THE CEMENT INDUSTRY IN THE UNITED STATES IN 1907.

By EDWIN C. ECKEL.

ACKNOWLEDGMENTS.

The data on cement production which form the basis of the following report are collected directly by the United States Geological Survey, requests for statistics being sent to every producing cement plant in the country. It is a pleasure to acknowledge the promptness and completeness with which these statistical inquiries are answered. For some years past returns have been received from every producing plant, so that the Survey's cement statistics have covered the industry completely. In this connection acknowledgment must be made of the services of Mrs. L. L. Kimball, of the Survey, who since 1902 has had charge of the receipt, comparison, and tabulation of the individual reports.

PRODUCTION.

Before taking up the statistics relative to the three kinds of cement separately, it is of interest to summarize the facts relative to the total cement production of the United States in 1907.

The total quantity of Portland, natural, and puzzolan cements produced in the United States during 1907 was 52,230,342 barrels, valued at $55,903,851. As compared with the production of 1906, which was 51,000,445 barrels, valued at $55,302,277, an increase of 2.4 per cent in quantity and of 1.1 per cent in value is shown. This increase is the smallest recorded in recent years.

The distribution of the total among the three main classes of cement is indicated in the following table:

Total production of cement in the United States in 1906 and 1907, by classes.

Class.	1906.		1907.	
	Quantity (barrels).	Value.	Quantity (barrels).	Value.
Portland	46,463,424	$52,466,186	48,785,390	$53,992,551
Natural	4,055,797	2,423,170	2,887,700	1,467,302
Puzzolan	481,224	412,921	557,252	443,998
Total	51,000,445	55,302,277	52,230,342	55,903,851

PORTLAND CEMENT.

STATISTICS OF PRODUCTION.

PRODUCTION BY STATES.

The total Portland cement production of the United States in 1907 was 48,785,390 barrels, valued at $53,992,551, an increase over the output of 1906 of 2,321,966 barrels, or about 5 per cent, in quantity, and of $1,526,365, or about 3 per cent, in value. The distribution of this total among the different producing States in 1907 is given in the following table. The production by States for 1906 is included for comparison:

Production of Portland cement in the United States in 1906 and 1907, by States.

1906.				1907.			
State.	Producing plants.	Quantity (barrels).	Value.	State.	Producing plants.	Quantity (barrels).	Value.
Illinois	4	1,858,403	$2,461,494	Illinois	5	2,036,093	$2,632,576
Indiana	6	3,951,836	4,964,855	Indiana	7	3,782,841	4,757,860
Kansas	4	3,020,862	3,908,708	Kansas	5	3,353,925	4,240,358
Michigan	14	3,747,525	4,814,965	Michigan	14	3,572,668	4,384,731
New Jersey	3	4,423,648	4,445,364	New Jersey	3	4,449,896	4,738,516
New York	9	2,414,362	2,725,744	New York	9	2,290,955	2,433,918
Ohio	8	1,422,901	1,709,918	Ohio	9	1,151,176	1,377,155
Pennsylvania	19	18,645,015	18,598,439	Pennsylvania	22	20,393,965	19,698,006
Alabama	1	1,172,041	1,432,023	Alabama	2	1,274,470	1,383,305
Georgia	1			Georgia	1		
Virginia	1			Virginia	1		
West Virginia	1			West Virginia	1		
Arizona	1	1,146,396	2,034,382	Arizona	1	534,534	915,301
Colorado	1			South Dakota	1		
South Dakota	1			Texas	2		
Texas	2						
Utah	1						
California	3	1,310,435	2,110,294	California	4	1,893,004	2,715,398
Washington	1			Washington	1		
				Colorado	1	864,938	1,395,179
				Utah	2		
Kentucky	1	3,350,000	3,260,000	Kentucky	1	3,186,925	3,320,248
Missouri	2			Missouri	2		
Total	84	46,463,424	52,466,186	Total	94	48,785,390	53,992,551

In the foregoing table, the outputs of States having only one or two active plants are combined, so as to prevent publication of individual figures. In 1907, for example, the following combinations are made: Alabama, Georgia, Virginia, and West Virginia; Kentucky and Missouri; Colorado and Utah; Texas, Arizona, and South Dakota; California and Washington.

RANK OF PRODUCING STATES.

The rank of the Portland-cement producing States has shown little change in the last two years. Pennsylvania is still the leading State by a large margin; New Jersey is second; Indiana third, Michigan fourth, and Kansas fifth. None of the remaining States produced as much as 3,000,000 barrels during the year, and the five States named contribute almost three-fourths of the total production.

Some of the changes in this respect which have taken place since 1890 are indicated in the following table:

Development of the Portland-cement industry in the United States since 1890.

Section.	1890.			1900.		
	Number of works.	Quantity (barrels).	Percentage.	Number of works.	Quantity (barrels).	Percentage.
New York	4	65,000	19.4	8	465,832	5.5
Lehigh and Northampton counties, Pa., and Warren County, N. J	5	201,000	59.9	15	6,153,629	72.6
Ohio	2	22,000	6.5	6	534,215	6.3
Michigan				6	664,750	7.8
All other sections	5	47,500	14.2	15	663,594	7.8
Total	16	335,500	100.0	50	8,482,020	100.0

Section.	1905.			1907.		
	Number of works.	Quantity (barrels).	Percentage.	Number of works.	Quantity (barrels).	Percentage.
New York	11	2,111,411	6.0	9	2,290,955	4.7
Lehigh and Northampton counties, Pa	15	13,713,910	38.9	18	19,967,790	40.9
New Jersey	3	3,654,777	10.4	3	4,449,896	9.1
Ohio	8	1,312,977	3.7	9	1,151,176	2.4
Michigan	16	2,773,283	7.9	14	3,572,668	7.3
All other sections	36	11,680,454	33.1	41	17,352,905	35.6
Total	89	35,246,812	100.0	94	48,785,390	100.0

PRODUCTION BY DISTRICTS.

The Portland-cement industry exhibits the same tendency toward geographic centralization, though to a less degree, that has given Pittsburg its preeminence as an iron producer. In the case of the Portland-cement industry the concentration of plants is in the so-called Lehigh district of Pennsylvania, with its New Jersey continuation. Here, 21 plants made over 24,400,000 barrels, or slightly over half of all the Portland cement produced in the United States in 1907. The Lehigh district was the point where American Portland-cement manufacture was first undertaken, and it owes its continued preeminence to the possession of good raw materials, good labor, good and fairly cheap fuel, and excellent transportation facilities to large eastern markets.

Taking a general view of the matter, the present geographic distribution of the cement industry is well shown in the following table. The term "East," as here used, includes plants in Pennsylvania, New York, and New Jersey, none being located in New England. The "Central" plants are those in Ohio, Indiana, Illinois, Michigan, and Missouri. Under "West" are included Kansas, Colorado, South Dakota, Arizona, and Utah. On the Pacific coast are the four active California plants and one recently started in Washington. The "South" includes Virginia, West Virginia, Georgia, Alabama, Arkansas, Texas, and Kentucky.

Geographic distribution of Portland-cement industry, 1905–1907.

	Plants in operation.			Output, in barrels.			Percentage of total output.		
	1905.	1906.	1907.	1905.	1906.	1907.	1905.	1906.	1907.
East	30	31	34	19,589,675	25,483,025	27,134,816	55.6	54.9	55.6
Central	32	34	37	10,723,802	14,030,665	13,479,703	30.4	30.2	27.6
West	7	8	10	2,470,349	3,834,656	4,463,397	7.0	8.2	9.2
Pacific coast	3	4	5	1,225,429	1,310,435	1,893,004	3.5	2.8	3.9
South	7	7	8	1,237,557	1,804,643	1,814,470	3.5	3.9	3.7
Total	79	84	94	35,246,812	46,463,424	48,785,390	100.0	100.0	100.0

RAW MATERIALS.

RAW MATERIALS USED IN MANUFACTURE OF PORTLAND CEMENT.

Numerous requests reach the Geological Survey for information concerning the raw materials used in the Portland-cement industry. As the new edition of Bulletin 243,[a] which discusses this subject in considerable detail, will not be ready for publication for some time, it has been thought desirable to present in this statistical report a summary of the more important facts relative to raw materials.

Portland cement is produced by burning a finely ground artificial mixture consisting essentially of lime, silica, alumina, and iron oxide, in certain definite proportions. Usually this combination is made by mixing limestone or marl with clay or shale, in which case about three times as much of the lime carbonate should be present in the mixture as of the clayey materials. The burning takes place at a high temperature, approaching 3,000° F., and must therefore be carried on in kilns of special design and lining. During the burning, combination of the lime with silica, alumina, and iron oxide takes place. The product of the burning is a semifused mass called clinker, and consists of silicates, aluminates, and ferrites of lime in certain definite proportions. This clinker must be finely ground. After such grinding, the resulting powder is Portland cement.

The finished product is blue to gray in color, has a specific gravity of 3 to 3.25, and when mixed with water will harden or set.

The product must be uniform in composition and quality; and as the processes of manufacture involve certain chemical as well as physical changes, four points may be regarded as of cardinal importance in making Portland cement. These are:

1. The cement mixture must be of the proper chemical and physical composition;
2. The raw materials of which it is composed must be finely ground and intimately mixed before burning;
3. The burning must be conducted at the proper temperature;
4. After burning the resulting clinker must be finely ground.

In the present report only such matters as directly concern the question of raw materials will be discussed, as questions relating to processes of manufacture do not fall within the field of work of the Geological Survey. For present purposes it will be sufficiently accurate to consider that a Portland-cement mixture, when ready for

[a] Eckel, E. C., Cement materials and industry of the United States, Bull. U. S. Geol. Survey No. 243, 1905.

burning, will consist of about 75 per cent of lime carbonate ($CaCO_3$) and 20 per cent of silica (SiO_2), alumina (Al_2O_3) and iron oxide (Fe_2O_3) together, the remaining 5 per cent including any magnesium carbonate, sulphur, and alkalies that may be present.

The essential elements which enter into this mixture—lime, silica, alumina, and iron—are all abundantly and widely distributed in nature, occurring in different forms in many kinds of rocks. It can therefore be readily seen that, theoretically, a satisfactory Portland-cement mixture could be prepared by combining, in an almost indefinite number of ways and proportions, many possible raw materials. Obviously, too, we might expect to find perfect gradations in the artificialness of the mixture, varying from the one extreme where a natural rock of absolutely correct composition was used, to the other extreme where two or more materials, in nearly equal amounts, are required to make a mixture of correct composition.

The almost infinite number of raw materials which are theoretically available are, however, reduced to a very few in practice under existing commercial conditions. The necessity for making the mixture as cheaply as possible rules out of consideration a large number of materials which would be considered available if chemical composition was the only thing to be taken into account. Some materials otherwise suitable are too scarce; some are too difficult to pulverize to the fineness necessary to bring about the requisite chemical combination of the mixture in the kiln. In consequence, a comparatively few combinations of raw materials are actually used in practice.

In certain localities deposits of argillaceous (clayey) limestone or "cement rock" occur, in which the lime, silica, alumina, and iron oxide exist in so nearly the proper proportions that only a relatively small amount (say 10 per cent or so) of other material is required in order to make a mixture of correct composition.

In the majority of plants, however, most or all of the necessary lime is furnished by one raw material, while the silica, alumina, and iron oxide are largely or entirely derived from another raw material. The raw material which furnishes the lime is limestone, chalk, or marl, while the silica, alumina, and iron oxide of the mixture are derived from clay, shale, or slate.

PRODUCTION ACCORDING TO RAW MATERIALS USED.

In the following table the production of Portland cement in the United States is classified according to the kinds of raw materials from which the cement was manufactured.

The production is grouped as follows:

Type 1 includes cement produced from a mixture of argillaceous limestone ("cement rock") and pure limestone. This is the combination of materials used in all the cement plants of the Lehigh district of Pennsylvania and New Jersey, and also at several western plants.

Type 2 includes cement made from a mixture of comparatively pure limestone with clay or shale. This mixture is employed at many plants all over the United States.

Type 3 includes cement manufactured from a mixture of marl and clay. This type of mixture is used only in the States of Michigan, Ohio, Indiana, and New York.

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Type 4 includes Portland cement manufactured from a mixture of limestone and blast-furnace slag.

Production, in barrels, and percentage of total output of Portland cement in the United States according to type of material used, 1898–1907.

Year.	Type 1. Argillaceous limestone (cement rock) and pure limestone.		Type 2. Limestone and clay or shale.		Tpye 3. Marl and clay.		Type 4 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	4,080,132	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

VALUATION OF DEPOSITS OF CEMENT MATERIALS.

Very erroneous ideas appear to be current concerning the value of deposits of cement materials. It should be clearly understood that in most parts of the United States excellent cement materials are common, and that the commercial value of undeveloped deposits of such materials is necessarily slight. In most of the Eastern, Southern, and middle Western States there is no difficulty whatever in securing lands containing limestones suitable for cement manufacture at prices ranging from $5 to $50 per acre, and it is only exceptional circumstances which would allow any cement deposit to be valued at more than the latter price. As indicated below, the value of the deposit depends less upon the character of the materials than upon other factors.

The determination of the possible value for Portland cement manufacture of a deposit of raw material is a complex problem, depending upon a number of distinct factors, all of which must be given due consideration. The more important of the factors are:

1. Chemical composition of the material.
2. Physical character of the material.
3. Amount of material available.
4. Location of the deposit with respect to transportation routes.
5. Location of the deposit with relation to fuel supplies.
6. Location of the deposit with respect to markets.

Ignorance of the respective importance of these factors frequently leads to an overestimate of the value of a deposit of raw material.

The characteristics of a deposit necessary for the manufacture of a good Portland cement may be briefly stated as follows: The raw material must be of correct chemical composition for use as a cement material. This implies that the material, if a limestone, must contain as small a percentage as possible of magnesium carbonate. Under present conditions 5 or 6 per cent of magnesium carbonate is the maximum permissible. Free silica, in the form of chert, flint, or sand must be absent, or present only in small quantities, say 1 per cent or less. If the limestone is a clayey limestone or "cement rock," the

proportion between its silica and its alumina and iron should fall within the limits

$$\frac{SiO_2}{Al_2O_3 + Fe_2O_3} > 2. \quad \text{and} \quad \frac{SiO_2}{Al_2O_3 + Fe_2O_3} < 3.5$$

A clay or shale should satisfy the above equation and should be free from sand, gravel, etc. Alkalies and sulphates should, if present, not exceed 3 per cent or so.

The nearer a limestone approaches in composition to the mixture used in Portland cement manufacture the greater its value for that purpose, for it will require the addition of less extraneous material to make the mixture absolutely correct in composition. The following are analyses of Portland-cement mixtures, ready for burning, as used at various large cement plants in the United States:

Analyses of Portland cement mixtures.

	1.	2.	3.	4.
Silica (SiO_2)	12.85	12.92	13.52	14.94
Alumina (Al_2O_3)	4.92	4.83	6.56	2.66
Iron oxide (Fe_2O_3)	1.21	1.77	.....	1.10
Lime carbonate ($CaCO_3$)	76.36	75.53	75.13	75.59
Magnesium carbonate ($MgCO_3$)	2.13	4.34	4.32	4.64

It will be seen that the usual mixtures carry from 75 to 77 per cent of lime carbonate. Bearing this in mind, it will be obvious that there is a great advantage in using, as one of the raw materials, a limestone of about this degree of purity. If rock of this composition occurs in sufficient quantity, it would require but little admixture of other materials to keep the cement correct in composition.

GEOGRAPHIC DISTRIBUTION OF CEMENT MATERIALS IN THE UNITED STATES.

It is of course impossible to discuss this subject within the limits permissible in this chapter, for any satisfactory treatment of it would require hundreds of pages, while the scope of the present report is necessarily restricted. Detailed descriptions of this character are contained in Bulletin 243 of the United States Geological Survey. This bulletin, which was published a few years ago, but was soon out of print, is now being rewritten and will be issued in an entirely revised form as soon as possible. In order to fill the requirements of the present report, an attempt has been made to summarize in the following schedule the main facts regarding the occurrence or non-occurrence of the more important cement materials in the various States.

In this table four symbols are used to denote various degrees of abundance or rarity. A indicates the occurrence of large and widely distributed deposits; B indicates the occurrence either of a few large deposits or of a number of small ones; C indicates the occurrence of a few small deposits only; 0 indicates that the material is either absolutely wanting or is so scarce as not to be of any possible commercial importance.

In regard to the fuel supplies noted in the table, a word of caution is necessary. The term "coal" is here limited to such coals as can be used in cement manufacture with reasonable economy. Peat, lignite, and many western "coals" are therefore omitted from consideration.

Occurrence of the more important cement materials, by States.

State.	Raw materials.			Fuels.			State.	Raw materials.			Fuels.		
	Low-magnesia limestones.	Fresh-water marls.	Soft limestones.	Coal.	Oil.	Gas.		Low-magnesia limestones.	Fresh-water marls.	Soft limestones.	Coal.	Oil.	Gas.
Alabama	A	0	A	A	0	C	Nebraska	B	0	B	0	0	0
Arizona	B	0	0	C	0	0	Nevada	B	0	0	0	0	0
Arkansas	A	0	B	A	0	0	New Hampshire	B	0	0	0	0	0
California	B	0	B	C	A	C	New Jersey	A	C	0	0	0	0
Colorado	A	0	A	B	A	0	New Mexico	B	0	0	C	0	0
Connecticut	C	0	0	0	0	0	New York	A	A	0	0	C	B
Delaware	C	0	0	0	0	0	North Carolina	C	0	A	C	0	0
Florida	A	0	A	0	0	0	North Dakota	0	0	C	0	0	0
Georgia	A	0	B	B	0	0	Ohio	A	A	0	A	A	A
Idaho	B	0	0	B	0	0	Oklahoma	A	0	B	A	A	A
Illinois	A	A	0	A	A	A	Oregon	C	0	0	C	0	0
Indiana	A	C	0	A	A	A	Pennsylvania	A	0	0	A	A	A
Iowa	A	0	0	A	0	0	Rhode Island	C	0	0	0	0	0
Kansas	A	0	C	A	A	A	South Carolina	C	0	B	0	0	0
Kentucky	A	0	0	A	A	A	South Dakota	0	0	B	0	0	0
Louisiana	0	0	C	0	B	0	Tennessee	A	0	0	A	C	C
Maine	B	0	0	0	0	0	Texas	A	0	A	C	A	A
Maryland	A	0	0	A	0	0	Utah	A	0	0	A	0	0
Massachusetts	C	C	0	0	0	0	Vermont	B	0	0	0	0	0
Michigan	A	A	0	A	0	0	Virginia	A	0	A	A	0	0
Minnesota	C	C	0	0	0	0	Washington	B	0	0	C	0	0
Mississippi	C	0	A	0	0	0	West Virginia	A	0	0	A	A	A
Missouri	A	0	0	A	0	0	Wisconsin	C	C	0	0	0	0
Montana	A	0	B	C	....	....	Wyoming	A	0	B	A	A	....

KILNS AND KILN PRACTICE.

NUMBER AND LENGTH OF KILNS IN OPERATION.

In 1907 the total number of rotary kilns in operation for all or part of the year was 876, an increase of 83 over the active kilns of 1906. Classified according to their length these kilns may be grouped as follows:

Kilns in operation, classified according to length, in 1906 and 1907.

Length.	Number of kilns operated.		Length.	Number of kilns operated.	
	1906.	1907.		1906.	1907.
60 feet and less	398	362	120 feet	17	41
70 to 78 feet	40	43	125 feet and over	57	117
80 feet	69	85	Of unspecified length	14	.....
85 to 95 feet	66	68			
96 to 100 feet	52	76	Total	793	876
104 to 110 feet	80	84			

AVERAGE ANNUAL OUTPUT PER KILN.

The relatively small quantity of Portland cement still made in vertical kilns being omitted, each active rotary kiln averaged 55,691 barrels

in 1907. Compared with 1906, when the average annual output per kiln was 58,592 barrels, a small but noticeable decrease is shown. This is not due to any falling off in the average capacity of the kiln, for that has really shown an increase, but to the stoppage of many kilns during the latter part of the year.

The data as to number and output of kilns collected in earlier years may be summarized as follows for convenience in comparison:

Number and average annual output of kilns, 1902–1907.

Year.	Number of active rotaries.	Average output per kiln (barrels).
1902	456	36,909
1905	722	48,818
1906	793	58,592
1907	876	55,691

KILNS UNDER CONSTRUCTION.

In the report for 1906 it was stated that, in addition to the 793 rotary kilns actually operated in 1906, 92 kilns were in course of construction and sufficiently far advanced to begin producing in 1907. This estimate was very close to the truth, for the number of kilns operated in 1907 was 876, a gain of 83 over the preceding year.

On January 1, 1908, there were under construction 87 new kilns, in plants sufficiently far advanced to become factors in the 1908 cement production, provided that market conditions should justify their operation. The number of these new kilns, classified according to size, is as follows:

Kilns under construction, classified according to size, in 1907.

Number.	Length.
20 kilns	100 feet.
22 kilns	110 feet.
9 kilns	120 feet.
36 kilns	125 feet and over.

MAXIMUM ANNUAL CAPACITY OF CEMENT PLANTS IN THE UNITED STATES.

In view of the often repeated statement that the output of Portland cement in the United States is still far behind the possible demand for the product, it is of interest to consider the data as to kiln capacity already presented.

It has been stated that 876 kilns were in operation in 1907, and that 87 new kilns will be ready some time in 1908. This gives a total of 963 kilns which can be used if the cement trade become prosperous enough to justify it. As all the new kilns are 100 feet or more in length, and as many old kilns are being lengthened, it seems entirely safe to estimate that the average possible output per kiln per year is now considerably over 60,000 barrels. Assuming for convenience that this average is now about 62,000 barrels per kiln, it will be possible to make Portland cement during the latter part of 1908 at the rate of 5,000,000 barrels per month, or 60,000,000 barrels per year. In

view of existing financial conditions, however, it would appear probable that the cement production of 1908 will not exceed that of 1907.

FUELS IN USE.

The fuels used in Portland-cement kilns are powdered coal, oil, natural gas, and producer gas. The relative importance of these four fuels is well brought out by the following table, which is based upon the 1907 statistics.

Oil is used by all of the cement plants in Arizona, California, Texas, and Washington. Natural gas is used by all the operating Kansas plants, and by one plant elsewhere. A small output on producer gas at one plant is included in the natural-gas figures. Powdered coal is, however, the principal fuel used, 79 plants, with a total of 753 kilns, and producing 88.5 per cent of the total output, being equipped with powdered-coal burners.

Fuels used in Portland-cement plants in 1907.

Fuel used.	Number of plants.	Number of kilns.	Output in 1907.	Percentage of total.
			Barrels.	
Powdered coal	79	753	43,151,461	88.5
Oil	8	64	2,229,004	4.5
Natural gas	6	58	3,404,925	7.0
Producer gas	1	1		
Total	94	876	48,785,390	100.0

CONCENTRATION OF INTEREST IN THE CEMENT INDUSTRY.

The Portland-cement industry affords a peculiarly interesting example of an important and growing branch of manufacture whose future organization and control is still a matter of uncertainty. Ten or even five years ago the business of making Portland cement in the United States was confined to a number of comparatively small mills, each of which was practically independent. To-day there is a noticeable degree of concentration of interest in the industry, and three processes are at work to increase steadily this concentration. Owing to the peculiar character of the industry, the final result is still a matter of much doubt. In an earlier report of this series it was pointed out that it is impossible for any one organization to gain control of the supply of raw materials, so that in this industry the most effective basis for monopoly is not available. The ownership of comprehensive basic patents would, as noted later, afford a peculiarly serviceable type of control, inasmuch as patent monopolies are thoroughly legal in form.

Setting aside for the moment the possibility of monopoly, it can be said that the three factors which make for concentration of control are—

1. The normal growth of profitable plants.
2. Consolidation by stock control.
3. The growth of the patent-holding company.

NORMAL GROWTH OF PROFITABLE PLANTS.

A well-located and well-managed plant always has opportunity for expansion which is denied to plants of less technical or financial soundness. Many plants in this country have had opportunities for growth, and some have seized these opportunities. Plants which are built or extended at the height of a boom period, and companies which pay out all the profits of prosperous years as dividends can hardly expect to share in this growth. For in by far the majority of instances, lack of growth in a cement plant has been due, not to defective raw materials or to lack of technical skill, but to unwise financial management either at the inception or during the active life of the company.

CONSOLIDATION BY STOCK CONTROL.

Several strong groups of plants connected by stock control rather than by direct ownership are now in existence. Of these the most important is the Iola or Nicholson group, which controls seven plants, mostly in the Kansas district. A second important group is that controlled by Mr. W. J. Dingee and his associates, including plants in California, Washington, and Pennsylvania. The Cowhan series of plants located in Michigan, Iowa, Kansas, and Texas also requires notice in this connection, and a number of smaller examples of "community of interest" are known to exist.

THE GROWTH OF THE PATENT-HOLDING COMPANY.

Numerous patents have been taken out in connection with various phases of the cement industry, but it is only within the last two years that the patent question has become of the first importance to the cement industry. This recent development is due to the organization and growth of a great patent-holding corporation.

Late in 1906 the North American Portland Cement Company was organized, with a capital stock of $10,000,000, this stock being held by the Atlas, Alpha, American, Lawrence, Lehigh, and Vulcanite cement companies. The North American Company took over from the Atlas Portland Cement Company the United States rights to the Hurry and the Seaman patents, which cover certain methods for the burning of pulverized coal in cement kilns. At a later date it acquired the Edison long-kiln and the Carpenter patents. The companies now licensed under this system include the six companies which control the North American and also the Whitehall, Northampton, Hexter, Edison, Nazareth, Pennsylvania, Penn-Allen, Catskill, Buckhorn, Phoenix, Bath, and Glens Falls Portland cement companies. In January, 1907, these licensed companies organized as the Association of Licensed Cement Manufacturers. The following material is quoted from a statement then issued:

> The purposes of the association include the general betterment of the mechanical and chemical processes used in making cement, the improvement of the quality of cement, dealing with matters of traffic and shipment and the establishment of an association laboratory for technical tests and experiments. It is understood that all existing and properly equipped cement plants will be granted licenses and admitted to membership. Infringers of the patents above referred to will be rigorously prosecuted.

Nearly 70 per cent of the output of the Portland-cement industry in this country is already represented by the association, this being double the annual production in Great Britain, the pioneer Portland-cement manufacturing country, equal to the combined output of England and France, and in excess of that of Germany

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The Association of Licensed Cement Manufacturers, with its facilities for tests and experiments, its investigation of mechanical and chemical problems, its establishment of standards of quality, and its assistance in obtaining proper shipping facilities and rates is expected to be of great benefit to its members.

PRESENT STATUS OF THE INDUSTRY

The facts discussed in preceding paragraphs may be summarized as in the schedule below, which is an attempt to indicate the groupings at present existing in the domestic Portland-cement industry. This table is based on information supplied by those in control of most of the plants mentioned, and is believed to be substantially free from error.

Present status of the Portland-cement industry in the United States.

Names of companies.	Location of plants.
1. North American Portland Cement Company·	
Alpha Portland Cement Company	Alpha, N. J.; Martins Creek, Pa.
Martins Creek Portland Cement Company	Martins Creek, Pa.
American Cement Company	Egypt, Pa.
Central Cement Company	Egypt, Pa.
Reliance Cement Company	Egypt, Pa.
Seaboard Cement Company	Norfolk, Va.[a]
Atlas Portland Cement Company	Northampton, Pa.; Hannibal, Mo.
Lawrence Cement Company	Siegfried, Pa.
Lehigh Portland Cement Company	Ormrod, Pa.; Wellston, Ohio; Mitchell, Ind.; Des Moines, Iowa.[a]
Shenango Portland Cement Company	Newcastle, Pa.
Vulcanite Portland Cement Company	Vulcanite, N. J.
2. Nicholson or Iola group:	
Iola Portland Cement Company	Iola, Kans.
United Kansas Portland Cement Company:	
Kansas Portland Cement Company	Iola, Kans.
Independence Portland Cement Company.	Independence, Kans.
Indian Portland Cement Company	Neodesha, Kans.
Dixie Portland Cement Company	Copenhagen, Tenn.
Iowa Portland Cement Company	Des Moines, Iowa.[a]
Texas Portland Cement Company	Dallas, Tex.
3. United States Steel Corporation:	
Universal Portland Cement Company	Chicago, Ill.; Buffington, Ind.; Pittsburg, Pa.[a]
4. Dingee group:	
Standard Portland Cement Company	Napa Junction, Cal.
Santa Cruz Portland Cement Company	Santa Cruz, Cal.
Northwestern Portland Cement Company	Kendall, Wash.[a]
Atlantic Portland Cement Company	Stockertown, Pa.[a]
Northampton Portland Cement Company	Stockertown, Pa.
Quaker Portland Cement Company	Sandts Eddy, Pa.[a]
5. Cowhan group:	
Peninsular Portland Cement Company	Cement City, Mich.
Southwestern States Portland Cement Company.	Dallas, Tex.[a]
Western States Portland Cement Company	Independence, Kans.
Northwestern States Portland Cement Company.	Mason City, Iowa.[a]
6. Sandusky Portland Cement Company	Bay Bridge, Ohio; Dixon, Ill.; Syracuse, Ind.; York, Pa.

[a] Plants thus designated are not yet in operation.

NATURAL CEMENT.

PRODUCTION.

The natural cement produced in the United States during 1907 amounted to 2,887,700 barrels, valued at $1,467,302. As compared with a production of 4,055,797 barrels, valued at $2,423,170, in 1906, this output indicates a decrease of about 29 per cent in quantity and of about 39 per cent in value in 1907.

PRODUCTION BY STATES.

In the following table the natural cement production of 1907 is classified by States, the figures for 1906 being added for comparison:

Production of natural cement in 1906 and 1907, by States.

State.	1906.			State.	1907.		
	Number of works.	Quantity (barrels).	Value.		Number of works.	Quantity (barrels).	Value.
Georgia	3	180,500	$98,075	Illinois	3	284,599	$92,750
Illinois	3	365,843	118,221	Indiana	12	400,000	140,000
Indiana	12	600,000	240,000	New York	15	947,929	633,170
Maryland	4	63,350	32,675	Pennsylvania	4	645,871	263,969
New York	16	1,515,866	1,055,785	Kansas	2	129,077	71,052
Pennsylvania	4	744,403	560,534	Texas	1		
Kansas	2	238,311	129,781	Georgia	2	338,195	176,379
Texas	1			Kentucky	2		
Kentucky	2	170,194	95,539	Maryland	4		
Ohio	1			Ohio	1		
Virginia	1			Virginia	1		
Minnesota	2	177,330	92,560	Minnesota	2	162,029	89,982
North Dakota	1			North Dakota	1		
Wisconsin	2			Wisconsin	2		
Total	54	[a] 4,055,797	[a] 2,423,170	Total	52	2,887,700	1,467,302

[a] A small quantity of hydraulic lime was produced in Georgia, Maryland, and New York, and is included in this table.

COMPARISON OF PRODUCTION OF PORTLAND AND NATURAL CEMENT 1890–1907.

On examining the cement statistics for a series of years, it will be seen that the output of Portland cement has so far shown an increase each year, rising from 42,000 barrels in 1880 to 335,500 barrels in 1890, to 8,482,020 barrels in 1900, and to 48,785,390 barrels in 1907. The natural cement production, on the other hand, reached its maximum in 1899, with an output of 9,868,179 barrels. Since that year it has shown an almost continuous and quite rapid decrease annually, until now it has become a relatively unimportant factor in the cement situation. These facts are brought out clearly in the appended diagram (fig. 1).

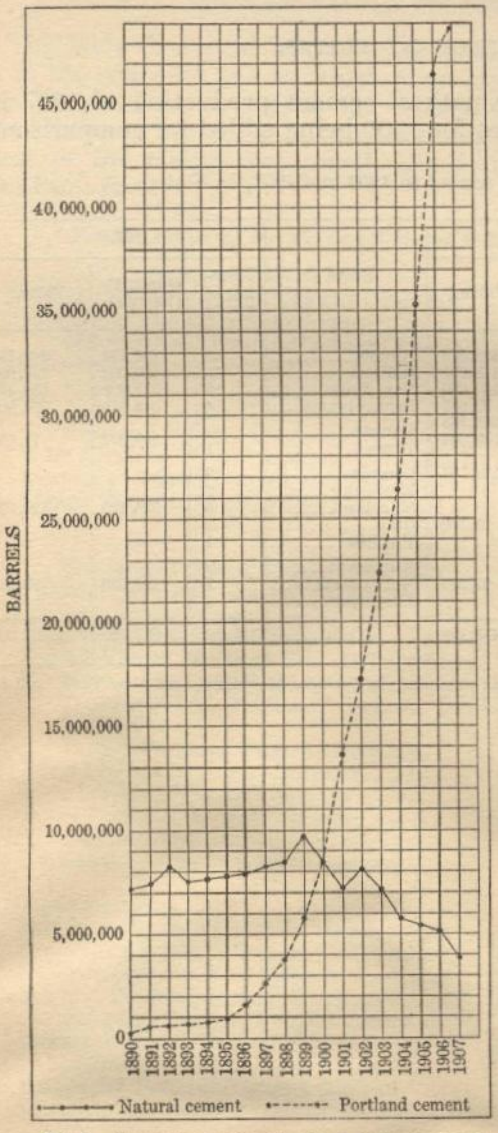

FIG. 6.—Comparison of production of Portland and natural cement, 1890–1907.

PRODUCTION OF HYDRAULIC LIME IN THE UNITED STATES.

For the last two or three years several domestic natural-cement plants have been manufacturing and marketing a true hydraulic lime, similar in every technical respect to the well-known French hydraulic lime of Teil.

In 1907 the production of hydraulic lime amounted to 49,769 barrels, valued at $23,133, as compared with a production in 1906 of 40,800 barrels, valued at $19,300.

PUZZOLAN CEMENT.

PRODUCTION.

Puzzolan cement, made by mixing slag with slaked lime, was manufactured during 1907 to the amount of 557,252 barrels, valued at $443,998.

There are 10 plants equipped for the manufacture of slag cement in the United States. Of these, the States of Ohio and Alabama contain 2 plants each, while Illinois, Kentucky, Maryland, New Jersey, New York, and Pennsylvania have 1 plant each. During 1907 the plants in Maryland and New Jersey were idle.

Owing to this fact, it is impossible to distribute the total production in any instructive manner without disclosing individual statistics.

The following table contains the leading facts relative to this industry for the four years from 1904 to 1907, inclusive:

Statistics of the puzzolan cement industry, 1904–1907.

	1904.	1905.	1906.	1907.
Number of plants:				
Alabama	2	2	2	2
Illinois	1	1	1	1
Kentucky	.....	1	1	1
Maryland	1	1	1	1
New Jersey	1	1	1	1
New York	.....	.....	1	1
Ohio	2	2	2	2
Pennsylvania	1	1	1	1
Total	8	9	10	10
Production, in barrels	303,045	382,447	481,224	557,252
Value of production	$226,651	$272,614	$412,921	$443,998

IMPORTATION OF JAPANESE VOLCANIC ASH.

Reports that cargo loads of Japanese volcanic ash, for use in puzzolan cement, were being shipped to the Pacific coast of the United States in 1907 attracted considerable attention to that type of material. The data below are summarized from a consular report issued during the year.

The puzzolanic ash is widely distributed in Japan, the present workings being on the island of Kyushu, 7 miles inland from the port of Karatsu. The ash is dug, dried in the open air, roasted, and ground to 50 mesh or slightly finer. Four analyses of various samples of the ash are as follows:

Analyses of Japanese volcanic ash.

Silica	41.95	42.10	44.15	42.63
Alumina	25.00	25.72	24.81	27.52
Iron oxide	18.56	18.28	17.40	16.83
Lime	1.33	1.15	1.57	0.03
Magnesia	0.82	0.85	0.94	0.96
Soda and potash	2.35	2.26	2.73	0.93
Loss on ignition	9.90	9.70	8.40	10.02

The following table shows the results of tensile tests of mixtures containing this material, made at the Sasebo naval depot, where large quantities have been used in Government work:

Tensile tests of mixtures containing Japanese volcanic ash.

Quality of water used in experiments.	Proportions in weight of mixture.				Tensile strength per square inch in English pounds.				
	Portland cement.	Lime.	Puzzolan cement.	Sand.	After 4 weeks.	After 3 months.	After 6 months.	After 12 months.	After 24 months.
Sea	7	.....	3	20	284	455	553	574	583
	6	.....	4	20	284	405	469	432	515
	5	.....	5	20	268	364	463	459	500
Sulphate of magnesia	7	.....	3	20	278	431	500	511	518
	6	.....	4	20	251	385	415	441	464
	5	.....	5	20	238	340	414	427	472
Fresh	7	.....	3	20	291	376	449	436	471
	6	.....	4	20	243	345	426	414	439
	5	.....	5	20	205	318	401	370	388
Sea	7	.....	3	30	167	325	401	400	423
	6	.....	4	30	158	264	300	300	349
	5	.....	5	30	147	244	291	291	333
Sulphate of magnesia	7	.....	3	30	167	277	296	260	311
	6	.....	4	30	133	175	195	177	206
	5	.....	5	30	116	170	162	176	265
Fresh	7	.....	3	30	161	247	293	306	345
	6	.....	4	30	152	256	285	291	331
	5	.....	5	30	124	210	249	229	288
Fresh	.....	2	8	20	160	312	271	306	.....
	.....	3	7	20	156	292	295	317	.....
	.....	2	8	30	122	215	214	214	.....
	.....	3	7	30	106	234	217	223	.....

The following is a report of compression test of Karatsu volcanic ash said to have been made at the Kioto Imperial University:

Compression test of Karatsu volcanic ash.

Description.	Proportion in volume.			Per square inch in pounds.				
	Portland cement.	Volcanic ash.	Sand.	After 1 week.	After 4 weeks.	After 3 months.	After 6 months.	After 1 year.
Fresh water	1	.....	3	782.25	1,177.63	1,639.88	1,880.25	2,104.97
Fresh water	.5	0.5	3	493.53	782.25	1,173.38	1,191.87	1,453.57

As a result of experience the Japanese company recommends the following mixtures, the proportions being in volumes:

For harbor, dock, and general sea work, ash 3, cement 2, sand 10; for water works, drains, river embankments, roads, and tunnels, ash 3, lime 1, cement 1, sand 10; for drains and plastering, ash 4, lime 2, cement 1.5, sand 10; for foundations and brickwork, ash 1, lime 1, sand 30 to 40; for concrete add gravel one and one-half to twice the quantity of sand used. Sand and gravel should be well washed and partially dried before mixing.

The following directions for mixing are given: Place the kneading stand at the desired spot. Have all the materials ready at hand. Have volcanic ash and lime or cement well mixed as desired, and adding sand to it, mix it again, pouring in a proper amount of water; knead it over and over, using sufficient pressure, and covering entirely the outside of sand with volcanic ash, etc., knead them until the different materials lose their own colors and come to one color.

The company prepares the ash, ready for use, packed in straw bags, weighing about 140 pounds each, the prices for which are at Nagasaki 70 sen (35 cents), at Kobe 80 sen (40 cents), and at Yokohama 1 yen (50 cents). In large quantities the prices, free on board ship,

per ton of 2,000 pounds, are at Nagasaki and Shimonoseki (Moji) 10.5 yen ($5.23), at Kobe 12 yen ($5.98), at Yokohama 15 yen ($7.47). Freights from Nagasaki and Shimonoseki (Moji) to Seattle and San Francisco per ton of 2,000 pounds are about $4, and from Nagasaki to Manila about $2.50.

As very extensive deposits of similar volcanic ash are known to occur in the Rocky Mountain and Pacific coast States, it seems probable that the importation of Japanese ash will result in the development of the domestic deposits in the near future.

IMPORTS, EXPORTS, AND CONSUMPTION.

The following tables show the imports for consumption, the exports, and the apparent consumption of hydraulic cement of all kinds in the United States for the years respectively mentioned:

Imports for consumption of hydraulic cement into the United States, 1902–1907, in barrels.

1902	1,963,023	1905	896,845
1903	2,251,969	1906	2,273,493
1904	968,410	1907	2,033,463

Exports of hydraulic cement, 1902–1907 in barrels.

1902	340,821	1905	897,686
1903	285,463	1906	583,299
1904	774,940	1907	900,550

Total consumption of hydraulic cement in 1907, in barrels.

Total production in the United States	52,230,342
Imports withdrawn for consumption	2,033,463
Total	54,263,805
Exports	900,550
Total apparent consumption	53,363,255