LIME AND SAND-LIME BRICK.[a]

By Edwin C. Eckel.

INTRODUCTION.

Until recently statistics relative to the lime industry were reported in the volume on Mineral Resources in the chapter on stone, while the sand-lime brick production was reported in the chapter on clay products. This practice had grown up quite naturally, as the earlier statistics on lime were gathered merely incidentally to the collection of limestone statistics, while the sand-lime brick industry was new and unimportant. The recent growth of both industries, however, seemed to make it desirable to devote a separate section to lime and its products, and accordingly this was done in 1905. This year the same plan has been followed, but additional material is now presented relative to certain technologic features of the industries reported on. This is possible owing to the complete responses made by individual producers to requests for information as to fuel used, uses of their lime, and other particulars.

LIME.

PRODUCTION.

The lime output increased from 2,984,100 tons, valued at $10,941,,680[b] in 1905 to 3,197,754 tons, valued at $12,480,653, in 1906, an increase of 213,654 tons in quantity and of $1,538,973 in value. The average price per ton was $3.67 in 1905 and $3.90 in 1906, an increase of $0.23 per ton.

There was an increase in value per ton in almost every State, the cause given in almost all cases being increase in cost of fuel and supplies and increase in cost of labor. The figures given represent the net value of the lime.

The number of lime burners reporting a production in 1906 was 1,012; the number giving complete record of fuel burned was 951.

[a] The tables on the production of lime and of sand-lime brick, respectively, were prepared by Miss A. T. Coons and Miss B. W. Bagley, of this Office.

[b] Does not include value ($408,548) of limestone burned at sugar refineries and alkali plants, but not included in the tonnage for 1905.

Detailed statistics of lime production during 1905 and 1906, by States, are given in the following table:

Quantity and value of lime burned in the United States in 1905 and 1906, by States, in short tons.

State.	1905.			1906.		
	Quantity.	Value.	Average price per ton.	Quantity.	Value.	Average price per ton.
Alabama	79,973	$292,162	$3.65	92,403	$341,627	$3.70
Arizona	5,298	32,557	6.15	14,084	96,470	6.85
Arkansas	29,424	114,846	3.90	30,348	121,953	4.02
California	67,476	535,157	7.93	73,941	601,557	8.19
Colorado	10,115	48,459	4.79	6,595	32,020	4.86
Connecticut	70,558	261,509	3.71	90,457	411,853	4.55
Florida	10,719	63,950	5.97	18,362	71,382	3.89
Georgia	16,200	49,580	3.06	18,903	72,840	3.85
Idaho	6,694	44,733	6.68	5,932	39,840	6.72
Illinois	98,907	421,589	4.26	121,546	534,118	4.39
Indiana	106,408	366,866	3.45	114,819	353,648	3.08
Indian Territory	100	650	6.50	510	3,350	6.57
Iowa	19,360	76,904	3.97	17,497	78,366	4.48
Kansas	2,795	17,242	6.17	1,560	10,217	6.55
Kentucky	9,556	28,393	2.97	9,784	28,081	2.87
Maine	220,927	971,305	4.40	228,208	1,066,275	4.67
Maryland	134,431	360,247	2.68	127,863	350,460	2.74
Massachusetts	84,380	395,326	4.69	119,267	563,100	4.72
Michigan	48,089	192,844	4.01	68,133	281,465	4.13
Minnesota	18,977	81,093	4.27	19,920	93,555	4.70
Missouri	186,173	787,069	4.23	207,334	916,693	4.42
Montana	4,073	22,436	5.51	4,745	30,098	6.34
Nevada	.....	.....	.....	150	2,400	16.00
New Jersey	40,659	168,775	4.15	42,714	187,978	4.40
New Mexico	400	2,625	6.56	1,790	9,975	5.57
New York	114,876	490,845	4.27	114,620	519,855	4.54
North Carolina	1,792	7,980	4.45	5,896	41,468	7.03
Ohio	327,373	1,056,721	3.23	331,972	1,100,133	3.31
Oklahoma	400	4,000	10.00	120	1,500	12.50
Oregon	7,886	74,745	9.48	3,934	32,388	8.23
Pennsylvania	620,018	1,672,267	2.70	624,060	1,857,754	2.98
Rhode Island	6,461	42,743	6.62	7,003	54,569	7.79
South Carolina	7,955	34,440	4.33	7,134	34,719	4.87
South Dakota	4,165	26,308	6.32	3,666	23,930	6.53
Tennessee	75,667	252,908	3.34	83,047	307,165	3.70
Texas	31,984	142,470	4.45	41,183	192,527	4.67
Utah	12,765	69,089	5.41	17,461	86,518	4.95
Vermont	39,620	188,921	4.77	32,755	167,393	5.11
Virginia	114,221	396,434	3.47	104,468	382,083	3.66
Washington	27,935	160,985	5.76	59,094	347,924	5.89
West Virginia	104,156	255,337	2.45	98,447	257,333	2.61
Wisconsin	214,872	726,071	3.38	225,633	769,808	3.41
Wyoming	262	3,099	11.83	396	4,265	10.77
Total	2,984,100	[a]10,941,680	3.67	3,197,754	12,480,653	3.90

[a] Not including value ($408,548) of limestone burned for lime at sugar refineries and alkali plants.

The following table gives the value of the total lime production in the United States for the years 1896 to 1906, inclusive:

Value of total production of lime in the United States, 1896–1906.

1896	$6,327,900	1902	$9,335,618
1897	6,390,487	1903	9,255,882
1898	6,886,549	1904	9,951,456
1899	6,983,067	1905	10,941,680
1900	6,797,496	1906	12,480,653
1901	8,204,054		

USES OF THE LIME PRODUCED IN 1906.

In the following table the total lime production for 1906 is classified according to the uses for which it was sold, as reported by the lime manufacturers. This table, though complete, is in far from satisfactory shape, but at present it does not seem possible to correct it. The desirable improvements are two: (1) A closer classification of the uses to which lime is put, for it will be seen that the table includes obviously conflicting and duplicate uses, and (2) an allowance for the limestone sold direct to users who burn it into lime and apply it in some of the industries covered by the table. At present this last item is partly included in the present chapter, under lime, and partly in the chapter on stone, under limestone. It is hoped that in future reports it will be possible to make a more satisfactory grouping.

Though defective to the extent above noted, the table is of interest as giving the first approximate data for determining the relative importance of the structural and the chemical uses of lime. It will be seen that the lime sold for structural uses as building lime, hydrated lime, for sand-lime brick manufacture, for slag cement, and for quick-lime brick, amounted to 2,647,724 tons out of the total lime production of 3,197,754 tons, leaving 550,030 tons for the various chemical industries.

Production of lime in the United States in 1906, by uses, in short tons.

Use.	Quantity.	Value.
Building lime	2,506,452	$10,247,579
Hydrated lime	120,357	479,079
Sand-lime brick	19,737	85,845
Slag cement	175	500
Quick-lime brick	1,003	4,391
Sugar factories	28,678	128,547
Fertilizer	300,024	713,336
Steel works	11,517	46,100
Paper mills	53,266	197,277
Glass works	20,558	62,216
Ammonia works	2,049	5,643
Water purification	2,965	10,950
Glue factories	1,050	3,000
Chemical works	79,932	282,400
Acetate lime	2,400	12,000
Lead smelters	10,750	55,375
Sheep dipping	70	525
Tanneries	7,472	37,780
Alkali works	2,450	9,000
Ground lime	18,627	58,220
Cyaniding plants	2,222	13,890
Soap	6,000	27,000
Total	3,197,754	12,480,653

FUELS USED IN LIME BURNING.

The total lime output of 1906 was 3,197,754 tons, made by 1,012 producers. Of these, 951 makers, producing 2,808,986 tons, replied to the questions as to character and quantity of fuel used. The data presented below cover, therefore, about 90 per cent of the total American lime industry.

Kind and quantity of fuel used in burning lime in 1906.

Kind of fuel used.	Quantity of fuel.	Quantity of lime burned.	Number of firms using.
		Short tons.	
Wood ..... cords..	412,359	921,073	285
Shavings ..... short tons..	22,945	43,677	3
Coal ..... do....	357,735	1,150,220	549
Coke ..... do....	2,160	9,889	7
Oil ..... barrels..	24,486	16,921	5
Gas ..... cubic feet..	236,435,000	60,760	6
Mixed fuels:			
Wood ..... cords..	71,282	429,411	76
Coal ..... short tons..	95,960		
Wood ..... cords..	300	1,120	1
Coke ..... short tons..	150		
Wood ..... cords..	300		
Coal ..... short tons..	2,000	18,286	1
Coke ..... do....	500		
Coal and coke ..... do....	9,288	28,685	9
Coal ..... do....	37,386	128,944	9
Gas ..... cubic feet..	193,543,000		
Total	.....	2,808,986	951

The total quantity of the various kinds of fuel consumed in the American lime industry during 1906 was, therefore, as follows:

Total fuel consumed in burning lime in 1906.

Wood	cords..	484,241
Shavings	short tons..	22,945
Coal	do....	501,081
Coke	do....	4,098
Gas	cubic feet..	429,978,000
Oil	barrels..	24,486

The "gas" in the above table includes both natural gas and producer gas, as can be determined from its fuel efficiency.

FUEL CONSUMPTION PER TON OF LIME.

The most valuable use to which the above data may be put is, of course, the determination of the average fuel consumption per short ton of lime burned with different kinds of fuel. Disregarding the product from the plants using mixed fuels, these averages are as shown in the following table:

Fuel consumption per short ton of lime burned in 1906.

Wood	cord..	0.448
Shavings	short ton..	.525
Coal	do....	.311
Coke	do....	.219
Oil	barrels..	1.447
Gas	cubic feet..	3,891

HEAT LOSSES IN THE LIMEKILN.

It is of course possible to carry these calculations a step further and to determine the average efficiency—or inefficiency—of all the limekilns in the country. By using average values for the heat units in the various fuels we can determine that in 1906 the heat utilized in all limekilns averaged 7,413,500 B. T. U. per ton of burned lime. In a volume[a] published recently the writer calculated the

[a] Eckel, E. C., Cements, Limes, and Plasters, New York, 1905, p 99.

theoretical heat requirements for lime burning and stated that in burning a pure nonmagnesian limestone they would amount to 2,113,600 B. T. U. per short ton of limestone, which is closely equivalent to 3,774,300 B. T. U. per short ton of burned lime. On comparing this quantity of heat actually required in burning a ton of lime with the quantity used during 1906 it will be seen that the average limekiln wastes almost exactly half of all the fuel put into it. There is evidently still considerable room for improvement in lime-burning methods.

HYDRATED LIME.

In sending out the statistical inquiries for 1906 an attempt was made to secure data relative to the hydrated-lime industry, with the results set forth in the following tables. Though a gratifying number of replies were made to the questions which bore on this industry, there is no doubt that the statistics below are relatively incomplete and do not give a fair idea of the present status of this comparatively recent development in lime manufacture. It is hoped that in future years greater completeness will be attained.

The reports show that in 1906 the total quantity of lime hydrated by the burners and marketed as hydrated lime was 120,357 short tons, valued at $479,079, or $4.15 per ton. It is practically certain, however, that much of the product reported as building lime was in reality hydrated lime.

The number of lime-hydrating plants which reported as having operated in 1906 was as follows:

Number of lime-hydrating plants in operation in 1906, by States.

Alabama	1	Michigan	1
Arizona	1	New York	1
Connecticut	1	Ohio	8
Georgia	2	Pennsylvania	8
Indiana	2	West Virginia	1
Iowa	1	Wisconsin	1
Kansas	1		
Maine	1	Total	30

IMPORTS AND EXPORTS.

The imports of lime for consumption into the United States in 1906 were 20,692 short tons, valued at $91,241, as against 22,247 short tons, valued at $84,564, in 1905, and 22,297 short tons, valued at $82,008, in 1904.

The exports in 1906 were valued at $101,668, as against $76,658 in 1905.

SAND-LIME BRICK.

PRODUCTION.

The year 1906 showed fairly prosperous conditions in the sand-lime brick industry, the product being valued at $1,170,005, an increase of 20 per cent over the value, $972,064, in 1905. During 1906 the value of the common building brick made by this process averaged $6.71 per thousand, as against $6.58 in 1905. The front brick averaged $10.42 per thousand, as against the 1905 average of $11.02. Almost 90 per cent of the entire sand-lime product is marketed as common brick, a result which could hardly have been anticipated when this brick was first introduced into this country.

Detailed statistics for 1905 and 1906 are presented in the following table:

Production of sand-lime brick in the United States in 1905 and 1906, by States.

1905.

State.	Number of operating firms reporting.	Common brick.		Front brick.		Fancy brick.		Blocks, value.	Total value.
		Quantity. (thousands).	Value.	Quantity. (thousands).	Value.	Quantity. (thousands).	Value.		
Alabama	3	1,552	$11,645	(a)	(a)	.....	.....	.....	$23,727
Arizona, Colorado, Oregon, and Washington	5	725	5,947	1,281	$15,151	(a)	(a)	$121	21,289
Arkansas, Kansas, Minnesota, Nebraska, South Dakota, and Texas	9	20,425	133,784	2,490	30,480	.....	.....	.....	164,264
California	5	4,215	32,534	(a)	(a)	(a)	(a)	.....	34,689
Delaware, Maryland, New Jersey, and Virginia	7	12,401	80,639	587	7,237	(a)	(a)	.....	88,876
Florida, Kentucky, Mississippi, South Carolina, and Tennessee	10	12,025	89,900	1,650	17,070	25	$500	.....	107,470
Illinois and Wisconsin	4	4,451	25,524	350	2,875	.....	.....	.....	28,399
Indiana	6	11,413	57,655	800	7,500	(a)	(a)	.....	65,905
Iowa	3	3,974	28,793	(a)	(a)	(a)	(a)	1,384	38,652
Michigan	12	24,841	155,883	1,577	12,893	(a)	(a)	.....	169,302
New York	7	11,841	81,804	3,478	41,300	.....	.....	.....	123,104
North Carolina	3	3,185	20,953	660	8,150	.....	.....	.....	29,103
Ohio	4	2,193	12,351	(a)	(a)	.....	.....	.....	14,058
Pennsylvania	6	5,890	46,290	(a)	(a)	(a)	(a)	.....	63,226
Other States [b]	.....	.....	.....	3,689	39,863	173	3,838	.....	(c)
Total	84	119,131	783,702	16,562	182,519	198	4,338	1,505	972,064
Average value per M	.....	.....	6.58	.....	11.02	.....	21.91	.....	.....

1906.

Alabama, Kentucky, Mississippi, and Tennessee	6	6,877	$51,079	1,276	$11,947	.....	.....	.....	$63,026
Arkansas, Kansas, Minnesota, Nebraska, South Dakota, and Texas	8	14,877	96,128	1,897	17,962	(a)	(a)	.....	114,390
California	4	4,837	38,789	1,900	22,400	.....	.....	.....	61,189
Colorado and Idaho	4	569	6,043	2,191	22,743	.....	.....	(a)	31,464
Delaware, Maryland, and Virginia	4	9,403	61,719	(a)	(a)	.....	.....	.....	67,119
Florida	8	11,678	83,306	(a)	(a)	.....	.....	.....	89,306
Georgia	3	5,139	37,701	(a)	(a)	.....	.....	.....	40,701
Illinois and Wisconsin	4	8,150	49,150	690	6,060	.....	.....	.....	55,210
Indiana	6	17,077	84,361	326	2,474	(a)	(a)	.....	86,880
Iowa	3	3,921	28,271	(a)	(a)	(a)	(a)	(a)	38,255
Michigan	11	27,281	162,879	1,796	12,022	(a)	(a)	.....	174,921
New Jersey	3	6,520	49,143	.....	.....	.....	.....	(a)	50,143
New York	9	21,288	169,257	1,910	22,064	.....	.....	.....	191,321
North Carolina	3	3,147	22,225	(a)	(a)	.....	.....	.....	32,975
Ohio	4	1,232	7,049	(a)	(a)	.....	.....	.....	10,184
Pennsylvania	7	6,673	50,211	978	12,710	.....	.....	.....	62,921
Other States [b]	.....	.....	.....	2,718	32,963	121	$3,473	$5,876	(c)
Total	87	148,669	997,311	15,682	163,345	121	3,473	5,876	1,170,005
Average value per M	.....	.....	6.71	.....	10.42	.....	28.70	.....	.....

[a] Included in Other States.

[b] Includes all products made by less than three producers in one State, to prevent disclosing individual operations.

[c] The total of Other States is distributed among the States to which it belongs in order that they may be fully represented in the totals.

Value of production of sand-lime brick in the United States, 1903–1906.

Year.	Number of plants.	Value of product.
1903	16	$155,040
1904	57	463,128
1905	84	972,064
1906	87	1,170,005

THE CONSTITUTION OF SAND-LIME BRICK.

In previous publications on the sand-lime brick industry the writer has stated that conclusive evidence had not yet been produced as to the constitution of the binding medium of sand-lime brick. The advocates of the new product not only claimed that a definite lime silicate was formed during processes of manufacture, but usually made the additional claim, by implication at least, that this silicate was the same as that which exists in Portland cement. The fact was overlooked that purely chemical means could not be relied on to prove these facts, if facts they were. Under these circumstances the writer, admitting his own incompetency to decide the question, believed it advisable to consider the matter unsettled, pending a decisive test by the only means possible—the petrographic microscope, used by one of the very few investigators intimately acquainted with the lime-silicate series.

During the past year evidence has been submitted which seems conclusive. Mr. Frederick E. Wright, at the writer's request, examined several specimens of commercial sand-lime brick in the geophysical laboratory of the Carnegie Institution. Mr. Wright states that the binding material of these specimens is a hydrous lime silicate somewhat akin to the familiar minerals of the zeolite group. The reactions involved in the formation of such a hydrous silicate from lime and sand in the presence of steam are simple and well known. It is to be noted, however, that these reactions are in no way comparable to those which take place during the processes of Portland cement manufacture and that the binding material of sand-lime brick is very different in composition and relationship from Portland cement clinker.

It may safely be assumed, then, that a sand-lime brick as marketed consists of (1) sand grains held together by a network of (2) hydrous lime silicate, with probably (if a magnesian lime were used) some allied magnesian silicate, and (3) lime hydrate or a mixture of lime and magnesia hydrates. These three elements will always be present, and the structural value of the brick will depend in large part on the relative percentages in which the sand, the silicates, and the hydrates occur.

21650—M R 1906——63