified with the business life of the community and became associated with F. W. Cowham in the cement business. He was prominent in the organization and development of the Southern States Portland Cement Company, Atlanta and Rockmart, Georgia; the Western States Portland Cement Company, Independence, Kansas; the Northwestern Portland Cement Company, Mason City, Iowa; the Southwestern Portland Cement Company, Dallas, Texas, and the International Portland Cement Company at Durham, Ontario.

Marl Plants in New York

Marl was also found in New York, and portland cement mills were established at favorable sites. Here the Millens were again pioneers in actual manufacture, though not the first to experiment along this line. The earliest experiments with marl started only a few years after manufacture of portland cement from rock commenced in the Lehigh district. They were conducted in the Rosendale region in 1875-76 by C. F. Dunderdale, at East Kingston, Ulster County, the capital being furnished by Messrs. Cornell and Coykendall. The marl was brought by way of the Erie Canal from the Montezuma marshes and clay was obtained near the plant. The cement was of good quality but the materials and processes were too expensive to make the experiment a financial success.

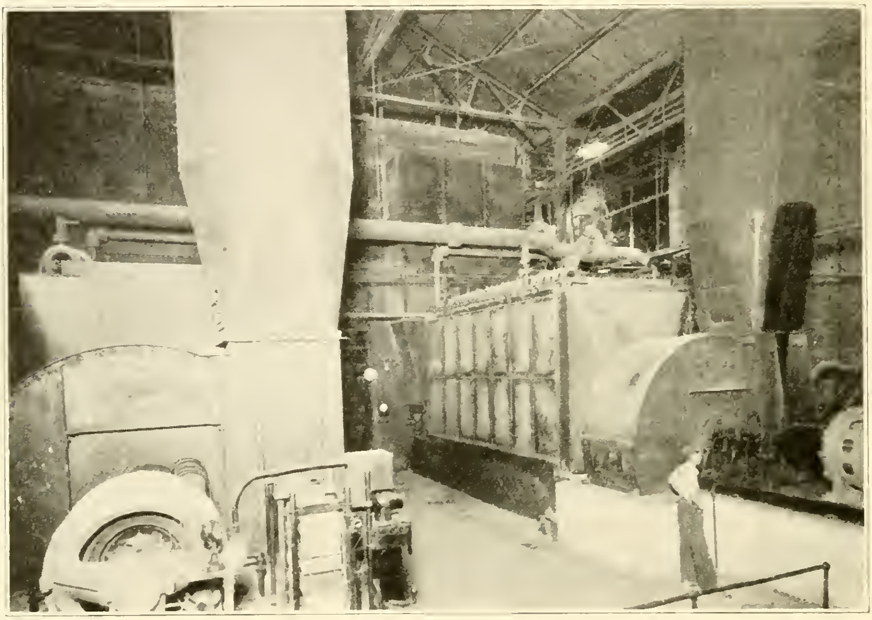
The Millens established the first marl plant at Warner, Onondaga County, in 1886, which they sold in 1890 to the Empire Portland Cement Company. This plant was built on one of the extensive marl deposits adjacent to the Erie Canal. The marl was immediately below the surface of the ground in a bed from 8 to 15 feet thick, underlaid with an abundance of clay. Equipment and methods were representative of some six or eight works subsequently engaged in the manufacture of portland cement from marl and clay by the semi-wet process. The Empire plant had 18 kilns of the regular intermittent dome type, these being 13 feet in diameter and 45 feet high. In 1893 rotary kilns were installed.

After selling their Warner plant to the Empire Company, T. Millen & Company erected a plant at Wayland, Steuben County, New York, at which cement was manufactured from marl. Production began in 1892. The works were destroyed by fire in 1893, but rebuilt the same year.

Among the men prominent in the industry in later years and who had interesting experiences in New York State at this period, was the late S. B. Newberry of Cleveland, President of the Sandusky Portland Cement Company. Shortly before his death he contributed the following:

> My interest in portland cement began about 1890 while teaching at Cornell University. My late brother-in-law, Frederick D. White, was financially interested in the Warner Cement Company, whose factory at Warner, ten miles west of Syracuse, New York, had been started under the direction of parties connected with the Solvay Process Company. At this plant marl and clay were mixed, dried and pulverized, and the mixture burned in rotary kilns 4 feet in diameter and 30 feet long. Much trouble was experienced in getting a sound product. The pats showed a pattern of cracks on the surface which led Mr. White to suggest, at a very blue meeting of the directors, that the cement be called "Alligator Brand." He afterwards suggested calling it the "Rooster Brand" because it would not set. At White's suggestion I was asked to go over from Cornell and look into the causes of the difficulty. I soon found that the trouble was due to imperfect burning and defective grinding of the raw materials. Following my suggestions these features of the process were improved and soon a sound product was obtained. By this time the financial affairs of the company were in such shape that an assignment was made and the concern went out of business.

In 1890 operations were commenced at Montezuma, New York, by the Duryee Portland Cement Company, of which George W. Duryee was Secretary. The company owned 1,700 acres of land underlaid by a deposit of marl and clay from 4 to 20 feet thick. The deposit lay below the level



An induced draft fan (left foreground) is used for drawing waste heat gases from the rotary kilns through waste heat boilers and economizers. More than forty cement plants in this country have installed this equipment.

of the Cayuga River and near its banks. The marl, containing about 50 per cent water, was drawn by a steam hoist up an incline into the second story of the works and above the upper end of a mixing machine into which the load was dumped without drying or other preliminary treatment. At the same time a weighed and ground portion of clay was added. The materials mixed as they gravitated toward the lower end of the machine, the entire process being practically continuous. The mixture passed through a stone mill which completed the mixing and ground any coarse materials. From the mill it was introduced directly by screw conveyor into a rotary kiln using oil as fuel. This kiln was sufficiently unique to be described somewhat in detail. It was 75 feet long, and opposite the lower end was a gas retort, or combustion chamber. The chamber was heated by a coal fire and vaporized the oil as it was sprayed into it. The air blast also passed into this chamber, coming from a rotary fan blower. It is claimed that this was the first American plant in which raw materials were fed without drying or briquetting directly into rotary kilns. The Montezuma works were destroyed by fire in 1893 and were not rebuilt.

Concerning the use of the rotary kiln in New York State, we find J. Gardner Sanderson writing on the subject of the original Navarro kiln in the Rosendale region to John S. Schantz of Milwaukee, under date of February 28, 1890. Speaking of this kiln at the Hudson River Cement Company's plant, which Coykendall owned, he makes the following statements:

> I wanted facilities for making practical tests of cement materials from New Jersey and other points, and with that in view entered into an arrangement with Mr. Coykendall to reconstruct the Ransome kiln, adapting it to our process, giving him the right to use the kiln for burning Rosendale cement. The result as to quantity and cost of burning Rosendale cement was so satisfactory that Mr. Coykendall had decided to put in two more of these kilns when an unforeseen difficulty appeared, and which I learned had been apparent to Navarro's people. The cement rock at East Kingston is seamed with pure carbonate of lime, varying in thickness up to an inch or more. In the revolving kiln process this lime is thoroughly mixed with the cement, and it would be impracticable to separate it. In the old lump burning process the rock separates in burning at the seams, most of the lime crumbling into powder, and in drawing, can to a great extent be separated. The Hudson River Cement Company has quarries and kilns near Rosendale which furnish the better quality of dark cement. They are erecting two of the old-fashioned coal-burning kilns at East Kingston in which to burn the light rock, intending to bring dark rock from their Rosendale works to mix with it. The revolving kiln remains and will be employed if they have suitable rock to burn in it. The thorough mixing during the process of burning of the materials fed into the cylinder, is a valuable feature of the revolving kiln process for portland cement and for cement made from a good but slightly variable natural rock.

Additional interest is lent to this from the fact that Coykendall, a number of years earlier, as already described, had started to make portland cement under the Dunderdale patent but was unsuccessful.

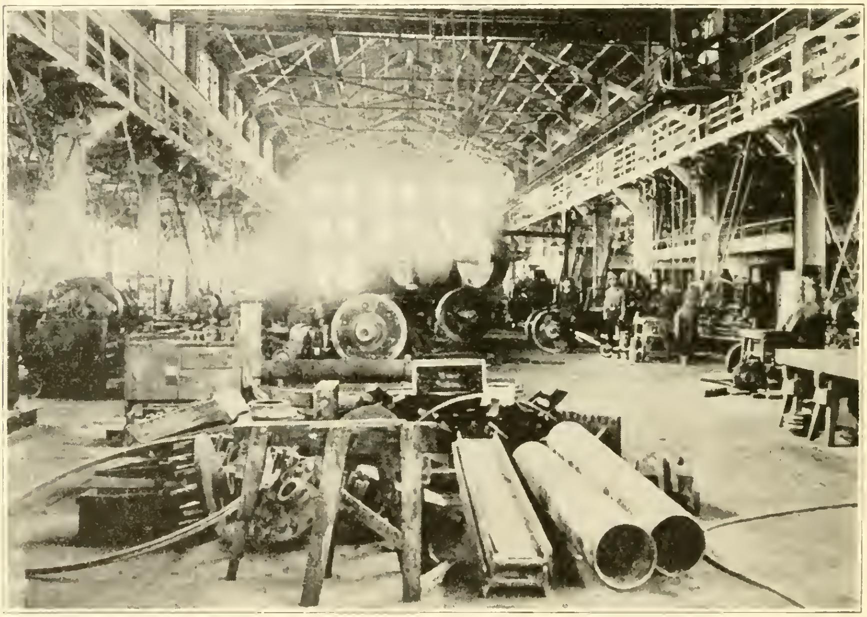
Another marl and clay plant was that of the American Cement Company, two miles east of Jordan, in Onondaga County, erected in 1892. Raw material was obtained from a marsh near the works, and the company also owned a bed of marl near Jordan station. At this plant a wire ropeway transported the raw materials to the mill. The clay was dried and ground separately and then mixed with marl in the pug mills. The slurry was spread over a drying floor and cut into bricks. The bricks were loaded on platform cars, dried in tunnels, heated by coal fires, and fed to twelve kilns of the dome type, coke being used as fuel.

Among the marl-using plants built about 1904 was that of the Iroquois Portland Cement Company, near Caledonia, Livingston County; and in 1896 the Wayland Portland Cement Company built a marl-using plant at Wayland, Steuben County.

In writing of these plants in 1905, Edwin C. Eckel says: "Until within the last few years the typical New York plant has been one using marl and clay, mixing wet, briquetting, and drying and burning in dome kilns."

Ohio Marl Plants

In Ohio the Buckeye Portland Cement Company established a plant near Bellefontaine, in 1889, the promoters of this enterprise being G. W. Bartholomew and associates. They had a double Dietsch (German) kiln. Mr. Bartholomew was previously connected with the San Antonio Portland Cement plant in Texas, and was familiar with foreign practice. The Buckeye Company had an abundance of soft white marl near blue clay. Later, four continuous shaft kilns, similar to the Candlot type, were built on designs prepared by the company. The raw material was introduced in



The machine shop is a vitally important part of any modern cement plant because of the necessity of keeping the equipment in perfect condition all the time.

the kiln in the form of bricks, but later a rotary kiln was introduced and proved so satisfactory that plans were made for the installation of others to escape the brick-making, drying, etc. This company also experimented with powdered coal for rotary kilns, which was reported to be satisfactory. Crude petroleum was the first fuel used.

Even earlier than the plant described above was a very small works at Columbus, Ohio, operated under the name of the Murphy Cement Company. It consisted of a single iron kiln lined with fire brick and a lot of junk in the shape of crushing and grinding machinery. The plant used limestone and clay and had a capacity of 30 to 40 barrels a day. It was in existence only a short time.

S. B. Newberry went to Ohio where he was interested in the establishment of a marl plant. Concerning this plant he wrote as follows:

My experience in New York led me to believe in the possibilities of the portland cement industry in this country, and with Frederick D. White I explored reported marl deposits in northern Ohio, finally locating large deposits of white marl in the neighborhood of Sandusky. With the help of my late brother, Arthur St. John Newberry, of Cleveland, a small company was formed in 1892 and a plant erected at Bay Bridge, near Sandusky, which turned out its first product in August, 1893. In the course of our explorations, Mr. White and I visited the Buckeye cement plant near Bellefontaine, Ohio, where cement was made in vertical kilns from marl and clay. In order to conceal the purpose of our inspection, Mr. White asked the superintendent if the product they made was a liquid cement like Le Page's. This showed such a depth of ignorance that the superintendent had no hesitation in admitting us.

Chalk Plants

Here and there companies were formed to manufacture portland cement from chalk and clay.

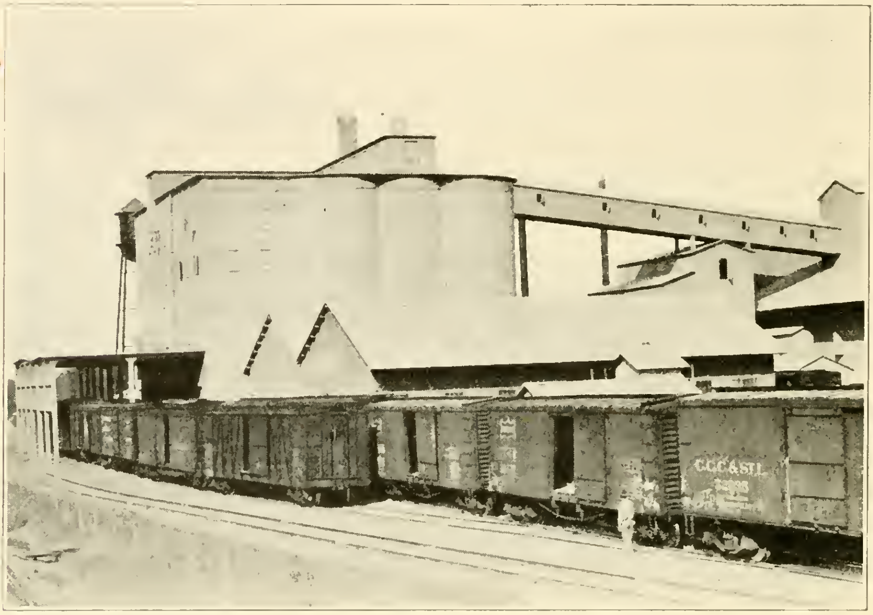
On the north side of the Missouri River, four miles west of Yankton, South Dakota, is an outcropping of chalk. Here, in 1889-90, a portland cement plant was erected by the Western Portland Cement Company, of which W. Plankinton, of Milwaukee, was President; D. J. Whittemore, formerly President of the American Society of Civil Engineers, Vice President, and John Johnson, cashier of the Wisconsin Marine & Fire Insurance Company's bank, Secretary and Treasurer. The plant was designed by Robert Yates, who had studied works in England and Germany, and it was patterned along the lines of plants on the Thames and Medway, England. Kilns were of the Johnson type, of which there were six with drying chambers and central chimney. A homogeneous mixture of chalk and clay was obtained by conveying all material in continuous courses through three sets of bassins dosseurs. Later this plant was sold to S. B. Newberry, of the Sandusky Portland Cement Company, who dismantled it as scrap.

In 1895 a chalk plant was established at Whitecliffs Landing, on Little River, Arkansas. Litigation between those financially interested arose, resulting in the closing of the plant in 1900. Operations were resumed in 1901, with the name of the company changed to the Southwestern Portland Cement Company. The works contained the most improved machinery made at the time. Four continuous dome kilns were used to burn the bricks, which were made of chalk and clay.

Until 1900 the nearest cement plant corresponding to the Whitecliffs works was at San Antonio, Texas. Then a plant was erected at Dallas, Texas, where chalk from the southern extension of the Whitecliffs formation was used.

Another early chalk plant was that of the old Alabama Portland Cement Company, organized in 1901, now the Gulf States Portland Cement

Company. In Brown's "Directory of American Cement Industries," published in that year by Charles Carroll Brown, it is stated that the Alabama Portland Cement Company, whose works were then under construction, had a capitalization of $500,000 and a capacity of 1,000 barrels per day.



The modern cement storage and packing-house provides enough room for thousands of tons of cement and is equipped with the latest labor-saving machinery.

Thomas C. Cairns was General Manager. In the 1904 edition of the same publication appear the names of J. Topham Richardson, President; Bristow Bovill, J. L. Spoor and C. A. W. Moon, Directors, all of London, England. Mr. Cairns had become a Director in the meantime, and F. W. Smyth had become General Manager. The main office of the company was at Demopolis, Alabama, and the works at Spocari. The capacity in the 1904 directory was given as 500 barrels per day.

George P. Dieckmann, Vice President and General Manager of the Gulf States Portland Cement Company, relates the following interesting incidents connected with the original works:

The Alabama Portland Cement Company manufactured the well-known "Red Diamond" brand. The company was organized in 1901 but the plant was shut down from 1908 to 1919, during which period several attempts were made to renew operations. The company was organized by English capital. The name Spocari, at which place the plant was located, originated in the following manner: Mr. Spookes (probably Spoor), Mr. Cairns and Mr. Richardson, in seeking for a name, selected the first two letters of each of their names which made "Spo-ca-ri." According to darkey legend, however, Spocari was the Greek for "cement." It may be of interest to state that the Gulf States Portland Cement Company owns its coal mine, is located on a navigable river and is in position not only to ship coal by river but also cement. I believe it is the only plant in the United States having these advantages and the only one having no quarry.

The calcareous material used for the manufacture of cement is obtained by a so-called excavator, which is a motor-driven apparatus, and works on the principle of a shaving machine. It shaves off a 50-foot face, and from the cutting knife drops these shavings into the buckets following the cutting knives. In other words, it is an elevator provided with cutting knives and driven with a motor delivering the stone without the use of crushing machinery. This apparatus can be operated by two men.

We find in other sections of the country listed as engaged in the manufacture of portland cement as early as 1901, the Alma Portland Cement Company, Wellston, Ohio, B. B. Lathbury, President; Buck Horton Portland Cement Company, with works at Manheim, West Virginia, John F. Storer, President; Castalia Portland Cement Company, Castalia, Ohio, W. J. Prentice, President; Chicago Portland Cement Company, Chicago, Norman D. Fraser, President; Colorado Portland Cement Company, Portland, Colorado, W. H. James, President; Diamond Portland Cement Company, Cleveland, Ohio, Z. W. Davis, President; German-American Portland Cement Company, Chicago, Carl Prussing, Germany, President and Fritz Worm, Chicago, Secretary; Iola Portland Cement Company, Iola, Kansas, Sheldon H. Bassett, President; Marquette Portland Cement Company, La Salle, Illinois, of which the Dickinson Cement Company, Chicago, were sales agents; Maryland Cement Company, Baltimore, Frank H. Sloan, President; Pembina Portland Cement Company, Grand Forks, North Dakota, E. J. Babcock, President; Portland Cement Company of Utah, Salt Lake City, Frank Richardson, London, England, President and Thomas C. Cairns, General Manager; Texas Portland Cement Company, Dallas, Texas, Leon Blum, President; Virginia Portland Cement Company, with works at Craigsville, Virginia, W. R. Warren, President.

CHAPTER VIII

DEVELOPMENT OF THE INDUSTRY

Some Figures on Early American Production

From what the reader has thus far learned of the early days of the cement industry in America, has no doubt come a realization that its pioneers had difficulties of every type to encounter, financial, mechanical and scientific. At the end of the first decade of their work, 1870 to 1879, the total output of American portland cement as shown by the United States Geological Survey records had reached only 82,000 barrels, valued at $246,000, while importations, as shown by official records, amounted to 92,000 barrels for 1878, the earliest figures recorded, and 106,000 barrels in 1879.

The next twenty years were full of interesting developments in the field, new figures appearing in the foreground and new methods finding their way into the art.

Comparison of Growth of American Industry with that in Germany

In order to realize, in a way, how the production and growth of the American industry followed that of Germany, and how similar were the difficulties encountered in both countries, one need but refer to the papers of Max Gary, the distinguished German expert, and Henry Faija, M. Inst. C. E., read at the Engineering Congress of the United States during the Columbian Exhibition, Chicago, 1893, and the paper by Robert W. Lesley, Assoc. Am. Soc. C. E., read at the International Engineering Congress in St. Louis in 1904. Gary's paper showed that the German Portland Cement Manufacturers' Association started in 1877, and represented at that time 29 factories, with an output of 2,400,000 barrels, while by 1903 the membership of the Association comprised 94 works, with an estimated production of 22,000,000 barrels. Both Gary's and Faija's papers describe fully the methods of manufacture used at that time in Germany and England and give details of processes, machinery, etc. In the description of manufacture in both papers much stress is laid upon the wet slurry, its proper drying, the advantage of wet grinding, and the method of handling the material after it had been dried by evaporation and decantation. Much is said of the advantages of the wet mixture; of the large area required for drying, the use of new types of drying tunnels attached to the old-style dome or bottle kilns; of drying floors utilizing the heat that formerly went up the stack of the old dome kilns; and of other methods for economical working of the wet mixture in the intermittent kilns then used.

There are also descriptions of the introduction and use of the Schoefer continuous kiln, the Dietsch continuous kiln, and the Hoffman-Ring kiln..

Some of the Early Mechanical Practices

So far as machinery was concerned there was little said, because in general the raw material was ground wet in large revolving vats with chasers, and the finished material on French buhr stones. European practice had been very largely based upon precedent. The first mills having been situated along rivers where wet chalks and clay were easily obtainable, the machinery was arranged for that purpose, and as water was abundant the precedents for mill power were water power, and the line shaft for driving mills was usually connected with a water wheel, and the mills were in turn connected with the line shaft by bevel or other forms of cog gearing. Thus the grinding machinery in many of the European works was situated in the second story of the building, losing considerable space, and the well-known forms of millstones used for grinding varied in size from three to six feet in diameter. As time went on, mills in many of the more advanced European plants were driven directly by belts from line shafts, which took the place of the old-fashioned cog gearing, and in several of them the first type of tube mill was used, the apparatus, consisting of a revolving cylinder containing a large number of Iceland pebbles.

In his paper of 1904, Lesley describes visits he made to the principal portland cement works in Germany, France and England, and with the information furnished by the contributions of Faija and Gary, he secured a fair insight into the status of the industry at the period mentioned. In describing this he says:

> The first interesting fact is that up to 1896 precedents in burning and grinding governed cement manufacture, and few radical changes were introduced. This seemed to apply more extensively to this than to any other industry then known to the writer.
>
> The milling or grinding of materials, as a rule, had always been done by water power. Water power had fixed the mode of grinding by millstones operated by water-wheels with bevel or cog gearing of one kind or another, between the power and the running parts. This method seemed to obtain in most of the mills in Europe, even though steam power had been adopted, and it was perfectly practicable to run millstones or other forms of grinding machinery by direct belting and shafting.
>
> Experience had shown that wet materials could be mixed intimately in a liquid or semi-liquid condition, that the sun and air would dry the paste thus made into a mass which could be easily broken up, and which, after drying upon heating floors, could be burned in dome kilns, and that the clinker thus produced, when properly selected, was easily ground, producing excellent results. All these traditions as to methods of manufacture were interwoven with the reputation which old mills—more especially in England

—manufacturing well-known brands of cement, had won for their product, and very few establishments in Europe in the early nineties had made much progress toward change in methods.

The same traditions governed the first manufacture of American portland cement. It was difficult to induce engineers and large investors to trust important construction to cements made of new and untried materials in a new country. It was even more difficult to induce them to consider any portland cement which had been made under methods showing any change from the well-known processes which had established the reputation of portland cement as a building material all over the world.

The early manufacturer in the United States had difficulty enough in persuading architects and engineers to use this material at all, and it was only upon the statement that, in chemical constitution, its ingredients were similar to those of the well-known portland cement of Europe, and that it was made by similar processes, that he was able to get a hearing. There was difficulty enough to achieve this result without securing the consent of the engineer to use material made, not only from new ingredients, but also by new processes.

American portland cement, in the nineties, had to show its right to exist as an engineering material, and its right to be trusted with the duty of carrying the strains which are now expected of it. The well-known and successfully-made brands of England and Germany had carried the burdens imposed, and had carried them well, and the market was at their command. During the past ten years, however, American portland cement has been steadily making its commercial and scientific reputation, and, these facts having been established, it became possible to adopt new methods and new machinery in almost all branches of the industry.

Owing to peculiar conditions as to labor, fuel, etc., American manufacturers found themselves handicapped, in the early days, when manufacturing under the European processes, and it became a part of their struggle for existence to challenge the old process, and to develop new ones, under which they could expand, not only in the United States, but in all the countries of the world.

From the foregoing the lack of mechanical progress in the early American plants can well be understood, and it was not until the period between 1880 and 1900, when American portland cement began to establish its foothold, that American manufacturers started in on the remarkable career of mill and kiln developments which have signalized the growth of the industry in this country.

The output of portland cement during this time was 150,000 barrels in 1885; 335,500 barrels in 1890; 990,324 barrels in 1895, and 8,482,020 barrels in 1900. With this growing demand for the American product and the gradual reduction of imports, American manufacturers were alive to every promising method of improving their manufacturing processes.

Lehigh District, Pennsylvania, First Important Manufacturing Center

As a historical fact, figures show that the real, early growth was in the Lehigh district in Pennsylvania. This was largely due to the remarkable raw material found in that field. In other words, the making of portland cement was largely an admixture of clay and chalk, limestone and clay, shales and limestone, and other similar materials, but in practically every case, except in Boulogne, France, the product was the result of the combination of two or more raw materials. In the Lehigh district, which in the early days embraced the large strip of territory running from the Delaware River near Martins' Creek and extending through Bath, Bangor, Nazareth, Northampton, Coplay, Whitehall, Egypt, and Ormrod,

Twenty years ago each filled sack was tied and weighed by hand, a tedious and inefficient process.

there existed a wonderful deposit of argillaceous limestone, such as has not been found in like extent and quality in any other part of the world. This deposit, of almost unknown depth, was sedimentary material, and occupied geologically a position between the slates and limestone formations. It partook, in a general way, of both materials, resulting in the combination of limestone and argillaceous material already described. Owing to their sedimentary character, they were, as a general rule, of moderate hardness, as contrasted with crystalline limestone and in many cases partook of the characteristics of slate. Thus, they were easy to grind and to handle, and in the early days of the industry, when tensile strength standards fixed by engineers were not too high, many of these rocks were almost adapted to portland cement manufacture in their original state without the addition of limestone. Even today in some of the choice locations materials are found that contain practically all the ingredients properly proportioned for portland cement.

Thus it was that once manufacture had started in the Lehigh district, a large body of workmen and managers familiar with the material were soon found, and the district manufactured, from 1890 to 1896, about 60 per cent of the total output of the United States; from 1897 to 1900 inclusive, slightly more than 70 per cent, gradually declining thereafter until in 1923 it produced but 25.9 per cent of the total output in the country.

Another feature of this material was that it was dry and did not require for its handling the large bodies of water needed in the European wet process where wet materials were the ingredients. The rocks were laminated water-lime rocks, and by reason of their chemical composition, as well as their structural character, were specially adapted to the manufacture of portland cement. Consequently, in Saylor's day, it took much less time to handle and dry this material than it did with the over-saturated European slurry; and Saylor found that by adding burned natural cement rock of quick setting type to his paste he was able to handle his brick on his drying floors at very early periods.

Along in 1883 and 1884, under the DeSmedt process, great economies were being made with this same raw material at the works of the American Improved Cements Company.

These American methods, however, at that period were easily explainable to the average engineer as the analysis of the raw mix was identical with the raw mix used in Europe, and therefore there was no material difference in the methods of manufacture of the American product as contradistinguished from that of Europe, the rest of the steps being practically identical with those pursued abroad.

During this twenty-year period, however, American ingenuity was constantly thinking in new terms in the manufacture of portland cement, and the period marks the development of two great lines of progress, each of which was in itself a master key.

High Labor Costs Met by American Ingenuity

The American manufacturer was confronted from the earliest days of the industry with high-priced labor, and economy in this direction was one requisite of success. Two fields for advanced thought offered themselves: On the one hand, the necessity for some improved form of kiln whereby, with costly American labor and cheap American coal, the process of clinkering could be accomplished at a lower cost in this country than in Europe. The other, the bringing forth of new machinery for crushing and grinding the raw rock, which in American practice had taken the place of the softer material used in Europe. Upon these two lines of development rests the whole American industry today, and a few words as to this are most pertinent in dealing with this period of the business.

The light iron crushers of coffee-mill type were constantly breaking down, and cost money in time and repairs, while the buhr stones used for grinding both raw material and the finished product were the source of unceasing expense for picking and dressing. From this necessity grew the introduction of the Gates crusher, the first of these great machines in operation in the industry being used at the works of the American Improved Cements Company, at Egypt, Pennsylvania. While in some mills the Sturtevant, Frisbie and some similar forms of iron and steel grinding apparatus had been introduced to take the place of mill-stones, it was not until 1887 that the advent of the Griffin mill marked a new era in cement mill grinding machinery.

In reference to this particular mill, which is used, together with the Gates crusher, for the purpose of illustrating standard types of iron and steel crushing and grinding machinery which marked the development of the American industry in the period of its growth between 1880 and 1900, it was this development in the substitution of heavy, high-power steel machinery that was of the greatest importance.

The names Griffin and Gates will always be identified with the industry because of the important mechanical devices described.

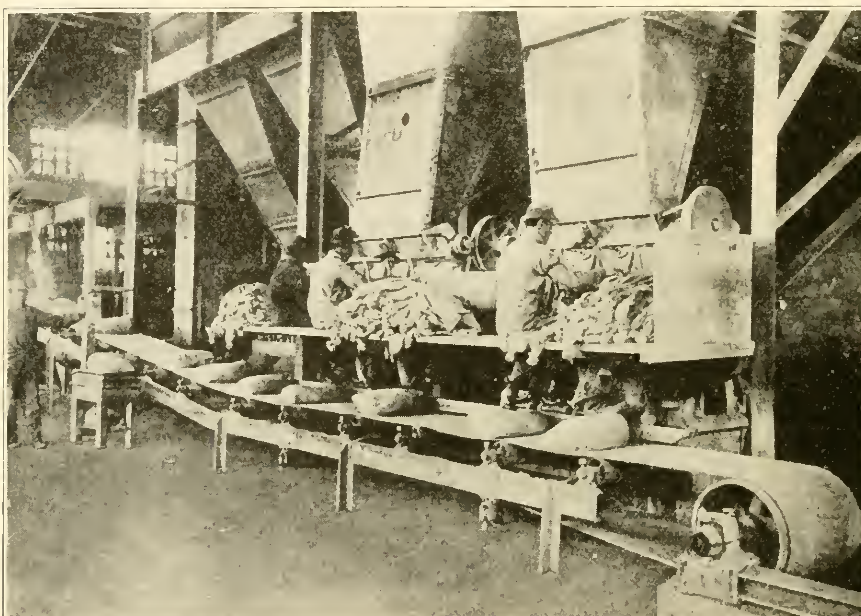
Edwin C. Griffin died on December 10, 1911, in Boston. Mr. Griffin, who was a native of Ontario, Canada, was born January 29, 1848. Owing to the importance of his inventions, chief among them the Griffin mill, he was as well known in the cement industry, both at home and abroad, as any of the leading manufacturers of cement. Mr. Griffin was a son of James K. Griffin, inventor of the original single roll mill that bore his name.

Ralph I. Gates was one of Chicago's pioneer citizens as well as an early manufacturer of cement. He died in Chicago on January 16, 1907, at the age of 67 years. He was a native of that city, and a son of Philetus W. Gates, one of the first manufacturers in what was then called the Far West. For many years he was treasurer of the Eagle Works Manufacturing Company, which was succeeded by the Gates Iron Works and Fraser & Chalmers. He severed his connection with the Gates Iron Works Company in 1887 to become secretary-treasurer of the Anglo-American Portland Cement Company, later merged into the Chicago Portland Cement Company.

CHAPTER IX

THE MECHANICAL SIDE OF THE INDUSTRY

This chapter is largely given over to recounting the development of the mechanical side of the portland cement industry in this country. Here American resourcefulness and inventive genius stand out at every



Modern cement packing machinery is the last word in mechanical ingenuity. Each sack, when automatically filled from a spout, receives exactly 94 pounds (one cubic foot) of cement. Then the flow stops, the filled and tied sack is shot onto a belt conveyor, loaded onto hand trucks, and wheeled to waiting freight cars or motor trucks.

turn. However, the mechanical side of the industry in this country was not developed without those difficulties which attend pioneer efforts to replace the old by the new.

The initial use of mechanical appliances in the cement industry is at the source of the raw material, and may be placed under the head of excavation. There are three general methods of excavating raw materials: quarrying, dredging and mining. The materials extracted by these methods are limestone, cement rock, marl, clay and slate or shale. It has been estimated that over 30,000,000 tons of raw material were handled in

1913 to produce 92,000,000 barrels of cement, and that at this time about 85 per cent of all material used was quarried.

The excavation of limestone, cement rock and shale is usually a quarrying operation, and with few exceptions a hillside proposition. In rare instances it is a mining operation.

The successive steps in quarrying are stripping, drilling and blasting, excavating and transporting. Sometimes difficult problems occur in the drilling and blasting operations, owing to variations in the hardness of material or its structural formation.

Clay is dug from pits, and marl, in most cases, is dredged. At some sources of supply, marl is extracted with pumps. When marl is under water, steam dredges mounted on barges bring up the raw material. Where the deposit is saturated, it is often the practice to drain the water into channels upon which float the barges carrying the dredges. The material is conveyed by barges to a wharf and thence to the mill.

The machinery used in stripping and excavating raw material from quarries, clay pits and marl beds includes shovels, scrapers, graders, steam shovels, scraper bucket excavators, locomotive cranes and floating dipper dredges.

Transportation methods used to convey the raw materials to the mill include gravity, elevator, hauling, serial conveying and pumping systems; and the machinery and appliances include wheelbarrows, wagons, dump cars in trains, aerial tramways or cableways and marl pumps.

As preliminary crushing and grinding of the raw material and the final grinding take place before and after burning, the kiln will be described first.

The Kiln the Most Important Mechanical Unit

The mill side of the portland cement industry involves the use of mechanical devices of many kinds, but the most important unit is the kiln, the receptacle in which raw materials are burned. The capacity of a plant is usually determined by the number of kilns in use. The kiln was a legacy from the old lime burners to the natural cement makers and they in turn passed it on to the makers of portland cement. The kiln has ever been a source of inspiration to inventors, resulting in innumerable patents or changes in types or parts thereof. From the first primitive furnace of the lime burners, cement kilns improved until there was finally evolved the great rotary cylinders which virtually revolutionized the business of making portland cement in so far as economy of operation and increased volume of production are concerned.

In the manufacture of natural cement, which was made from raw rock, the material was simply placed in the vertical kiln with alternate layers of low-grade coal and burned without previous manipulation or treatment.

Wet, Semi-Wet and Dry Processes Described

Portland cement, which is made in some cases from rock and in others from marl and clay or limestone and clay, required considerable preparation of raw materials before burning. It was manufactured by three

A fine example of concrete building construction in cement plant office and laboratory.

methods, known as the wet method, semi-wet method, and dry method, all of them mechanical until the stage of burning was reached, and all intended to bring about thorough combination of the different ingredients of the raw material.

The wet method was usually employed where the raw materials consisted of chalk and clay. During the crushing or grinding operation water was used to bring about an intimate mixture. The mixture was then run into settling "backs," some of them covering acres of ground. There evaporation and decantation took place, thus disposing of a large amount of water. After further drying in the vicinity of the kiln, the mixture was placed in the kiln with alternate layers of fuel and burned.

In the semi-wet method, a French invention, the mixture, after grinding and wetting, was passed between horizontal mills in semi-plastic state and then placed on the drying floors and later burned as described in the wet method. In the wet and semi-wet processes, the materials in the wet state were called "slurry"; and where the wet method was used months might elapse before the material was dry enough to go into the kiln.

In the third, or dry method, the raw material as treated in the early days of the portland cement industry was first reduced in the dry state by crushing and grinding machinery and then given sufficient water to transform it into a plastic mass which was molded into bricks. The bricks were dried and then burned as in the two methods previously described. But upon the advent of the rotary kiln the dry process became literally dry, no water being used. The materials are now crushed and ground to a fine powder, which is fed directly into the kiln and burned.

Before the days of the rotary kiln one difficulty experienced by American manufacturers was due to lack of binding quality in the raw material after being placed in the kiln. The American materials, not being as plastic as the European chalks and clays, the lower contents of the kiln would settle under the weight of the upper charge. At Saylor's plant, quick setting natural cement was used as a binder for the brick and another ingenious method devised by the American Cement Company has been described.

Three types of kilns have been used in the manufacture of portland cement in the United States, the intermittent vertical dome kiln, the continuous vertical kiln and the rotary kiln. American manufacturers used the old vertical continuous kilns for making natural cement and, later, in the manufacture of portland cement.

The Dome Kiln

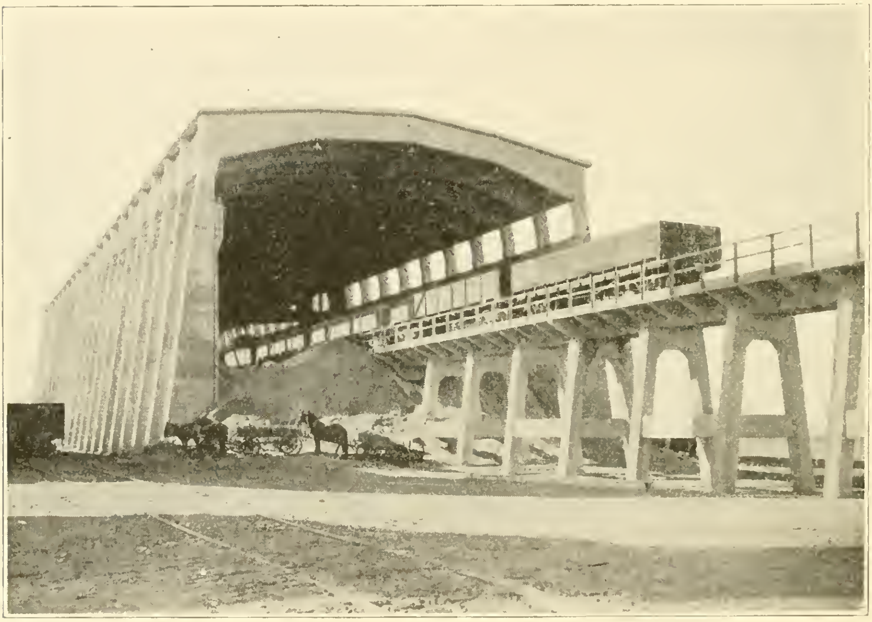
The upright dome kiln, the first type used in America, was not operated continuously, each burning requiring a fresh charge, hence the name intermittent kiln. It was also called the bottle kiln, owing to its shape. Having been burned with alternate layers of coke, the material was extracted from the bottom of the kiln and sorted for overburned and underburned clinker. The first portland cement made from the Lehigh rocks by Saylor was burned in a dome kiln, and also the marl cement of the Millens at South Bend.

The uneconomic features of the dome kiln soon became apparent. The labor costs involved in the charging of the kiln were high and the output was limited.

A great deal of heat escaped from the top of the kiln, and as drying of brick before burning was essential, it was logical that the utilization of waste heat for this purpose should be suggested to the inventor. I. C. Johnson, of England, invented a kiln from which the heat ascended and entered one end of a long horizontal chamber built above the kiln. Brick were placed there to dry while those previously dried were being burned in the kiln. The Western Portland Cement Company, of Yankton, South Dakota, installed kilns of this type.

The Continuous Kiln

The disadvantages of the intermittent kiln led to further improvements, and finally there was invented in Germany the continuous kiln, charging being carried on continuously at the top and the clinker drawn from the bottom. These kilns were several stories in height and continuous charging made for economy in the use of fuel. The two important kilns of this type used in America were the Schoefer and Dietsch kilns. The Dietsch kiln had three chambers for heating, burning and cooling



Modern cement plants contain many examples of the adaptability of concrete to industrial construction.

the material. The dry slurry passed into the heating chamber and from there was raked into the combustion chamber. The removal of clinker from the bottom permitted the slurry to drop into the heating chamber where it was gradually subjected to high temperature preparatory to going into the combustion chamber. The Schoefer kiln was a modification of the Dietsch kiln, and worked upon the same principle.

The Rotary Kiln

When kilns of the foregoing types were first introduced in the United States in an experimental way, demand for better methods of burning cement was imperative, and concurrent with the introduction of the kilns described came that great invention, the rotary kiln, then in the initial stage of development. The rotary kiln, which finally supplanted the more primitive types in all important cement works, consists of a long cylinder of sheet steel lined with firebrick. These kilns had been made in varying lengths, but a prevalent dimension for some years was 60 feet long by 6 feet in diameter. The kiln, which rests at a slight incline, revolves on tires resting on trunnions. The cement-making material is fed into the upper end, which projects into a brick flue surmounted by a stack. Where portland cement is made from rock, the material is reduced to a fine powder before it enters the kiln, where it is burned at temperatures of 2500 degrees to 3000 degrees F., which transforms it into "clinker." The clinker is ground to the fine powder known as portland cement. In the case of marl, the raw material in the form of slurry is pumped from vats into the kiln.

The First American Rotary Kiln

How the first rotary kiln in America was installed is an interesting story. The following account is contributed by Alfonso de Navarro, Vice President of the Atlas Portland Cement Company, whose father, Jose F. de Navarro, was responsible for the introduction of the rotary kiln in the United States.

In 1886, Jose F. de Navarro and his two sons, Antonio and Alfonso de Navarro, erected in the United States the first rotary cylinder for the burning and manufacture of cement. This cylinder was erected under patents taken out by Henry Mathey, which were controlled by the de Navarro family.

The cylinder was erected at the Union Cement Company works, Rondout, New York. It was 24 feet in length with a diameter of 12 feet, and was similar to a large peanut roaster. This cylinder was charged from the center up to one-third of its capacity. The fuel used in the burning of the cement rock was crude Lima oil. The market price of this oil was from 2 to 2⅛ cents a gallon, delivered. The burner used was known as a Rose burner. The cylinder was slowly revolved for eight or ten hours, after which time it was discharged from the same aperture that it was charged. After two years of experiment, it became evident that this cylinder was a failure and it was abandoned.

Jose F. de Navarro, by chance, saw an article in the Engineering News describing a rotary cylinder process for burning cement, which was being experimented with by Frederick Ransome, at the Gibbs Portland Cement Works, at Grays, on the Thames, England.

Alfonso de Navarro in January, 1888, went to England, and with a letter of introduction to Mr. Ransome from the Baring Brothers, visited the works where the rotary cylinder was in operation. This cylinder was 5 feet in diameter and 25 feet long and was similar in construction to the cylinders now in operation throughout the country. The fuel used by Mr. Ransome was producer gas, and the material manufactured by this process was of the best quality, samples of this cement being taken from the cylinder by Mr. de Navarro and tested by a London cement expert.

The cylinder then in operation was the third erected by Mr. Ransome, the first cylinder being 18 inches in diameter and 12 feet long and the second cylinder 2½ feet in diameter and 18 feet in length.

After several months of negotiation, Mr. de Navarro acquired the American rights for the manufacture of portland cement under the Frederick Ransome patents.

In July, 1889, an exact duplicate of Mr. Ransome's last rotary cylinder was erected by the Keystone Portland Cement Company, which was controlled by the de Navarro family, at Coplay, Pennsylvania, and in November, 1889, operations under this process were begun. At first the experiments were unsuccessful and the product unsatisfactory, owing to the fact that the cement rock was burned in small pieces varying from half-inch to 2 inches in diameter.

In the Spring of 1890 it was decided to grind the raw material to an impalpable powder and to adjust the proportion of lime and silica thoroughly before the material was delivered into the cylinder. The product, after having been thoroughly burned and thereafter ground to a powder, 95 per cent of which would pass through a No. 50 sieve, produced a portland cement which compared favorably with the best English and German brands. At this time the Keystone was changed to the Atlas Cement Company, being still under the same ownership.

It soon became known in the portland cement world that the rotary cylinder process was a practical and economical method of manufacturing portland cement and that the product was superior to that manufactured by the old vertical kiln process. It was but a few years thereafter when the process for the manufacture of portland cement was completely revolutionized and for the past twenty-five years all portland cement works have been erected and operated throughout the world under the Frederick Ransome rotary cylinder process.

Group of cement men at St. Louis in 1903, just before the opening of the World's Fair, including (1) Ernest R. Ackerman, (2) John B. Lober, (3) Robert W. Lesley.

The size of rotary kilns continued to increase until a maximum length of 260 feet was reached, the Edison portland cement works, under patents granted to Thomas A. Edison, being the pioneer in the installation of kilns of extreme length. The following table gives the lengths of rotary kilns in active plants in 1917-1923, and also discloses fluctuations in the number of kilns in use during that period:

LENGTHS OF ROTARY CEMENT KILNS IN ACTIVE PLANTS IN THE UNITED STATES, 1917-1922

Length (feet)	Number of Kilns					
	1917	1918	1919	1920	1921	1922
40 to 60	108	77	71	74	74	78
61 to 99	94	90	87	87	87	91
100 to 109	84	105	98	98	91	102
110	83	65	55	66	56	54
120	88	88	95	97	99	101
125	194	183	166	172	164	162
126 to 149	65	63	63	63	64	66
150 to 199	73	63	66	73	76	75
200 to 260		15	19	23	29	31
	789	749	720	753	740	760

Kiln Fuels

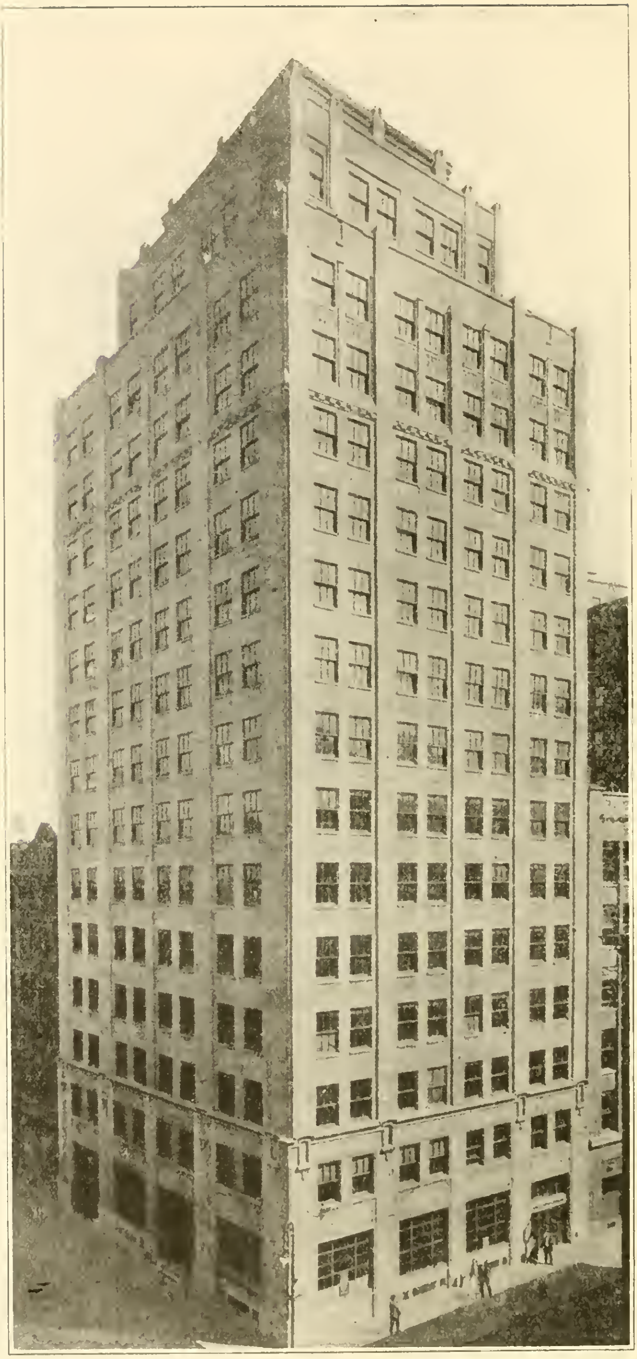
The fuel customarily used in burning portland cement in the rotary kiln is powdered coal, but a number of plants use crude oil and a few natural gas.

The records of 1922 are noteworthy in showing that over 75.7 per cent of the portland cement produced was burned with coal alone, a decrease from 81.5 per cent in 1921. Records from 1907 to 1921 show that the percentages of cement burned with powdered coal ranged from 81.2 in 1920 to 88.5 in 1907 and ran generally about 82 per cent. Increased consumption of crude oil and natural gas, due to the greater abundance of crude oil for fuel in 1922, accounts for the difference.

KILN FUELS

PORTLAND CEMENT BURNED BY DIFFERENT FUELS IN 1922

	Number of Plants	Number of Kilns	Barrels of Cement	Percentage of Total
Coal	90	590	86,864,274	75.7
Coal and oil	7	64	12,030,542	10.5
Coal and gas	1	6		
Oil and gas	......	......	....	....
Oil	17	85	12,794,890	11.1
Coal, oil and gas	2	8	3,100,278	2.7
Natural gas	1	7		
	118	760	114,789,984	100.0



The eighteen-story, reinforced concrete Hide and Leather Building, New York City, when erected, was the tallest concrete building in the world. It is of further interest that it was built during winter weather.

KILN FUELS
PORTLAND CEMENT BURNED BY DIFFERENT FUELS IN 1923

	Number of Plants	Number of Kilns	Barrels of Cement	Percentage of Total
Coal	101	641	108,272,858	78.7
Coal and oil	1	24		
Coal and gas	......	......	8,091,506	5.9
Oil and gas	2	9		
Oil	18	95	16,313,410	11.9
Coal, oil and gas	3	18	4,782,464	3.5
Natural gas	1	6		
	126	793	137,460,238	100.0

Preparation of coal for the kilns has led to the establishment of what are termed the coal grinding plants of the mills, the powdering of coal requiring drying, and pulverizing machinery of various types.

Crushing and Grinding Machinery

Increased efficiency in kilns was accompanied by equally essential improvements in crushing and grinding machinery. Progress in the development of kilns and crushing and grinding machinery was attended with competitive spirit rather than coordinated procedure. The crushing and grinding machinery first used to reduce raw materials and clinker soon failed to meet requirements both as to quantity and fineness.

While different works have different installations, in general practice the raw material goes to the powerful initial crushers and thence to the finer grinding machinery, some of which is used in the reduction of material both before and after burning. Some of these devices operate on the coffee mill principle and others reduce the material by attrition as distinguished from grinding. The latter include the tube mills, ball mills and kominuters. The tube mill is a revolving cylinder containing steel balls, steel slugs or flint pebbles. The ball mills are revolving drums containing steel balls. Material has also been crushed by revolving steel rolls.

An intermediate step between the burning and final reduction of the clinker into the powder called portland cement, is the cooling of the clinker, which comes from the kiln at very high temperatures. Sundry methods have been used to cool clinker. In many cases it is merely stored until needed for grinding. In earlier practice, clinker pits and rotary coolers were employed, followed by the upright clinker cooler which is still used at many works. The upright cooler is a steel cylinder about 35 feet high and 8 feet in diameter. The clinker enters at the top and descends over baffle plates and shelves. In its descent it comes in contact with air currents introduced by a perforated pipe running through the center of the oler.

Packing and Weighing Cement

The grinding of the clinker is the last step in the manufacture of portland cement. The finished product is conveyed to the stock houses where it is placed in bins preparatory to weighing and packing. Except where intended for bulk shipment, cement is packed in barrels containing 376 pounds and in cloth bags or paper sacks containing 94 pounds, these being filled by packing machines. Rebates are given for the return of cloth sacks, and out of this practice arose complications and problems of the most vexatious nature.

The Cement Mill Power Plant

The heart of all the cement mill mechanism, which has been but briefly outlined, is the steam or electrical power plant and its auxiliary resources. From a mechanical standpoint the past twenty-seven years have witnessed many radical changes and in some cases complete revolution in practice.

In the crushing department we have seen small gyratory crushers replaced by huge ones of the same type. Mammoth jaw and giant roll crushers have likely replaced the small crushing units of similar types used in the early days. The introduction of the steam shovel is largely responsible for larger pieces of rock being handled and this in turn has produced economy in the number of men required to quarry raw materials.

H. A. Schaffer, long known in the field of cement manufacture as a chemical engineer and for a number of years past Conservation Engineer of the Portland Cement Association, contributes the following:

> Persons familiar with driving machinery in cement mills from twenty to twenty-five years ago recognize little in the practices with which they were most familiar compared with practices today. Formerly all crushing and grinding machinery was driven from a common line shaft extending throughout the raw department. Each machine was connected to this main shaft by a belt driven pulley and was started and stopped by means of a friction clutch. These clutches were the bane of the cement operators' existence.
>
> The machinery on the clinker side was driven in a similar manner from a main shaft connected to a large steam engine.
>
> Today we find each and every unit throughout a modern cement plant directly connected either to an induction or synchronous motor, depending upon the size of the unit, wholly independent of every other piece of machinery in the plant.
>
> The introduction of electrical drives has proved a great economy. It has greatly reduced necessity for repairs and renewals and in this way has contributed a most important part to continuous mill operation.

Referring briefly to the development of the waste heat boiler in the cement industry, Mr. Schaffer writes as follows:

> The first attempt to utilize the heat of waste gases from rotary kilns was in 1898 at the works of the Nazareth Cement Company. Although this attempt

successful because of lack of provision for handling dust accumulations in the boiler, it nevertheless marked the initial effort of what has proved to be real saving of fuel in the industry.

The second installation, which was made at the plant of the Cayuga Cement Company, Portland Point, N. Y., was also abandoned after several years' operation, although a marked improvement was shown over the original waste heat boiler at Nazareth.

The third effort to generate steam from waste kiln heat was made at the Kosmos plant, Kosmosdale, Ky. This installation has been in operation for twenty years.

In late years many cement plants have been equipped with waste heat boilers. More will undoubtedly do so when the large financial outlay which such an installation requires can be justified. At the present time approximately forty different cement plants are developing from 50 to 100 per cent of their total power requirements from the heated gases which formerly were allowed to escape through the stacks into the atmosphere.

Classification of Portland Cement Production According to Raw Materials Used

A classification of portland cement production according to the raw materials used was made by the United States Geological Survey in 1914. The figures are interesting as showing changes in percentages of the different raw materials used from 1898 to 1914, the percentages being based on the total production of four classifications of portland cement material, namely, cement made from cement rock and pure limestone, that made from limestone and clay or shale, cement made from marl and clay, and that made from blast furnace slag and limestone. The figures are as follows:

Production, in barrels, and percentage of total output of portland cement in the United States, according to type of material used, 1898-1914.

Year	Type 1. Cement rock and pure limestone.		Type 2. Limestone and clay or shale.		Type 3. Marl and clay.		Type 4. Blast-furnace slag and limestone.	
	Quantity	Percentage	Quantity	Percentage	Quantity	Percentage	Quantity	Percentage
1898	2,764,694	74.9	365,408	9.9	562,092	15.2	....	.....
1899	4,010,132	70.9	546,200	9.7	1,095,934	19.4	....	.....
1900	5,960,739	70.3	1,034,041	12.2	1,454,797	17.1	32,443	0.4
1901	8,503,500	66.9	2,042,209	16.1	2,001,200	15.7	164,316	1.3
1902	10,953,178	63.6	3,738,303	21.7	2,220,453	12.9	318,710	1.8
1903	12,493,694	55.9	6,333,403	28.3	3,052,946	13.7	462,930	2.1
1904	15,173,391	57.2	7,526,323	28.4	3,332,873	12.6	473,294	1.8
1905	18,454,902	52.4	11,172,389	31.7	3,884,178	11.0	1,735,343	4.9
1906	23,896,951	51.4	16,532,212	35.6	3,958,201	8.5	2,076,000	4.5
1907	25,859,095	53.0	17,190,697	35.2	3,606,598	7.4	2,129,000	4.4
1908	20,678,693	40.6	23,047,707	45.0	2,811,212	5.5	4,535,300	8.9
1909	24,274,047	37.3	32,219,365	49.6	2,711,219	4.2	5,786,800	8.9
1910	26,520,911	34.6	39,720,320	51.9	3,307,220	4.3	7,001,500	9.2
1911	26,812,129	34.1	40,665,332	51.8	3,314,176	4.2	7,737,000	9.9
1912	24,712,780	30.0	44,607,776	54.1	2,467,368	3.0	10,650,172	12.9
1913	29,333,490	31.8	47,831,863	51.9	3,734,778	4.1	11,197,000	12.2
1914	24,907,047	28.2	50,168,813	56.9	4,038,310	4.6	9,116,000	10.3

"The Fountain of Time," on the Midway, Chicago, designed by Lorado Taft, world-famous artist, and executed in concrete by John J. Early, the noted architectural sculptor.

Progress in Mechanical Side of Industry Slow

It is needless to say that progress in the mechanical side of the industry in America was anything but plain sailing. In Europe labor was cheap and time was aplenty, and, as already described, it took many acres of settling "backs" and many months of preparation of the raw material before it was put in the kiln. In this country, Saylor, by the use of the wonderful raw materials found in the Lehigh district, which could be ground dry and mixed into brick with the minimum of water, was able, with enormous steam-heated drying floors, to dispense with much of the time and space required under European methods. Lesley, under patents of DeSmedt, Wilcox, and his own, supplied another means of economy in the direction above named. By these patents, which were in use for several years at the works of the American Cement Company at Egypt, liquid hydrocarbon (coal tars), was mixed with the raw cement material, which was then compressed in matched cells under high pressure into the form of eggs which, owing to their small size and their shape, were called "eggettes." The eggs were carried on conveyors to the top of the kilns where with the minimum of labor, they were charged with layers of coke prior to the burning process. In both cases the dried bricks of Saylor and the eggs of the Lesley process were put in layers with coke in intermittent bottle kilns modeled after those in use on the Thames and Medway in England. It took a great number of these kilns to make the few hundred barrels a day that were then produced in the respective plants, as the time of loading and burning consumed from eight to ten days, and the material, after burning, had to be carefully selected, so that neither overburned nor underburned material was fed to the crushers and mills.

These American processes, which did away with the settling "backs," the long period of evaporation and decantation which marked the European methods, enabled the material to reach the kiln in the minimum of time and with the minimum of labor. Then came the rotary kiln.

As stated by Mr. de Navarro, the first rotary kiln had many disadvantages, and the raw material used, being high in iron and magnesia, was not available for the production of portland cement. A. B. Bonneville, who in the eighties, had come from the plaster business into the Lehigh district and was operating a small mill there, was largely instrumental in inducing the Navarros, owners of the Mathey Process, to bring their plant into the Lehigh district, where portland cement material existed.

Difficulties Attending Initial Use of Rotary Kiln

Endless difficulties seemed to meet the attempt to establish the rotary kiln in the cement industry. The quality of the early cement did not recommend itself, and it was attacked on all sides by the American manufacturers who, following the practices of Europe, had established their brands in the highest engineering circles. The cement which was burned by oil was quick-setting in quality and presented difficulties in practical handling on the work.

While the Keystone Portland Cement Company was going through its trials and tribulations with the first kiln, Mr. de Navarro, who had been instrumental in building the elevated railways of New York and the great Navarro apartments in that city, and who, himself, had been recognized as a man of indomitable courage and enterprise, succeeded in interesting J. Rogers Maxwell, of the Central Railroad of New Jersey, a leading figure in Wall Street circles, in his enterprise. The story goes that a trainload of capitalists came up to look at the works, and while they were there the kiln was successfully revolved and good clinkers were burnt, but that just as the train was leaving after the inspection had been completed and capital had been satisfied, the kiln stopped, owing to mechanical difficulties, and all the old troubles were again in the works, while in the Wall Street district new prospects had been opened up by the investigating trip.

Contemporaneously with this development at Coplay by the de Navarro interests, Whittaker, the Philadelphia cotton manufacturer, with the cooperation of George E. Bartol, the Philadelphia capitalist, to whom reference has been made, had started a works near Phillipsburg, New Jersey, where rotary kilns were also installed.

Discovery of Retarding Influence of Gypsum in the Set of Cement

At this time the fuel used was oil, then selling around two cents a gallon. Both of these new concerns had difficulty at first in finding a market, for the reason above stated, the irregular time of setting of the cement being the determining influence. The de Navarro interests brought to their works as chemist, a French expert named Giron, who had found out in France that by mixing plaster with the water used in making cement sidewalks, the time of setting of the mortar was materially retarded, and he applied this knowledge to the manufacture of portland cement at the de Navarro works and succeeded in so regulating the time of setting of the rotary kiln cement, that it soon became recognized as a valuable material of construction. Whittaker, at Alpha, near Phillipsburg, followed in the same lines, and achieved equal success.

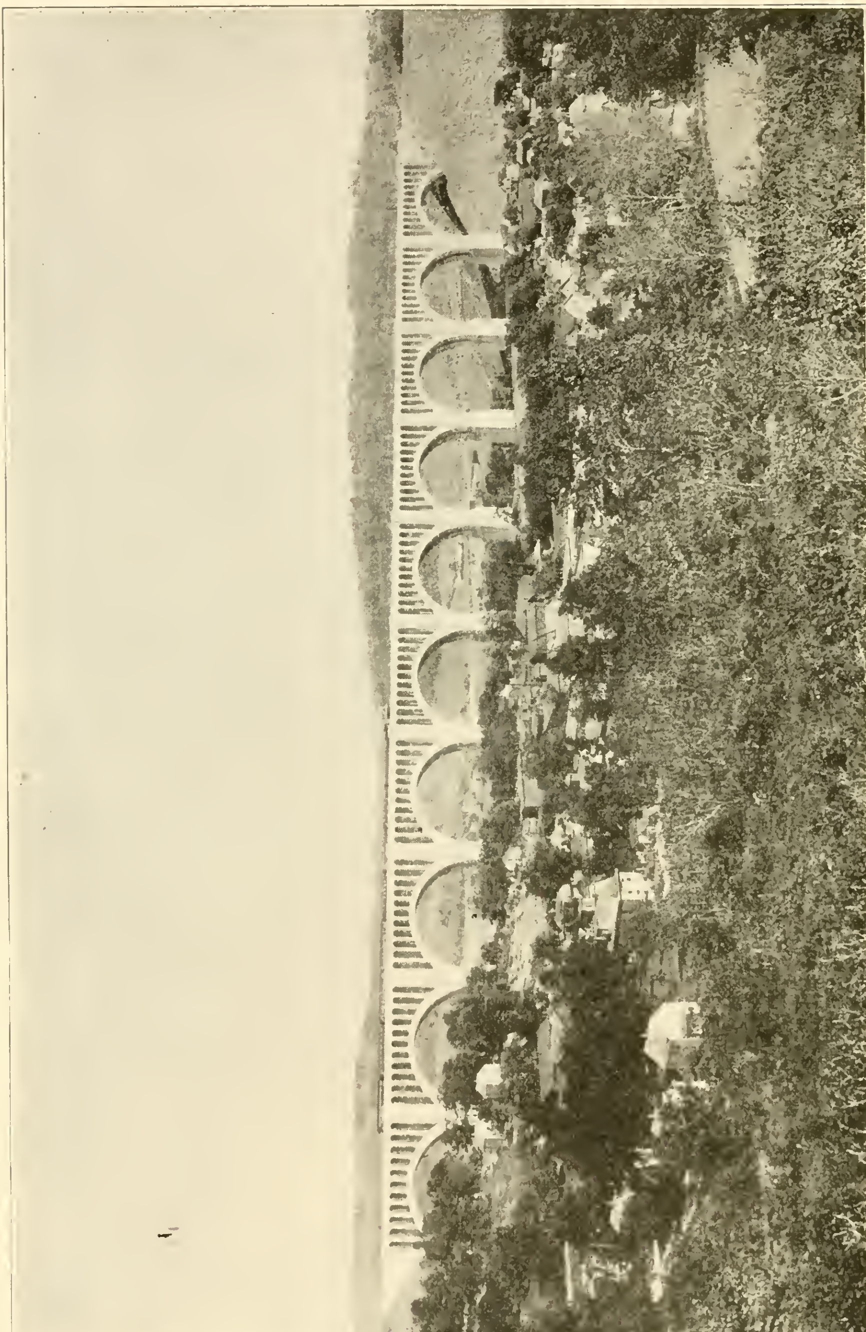
Giron's initials were P. I. and when he went to order his monthly commutation book by telephone from the station master at Coplay, the only thing the agent could make of his request was that a ticket was to be made out in the name of Mr. "Pig Iron."

Efforts to Reduce Fuel and Labor Costs Reveal Utility of Rotary Kiln

While this progress was being made with the rotary kiln, two developments were going on in the original Saylor's and American Cement Company's plants. After a trip to Europe by Saeger, the manager of the Coplay works, that company followed the European practice based upon cheap labor and high coal as against the American conditions of high labor and cheap coal, and installed a group of Schoefer continuous kilns, in place of their intermittent vertical kilns. At the American Cement Company's plant the process of using liquid hydrocarbon in making the little eggs was abandoned in the later eighties, the introduction of the Lowe water gas process having made coal tar too expensive for use in cement making; and after going under the management of John W. Eckert, for many years associated with Saylor as chemist and superintendent, the American Company returned for a time to the process of brick making as used in the original Saylor process. This, however, did not continue long. Oil advanced rapidly in price and a few years later powdered coal superseded it in rotary kilns. The American Cement Company then threw its fortunes with the rotary kiln and built its first plant of 60-foot kilns of this type.

The rotary kiln proved exceptionally well adapted to American cement practice. Coal slack, which in the summer was made in the bituminous fields to the extent of many millions of tons, was available as pulverized fuel and could be bought as low as thirty and forty cents a ton at the mine. Coal was essentially cheap and labor had already advanced far beyond the cost of similar labor in Europe; consequently, as a historical fact, it may be stated that the rotary kiln, as an economical method of production, had its especial and distinct field in this country, which had cheap coal and dear labor, as against the opposite condition of high coal and cheap labor in Germany, England, France, and Belgium.

In the early days the small coffee-mill crushers with corrugated sides were constantly choking while digesting the raw rock broken by hand and shoveled into them. These constant breakdowns, tearing of belts, etc., added greatly to the cost of cement, and the American Cement Company was among the pioneers to substitute for these inefficient methods of crushing, the large type of Gates crushers which were able to take great pieces of rock, and deliver these in turn to the smaller coffee-mill crushers, which remained part of a gradual reduction process. Nor was this all that the American Cement Company, in the line of grinding and crushing, had to do with the industry. Up to 1886 or 1887 all grinding, both of natural and portland cements, had been done on old-fashioned buhr mills. Some of these were made of French buhr stone, and others of the Esopus stone found near the Rosendale district, in New York. To visit a cement mill



The largest concrete viaduct in the world—the Tunkhannock Viaduct, on the Lackawanna Railroad.

in these early days was to risk one's eyesight in the shower of flying bits of stone that active millstone dressers were constantly picking while sharpening the faces of the millstones. The merry clink of steel against stone made music in the mill, and the product, while fairly fine, was not sufficient in quantity as compared with the enormous cost of sharpening and renewing millstones.

Pioneer Work of John W. Eckert in Advancing Mechanical Side of Industry

To this side of the industry, embracing both crushing and grinding, the thought of John W. Eckert was devoted. Having adopted the Gates crusher for dealing with his large rocks in their raw condition, it was he who first introduced the iron mills of the Griffin type for pulverizing the finished clinker coming from the kilns in its very hard and crystalline condition. In company with Robert W. Lesley, he visited the works of the Bradley Fertilizer Company, at Wymouth, Massachusetts, where phosphate rocks were being ground in Griffin mills for the purpose of making fertilizers, and so impressed were he and his associates with the work done, that the first Griffin mill ever used on portland cement was ordered at once, and was later installed at Egypt, where it was in existence until four or five years ago.

To Mr. Eckert some improvements and patents involving modifications in the Griffin mill are due and to his foresight and perseverance we owe the iron mill in the cement industry. Whittaker, at Alpha, had heard of these mills, but he was not ready to put them in, and the story goes that he spent two days and two nights without sleep on the hills above the American Cement Company's mill at Egypt listening to the booming noise of the constantly revolving Griffin mill. When at the end of that time the mills were still rolling along merrily and he had heard no stoppage, he went home and put in his order for similar mills. Later on the de Navarro works, then under the name of the Atlas Portland Cement Company, introduced iron mills of the Narod type, and after a long litigation between the owners of the Narod and Griffin patents, which was carried to the higher courts, the validity of the later patent was sustained. Since that period there have been many other iron mills invented and introduced, such as the Kent, the Hardinge, Fuller, Sturtevant, and Frisbie. All portland cement today is either ground in mills of this type or in the later type of tube mills of Krupp, Allis-Chalmers, F.L. Smidth & Company, and other similar types. The old buhr stone is a thing of the past, as is the old vertical intermittent bottle kiln in which the first American portland cement was manufactured.

To the historian this constant race between the development of the rotary kiln and the iron mill presents many of the most interesting facts in the development of the industry. The old cast iron crushers and millstones had not enabled the American manufacturer to grind his raw and finished product economically. The great change described above was one of two that had a marked effect in establishing the American industry and, followed as it was later in the development of these various types of machinery—in the introduction of tube mills, kominuters and similar apparatus—dispensed largely with labor.

While these great developments on the mill side were going on, equally important advances were made in the burning of portland cement. The old vertical intermittent dome kilns, used by Saylor and the American Cement Company, had a capacity of 150 to 200 barrels of cement every ten days, depending upon atmospheric conditions. The raw material, after drying, was loaded with intervening layers of coke until the kiln was filled. The torch was then applied and the fire was on. This mass of material gradually burned through, flames coming out of the top of the stack. In cooling off, the material contracted and the mass of clinker had to be dug out. It was loosened with bars and taken from the kiln. The yellow and the underburned and overburned material were selected by hand. The yield of these kilns was about 200 barrels every ten days, and in order to reach a production of 200 to 250 barrels of cement a day, it can be readily seen that a large number of kilns were required. Thus it was that in the early works of the Lehigh district, large rows of these intermittent vertical kilns were built, some of which stand today in dismantled state as monuments to the early cement manufacturers.

During the latter part of the decade 1880-1900, the first rotary kiln used in the portland cement industry was put into operation as described in Mr. de Navarro's account already given. This marked a critical and vital change in American methods, and, in fact, in cement manufacturing methods throughout the entire civilized world. Invented by Ransome in England and brought to this country by de Navarro, it was at first a failure, owing to the selection of the raw materials then used, and later on was again a failure owing to the character of the ground powder from the Lehigh rocks as first used in the rotary kiln. Undaunted, however, by these difficulties, the de Navarro interests courageously continued their operations until it was discovered that by the addition of gypsum in any form the quick-setting cement manufactured in the rotary kilns could be regulated and made slow setting.

The early story of the numerous experiments made at the old Keystone works in the nineties would almost fill a book, but the concluding chapter may be said to have been written when, through experiments in Germany and France, brought to this country through the instrumentality of the de Navarro interests, the scientific regulation of the hitherto abnormally quick-setting cement produced from rotary kiln clinker was made possible.

The fuel problem was also of great interest. The producer gas used by Ransome lacked sufficient heat units to manufacture portland cement clinker successfully within reasonable time and at reasonable cost for fuel. The oil then being produced in large quantities in Ohio was available to manufacturers, who used this valuable fuel in an economical way in the early days of rotary kiln installation. This fuel, however, gradually advanced in price until the end of the nineties, when the cost became almost prohibitive, and new methods of dealing with the fuel problem were essential. It was at this time that Hurry and Seaman, the former an English mill engineer and the latter superintendent of the Atlas Cement Company, experimented with pulverized coal. Shortly thereafter the well-known Hurry and Seaman patent, which became the subject of so much litigation in the portland cement industry, was granted to the inventors.

Pulverized Coal Comes Into Use as Cement Mill Fuel

The use of pulverized coal solved the fuel problem for the rotary kiln, and made it what it has been for so many years, a mechanical success in the highest degree. As a labor saving device which enabled the manufacturer simply to grind his raw material and put it in the rotary kiln in either dry powder or wet slurry, according to whether the "dry" or "wet" process was used in the mill, the use of powdered coal was essentially an American device in labor saving utility. Man power was the great extravagance in which the American manufacturer could not afford to indulge. The milling and crushing machinery already described effected great economies as a substitute for man power, but it was the American method of using the rotary kiln which had dispensed with all handling of the raw material from the raw mills to the finishing mills, that became the capstone of the monument American ingenuity had reared in the manufacture of cement. The original rotary kilns were from 40 to 60 feet in length, and from 5 to 6 feet in diameter, and for a time kilns 80 to 100 feet long were considered the maximum size to which successful manufacturing could safely venture.

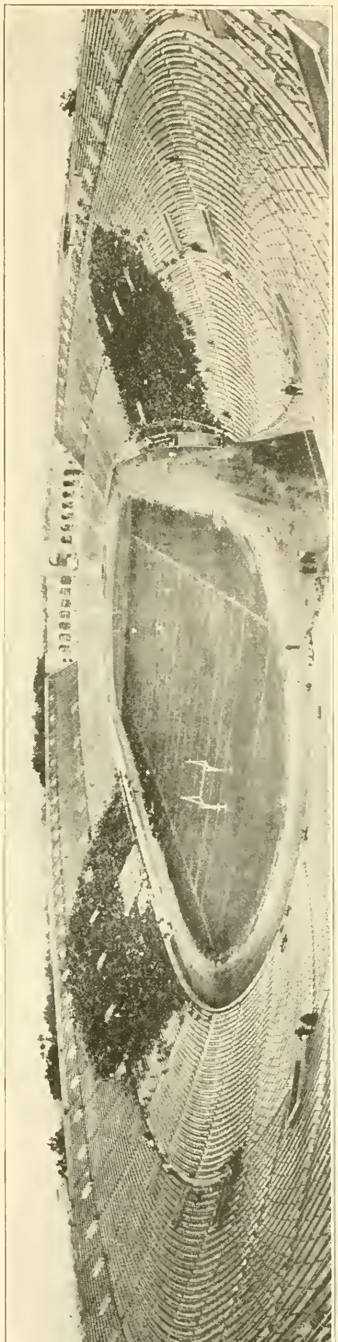
Thomas A. Edison First to Use Rotary Kiln of Greatly Increased Length

In 1909 Thomas A. Edison was granted a patent for the use of kilns 150 feet and longer, every one predicting that it would be impossible to turn kilns of this length without warping. The proof of the pudding, however, was in the eating, and it was not long after Edison's invention that kilns of 125 feet became almost standard as substitutes for the old 60-foot kiln. Mr. Edison not only designed the long kiln described, but was the first to use steam shovels for loading rock in the quarries. He also introduced the well-drill in quarry operation. Later on the length of the Edison kiln was far exceeded. Some kilns now in use are 260 feet long, with capacities of a thousand or more barrels of cement per day.

Continuous Vertical Kiln Competing with Rotary Kiln

While this development of the rotary kiln was progressing in the Lehigh district, the old-time manufacturers there were still in a state of uncertainty. They had used intermittent vertical kilns successfully. They had banked upon following European practice in every detail as best calculated to give them a talking point to engineers when urging the adoption of the newly-created American product for the great engineering works of the period. Consequently a revolving kiln turning out clinker in hours as against days under old methods, struck them as something entirely irregular and improper. They could not believe in the final success of such methods, and when at about the same period Europe, especially Germany, began to use continuous vertical kilns of the Schoefer, Dietsch and similar types, the old-time American producer began to see that with which he could offset the progress the rotary kiln had begun to make, something he was used to, and which had behind it the authority of European practice. These kilns, 50 and 60 feet high, were fed continuously at the top with raw material in the form of bricks, blocks or other combinations of material, the latter drawn from time to time and the clinker taken to the finishing mills. The use of the raw material in this form was well known to the old manufacturers, and they believed that this type of kiln would be the one finally adopted. As a result, the Coplay Cement Company installed a number of kilns of the Schoefer type at their Coplay mill, which they operated successfully for many years, and the Glens Falls Cement Company, of which Captain W. W. Maclay was then President, installed ten Schoefer kilns between 1894 and 1899. Other installations were also under consideration, but the successful manufacture of portland cement with pulverized coal under the rotary kiln process was so marked as practically to terminate competition between the rival types of kilns, thus turning the entire American industry over to the rotary kiln which is now in use in every mill in the country.

In considering this victory of the rotary kiln in America, the fact must not be lost sight of that the old type of kiln used coke as fuel, and coke ruled at much higher prices than coal. In the early days of the rotary kiln, and up to a very recent period, enormous bodies of slack coal derived by the screening of run of mine coal to produce lump bituminous coal, existed in many parts of the United States. This was sold at such a low price as



The Coliseum at Los Angeles, seating 75,000 people, is one of the largest concrete stadia in the world.

to make the calcining operation in portland cement mills using the rotary process not only economical in labor as compared with European countries, but also far more economical in fuel than ordinary comparative figures between the market sizes of bituminous coal in this country and in Europe would seem to indicate.

Old methods in mill practice gave way in the American industry to new and improved machinery, in many cases of American invention and design. The calcining operation in portland cement was revolutionized by the American adoption of the rotary kiln. The progressive war in American cement mills has been that of constant improvement in each of these two wonderful fields of development. The old fleets of carts and wheelbarrows that conveyed rock from the quarry to the mill have been supplanted by the steam shovels and trains of cars, the latter carrying the rock to enormous crushing plants, where giant crushers, handling hundreds of tons of raw rock per hour, prepare it for storage in great silos, where it is carried to one or more mills located in the vicinity and tributary to the quarry itself.

Some of Those Who Contributed to Mechanical Advancement

Many types of milling machinery have been devised since the industry began, and many of the earlier types have grown from small mills to enormous apparatus with great capacity. The history of the Griffin mill has been that of steady growth in size and capacity. The Fuller mill has a history of equal interest, while the Kent mill, the Williams hammer mill, and the Hardinge mill are all cited as types of the big development in this field of cement manufacture.

The tube mill was another important factor introduced through the great Danish firm of F. L. Smidth & Company. This firm kept constantly abreast of the times in its various forms of tube mills, kominuters, ball mills, etc., and German and American improvements in the same line have so developed this form of grinding machinery that some of the modern mills require as much as 400 h. p. to turn them in order that they may produce the greatly increased capacity now demanded of all American machinery.

In considering the subject as a whole, there is forced upon one the conclusion that without these discoveries the world, in its great demand for cement for all of the numerous uses for which it is now accepted, might have been much longer in attaining its object. Had the developments on these two sides of this great industry not proceeded as they did in parallel lines, and at practically the same time, there never would have been the present enormous production of portland cement. The manufacturers did well their part in providing energy and capital for all this great development, but it must not be forgotten that such engineers as Frederick H. Lewis, Lathbury & Spackman, the Hunt Engineering Company, F. L. Smidth & Company, and other prominent engineering firms, also contributed greatly to the successful work. If all the improvements in the grinding and crushing side of the industry had been made and the old crackers and buhr mills discarded without a new form of calcining apparatus, the enormous amount of material these forms of improved crushing and grinding apparatus produced would have been far in excess of the capacity of kilns of the old vertical type. On the other hand, had the rotary kiln been developed to its full extent without the improved crushing and grinding machinery, there never would have been sufficient material to meet its great capacity. Thus it was fortunate that contemporaneous with the introduction of the rotary kiln and keeping pace with its commercial establishment, there was the great development in crushing and grinding machinery.

Typical Example of Progress in the Mechanical Side of the Industry

This chapter might well conclude with the story of the Glens Falls Portland Cement Company's founding and development as told by Mr. Bayle, for as stated previously, the experience of that company was typical of the period that witnessed the discarding of the vertical intermittent kilns for those of the rotary type as well as changes in crushing and grinding machinery. Mr. Bayle says:

> For some years previous to and during the time of the Civil War, and continuing in a lesser degree to the present day, one of the important industries of Glens Falls was the production of lime, made from an extensive deposit of black marble, which underlaid strata of clay and inferior lime rock locally known as "buckwheat." These upper strata varied in thickness of from 4 to 15 feet. About 1885 the Jointa Lime Company contemplated the manufacture of brick from this clay deposit, and in its search for proper machinery, fell in with an intelligent Scotchman who had worked in cement plants in the old country. He had been making some experiments with the product at Howes Cave, New York, with minor success and was employed to experiment with the limestone and clay at Glens Falls.
>
> After somewhat more extended investigation the Glens Falls Portland Cement Company was organized early in 1893 with a capital of $48,000, estimated as sufficient to erect a plant capable of profitable production of 100 barrels a day. This plant was completed during 1893. It was a well-built plant but had several mechanical and scientific defects; for instance, the clay dryer would not dry the clay, the mill could not reduce the rock, and the kiln could not produce the clinker. Were a cement expert of the present day to investigate it without a guide, he would wonder what it was intended to produce. No indication of discouragement existed among the projectors of the enterprise. Cement had been produced from the raw materials and a commercial article was possible through intelligent persistence. They had nearly absorbed their capital without results, and early in 1894 the capital was increased to $72,000. Two Schoefer kilns were erected and machinery was installed to prepare the materials and reduce the clinker. The problem of maintaining the uniform product was worked out to some extent.

The first few barrels of cement produced set as hard as the sides of an iron clad the moment they came near water. The Federation of Labor in those days had not instructed its members in the matter of efficiency and rapidity of motion to a sufficient extent to make the product of commercial value. A few barrels were finally produced called "slow setting," and one of the prominent stockholders was induced to lay a new cellar floor on his property. It is said that the floor is still in existence and holds the finger prints of a majority of the then stockholders.

About this time the bank of the Champlain Canal adjoining the works gave way, washing out many foundations and depositing materials of much value into the Hudson River. It may be stated that this unauthorized watering of the stock was the only incident of its kind in the financial history of the company.

In 1895 four more Schoefer kilns were erected, and the necessary machinery installed. The reliability of the product began to be recognized in the trade. The capital was again increased, from $72,000 to $200,000, each increase in capital being absorbed by the stockholders taking their pro-rata share. The year failed to close without a discouraging incident. The 600 h.p. engine evidently concluded the plant was not working up to capacity, and took matters in its own hands. It raced up beyond its endurance and threw its 18-foot fly-wheel through the mill and to the heavens above. Fortunately the only casualty recorded was the seat from the trousers of the engineer.

In 1899 four new Schoefer kilns were added to the six already in use, but before they were put into commission the entire plant was destroyed by fire, leaving only the ten kilns standing. As these were the only remaining asset, and the rotary kilns had not then developed their present admitted superiority, the plant was rebuilt by July, 1900, with the old kilns as a nucleus. The principal advances made at the time of rebuilding included the installation of tunnels for drying the raw mixture bricks with waste heat gases from the power plant, and the addition of clay to limestone by automatic scales when each material had been crushed to one-half inch, and the combined material pulverized in a Griffin mill to a complete raw mixture. This change seems simple enough today, but from the establishment of the plant these materials had been pulverized separately and then mixed together in the proper proportions by batches in a rotating cylinder, and the change seemed quite revolutionary. Also, advantage was taken of the opportunity during reconstruction, to separate the raw and clinker departments, providing separate steam power units and routing material in the direction of the successive steps of manufacture.

The ten stationary Schoefer kilns were then producing about 600 to 700 barrels per day, as an average of one kiln was out of commission for relining at all times. About 1902 induced draft was applied to these kilns by means of a fan system at the tops, and three shifts of burners instead of two were employed to increase the number of "draws." This increased the capacity to about 1,000 barrels per day.

In order to decrease the loss of waste clinker caused by uneven burning, an old ball mill was loaded with it and rotated until the hard burned pellets of clinker pulverized the softer under-burned pieces which passed out through screens, and the retained hard burned part added to the good clinker. This mixture of "fines" (amounting sometimes to 10 per cent of the output) containing much hard burned clinker, had been previously thrown away. About the same time 5 per cent soft coal was added to the raw mix in the Griffin mills to improve the uniformity of burning in the kilns and promote the soundness of the clinker, but without effect, although it made a better raw mix brick, which was more resistant to crushing in the kiln.

About 1906 a deposit of cement rock was discovered and opened on the Saratoga County side of the Hudson River at about the same time that the initial pair of rotary kilns was being installed in hope of reducing labor costs. The use of this material reduced the amount of clay required, but compelled the addition of more efficient drying equipment for the stone, which carried more water than the 90 per cent "buckwheat" limestone in use before. These changes permitted the abandonment of the clay storage and dryer outfit previously operated, and the entire raw product was then passed through the raw mill crushers, greatly simplifying the raw grinding.

When the first two rotary kilns were started up it was found that the same raw mixture, whether of limestone and clay, or plain cement rock, would not give a cement passing the boiling test in the rotary kiln, while it would in the Schoefers. As the obvious economy of rotary kilns compelled their continued use, the problem was attacked in the direction of a better raw mix fineness for the rotary kilns. A tube mill was added for the purpose of increasing the fineness of the raw material being furnished to the rotaries, and an increase of 5 to 6 per cent on the 200-mesh sieve produced a fairly consistent boiling test from the rotary clinker, and demonstrated that a mix being clinkered in 20 to 30 minutes would require a greater fineness to undergo complete reaction than one kept at red heat for many hours, as in the Schoefer kiln.

As soon as the economic success of the combination of cement rock for raw material and rotary kilns for burning was proved, the entire Schoefer plant was discarded and two more rotary kilns of slightly larger diameter were purchased. At the same time the substitution of kominuters for ball mills enabled the company to reduce their raw grinding plant to the simple modern units of crusher, dryer, kominuter, and tube mill, turning out a raw mixture of 90 per cent through the 200 sieve.

In the early period of rotary burning it was found that the variations in the composition of the cement rock raw mix were too great to produce a uniform cement. On account of the large amount of material in the Schoefer kiln in proportion to the output, variations of 3 to 5 per cent in lime carbonate had not been prohibitive, especially as the quality of the cement was largely dependent upon the burning which, while good on the average, could not be closely controlled.

In the rotary kiln a small stream of material passing rapidly through the kiln showed these variations to such an extent as to reduce the capacity of the kiln and threaten the quality of the output. As a remedy the automatic scale system was removed and six bins were placed between the kominuters and tube mills, and their contents after analysis while filling, were blended with succeeding bins in proportion to their variation from correct composition by means of variable speed worm conveyors. The accumulation of too many high or low bins was prevented by addition of either high calcium limestone or clay at the crushers, as indicated by the composition of the bins already on hand. The additional cost of this system is considered compensated for by the extra storage capacity it affords, and the increased output of the kilns with uniform raw mixture.

CHAPTER X

COMMERCIAL DEVELOPMENT OF THE INDUSTRY

Pioneers in the Field of Cement Salesmanship

To establish a new product in a market where its use in great buildings and engineering works involved great responsibility to the architect and engineer was no easy task. The difference in cost between imported and domestic cements was so slight in proportion to the total cost of any building project as to make the change from the well-known foreign to the domestic cement a matter of slight financial interest. Consequently, the early days of the industry also brought forth brilliant salesmen. They were hard fighters, always having the affirmative of the question, always having to lead the attack upon an established product. It was due to the tact and intelligence of these men in their contact with engineers and the convincing arguments they presented, that the commercial growth of American portland cement forged ahead.

To Johnson & Wilson, the representatives of Saylor's cement in New York and in most of the Western country, the use of that brand upon the Eads jetties at New Orleans, upon the great works of the Lackawanna Steel Company at Scranton, and upon other monumental engineering works in the country was directly and distinctly due. It was through their able presentation of the cause of the American portland cement manufacturer, that American portland cement began to receive favorable consideration at the hands of the American engineer.

The firm of Lesley & Trinkle, which had been large importers of foreign portland cement, and which was also associated with David O. Saylor in the introduction of "Saylor's Portland Cement," and later on in the introduction of the "Giant Portland Cement" of the American Cement Company, did similar work. It was due possibly to the work of Robert W. Lesley, who was the senior partner of the last-named firm, and later President of the American Cement Company, that the engineering world became better acquainted with the qualities of American portland cement. Lesley's papers presented at various meetings of engineering societies, his association with the very beginning of the industry as well as with leading engineers, and his membership in many of the engineering associations, enabled him, both in public discussion and private argument, to convince engineers and scientists of the value of the American product. An argument presented by him to Alphonse Ftely, Chief Engineer of the Croton Aqueduct Board, was the means whereby the use of American portland cement was permitted to be used "under closest scrutiny" in that important engineering work to the extent of millions of barrels when the original specification called for "imported portland cement." A

A beautiful example of portland cement stucco over concrete, at Los Angeles.

similar argument presented to the engineers of the Third Avenue Railway, in New York, secured the adoption of American portland cement in the conduits of that line, while by personal argument the engineers of the Metropolitan Street Railway were likewise persuaded to use the American product.

Hiram Snyder, of New York, an old Rosendale man, James Davis, of Boston, Donaldson of Philadelphia, were all salesmen of wonderful ability and talent in presenting the case of the American portland cement manufacturer. By degrees the American cause found equally able advocates in the West, and by the selling qualities and force of character and the ingenious arguments of these men, American portland cement may be said to have been put upon the map.

To mention the progressive and able engineers who listened to these arguments and who, after investigation, were convinced of their value and gave effect to their weight by permitting the domestic article to be used in lieu of the foreign, would be to name a list of all great engineers who were foremost in the field of engineering construction at the time. Among them were Alphonse Ftely, Chas. S. Gowan, Robert Ridgway, Alfred

Craven, George S. Rice, Jr., of the New York Croton Aqueduct and later one of the New York Aqueduct Board; William N. Brown and Joseph T. Richards, of the Pennsylvania Railroad; A. Katte, of the New York Central Railroad; Alfred P. Boller and Thomas Curtis Clarke, the great bridge engineers; George B. Burbank, the engineer of the first Niagara tunnel; Eads, the builder of the Mississippi jetties; William W. Scranton, the builder of the Lackawanna Steel Works; Andrew Carnegie, of the great steel works in Pittsburgh; Joseph M. Wilson of Philadelphia; George S. Webster, of the Philadelphia Bureau of Surveys; William M. Marple, of the Scranton Water Works; and Frederick Pike Stearns and Thomas E. Richardson of the Metropolitan Water Board of Boston.

Whole books could be written on the difficulties of the early pioneers in the field of cement salesmanship, of the continuous butting of heads against the stone wall of established practice and prejudice, of the days and nights spent in assiduous personal solicitation of customers, of the personal visits to important engineering works, and the supervision of concrete mixing and testing of briquettes to satisfy both the technical and practical minds in charge of the work. Interesting stories could be told of personal guarantees given by many of these men to introduce their product, and how, day in and day out, for better or for worse, in times of car shortage, in times of coal shortage, in times of delay in manufacturing, they kept the work going and kept quality up to the highest standard.

Too much cannot be said in praise of these men and their work. To them the brand they sold was a fetish; its reputation was to be guarded like that of Caesar's wife. No task was too great, no labor too severe to maintain the reputation and the trade they had built up.

The Favor Accorded a Brand Name

In these early days the brand was the thing. Testing was in its early stages. The dead level of many brands of equal quality had not been reached, for the manufacturers were few and each fought bitterly to maintain his own standard and his own brand.

People Did Not Believe Good Portland Cement Could Be Made in Rotary Kiln

In the period following the introduction of the rotary kiln, the "War of the Roses" was nothing to the battle waged between those who were the advocates of the "substantial, well-established old methods of Europe" against the "new-fangled abomination of cement made in rotary kilns." The clever salesmen, in many cases members of engineering clubs and engineering societies, were constantly called upon to read papers or make arguments before crowded meetings on this important subject, and it got to be a well-known fact in engineering circles that whenever a crowded meeting was required and interest was to be awakened, a discussion between representatives of vertical kilns and rotary kilns in the cement industry would draw full houses. In those days it was doubtful whether a great prize fight aroused more public interest than the fight between representatives of these two sides of the cement industry. This work, however, was all propaganda of the highest degree. It centered the attention of engineers of the country upon the growth of a great and valuable industry. It set many to thinking of the potential worth of this plastic material, and of the great field which it was destined to fill; and while, in a general way, wishing "plague on both your houses," the engineers ceased thinking in terms of foreign portland cement in favor of the American or home-made article.

Early American Portland Cement Often Condemned Without Reason

Those days were filled with the sad tales of "condemned" cement, a word with which all the old manufacturers were thoroughly familiar. While in many cases any old foreign portland cement would go through on its brand, American cement was always received, as described in the words of Alphonse Fteley, Chief Engineer of the Croton Aqueduct Board, "with strictest scrutiny." For this reason the slightest defect in time of setting, fineness, color or any other slight deviation, would be sufficient excuse to turn the cement down, a situation requiring the immediate attention of the higher officials of the company, who, in those days, were what were known to engineers as "cement doctors."

It was no boy's job to maintain the sacred reputation of American portland cement. Owing to the fact that the earliest works first commercially successful were located in the Lehigh district, it was there that the principal portland cement testing laboratories made their appearance. In Philadelphia many cement securities were owned, and two engineering firms in that city, Booth, Garrett & Blair, and Lathbury & Spackman, were prominent figures in both testing and engineering in connection with early cement. It was generally to their laboratories that disputed questions were referred for final test and arbitration. In New York, Dr. McKenna had entered the field with his chemical laboratory, and in Boston, Eliot C. Clark, of the Metropolitan Sewerage Department, had also become an authority, while Maclay's work in the New York Dock Board had made him an arbiter of cement quality.

In reminiscences contributed by Frederick H. Lewis, much interesting information is given as to the connection of the firm of Booth, Garrett & Blair with the cement industry, and also of Mr. Lewis' own experience. His first interest in portland cement as a material of construction began in

1890, in which year American production of portland cement amounted to 335,000 barrels. The domestic cement was getting a foothold, though, as Mr. Lewis states, engineers continued to specify some brands of imported portland cement. As the laboratory of Booth, Garrett & Blair, Philadelphia, had for years been identified with another Pennsylvania industry, the chemical analysis and physical testing of iron and steel, it was but natural that the American portland cement manufacturers in the vicinity of Philadelphia should, when in trouble, seek the assistance of this well-known firm. Many were the days when those who were upbuilders of American portland cement spent hours in the old laboratory on Locust Street making cement pats, supervising the making of briquettes and then testing, thus endeavoring to overcome through the arbitration of engineers the complaints made by contractors and others unfamiliar with the advance in cement making in this country. It is true, as Mr. Lewis says, that American technology in portland cement was quite limited in scope and rudimentary in quality throughout the period between 1880 and 1892, and aside from Eckert, who was a trained chemist then superintending manufacture by the American Cement Company, and Pierre Giron, the Belgian engineer who later went into the employ of the Atlas Company, there were few, if any, cement workers whose knowledge corresponded to the well-known "technikers" usually in charge of the German cement works, at that time the most scientifically successful in the world. Lewis went to Europe in 1892, visiting representative laboratories and hunting up cement technology. "I returned," he says, "convinced that portland cement in America represented a great business opportunity, and on the technical side I was very keenly interested in the experiments and the theories of Le Chatelier and Candlot, the French experts whose writings were then, and I think are still, the best technical treatises on portland cement." This visit put the Booth, Garrett & Blair firm, with which Mr. Lewis was associated, far ahead in the field of scientific testing and handling of both American and foreign portland cements. Mr. Lewis says:

> Mr. Whitfield did the chemical work and I did the physical testing, and our senior partner, Andrew A. Blair, cordially cooperated with both of us. Every American and every European brand to be found in America came under our scrutiny. We had put in a lot of special grinding machinery and built laboratory kilns, in which we burned many batches of cement clinker, using a few pounds at a time. We ground each lot into cement for experimental purposes. There was no phase of the portland cement problem which did not receive our attention between 1893 and 1897, and during that time I acquired an intimate personal acquaintance with American cement plants, both natural and portland.

In 1897, Mr. Lewis went to Europe again, visiting cement plants in England, Belgium, Germany and France, as well as the great laboratories abroad, bringing back much information and many technical books. He was essentially one of the men upon whom American manufacturers leaned during the formative period between 1890 and 1900. He was among the first to test and realize the value of rotary kiln cement, and had much to do with giving it a standing among engineers at the time the bitter war of the old companies was being waged upon this new product. As Lewis says in summing up the discovery of the rotary process and his investigations in Europe:

> Europe had cheap labor and expensive coal; America paid wages from two to four times that of Europe, but bought coal for half the European prices. The short kilns or the ring ovens in England and Germany were quite economical in fuel, much more economical than could be expected of a rotary kiln, but required far more labor than an American could afford. If, therefore, good cement clinker could be produced in a continuous rotary kiln at any reasonable cost, then an American portland cement industry was assured. The preparation of material for the rotary kiln, the handling of the clinker from such kilns, and the handling of the kilns themselves, could all be done with very low unit cost for labor.

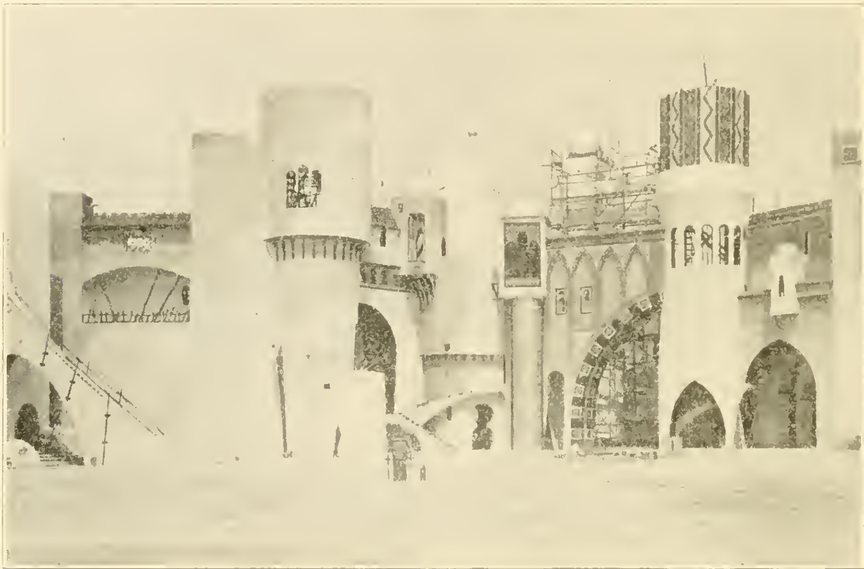
It was with these thoughts in mind that Mr. Lewis, while progressive and fair to all the manufacturers of the old type of cement, was inclined to believe in the new type and from that point of view engaged in exhaustive study of rotary kiln cement.

The Firm of Lathbury and Spackman

Another firm, that of Lathbury & Spackman, composed of B. B. Lathbury and Henry S. Spackman, both engineers of distinction, had also become established in Philadelphia, and like Booth, Garrett & Blair, were constantly consulted as experts. They, too, had numerous clients among the Pennsylvania manufacturers, and their reputation as cement experts spread far and wide, just as Maclay's contribution to the literature of cement had made him an arbiter in New York, and Clarke's work had given him distinction in Boston.

The firm of Lathbury & Spackman, subsequently the Henry S. Spackman Engineering Company, was one of the first to enter the cement industry. Mr. Lathbury had established a laboratory in Philadelphia for the inspection and testing of cement and other engineering materials in 1895. He was employed by the architects of the Philadelphia Bourse Building to inspect the cement used in its construction, and in this way became interested in the subject of portland cement generally. This work made it necessary for him to study the manufacture of cement at the mill and he became familiar with that side of the industry. While conducting experiments and tests he demonstrated the practicability and economy of powdered coal as fuel in rotary kilns.

In 1897, Henry S. Spackman became a member of the firm which opened offices and laboratories on Filbert Street, Philadelphia. Shortly after, the Alpha Cement Company, at whose plant Mr. Lathbury had gained his early experience, was unable to supply cement to its Pittsburgh agents. They decided to construct a mill of their own near the marl beds at Castalia, Ohio. In looking for engineers competent to build the mill, the firm of Lathbury & Spackman was recommended, the sponsor stating that there was only one firm, to his knowledge, who knew anything at all about cement manufacture and that "they knew damned little," this flattering



This dream city is a portion of the setting and courtyard for Douglas Fairbanks' photoplay, "The Thief of Bagdad." Both the courtyard and the buildings are of concrete.

recommendation referring to Lathbury & Spackman. They were engaged to build the Castalia plant and to superintend the erection and first operation of the mill, manufacture beginning in the spring of 1898. The usual difficulties were encountered and in course of time it was found that certain mechanical appliances did not have sufficient capacity to meet requirements.

First Mill Built for Burning Powdered Coal in Kiln

To Lathbury & Spackman has been given the credit of designing the first mill equipped specifically for burning powdered coal as fuel in the rotary kiln, although it was a close race between them and Matcham, who left the Alpha Company to design and build the first mill of the Lehigh Portland Cement Company. Matcham, however, did not commence his plans for this mill until some time after work on plans of the Castalia plant had started. It is interesting in this connection to note the marked difference between the cost of machinery installed in the early mills and that now in use. The mill of the Castalia Company cost, ready to operate, exclusive of ground, less than $125,000.

The success attending the construction of the Castalia plant led to the retention of Lathbury & Spackman by a number of companies during 1898 and 1899. During this period they built mills in Pennsylvania, Ohio, Utah, and Michigan, and were employed by manufacturers abroad, designing and constructing important plants in Denmark, Canada and England.

Having entered the cement industry with minds trained along engineering and chemical lines, and without being hampered by old traditions and preconceived opinions or the precedents so venerated by those brought up in the cement industry, the work of the firm was accompanied by many innovations and improvements, marking wide divergence from standard practice. Today these have become standard in mill construction, but their early adoption required courage and the spirit of the pioneer. In addition to bringing into general use powdered coal as fuel, they may be credited with the first successful installations of rotary kilns in Europe. It is said that they were the first to use electric power transmission, which was introduced in the Alma Portland Cement Company plant and the Utah Portland Cement Company plant. They were the first to manufacture portland cement from blast-furnace slag and limestone, which occurred at the Clinton Cement Company plant in Pittsburgh in 1898, and the first to use limestone and clay by the dry process in rotary kilns, which occurred the same year. Lathbury & Spackman were again pioneers in the use of waste from the alkali industry, and the first to install rotary kilns for lime burning, which took place between 1902 and 1904.

Enlarging the Field in Cement Mill Construction

Upon Mr. Lathbury's retirement in 1904, Mr. Spackman continued the business under the name of Henry S. Spackman Engineering Company, greatly enlarging his field, especially the business of inspection and testing. The firm has built approximately twenty large and important mills, located in all parts of the world. In the United States they designed and constructed plants in Ohio, New York, Pennsylvania, Michigan, Indiana, North Dakota, Maine and California; while their foreign work included plants in Germany, New Zealand, Cuba and Mexico. They were also retained to make examinations and reports on cement properties, these comprising some fifteen localities throughout the United States, two in England, one in Canada, and one in France.

Mr. Spackman is the author of many valuable papers relating to cement and concrete, having been a contributor in this field for years. His chemical and physical research covers the testing and use of cement as well as its manufacture. He has taken an active part in the work of Committee C-1 of the American Society for Testing Materials since its formation.

In referring to all this testing of cement as part of the commercial development of the industry, it must be understood that there was required just such work as was done by testing laboratories of established reputation before the American cement could acquire merited standing.

In those days there were no definite specifications, though there were standard methods for the testing of cement adopted by the American Society of Civil Engineers in 1885, these accompanied by suggestions as to possible requirements. With this door open and in dealing with a new material, it was common practice for nearly every engineer to make his own specifications, and consequently "condemned" cement was not, in many cases, so much a matter of careless manufacture as varying specifications.

In looking at trade conditions and the general growth of the industry from a retrospective point of view, it may well be said that for many years the commercial or selling side of the industry was just as important as the mechanical or manufacturing side. In those days knowledge of the subject and personal equation counted heavily and the man fitted by these to make sales in large quantities at good prices was a factor of the greatest value to a newly established company, his capabilities having as much to do with successful results as did the iron and steel fashioned into the important mechanical devices that produced the cement.

Captains of Industry Begin to Appear in Cement Manufacturing

As time went on, what may be termed the second formation in the industry arrived. New conditions supplanted those attending the work of the pioneers from 1880 to 1900. The selling side began to shrink into a position of secondary importance. This was because portland cement was becoming a staple article of commerce carried by dealers all over the country, who distributed it in large and small quantities to customers. Therefore, in many cases, the great arguments that had been addressed by skilled salesmen and the engineering type of vendors to trained engineers, ceased to have their former powerful influence and effect. The material was better known, had a standing of its own, and through established dealers was beginning to find a market everywhere. So it was that when the second period marking the organization of captains of industry who began to operate and own cement works of great capacity between 1900 and 1910 was reached, machinery of great capacity, great quarries, great facilities, began to occupy their minds in a fuller degree than the salesmanship which, in the earlier days, had been so instrumental in building up the industry. This is said in full realization of the fact that with greatly increased output of cement, salesmanship is as important now as it ever was, and that it is never to be belittled in any great industry. The purpose is to make clear the distinction between modern salesmanship and that of early years when salesmen fought like the single warriors of ancient Rome or the feudal period as distinguished from the thoroughly officered and fully equipped great army engaged in fighting the battles of the world in this day.

CHAPTER XI

THE SCIENTIFIC SIDE

To understand and appreciate the enormous importance and development of the scientific side of the portland cement industry one must turn back to the period when the early manufacturers began their work so as to realize conditions that pertained to the testing and use of cement.

Scientific Studies Handicapped by Lack of Literature

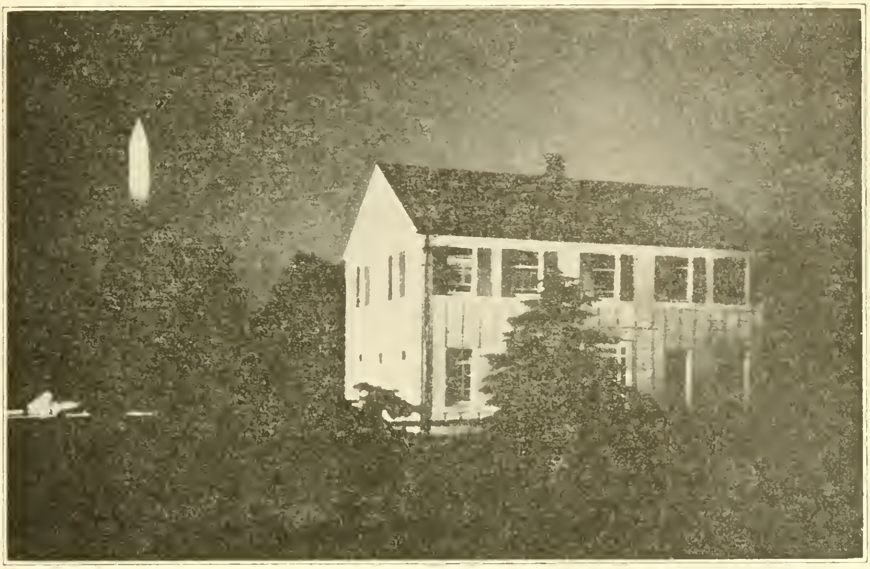
There was little or no literature on the manufacture or use of portland cement. American scientific papers contained little reference to this material, and when the American manufacturer would scan the French, German and English engineering papers he was seldom rewarded for his efforts. A paragraph now and then was a great prize and highly valued. Some few writers in Germany and England had begun to contribute their experience, and while distinguished engineers in the latter country had written papers on the use of portland cement and had read them before the British Institute of Engineers, there was very little literature in this country relating to the material. Hardly anything was known of the many uses to which cement is now adapted or employed. It is necessary to visualize a practically clear and untraveled field. There were no paths nor even footprints to guide the American manufacturer of cement or the American producer of concrete in any of its forms.

These were the days of the late seventies and the early eighties, and specifications were rare. The quality and methods for testing cement had just begun to be understood and to take some definite shape. Among the earliest tests of portland cement in the United States were those made by Eliot C. Clarke, in charge of the Boston Main Drainage Works, who, in his report covering the period from 1878 to 1884, gave the following figures as his results of tests of portland cement, practically all of it foreign brands:

Neat Cement	1 day	1 week	1 month	6 months	12 months
Portland Cement	102	303	412	468	494
With Sand					
Portland Cement	....	160	225	347	387

Preliminary Report of Committee on Uniform Tests

It was just about that time that the American Society of Civil Engineers received at its annual meeting on January 16, 1884, the preliminary report of its Committee on Uniform System for Tests of Cement. The members of the committee submitting the above report were: Q. A. Gill-



A modernized adaptation of the house that inspired John Howard Payne to write "Home, Sweet Home." Built on the White House grounds by the Better Homes Movement, the house is now occupied by the Girl Scouts.

more, D. J. Whittemore, J. Herbert Shedd, Eliot C. Clarke, Alfred Noble, F. O. Norton, and W. W. Maclay. In commenting upon the report, Mr. Whittemore stated:

> The relative importance of the two cements, the American hydraulic cement and the portland cement, might well be brought out at this meeting. I am placed in a position to assert pretty confidently that the amount of American (natural) hydraulic cement anually used in this country this side of Buffalo is nearly 2,000,000 barrels; that made on the other side amounts to about 1,250,000 barrels a year. The amount of portland cement used in this country is, as you know, very much less than that; that is to say, perhaps half a million barrels would cover the entire annual consumption of portland cement on this continent at the present time. So when we are devising methods for testing cement we want to bear in mind what a very large proportion of the cement used is the product of our own country.

The following year, on January 21, 1885, the committee, to which had been added Leonard F. Beckwith and Thomas C. McCollom, submitted its report which dealt practically with methods of testing and not with actual specifications for portland cement. In the report the committee started with the truism, "The testing of cement is not so simple a process as it is sometimes thought to be," and then gave methods by which cements of both natural and portland types should be tested, and at one point it inserted a table, "showing the average minimum and maximum tensile strength per square inch which some good cements have attained under the conditions specified elsewhere in this report."

American and foreign portland cements, neat: 1 day, 1 hour, or until set, in air, the rest of the 24 hours in water, from 11 pounds to 140 pounds.

1 week, 1 day in air, 6 days in water, from 250 pounds to 550 pounds.

1 month (28 days), 1 day in air, 27 days in water, from 350 pounds to 700 pounds.

1 year, 1 day in air, the remainder in water, from 450 pounds to 800 pounds.

It will be noted that there is a wide margin in these requirements and that in a way the figures compare with those given above as being obtained by Mr. Clarke, of the Boston Sewerage System.

In dealing with the question of sampling, the committee again illustrates the condition of the art of testing by stating:

There is no uniformity of practice among engineers as to sampling of the cement to be tested, some testing every tenth barrel. others every fifth and others still every barrel delivered.

The committee went on to say, however, that the "testing of every fifth barrel would answer for ordinary work where the cement had a good reputation, but in important construction where strength might be affected by a particular barrel, each should be tested."

Prominent Engineers and Others Assist in Developing Testing Standards

The membership of the committee itself represented men of the highest distinction in engineering and in knowledge of cements. General Q. A. Gillmore was Chief of Engineers of the United States Army. Don J. Whittemore was the Chief Engineer of the Chicago, Milwaukee and St. Paul Railroad. J. Herbert Shedd was in charge of the Providence, R. I., Public Works. Eliot C. Clarke was the Engineer of the Boston Main Drainage Works. Alfred Noble was one of the most distinguished civil engineers in New York. F. O. Norton was the manufacturer of the well-known "Norton Brand" of Rosendale cement. Captain W. W. Maclay was in charge of the concrete work for the New York Dock Department. Thomas C. McCollom was an engineer of construction for the United States Navy and building dry docks at League Island, while L. F. Beckwith was another well-known engineer in New York State. The committee worked hard and did good work, making a foundation upon which specifications were later built.

It was under these methods recommended by the American Society of Civil Engineers that the use of many millions of barrels of both portland

and natural cement in the United States were made, and their elasticity and definiteness produced a state of facts that was bound to lead to new specifications. And it was to meet the "57 varieties" of specifications which engineers of all sorts prepared to suit their own ideas of requirements that the American manufacturer of portland cement struggled from 1886 to 1904. The specifications for various pieces of engineering work, which have been commented upon above, were the subject of a paper on cement and cement testing read by Robert W. Lesley, associate member of the American Society of Civil Engineers, before the Engineers' Club of Philadelphia, in 1898, and were also the subject of an article in "Brown's Directory of Cement Industries," issued in 1901. Mr. Lesley in his paper states that in a period of six or eight years he had gathered various specifications for all kinds of work numbering altogether between two and three hundred, no two of which were alike; while Brown in his book mentions no fewer than sixty different specifications. In the Lesley paper the variations in specifications are classified and many interesting things are shown, among them the great differences between the specifications of engineers in the same department of the government or municipality, the enormous variations in the types of tests to be applied, the variations required in tensile strength and fineness, and the tests for constancy of volume. The author states:

> By many specifications, pats of cement in air and water are observed for a period of twenty-eight days for checking and cracking; while by other specifications they are submitted to accelerated tests by heat, by boiling, cooking, stewing, simmering, and other forms of violence for the same purpose.

In addition there were requirements for tests for adhesion, for porosity, for density, for specific gravity, and chemical tests of all kinds and sorts.

Under such conditions it seems a marvel that the American product was able to make its way against the variety of obstacles encountered in these many and differing specifications. However, every evil soon brings about its remedy, and during 1896, at the instigation of Richard L. Humphrey, who for many years had charge of testing for the Bureau of Surveys, City of Philadelphia, and who was himself one of the pioneers in cement testing in this country, a series of editorials appeared in the Engineering Record, New York, calling attention to the inadequacy of the recommendations for cement testing of the American Society of Civil Engineers, and urging the appointment of a new committee to revise them.

Following this a resolution was presented by Edward P. North at a meeting of the American Society of Civil Engineers held November 4, 1896, requesting the Board of Direction to report on the advisability of appointing a committee to report on "The Proper Manipulation of the Tests of Cement."

The Board reported at the annual meeting of the society on January 20, 1897, and on July 1st of the same year the Board appointed a committee consisting of George F. Swain, Boston; Alfred Noble, New York; George S. Webster, Philadelphia; W. B. W. Howe, L. C. Sabin, O. M. Carter and H. M. York. The last two members subsequently resigned. On January 16, 1901, the Board of Direction was authorized to increase the membership of this committee to nine, and in accordance therewith appointed S. B. Newberry, Clifford Richardson, Richard L. Humphrey, and F. H. Lewis. Professor Swain was elected Chairman and Mr. Humphrey, Secretary.

Of the men forming this committee, many had most important interests involving the use of cement and their influence in the matter of specifications, as well as the use of cement and concrete, was pronounced. Mr. Swain was one of the leading engineers in Boston, in charge of most important municipal and state work. Mr. Noble, of New York, was later in charge of all the Pennsylvania railroad system of terminals and tunnels into that city. Mr. Webster was the Chief of the Bureau of Surveys of the City of Philadelphia. Mr. Sabin was a distinguished government engineer. Mr. Newberry was then, and throughout his life* remained, one of the great scientific men of the cement industry. Mr. Richardson, who had been in charge of the cement testing laboratory of the United States Government at Washington, has for many years been one of the great chemists and scientists in connection with cement. Mr. Lewis was of the Booth, Garrett & Blair laboratories, and in other chapters of this book his work is fully described, while Mr. Humphrey was then, and is today, one of the leading engineers in cement and concrete, and has given unselfish, continuous, and valuable service to the making of specifications for cement and concrete in the United States.

While this committee was at work, the Board of United States Engineers, appointed by the authority of the Secretary of War, presented a report on methods of testing hydraulic cements, to which was appended standard specifications for both natural and portland cements.

Concurrent with this, the American members of the various committees of the International Association for Testing Materials endeavored to secure the adoption of standard specifications for cement, but this effort came to naught in the way of definite results.

First Step Toward a Standard Specification

This was the state of affairs when at the first meeting of the American Society for Testing Materials in June, 1902, this society, then newly organized and taking the place of the American Section of the International

*Died November 28, 1922.

Association for Testing Materials, the Executive Committee on motion of Robert W. Lesley was authorized to appoint a committee to report on standard specifications for cement. This was the first step toward specifications, and it will be noted further that this action marked the dividing line between the work of the American Society of Civil Engineers, which dealt with methods of testing in its cement committee work, and the Society for Testing Materials, which dealt with the specifications to govern the acceptance of the material itself. The members of the committee named were Robert W. Lesley, Booth, Garrett & Blair, A. W. Dow, Edward M. Hagar, Richard L. Humphrey, Lathbury & Spackman, Andreas Lundteigen, Charles F. McKenna, W. W. Maclay, S. B. Newberry, J. M. Porter, Clifford Richardson and George F. Swain. This committee had power to increase its membership with the approval of the Executive Committee.

The committee assembled at the call of Robert W. Lesley, member of the Executive Committee and temporary Chairman, on October 30, 1902, and organized by the election of George F. Swain, Chairman; George S. Webster, Vice Chairman; and Richard L. Humphrey, Secretary.

The committee was increased by the addition of the following members: T. J. Brady, C. W. Boynton, Spencer Cosby, T. H. Dumary, A. F. Gerstell, William H. Harding, F. H. Lewis, John B. Lober, Charles A. Matcham, Alfred Noble, H. W. Parkhurst, Joseph T. Richards, L. C. Sabin, H. J. Seaman, S. S. Voorhees, W. J. Wilgus, George S. Webster, H. G. Kelly, Vice-President, American Railway Engineering and Maintenance of Way Association; and W. S. Eames, President, American Institute of Architects.

The names composing the committee show that the entire membership of the American Society of Civil Engineers' Committee was appointed on this new committee; that there were representatives of the Association of American Portland Cement Manufacturers, representatives of the great railroads of the country, representatives of the American Railway Engineering and Maintenance of Way Association, and of the American Institute of Architects. It is a very interesting historical fact that this was possibly one of the earliest joint committees appointed by the engineering societies in the United States, a practice which now is universal in dealing with all important engineering subjects.

The American Society of Civil Engineers' committee made a progress report on uniform methods for tests of cement on January 21, 1903, and on February 4, 1903, the new Committee on Standard Specifications for Cement of the American Society for Testing Materials adopted as a basis for its work the report on uniform methods for tests of cement as above stated. A number of examinations of materials were made in order to obtain data for a specification, and finally a tentative specification was presented by Richard L. Humphrey, Secretary, which was considered on

December 3, 1903, approved March 29, 1904, and adopted by the committee by letter ballot on June 11, 1904. It was finally, after approval by the American Society for Testing Materials at its annual meeting, adopted by letter ballot by the Society on November 14, 1904.

Contemporaneous with this work, the Association of American Portland Cement Manufacturers, in December, 1902, appointed a committee on Standard Specifications for Cement, consisting of W. W. Maclay, Chairman; A. F. Gerstell, W. H. Harding, S. B. Newberry, Charles A. Matcham, H. J. Seaman, and Charles F. Wade. The latter committee recommended these specifications for cement, and they were adopted by this Association on June 16, 1904.

On March 19, 1903, the American Railway Engineering and Maintenance of Way Association, at its annual convention, was also at work on specifications. In concluding its report adopting the specifications, the committee on cement specifications stated:

> These reports on Uniform Tests of Cement and Standard Specifications for Cement are the result of over six years' labor of a thoroughly representative body of experts, covering every field from the manufacturer to the consumer; they stand for the very best thought on the subject.
>
> The various committees are still in existence and will from time to time recommend such changes as are found by experience to be desirable, thus gradually perfecting the specifications as a whole.
>
> In the meanwhile by the adoption of these specifications a standard of excellence is set which will enable the manufacturer to concentrate his efforts in operating his plant so as to produce uniformly the grade of cement required, and at a minimum cost to the consumer.

This was a great step forward, but as will be shown later, by no means completed work in this field, although it did mean just what the last paragraph of the report said, namely, an opportunity for the American manufacturer, who had shown a spirit of cooperation and willingness to meet every requirement of the engineering profession in the preparation of his product, to manufacture a standard and uniform product—an American portland cement which would meet every requirement of the most critical buyer for every type of engineering work. It was this opportunity of cooperation that brought the great engineers of the country and the early manufacturers of portland cement in close union, and while differences would exist in meetings, the spirit of give and take was always manifested and fair play ruled all the deliberations. It was due to the manifestation of this same spirit of cooperation between manufacturer and consumer that permanent results were achieved. Engineering comment throughout the country was emphatic in its praise of the liberal and conscientious way in which the cement manufacturers had cooperated with the engineering profession.

Leaving the matter of specifications aside, these early years were not lacking in other developments on the scientific side of the industry. There were, as stated in previous chapters, all the developments in machinery and kilns, for example, such as marked Thomas A. Edison's advent into the field of cement manufacture. This well-known inventor, whose long kiln has been described, also devised a system of fine grinding which was

The nineteen-story Medical Arts Building, Dallas, Texas, is now the tallest reinforced concrete building in the world.

used first at the Edison cement works. There were also the numerous contributions by S. B. Newberry, former Professor of Chemistry at Cornell University; those of Professor R. C. Carpenter of the same institution; those of Mr. Richardson and Mr. Sabin on rotary kilns and their use, while William B. Newberry, Professor A. B. Bleininger, Professor E. D. Campbell, Richard K. Meade, and others wrote not only on kilns but also on the chemical constitution of portland cement, the use of calcium chloride and gypsum to retard the setting time of cement, and many other subjects of great scientific interest in connection with the industry.

To these were added papers upon cement manufacture appearing in the technical press by Newberry, Lathbury, Spackman, Lesley, Carpenter, Eckel, Meade, Lewis and Lundteigen.

Several trade papers, such as Cement Age, Concrete, Concrete Engineering, Cement and Engineering News, and Rock Products, sprang into existence, while a number of important books on the subject of portland cement manufacture were published. As a matter of fact everyone interested in cement contributed to the literature current during the period covered by the work of the committees of the American Society of Civil Engineers and the American Society for Testing Materials.

Madison Porter investigated the lack of uniformity in cement testing methods, as stated by Meade in his paper delivered before the American Chemical Society in September, 1906. Maclay, Lundteigen, Lewis and W. Purvis Taylor made a study of the accelerated tests for constancy of volume; Lazell showed the lack of uniformity in standard sieves. Meade proved the sieve test to be inadequate for determining fineness in cements ground by different processes. Taylor investigated the influence of aeration on specific gravity. Spaulding, Jamison, Meade and Taylor published treatises upon the subject of cement testing. Meade says on the subject:

> Much improved apparatus for testing cement has also been perfected in this country. Jackson and McKenna have both devised apparatus for determining specific gravity. Gillmore's Needles were for a long time used for testing and setting time of cement, and now that the Vicat apparatus has been recommended, Bramwell has simplified this. The Fairbanks Company manufacture an improved form of testing machine which is much used and possesses many points of advantage over its standard German counterpart, the Michaelis machine. Olsen and Riehle have also brought forward excellent testing machines which are much used in this country. Much has also been done in improving methods of analysis. The New York Section of the Society of Chemical Industry appointed a committee to investigate the subject as did also the Lehigh Valley Section of the American Chemical Society. Both committees reported and advised methods of analysis.

Common Lack of Knowledge on Possibilities of Concrete

The same conditions that governed methods of testing of portland cement, and the same lack of knowledge and experience as marked that branch of the business, were most noticeable in connection with the use of cement in the form of concrete and reinforced concrete. The foreign portland cement brought into this country had been used largely for sidewalks, concrete foundations, brickwork and heavy masonry types of construction. Reinforced concrete was but little known, and while among engineers there had been considerable study of the work of Coignet, Bordenave and Hennebique in France, Italy and along the Suez Canal, there was little or no general knowledge on the subject. In fact, so marked was this state of affairs during the late nineties that a distinguished contractor and engineer of New York who had been asked to investigate the work of the French concrete engineers with a view of engaging in the reinforced concrete business in this country, reported to his principals that he would not stake his reputation as an engineer upon any such reinforced concrete work as was being done in France, because American labor was too careless and inefficient to observe the nice requirements of successful construction.

Committee Appointed to Study Concrete-Steel Construction

With an illustration of this kind showing the lack of actual information on the tremendous possibilities of reinforced concrete, it is easy to understand how the engineering mind began to focus itself upon the necessity for specifications or methods governing this new art. The American Society of Civil Engineers at its annual convention in Asheville, June, 1903, adopted a resolution for "the appointment of a special committee to take up the question of concrete and steel concrete and that such committee cooperate with the American Society for Testing Materials and the American Railway Engineering and Maintenance of Way Association." Such committee was appointed in May, 1904, consisting of the following members: J. E. Greiner, Consulting Engineer, Baltimore and Ohio Railroad, Baltimore; W. K. Hatt, Professor of Civil Engineering, Purdue University, Lafayette, Indiana; Olaf Hoff, Vice President, Butler Brothers, Hoff & Company, New York City; Richard L. Humphrey, Consulting Engineer and Engineer in Charge of St. Louis Structural Materials Testing Laboratories of United States Geological Survey, Philadelphia; Robert W. Lesley, President, American Cement Company, Philadelphia; J. W. Schaub, Consulting Engineer, Chicago; C. C. Schneider, Consulting Engineer, Philadelphia; Emile Swensson, Consulting Engineer, Pittsburgh, Pennsylvania; A. N. Talbot, Professor of Municipal and Sanitary Engineering, in Charge of Theoretical and Applied Mechanics, University of Illinois, Urbana; J. R. Worcester, Consulting Engineer, Boston.

The first meeting was held at Atlantic City in June, 1904, and the name was changed to Special Committee on Concrete and Reinforced Concrete. C. C. Schneider was appointed Chairman, and J. W. Schaub, Secretary. Subsequently, Mr. Schaub resigned and Richard L. Humphrey was appointed Secretary on October 11, 1905.

Formation of Joint Committee on Concrete and Reinforced Concrete

Concurrent with this work of the American Society of Civil Engineers' committee, the American Society for Testing Materials in December, 1903, appointed a Committee on Reinforced Concrete while the American Railway Engineering and Maintenance of Way Association, in March, 1904, authorized its Committee on Masonry to cooperate with the Special Committee on Concrete and Reinforced Concrete of the American Society of Civil Engineers referred to above. At a meeting of the several special committees representing the above mentioned societies held at Atlantic City, June 17, 1904, arrangements were completed for collaborating the work of these several committees through the formation of a Joint Committee on Concrete and Reinforced Concrete. C. C. Schneider was elected temporary Chairman and Professor A. N. Talbot temporary Secretary, and among the first acts of the new Joint Committee was the extending of an invitation to the Association of American Portland Cement Manufacturers to join in its deliberations through a committee appointed for the purpose.

The Joint Committee thus formed consisted of ten appointees from the American Society of Civil Engineers, fifteen from the American Society for Testing Materials, five from the American Railway Engineering Association, and four from the Association of American Portland Cement Manufacturers. To follow the history of this committee from its organization in 1904 to the present date would involve the writing of a book on concrete and reinforced concrete. The progress report presented to the various constituent societies in the year 1912-1913 embodied a bibliography of the art and a series of chapters dealing with the materials, the uses, the adaptability of concrete and reinforced concrete, forms, design, and the various other elements entering into the successful use of these new materials of construction. It was no easy task to obtain the practically unanimous report on a subject of such wide scope and much credit is due to the secretary, Richard L. Humphrey, who certainly kept the committee in action and contributed much to the important results obtained. At one time it became necessary almost to keep the committee together like a "hung jury," hardly permitting them to separate for sleep and practically insisting that they should take all their meals together until their deliberations produced fruit.

In both of the preceding cases the appointment of committees and the ensuing results grew out of evils and lack of knowledge among those having to do with the subject matter under discussion. The adoption of a uniform cement specification had been a great step forward and so was the Progress Report of the Committee on Concrete and Reinforced Concrete. In both cases new light was obtained and evils were cured, and it is a remarkable fact in considering the work mentioned that the joint committees or committees formed of representatives of all interests were engaged in the work and practically marked the advent of a new form of engineering cooperation. It was still further remarkable that while the subject under consideration was that of cement in which large interests were involved on its manufacturing side, nevertheless, in the case of both of these committees there was a large preponderance of representatives of consumers (engineers, testing laboratories, etc.) as distinguished from producers (manufacturers, contractors, etc.) thus showing the fair spirit in which the cement manufacturer had dealt with the subject of tests from the earliest days of discussion. This marked a material difference in respect to these committees as compared with other and similar bodies of the American Society for Testing Materials so far as the representative proportionate constituents of producers and consumers were concerned.

Through these two great engineering bodies, working along the lines stated, many evils were remedied and much work of great value was done; but there remained still another side of the subject and one that involved great peril to the growing industry of cement and its many uses. While the recommendations for the tests of cement and the recommendations for the use of concrete and reinforced concrete showed the way in broad and greater lines, there had developed a large field for the use of cement in sidewalk work and in the making of brick and block. It was necessary that some method of supervision or at least of correlated thought should be found to obviate any possible evils growing out of bad work in these two fields.

National Association of Cement Users Organized

The formation in 1905 of the National Association of Cement Users, whose first convention was held at Indianapolis that year, was a step in this direction. The purpose of this association, which was incorporated in 1906, was to bring into one organization that great body of smaller contractors and cement users who were working in the fields mentioned. Especially was it the purpose to gather together the proper information and data to govern the manufacture of cement block and brick, which were coming into use in a large way and causing considerable trouble and discredit in some cases to the makers and sometimes to cement itself.

At the first meeting of this association, Richard L. Humphrey was elected president and continued in that office from 1905 until 1915 as President of the National Association of Cement Users, and its successor, the American Concrete Institute, a strong and flourishing organization. Interesting contrasts between the early days of this organization, whose members at first were chiefly the non-technical but very practical type of working contractors and block makers, to the more deliberative and scientific organization that now exists, may be cited. The one great feature of the early conventions was the "Question Box," in which every one who did not know, was invited to put his question to be answered by someone who did know. This produced excellent results and was one of the elements that bound the early members thoroughly together. The development, however, of the society from its early purposes, which were rather along the lines of selection of different types of block making machinery and of the methods of making block and sidewalks, to the high engineering lines it now covers, was due to the fact that from its earliest day the society had at its head an engineer preeminent in the field and whose influence was always toward the elevation of the standards and ideals of the organization. When Mr. Humphrey resigned he was succeeded by Leonard C. Wason, another leading exponent of concrete construction. Mr. Wason was succeeded by Professor W. K. Hatt, and he in turn by H. C. Turner, all eminent authorities in the field.

It was a fitting tribute to the development of the art of testing and of the making of specifications for materials in the United States when the International Association for Testing Materials, representing practically all the leading nations of the world decided to hold its Fifth International Congress in New York in 1912, where the subjects should have the widest discussion by authorities of world-wide standing. Illustrating the growth of cement and of concrete and reinforced concrete in the engineering mind, it is sufficient to state that one section of this great congress was devoted to these subjects alone, and papers were read and discussion had upon their many-sided elements by men of the greatest distinction from France, Germany, England, Denmark, Russia, Italy, and some of the South American countries. The deliberations were in French, in German, and in English, and the section over which Robert W. Lesley, the Vice President of the American Society for Testing Materials presided, had among its other presiding officials, Dr. Schule, of Switzerland; Dr. Reitler, of Vienna, and Dr. Foss, of Copenhagen.

Single Standard Specification Adopted by All Engineering Societies and United States Government

After the presentation of the first report of Committee C-1 on Cement Specifications in 1904, wherein the first standard specifications were adopted, it was found that a number of changes requiring revisions of the specifications were necessary. This led to the first revision adopted in 1908 and a second revision in 1909; and for a time the specification was in existence and successfully used in practically all branches of the engineering profession except under government contracts. As a result of efforts to correlate the government specifications with those of the Committee C-1 on Cement Specifications, many conferences were had, covering a period of several years, between representatives of the government and of the committee above referred to. As a result of this, a third revision was adopted in 1916 to become effective January 1, 1917, which represented practically an agreement between the United States Government engineers and representatives of the committee. Much heated discussion was had at various meetings before the adoption of this specification. Under nine sub-committees of the general Committee C-1, dealing with the elements of the specification, an agreement was arrived at on all points and the result of the study of the committee, which was published by it under the auspices of the American Society for Testing Materials, is a classic so far as records of various methods of testing are concerned. The final agreement under the fourth revision was adopted in 1920 and became effective January 1, 1921, and represents an agreement between all authorities in the United States having to do with the making of a single uniform cement specification. This specification, approved January 15, 1921, is the first standard United States Specification to be adopted by the new Engineering Standards Committee of all the engineering societies. The Committee C-1, whose specifications are above referred to, consisted of thirty-seven non-producers (consumers, engineers, testing laboratories, etc.) and twenty-five producers (manufacturers of portland cement).

On March 31, 1922, this specification became the first American Standard Specification marking common accord among the various engineering societies who had long contributed to the work. The United States Government Specification also included exactly the same requirements. These specifications are given in Appendix D of this volume.

As mentioned before, the Committee on Concrete and Reinforced Concrete originally appointed by the American Society of Civil Engineers, subsequently forming the Joint Committee, whose report on dealing practically with methods of concrete and reinforced concrete construction had been approved by the various constituent organizations, finished its report. The subject, however, like the subject of cement specifications and methods of testing cement, was not finally concluded, as it remained still a duty for someone to actually make specifications for reinforced concrete. Accordingly, on June 27, 1917, Committee C-2 of the American Society for Testing Materials considered the recommending of specifications for concrete and reinforced concrete and adopted resolutions to that end. In August, 1917, its recommendations in the matter were presented to the Executive Committee of the American Society for Testing Materials. This Committee took favorable action upon the report of Committee C-2 recommending that the American Society of Civil Engineers, the American Railway Engineering Association, the American Concrete Institute and the Portland Cement Association be invited to "form with our Society a Joint Committee for the purpose of preparing specifications for reinforced concrete," these four organizations, with the American Society for Testing Materials, having cooperated in the work of the former Joint Committee on Concrete and Reinforced Concrete. The Executive Committee extended invitations to these four organizations, and by November 22, 1919, acceptances had been received from all of them. The five cooperating bodies agreed to appoint

An interior view of the Sacred Heart Church, Washington, D. C. The concrete work was executed by John J. Early, architectural sculptor.

five representatives each to the Joint Committee. After receipt of these replies naming the representatives, a call was issued by the Executive Committee of the Society for Testing Materials to the 25 representatives thus appointed to attend an organization meeting on February 11, 1920. At this meeting Richard L. Humphrey was elected Chairman, J. J. Yates, Vice Chairman and Duff A. Abrams, Secretary. Committees were appointed on the subject of: materials other than reinforcing, metal reinforcement, proportioning and mixing, forms and placing, design, details of construction and fireproofing, waterproofing and protective treatment, surface finish, form of specification.

The first report of this committee, entitled, "Progress Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete," was published in June, 1921. Since that time the report has been thoroughly discussed before each of the constituent societies and by individuals through the medium of the technical press and otherwise. In the light of this discussion and of field tests to demonstrate the practicability of some of the recommendations contained in the progress report, the committee has made quite a number of amendments which, included in a new report, are published in the October (1924) proceedings of the American Society of Civil Engineers.

Much that represents a distinct advance with regard to refinements of design is included in the report. Recognition of the dependability of the strength of concrete when scientifically proportioned, carefully placed, and properly cured, shows that marked advance has been made in the scientific study of this material and of its practical uses.

The report is not submitted as final and future amendments will probably be made, but in the general application of the specifications, the committee considers its forthcoming report as practically completing its endeavors.

At the present time (October, 1924), the membership of the Joint Committee is as follows:

AMERICAN SOCIETY OF CIVIL ENGINEERS

W. A. Slater, Chairman,
Engineer-Physicist, U. S. Bureau of Standards, Washington, D. C.

Milton H. Freeman,
Division Engineer, N. Y. & N. J. Bridge & Tunnel Comm., New York City.

A. E. Lindau,
President, American Wire Fence Company, Chicago; formerly General Manager of Sales, Corrugated Bar Company, Buffalo, N. Y.

Franklin R. McMillan,
Consulting Engineer, 628 Metropolitan Bank Building, Minneapolis, Minn. Appointed to fill vacancy.

Sanford E. Thompson,
Consulting Engineer, Boston, Mass.

W. K. Hatt,
Professor of Civil Engineering, Purdue University, Lafayette, Ind. Resigned Sept. 14, 1921. Succeeded by Milton H. Freeman.

Rudolph P. Miller,
Consulting Engineer, New York City.
Resigned March 28, 1921. Succeeded as Chairman by W. A. Slater.

AMERICAN SOCIETY FOR TESTING MATERIALS

Richard L. Humphrey, Chairman,
Consulting Engineer, Philadelphia, Pa.

Albert T. Goldbeck,
Engineer of Tests, U. S. Bureau of Public Roads, Washington, D. C.

Edward E. Hughes,
Vice-President, Franklin Steel Works, Franklin, Pa.
Henry H. Quimby,
Chief Engineer, Department of City Transit, Philadelphia, Pa.
Leon S. Moisseiff,
Engineer of Design, Delaware River Bridge, Brooklyn, N. Y.

AMERICAN RAILWAY ENGINEERING ASSOCIATION*

J. J. Yates, Chairman,
Bridge Engineer, Central Railroad of New Jersey, Jersey City, N. J.
T. L. D. Hadwen,
Engineer of Masonry Construction, Chicago, Milwaukee and St. Paul Ry., Chicago.
Frederick E. Schall,
Bridge Engineer, Lehigh Valley Railroad, Bethlehem, Pa.
C. C. Westfall,
Engineer of Bridges, Illinois Central Railroad Company, Chicago.
George E. Boyd,
Division Engineer, Delaware, Lackawanna and Western R. R., Buffalo, N. Y.
Resigned November 7, 1921. Succeeded by T. L. D. Hadwen.
H. T. Welty,
Engineer of Structures, New York Central Railroad, New York City.
Resigned December 27, 1922.

AMERICAN CONCRETE INSTITUTE*

S. C. Hollister, Chairman,
Consulting Engineer, Philadelphia, Pa.
Robert W. Lesley,
Past President, Portland Cement Association, Pennsylvania Building, Philadelphia, Pa.
Egbert J. Moore,
Vice President, Turner Construction Company, New York City.
Angus B. McMillan,
Chief Engineer, Aberthaw Construction Company, Boston, Mass.
Arthur R. Lord,
President, Lord Engineering Company, Chicago.
Resigned April 17, 1923.
Leonard C. Wason,
President, Aberthaw Construction Company, Boston, Mass.
Resigned October 19, 1920. Succeeded by Angus B. McMillan.

PORTLAND CEMENT ASSOCIATION

Frederick W. Kelley, Chairman,
President, Portland Cement Association, 126 State Street, Albany, N. Y.
Duff A. Abrams,
Professor in Charge, Structural Materials Research Laboratory, Lewis Institute, Chicago.
Ernest Ashton,
Chemical Engineer, Lehigh Portland Cement Co., Allentown, Pa.
Edward D. Boyer,
Cement Expert, Atlas Portland Cement Company, New York City.
A. C. Irwin,
Engineer, Structural Bureau, Portland Cement Association, Chicago.

*At the time of the completion of this report a vacancy existed in the representation of both the American Railway Engineering Association and the American Concrete Institute.

Many Cooperate in Study of Cement, Concrete and Aggregates

To give some idea of the importance of the field covered by cement and concrete in the work of the American Society for Testing Materials alone, it may be stated that the number of committees having to do with the two subjects is no fewer than twenty-eight; and again it may be stated that in each of the great main committees, namely, the committees on cement, concrete and reinforced concrete and on aggregates, the representation of consumers and producers is respectively 37 nonproducers, 25 producers; 16 nonproducers, 5 producers; and 23 nonproducers, 11 producers, again emphasizing the fair play that governed the constitution of the committees and the work in general.

In looking over the names of those who had to do with all the work above described, certain individuals stand out, among them C. C. Schneider and Emil Swensson, who were on the original Committee on Concrete and Reinforced Concrete and represented important steel and bridge constructing interests, but who took active part in the early work of the committee. There were also Professor W. K. Hatt, of Purdue University; John B. Lober, Vulcanite Portland Cement Company; Robert W. Lesley, American Cement Company; S. B. Newberry, Sandusky Cement Company; Ernest Ashton, Lehigh Portland Cement Company; George S. Webster, Philadelphia; Rudolph J. Wig, United States Bureau of Standards; R. B. Young, Pennsylvania Railroad; H. H. Quimby, Bureau of Surveys, Philadelphia; Sanford E. Thompson, Boston; S. T. Wagner, Philadelphia; A. N. Talbot, University of Illinois. All these men contributed of their time and ability to the furtherance of the work and may be classed among those who were associated with the committees in their early days and many of whom are with them still.

With the growth of new thought and the advent of new men, valuable additions have been made to the committee by the appointment of A. C. Tagge, Canada Cement Company; F. W. Kelley, Helderberg Cement Company; W. M. Kinney, Portland Cement Association; P. H. Bates, United States Bureau of Standards; R. S. Greenman, New York Canal Board; A. T. Goldbeck, United States Bureau of Public Roads; S. C. Hollister; E. L. Conwell, Conwell Testing Laboratories; C. N. Chapman and N. C. Johnson, all of them representing modern thought and ideas.

It is difficult to enumerate in this day all the writers of importance in the field of cement and reinforced concrete within the past fifteen years. While the earlier writers were few and far between, the field has so broadened and so many men of distinction and great minds and intelligence have contributed in scientific papers and in magazine articles, books, etc., to the subject, that it would take up considerable space to name them. So, too, it would be invidious to name some to the exclusion of others of that body of disinterested scientists who at the various meetings of the Portland Cement Association contributed papers dealing with all branches of concrete and of the manufacture of cement. These papers form in themselves a compendium of knowledge and emphasize, as do all the proceedings, the broad and thorough development of the scientific side of the industry.

From an examination of the preceding facts it will be noted with what full spirit of cooperation and with what unselfish, altruistic interest the cement industry gave itself to the solution of the problems involving the specifications for its material and the use of concrete and reinforced concrete. The broad definition of "service" may well apply to the work done. In time, in money, in suggestion, and in action, the cement manufacturers were found at all times in the forefront of the various committees and organizations dealing with these important subjects pertaining to their product. It is a tribute to a trade organization such as the Portland Cement Association that in all the joint committees dealing with cement, concrete, and reinforced concrete that body should have a definite representation and be invited to join in the action to be taken.

CHAPTER XII

THE DAY OF THE PROMOTER

Michigan and Kansas Give the Promoter His Cue

The great development of the cement industry by the construction of new mills in the marl fields of Michigan and in the gas territory of Kansas was a signal for the "promoter" to rush in and organize new companies. The growth of the Michigan and Kansas fields, together with the increase of cement business generally throughout the country, resulted in many exaggerated statements concerning the profits of the industry. The attention of unscrupulous promoters was attracted to this promising field for their talent, beginning as far back as 1897 and continuing all through the first decade of the present century. They were ready to take advantage of the situation following the wonderful growth of the new industry in the short period since it had been founded, and began organizing companies in which the get-rich-quick appeal was successfully used.

The stock salesman, the banker, the printing press, the photographer and the lithographer were all impressed into the service, and while the number of promoters was small compared with the number in some other industries, notably mining, the situation became sufficiently acute to attract attention. In 1908 Edwin C. Eckel, in his book entitled "The Portland Cement Industry from a Financial Standpoint," published an interesting account of this phase of the industry, the following paragraph from the preface of his book describing the situation concisely:

Eckel Warns Against the Promoter

There is at present every indication that the first broad improvement in the general business situation will be the signal for the attempted flotation of an unprecedentedly large mass of cement securities. Some of the enterprises against which these securities are issued will ultimately prove successful and profitable; some, though exploited honestly, will prove to have been mistakenly planned; a third and not inconsiderable group of projects will be exploited for the sole purpose of defrauding the investors.

Typical Example of His Methods

After calling attention to the great and growing importance of the portland cement industry, and how properly financed, located, constructed and managed plants had made satisfactory returns to the stockholders, Eckel exposed the fraudulent methods in operation. A promoter, he said,