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CENSUS OF MANUFACTURES: 1905

CHEMICALS AND ALLIED PRODUCTS

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BULLETINS OF THE PERMANENT CENSUS.

1. Geographical distribution of population.
2. Quantity of cotton ginned in the United States (crops of 1899 to 1902, inclusive).
*3. Street and electric railways.
4. A discussion of increase of population.
*5. Central electric light and power stations.
6. Mineral industries of Porto Rico.
7. Estimates of population of the larger cities of the United States for 1901, 1902, and 1903.
8. Negroes in the United States.
9. Mines and quarries.
*10. Quantity of cotton ginned in the United States (crops of 1899 to 1903, inclusive).
11. Municipal electric fire alarm and police patrol systems.
12. The executive civil service of the United States.
13. A discussion of age statistics.
14. Proportion of the sexes in the United States.
15. A discussion of the vital statistics of the Twelfth Census.
16. Irrigation in the United States: 1902.
17. Telephones and telegraphs: 1902.
18. Census of manufactures: 1904. Michigan.
*19. Quantity of cotton ginned in the United States (crops of 1900 to 1904, inclusive).
20. Statistics of cities having a population of over 25,000: 1902 and 1903.
21. Commercial valuation of railway operating property in the United States: 1904.
22. Proportion of children in the United States.
23. Census statistics of teachers.
24. Insular and municipal finances in Porto Rico for the fiscal year 1902–3.
25. American cotton supply and its distribution for the year ending August 31, 1905.
26. Illiteracy in the United States.
27. Census of manufactures: 1905. Maryland and District of Columbia.
28. Census of manufactures: 1905. Kansas.
29. Census of manufactures: 1905. Nebraska.
30. Census of manufactures: 1905. Arizona, Indian Territory, New Mexico, and Oklahoma.
31. Census of manufactures: 1905. Delaware.
32. Census of manufactures: 1905. Iowa.
33. Census of manufactures: 1905. Florida.
*34. Census of manufactures: 1905. Montana, North Dakota, South Dakota, and Wyoming.
35. Census of manufactures: 1905. Missouri and Arkansas.
36. Census of manufactures: 1905. Rhode Island.
37. Census of manufactures: 1905. Colorado, Idaho, Nevada, and Utah.
38. Census of manufactures: 1905. Indiana.
39. Census of manufactures: 1905. North Carolina and South Carolina.
40. Cotton production and statistics of cottonseed products: 1905.
41. Census of manufactures: 1905. New Hampshire and Vermont.
42. Census of manufactures: 1905. Connecticut.
43. Census of manufactures: 1905. Alabama.
44. Census of manufactures: 1905. Virginia and West Virginia.
45. Statistics of cities having a population of 8,000 to 25,000: 1903.
46. Census of manufactures: 1905. Minnesota.
47. Census of manufactures: 1905. Kentucky and Tennessee.
48. Census of manufactures: 1905. Louisiana, Mississippi, and Texas.
49. Census of manufactures: 1905. California, Oregon, and Washington.
50. Statistics of cities having a population of over 30,000: 1904.
51. Census of manufactures: 1905. Maine.
52. Census of manufactures: 1905. Illinois.
53. Census of manufactures: 1905. Massachusetts.
54. Census of manufactures: 1905. New Jersey.
55. Census of manufactures: 1905. Georgia.
56. Census of manufactures: 1905. Wisconsin.
57. Census of manufactures: 1905. United States.
58. Census of manufactures: 1905. Ohio.
59. Census of manufactures: 1905. New York.
60. Census of manufactures: 1905. Pennsylvania.
61. Census of manufactures: 1905. Canning and preserving, rice cleaning and polishing, and the manufacture of beet sugar.
62. Census of manufactures: 1905. Glass and clay products.
*63. Supply and distribution of cotton for the year ending August 31, 1906.
64. Census of manufactures: 1905. Butter, cheese, and condensed milk, flour and grist mill products, and starch.
65. Census of manufactures: 1905. Coke.
66. Census of manufactures: 1905. Automobiles and bicycles and tricycles.
67. Census of manufactures: 1905. Metal working machinery.
*68. Child labor in the District of Columbia.
69. Child labor in the United States.
70. Census of manufactures: 1905. Petroleum refining.
71. Estimates of population: 1904, 1905, 1906.
72. Census of manufactures: 1905. Boots and shoes, leather, and leather gloves and mittens.
73. Census of manufactures: 1905. Electrical machinery, apparatus, and supplies.
74. Census of manufactures: 1905. Textiles (combined textiles, cotton manufactures, hosiery and knit goods, wool manufactures, silk manufactures, flax, hemp, and jute products, and dyeing and finishing textiles).
75. Census of manufactures: 1905. Agricultural implements.
76. Cotton production: 1906.
77. Census of manufactures: 1905. Lumber and timber products.
78. Census of manufactures: 1905. Iron and steel and tin and terne plate.
79. Census of manufactures: 1905. Printing and publishing.
80. Census of manufactures: 1905. Paper and wood pulp.
81. Census of manufactures: 1905. Shipbuilding.
82. Census of manufactures: 1905. Musical instruments, attachments, and materials.
83. Census of manufactures: 1905. Slaughtering and meat packing, manufactured ice, and salt.
84. Census of manufactures: 1905. Carriages and wagons, and the steam and street railroad car industry.
85. Census of manufactures: 1905. Pens and pencils, buttons, needles, pins, and hooks and eyes, oilcloth and linoleum, and turpentine and rosin.
86. Census of manufactures: 1905. Copper, lead, and zinc, smelting and refining.
87. Census of manufactures: 1905. Tobacco.
88. Census of manufactures: 1905. Power employed in manufactures.
89. Census of Oklahoma and Indian Territory: 1907.
90. Supply and distribution of cotton for the year ending August 31, 1907.
91. Transportation by water: 1906. United States.
92. Census of manufactures: 1905. Chemicals and allied products.

NOTE.—Bulletins in this list, except those marked with an asterisk (*), may be obtained upon application to the Director of the Census.

CONTENTS.

CHEMICALS AND ALLIED PRODUCTS.

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SCOPE OF THE CENSUS.

The first special report on the manufacture of chemicals was made at the census of 1880 under the caption "chemical production." At each subsequent census a special report on this topic has been made under the caption "chemicals and allied products." Inspection of these reports shows that the industries included have varied considerably, though each report has embraced the industries producing acids, sodas, potashes, alums, glycerin, dyestuffs and extracts, explosives, fertilizers, pigments, wood distillation products, salts, and certain elementary substances, such as bromine and phosphorus. The special report at the census of 1880 also embraced the industries producing soap, candles, castor oil, glucose, and sulphur, the products of which had a total value of $28,010,152. These latter industries did not appear in the special report of 1890, but those producing pharmaceutical preparations, ready mixed paints, and varnishes and japans were added, the pharmaceutical preparations having a value of $16,744,643. All the industries embraced in the special report for 1890 were included in the special report for 1900 and in the present report, with the exception of pharmaceutical preparations, while those producing essential oils and bone, ivory, and lamp black were added, these latter industries reporting in 1900 products valued at $1,173,282, and in 1905 products valued at $2,112,379. The manufactures included under any industry may, however, differ somewhat from census to census as new products of the same general character are put upon the market or older ones cease to be used. The returns in the establishments enumerated were classified according to that class of product which had the maximum value, as is the rule in all Census classification, but many of these establishments produced also subsidiary products of less value, which, had they been returned as principal products, would have placed these establishments in other classes. Such subsidiary products appear in the tabular summaries of the Census reports under the heading "all other products," but in some cases they are also treated of in the text and in the minor tables of their special classes.

A reason for the variation in the industries included at the different censuses is found in the very general and indefinite title used, for in the strictest technical sense every material thing is a chemical, and accordingly every industry in which the materials used undergo a chemical change in the process of manufacture, as in the smelting of iron from its ores or the production of leather from a hide, may be considered as a chemical industry. It is evident that if this view of the significance of the title were taken, "chemicals and allied products" would properly cover every manufacture except those like furniture making, machine construction, or textiles, in which the material remains unchanged in composition during the manufacture but is turned, or cast, or woven into other shapes. The popular idea of the term limits its application but admits as chemical industries the manufacture of gunpowder, fertilizers, and similar mixtures, whose ingredients undergo no chemical change during the process of compounding the mixtures. It thus becomes necessary to decide arbitrarily upon the industries to be included. Those so included at the census of 1905 may be divided into the following classes:

I. A. Sulphuric, nitric, and mixed acids.
I. B. Other acids.
II. Sodas.
III. Potashes.
IV. Alums.
V. Coal tar products.
VI. Cyanides.
VII. Wood distillation.
VIII. Fertilizers.
IX. Bleaching materials.
X. Chemicals produced by the aid of electricity.
XI. Dyestuffs.
XII. Tanning materials.
XIII. Paints and varnishes.
XIV. Explosives.
XV. Plastics.
XVI. Essential oils.
XVII. Compressed and liquefied gases.
XVIII. Fine chemicals.
XIX. General chemicals.

This classification is precisely that followed at the census of 1900, except that Class I is at the present census subdivided into Subclasses A and B, and precisely the same industries are included in each case. From the list given it is apparent that "chemicals and allied products" includes twenty distinct industries. As a matter of fact, the number is very much greater. This becomes evident when it is recalled that nitric acid differs from sulphuric acid as greatly as paper from leather, and that the processes used in the manufacture of the two acids differ as much as do those used in making paper and leather.

TABLE 1.—*Chemicals and allied products—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	1,786	1,691	95	5.6
Capital	$323,997,131	$238,471,290	$85,525,841	35.9
Salaried officials, clerks, etc., number	11,147	8,602	2,545	29.6
Salaries	$15,014,018	$11,339,595	$3,674,423	32.4
Wage-earners, average number	59,198	46,700	12,498	26.8
Total wages	$29,515,863	$21,783,335	$7,732,528	35.5
Men 16 years and over	56,678	44,574	12,104	27.2
Wages	$28,834,403	$21,198,520	$7,635,883	36.0
Women 16 years and over	2,362	1,949	413	21.2
Wages	$649,296	$554,128	$95,168	17.2
Children under 16 years	158	177	[1] 19	[1] 10.7
Wages	$32,164	$30,687	$1,477	4.6
Miscellaneous expenses	$26,258,768	$14,822,853	$11,435,915	77.2
Cost of materials used	$176,400,680	$124,018,044	$52,382,636	42.2
Value of products	$282,169,216	$202,506,076	$79,663,140	39.3

[1] Decrease.

Because of the variation in the industries included at the successive censuses, only a partial comparison of the data can be made, except for the censuses of 1900 and 1905, when the industries included were identical. The general statistics for the establishments actively engaged in the manufacture of chemicals and allied products in 1900 and 1905, together with the amount and per cent of increase in each item for this period, are set forth in Table 1.

The term "capital" as used in the Census reports refers only to the sum invested in lands, buildings, machinery, and tools and implements, and the funds required to carry on the business, and does not include capital stock.

Table 1 shows an increase for 1905 over 1900 in every item except the number of children employed. It is particularly to be noted that though the number of children employed was reduced by 19, the wages paid them increased by $1,477. The data given in this table indicate a most flourishing condition for the industry as a whole. A clearer idea would be gained of the economic conditions that existed if a separate presentation were made of each industry included in this class. This is not feasible at this point, but the data may, as in 1900, be divided for comparison among six subclasses which are popularly regarded as separate industries. Table 2 presents a comparative summary of these subclasses.

TABLE 2.—COMPARATIVE SUMMARY, BY INDUSTRIES: 1905 AND 1900.

	CHEMICALS.[1]		DYESTUFFS AND EXTRACTS.		ESSENTIAL OILS.		EXPLOSIVES.		FERTILIZERS.		PAINTS AND VARNISHES.[2]	
	1905	1900	1905	1900	1905	1900	1905	1900	1905	1900	1905	1900
Number of establishments	448	433	98	77	52	47	124	97	400	422	664	615
Capital	$119,890,193	$89,069,450	$14,904,150	$7,839,034	$723,004	$576,286	$42,307,163	$19,465,846	$69,023,264	$60,685,753	$77,149,357	$60,834,921
Salaried officials, clerks, etc., number	3,387	2,123	361	229	37	39	1,289	768	1,618	1,712	4,455	3,731
Salaries	$4,901,523	$2,923,033	$608,790	$312,109	$40,002	$24,733	$1,797,050	$914,447	$1,940,712	$2,124,972	$5,725,941	$5,040,301
Wage-earners, average number	24,525	19,020	2,707	1,647	132	168	5,800	4,502	14,201	11,581	11,833	9,782
Total wages	$13,361,972	$9,393,236	$1,264,492	$787,942	$69,711	$61,415	$3,308,774	$2,383,756	$5,142,147	$4,185,289	$6,368,767	$4,971,697
Men 16 years and over	23,366	18,101	2,678	1,607	127	161	5,708	4,349	14,065	11,435	10,734	8,921
Wages	$13,053,704	$9,133,868	$1,256,946	$781,370	$68,370	$59,576	$3,283,729	$2,346,887	$5,113,232	$4,142,853	$6,058,422	$4,733,966
Women 16 years and over	1,082	853	25	35	5	7	91	117	110	131	1,049	806
Wages	$291,269	$247,716	$6,966	$5,911	$1,341	$1,839	$24,945	$30,781	$25,446	$39,463	$299,329	$228,418
Children under 16 years	77	66	4	5	....	....	1	36	26	15	50	55
Wages	$16,999	$11,652	$580	$661	....	....	$100	$6,088	$3,469	$2,973	$11,016	$9,313
iscellaneous expenses	$8,937,242	$4,362,608	$944,360	$458,212	$78,886	$48,763	$1,657,665	$1,096,604	$4,919,824	$3,734,285	$9,720,791	$5,122,381
stofmaterials used	$51,883,219	$34,545,862	$6,829,340	$4,745,912	$1,110,470	$588,594	$17,203,667	$10,334,974	$39,343,914	$28,958,473	$60,030,070	$44,844,229
lue of products	$92,088,378	$62,637,008	$10,893,113	$7,350,748	$1,464,662	$813,495	$29,602,884	$17,125,418	$56,632,853	$44,657,385	$91,487,326	$69,922,022

[1] Includes sulphuric, nitric, and mixed acids, and wood distillation.

[2] Includes bone, ivory, and lamp black.

At each census chemicals ranked first in capital, mber of wage-earners employed, and total wages id, being followed at each census by paints and varhes, fertilizers, explosives, dyestuffs and extracts, d essential oils in the order named. At each census ints and varnishes ranked first in number of salaried officials, clerks, etc., salaries, miscellaneous expenses, and cost of materials used, with chemicals second, and the other industries in the order given above. Paints and varnishes ranked first in value of products, and chemicals second at the census of 1900, but this order was reversed at the census of 1905.

TABLE 3.—INCREASE AND PER CENT OF INCREASE IN THE SEPARATE INDUSTRIES: 1900 TO 1905.

	CHEMICALS.		DYESTUFFS AND EXTRACTS.		ESSENTIAL OILS.		EXPLOSIVES.		FERTILIZERS.		PAINTS AND VARNISHES.	
	Increase.	Per cent of increase.	Increase.	Per cent of increase.	Increase.	Per cent of increase.	Increase.	Per cent of increase.	Increase.	Per cent of increase.	Increase.	Per cent of increase.
Number of establishments	15	3.5	21	27.3	5	10.6	27	27.8	[1] 22	[1] 5.2	49	7.8
Capital	$30,820,743	34.6	$7,065,116	90.1	$146,718	25.5	$22,841,317	117.3	$8,337,511	13.7	$16,314,426	26.8
Salaried officials, clerks, etc., number	1,264	59.5	132	57.6	[1] 2	[1] 5.1	521	67.8	[1] 94	[1] 5.5	724	19.4
Salaries	$1,978,490	67.7	$296,681	95.1	$15,269	61.7	$882,603	96.5	[1] $184,260	[1] 8.7	$685,640	13.6
Wage-earners, average number	5,505	22.4	1,060	64.3	[1] 36	[1] 21.4	1,298	28.8	2,620	22.6	2,051	21.0
Total wages	$3,968,736	42.3	$476,550	60.5	$8,296	13.5	$925,018	38.8	$956,858	22.9	$1,397,070	28.1
Men 16 years and over	5,265	29.1	1,071	66.6	[1] 34	[1] 21.1	1,359	31.2	2,630	23.0	1,813	20.3
Wages	$3,919,836	42.9	$475,576	60.9	$8,794	14.8	$936,842	39.9	$970,379	23.4	$1,324,456	28.0
Women 16 years and over	229	26.8	[1] 10	[1] 30.6	[1] 2	[1] 28.6	[1] 26	[1] 22.2	[1] 21	[1] 16.0	243	30.1
Wages	$43,553	17.6	$1,055	17.8	[1] $498	[1] 27.1	[1] $5,836	[1] 19.0	[1] $14,017	[1] 35.5	$70,911	31.0
Children under 16 years	11	16.7	[1] 1	[1] 20.0	(2)	....	[1] 35	[1] 97.2	11	73.3	[1] 5	[1] 9.1
Wages	$5,347	45.9	[1] $81	[1] 12.3	(2)	....	[1] $5,988	[1] 98.4	$496	16.7	$1,703	18.3
Miscellaneous expenses	$4,574,634	104.9	$486,148	106.1	$30,123	61.8	$561,061	51.2	$1,185,539	31.7	$4,598,410	89.8
Cost of materials used	$17,337,357	50.2	$2,083,428	43.9	$521,876	88.7	$6,868,693	66.5	$10,385,441	35.9	$15,185,841	33.9
Value of products	$29,451,370	47.0	$3,542,365	48.2	$651,167	80.0	$12,477,466	72.9	$11,975,468	26.8	$21,565,304	30.8

[1] Decrease.

[2] None reported in 1905.

In but one industry—chemicals—was there an increase in every item. The number of establishments increased in every industry except fertilizers, which showed a loss of 22. In each of the six industries there was a gain in capital, wages, miscellaneous expenses, cost of materials, and value of products. In two industries, fertilizers and essential oils, the number of salaried officials, clerks, etc., decreased, though the amount paid in salaries declined only in the former. The absolute increases were greatest in chemicals for every item except number of establishments, numbers of women and children wage-earners, wages paid to women, and miscellaneous expenses, but the percentages of increase fluctuated markedly, explosives showing the greatest percentage of increase in number of establishments, capital, salaried officials, and salaries; dyestuffs and extracts the greatest for wage-earners, wages, and miscellaneous expenses; and essential oils the greatest for cost of materials and value of products.

Marked fluctuations are shown in the number of establishments in the different states and territories, the largest increase, 29 establishments, occurring in Georgia, and the greatest decrease, 21 establishments, in New York. Increases occurred in 25 states and territories, and decreases in 17 states and territories. Three states and territories, Alaska, Indian Territory, and Wyoming, appear for the first time at this census, while Arizona, which reported 1 establishment in 1900, did not return any in 1905. Considered by geographic divisions, the North Atlantic suffered a decrease of 26 establishments, the South Atlantic gained 59, the North Central 25, the South Central 21, and the Western 16 establishments. In 1900 establishments were reported from 40 different states and territories, and in 1905 from 42, there being at the latter census 8 states and territories, namely, 2 in the North Central, 2 in the South Central, and 4 in the Western division, from which no returns for establishments were received.

TABLE 4.—*Number of establishments, by states and territories, with increase and rank: 1905 and 1900.*

STATE OR TERRITORY.	ESTABLISHMENTS.		Increase.	RANK.	
	1905	1900		1905	1900
United States	1,786	1,691	95	....	....
Alabama	27	19	8	16	17
Alaska	1	....	1	39	....
Arizona	....	1	[1] 1	....	39
California	63	53	10	8	10
Colorado	6	4	2	31	35
Connecticut	40	31	9	15	14
Delaware	13	15	[1] 2	24	19
District of Columbia	3	8	[1] 5	35	27
Florida	15	10	5	23	24
Georgia	75	46	29	7	11
Illinois	89	88	1	5	5
Indian Territory	1	....	1	39	....
Indiana	52	35	17	11	13
Iowa	6	8	[1] 2	31	27
Kansas	10	5	5	26	31
Kentucky	21	18	3	20	18
Louisiana	12	10	2	25	24
Maine	9	13	[1] 4	28	21
Maryland	58	63	[1] 5	10	8
Massachusetts	77	83	[1] 6	6	6
Michigan	52	55	[1] 3	11	9
Minnesota	10	8	2	26	27
Mississippi	7	4	3	30	35
Missouri	47	39	8	13	12
Nebraska	4	5	[1] 1	33	31
Nevada	3	4	[1] 1	35	35
New Hampshire	1	1	....	39	39
New Jersey	144	160	[1] 16	3	3
New York	264	285	[1] 21	2	2
North Carolina	42	23	19	14	15
Ohio	128	137	[1] 9	4	4
Oregon	4	5	[1] 1	33	31
Pennsylvania	315	306	9	1	1
Rhode Island	17	12	5	22	22
South Carolina	26	22	4	17	16
Tennessee	22	14	8	19	20
Texas	3	7	[1] 4	35	30
Vermont	3	5	[1] 2	35	31
Virginia	62	64	[1] 2	9	7
Washington	9	4	5	28	35
West Virginia	25	9	16	18	26
Wisconsin	19	12	7	21	22
Wyoming	1	....	1	39	....

[1] Decrease.

Notwithstanding considerable decreases in 3 of these states, Pennsylvania, New York, New Jersey, and Ohio occupied the first four places in rank, in the order named, at the census of 1905 as well as at that of 1900. Illinois occupied fifth place at both censuses, and Massachusetts sixth. Georgia advanced from eleventh to seventh place, and California from tenth to eighth, while Virginia fell from seventh to ninth, Maryland from eighth to tenth, and Michigan from ninth to eleventh, a rank shared at this census with Indiana. The greatest advance in rank was made by West Virginia, which passed from twenty-fourth place in 1900 to seventeenth in 1905. The largest decline in rank was that of the District of Columbia, which dropped from twenty-fifth to thirtieth place.

TABLE 5.—QUANTITY AND COST OF MATERIALS USED, WITH AMOUNT AND PER CENT OF INCREASE, AND AVERAGE COST PER UNIT: 1905 AND 1900.

	CENSUS.		Increase.	Per cent of increase.	COST PER UNIT.	
	1905	1900			1905	1900
Materials used, total cost	$176,400,680	$124,018,044	$52,382,636	42.2		
Fish—						
Thousands	923,305	458,963	464,342	101.2		
Cost	$880,142	$183,542	$696,600	379.5	$0.95	$0.40
Gums	$4,328,624	$3,817,112	$511,512	13.4		
Kainit—						
Tons	190,493	54,700	135,793	248.3		
Cost	$1,891,073	$520,833	$1,370,240	263.1	$9.93	$9.52
Limestone—						
Tons	789,056	790,456	[1] 1,400	[1] 0.2		
Cost	$972,546	$717,910	$254,636	35.5	$1.23	$0.91
Phosphate rock—						
Tons	999,370	797,772	201,598	25.3		
Cost	$4,312,607	$3,620,262	$692,345	19.1	$4.32	$4.54
Pyrites—						
Tons	689,627	633,837	55,790	8.8		
Cost	$3,834,450	$3,101,075	$733,375	23.6	$5.56	$4.89
Wood for alcohol—						
Cords	586,144	495,073	91,071	18.4		
Cost	$1,783,004	$1,255,794	$527,210	42.0	$3.04	$2.54
Wood for extracts—						
Cords	258,981	211,040	47,941	22.7		
Cost	$795,786	$675,321	$120,465	17.8	$3.07	$3.20
Sulphuric acid—						
Tons	422,320	280,028	142,292	50.8		
Cost	$3,348,982	$1,946,742	$1,402,240	72.0	$7.93	$6.95
Nitric acid—						
Pounds	10,766,367	3,131,894	7,634,473	243.8		
Cost	$540,865	$154,144	$386,721	250.9	$0.05	$0.05
Mixed acids—						
Pounds	109,072,130	69,566,011	39,506,119	56.8		
Cost	$3,251,080	$1,560,133	$1,690,947	108.4	$0.03	$0.02
Acid phosphate—						
Tons	320,559	287,147	33,412	11.6		
Cost	$2,912,010	$2,182,316	$729,694	33.4	$9.08	$7.60
Argols	$2,013,400	$2,204,800	[1] $191,400	[1] 8.7		
Ammonia, aqua—						
Pounds	26,249,683	16,185,257	10,064,426	62.2		
Cost	$878,992	$547,040	$331,952	60.7	$0.03	$0.03
Ammonium sulphate—						
Tons	16,216	8,493	7,723	90.9		
Cost	$956,965	$657,726	$299,239	45.5	$59.01	$77.44
Alcohol, grain—						
Gallons	1,095,632	331,207	764,425	230.8		
Cost	$815,361	$510,375	$304,986	59.8	$0.74	$1.54
Alcohol, wood—						
Gallons	7,591,772	3,692,803	3,898,969	105.6		
Cost	$3,084,380	$1,751,345	$1,333,035	76.1	$0.41	$0.47
Bones, tankage, and offal	$5,398,329	$10,313,661	[1] $4,915,332	[1] 47.7		
Common salt—						
Tons	188,018	42,189	145,829	345.7		
Cost	$496,642	$142,398	$354,244	248.8	$2.64	$3.38
Cottonseed and cottonseed meal	$2,376,448	$167,410	$2,209,038	1,319.5		
Dry colors	$10,769,926	$9,476,333	$1,293,593	13.7		
Glycerin—						
Pounds	46,043,611	34,635,822	11,407,789	32.9		
Cost	$5,062,919	$3,419,406	$1,643,513	48.1	$0.11	$0.10
Lead—						
Tons	129,027	104,401	24,626	23.7		
Cost	$11,173,615	$8,618,097	$2,555,518	29.7	$86.60	$82.55
Lime—						
Bushels	6,191,318	7,428,885	[1] 1,237,567	[1] 16.7		
Cost	$761,937	$442,252	$319,685	72.3	$0.12	$0.06
Linseed oil—						
Gallons	20,407,104	16,157,117	4,249,987	26.3		
Cost	$7,869,270	$7,495,196	$374,074	5.0	$0.39	$0.46
Nitrate of potash—						
Tons	4,169	6,084	[1] 1,915	[1] 31.5		
Cost	$267,297	$300,199	[1] $32,902	[1] 11.0	$64.12	$49.34
Nitrate of soda—						
Tons	220,977	147,020	73,957	50.3		
Cost	$9,290,631	$4,899,622	$4,391,009	89.6	$42.04	$33.33
Potash salts	$4,237,313	$3,891,818	$345,495	8.9		
Sulphur—						
Tons	76,859	83,530	[1] 6,671	[1] 8.0		
Cost	$1,674,031	$1,724,857	[1] $50,826	[1] 3.0	$21.78	$20.65
Tallow and fat	$238,881	$380,517	[1] $141,636	[1] 37.2		
Wood ashes—						
Bushels	210,083	801,047	[1] 590,964	[1] 73.8		
Cost	$26,175	$39,507	[1] $13,332	[1] 33.8	$0.12	$0.[illegible]
All other components of products	$32,381,443	$24,497,258	$7,884,185	32.2		
Fuel	$7,560,710	$5,515,636	$2,045,074	37.1		
Mill supplies	$760,642	$779,814	[1] $19,172	[1] 2.5		
All other materials	$37,154,806	$13,066,053	$24,088,753	184.4		
Rent of power and heat	$773,672	$297,568	$476,104	160.0		
Freight	$1,525,726	$3,143,972	[1] $1,618,246	[1] 51.5		

[1] Decrease.

Unless otherwise specified, the ton mentioned in xt and tables is the short ton of 2,000 pounds. It appears that in 1905 as compared with 1900 there was an increase in the quantity of each of the materials reported as used in every case except for limestone, lime, nitrate of potash, sulphur, and wood ashes. For the cost of materials used, increases were reported in every item except bones, tankage, and offal, nitrate of potash, sulphur, tallow and fat, wood ashes, mill supplies, and freight, in which there was reported a decrease in total cost. The decrease in quantity and cost of nitrate of potash is more than offset by the increase in quantity and cost of nitrate of soda, which is a substitute for the former for the majority of uses and is much cheaper. The decrease in quantity and cost for sulphur is more than offset by the increase in quantity and cost of pyrites, which, as later shown, is a most satisfactory substitute for sulphur in the sulphuric acid industry. The decrease in quantity and cost of wood ashes, which are used as a source of potassium compounds, is more than offset by the increase in potash salts. Part of the decrease in wood ashes is, however, to be accounted for by the difference in the method of taking the census of 1905 from that of 1900, as this industry is largely a neighborhood industry. The decrease in bones, tankage, and offal, which are used as sources of nitrogen, phosphorus, and potassium in the compounding of fertilizers, is more than offset by the increases in fish, ammonium sulphate, cottonseed meal, and nitrate of soda, all of which supply nitrogen; in fish, phosphate rock, and acid phosphate, which supply phosphorus; and in potash salts, which supply potassium. The other decreases are not as well accounted for, but it is probable that the decreases in mill supplies and freight are to some extent offset by the increase of 264.2 per cent in "all other materials," while the cost of freight may also have been included in the cost returned for the various materials to a larger extent in 1905 than in 1900. No obvious explanation is at hand to account for the decrease in limestone and lime, but that in tallow and fat probably arose from the fact that soap, candles, etc., for which these materials are chiefly used, have become the product of maximum value in certain establishments, so as to carry them out of the classification of chemicals and allied products, under which they were included in 1900, and into another class.

The average cost per unit of quantity shows an increase for every item presented except phosphate rock, wood for extracts, aqua ammonia, ammonium sulphate, grain alcohol, wood alcohol, common salt, and linseed oil. It is surprising that there have not been more instances of decrease when it is considered that these averages take no account of grades and that there are wide variations in the quantities and values of the different grades of many of these articles. This is emphasized in the detailed study of sulphuric acid, given further on, when four different commercial grades, ranging in value from $7.11 to $27.20 per ton, are shown. It is probable that the decrease in the cost of wood for extracts was due to an increased use of a lower grade of wood. The decrease in the cost of aqua ammonia and ammonium sulphate is in entire harmony with the statistics set forth in Census Bulletin 65, on Coke, and results from the extension of the by-product coke industry and the greatly increased production, through this means, of ammonia liquor and ammonium sulphate. The decrease in the cost of wood alcohol follows a similar extension of the wood distillation industry, which is another by-product industry; while that in the cost of grain alcohol is due to the greatly increased use of tax-free alcohol in the manufacture of smokeless powder for the United States Government.

TABLE 6.—*Quantity and value of products, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Aggregate value	$282,178,216	$202,506,076	$79,672,140	39.3
Acids:				
Sulphuric—				
Tons	607,226	588,375	18,851	3.2
Value	$7,440,236	$7,305,444	$134,792	1.8
Nitric—				
Pounds	46,264,081	30,961,501	15,302,580	49.4
Value	$2,250,944	$1,454,909	$796,035	54.7
Mixed—				
Pounds	65,331,327	42,368,819	22,962,508	54.2
Value	$1,957,359	$1,111,158	$846,201	76.2
Tartaric—				
Pounds	2,684,000	2,677,004	6,996	0.3
Value	$680,280	$781,603	[1]$101,323	[1]13.0
Acetic—				
Pounds	27,001,322	26,660,565	340,757	1.3
Value	$537,542	$426,892	$110,650	25.9
All other	$6,606,743	$2,070,252	$4,536,491	219.1
Sodas:				
Sal soda—				
Tons	57,950	63,249	[1]5,299	[1]8.4
Value	$804,561	$779,443	$25,118	3.2
Soda ash—				
Tons	518,954	386,361	132,593	34.3
Value	$8,204,545	$4,768,383	$3,436,162	72.1
Bicarbonate—				
Tons	68,867	68,185	682	1.0
Value	$1,135,610	$1,324,843	[1]$189,233	[1]14.3
Caustic—				
Tons	80,173	78,779	1,394	1.8
Value	$2,924,850	$2,917,955	$6,895	0.2
Biborate (borax)—				
Tons	20,882	5,637	15,245	270.4
Value	$2,122,808	$502,480	$1,620,328	322.5
All other	$1,863,822	$1,344,947	$518,875	38.6
Alums:				
Pounds	202,106,850	179,465,871	22,640,979	12.6
Value	$2,352,746	$2,446,576	[1]$93,830	[1]3.8
Coal tar products:				
Distillery products	$364,642	$826,546	[1]$461,904	[1]55.9
Chemicals from	$504,176	$512,264	[1]$8,088	[1]1.6
Cyanides:				
Potassium and sodium—				
Pounds	2,928,584	2,317,280	611,304	26.4
Value	$388,438	$601,362	[1]$212,924	[1]35.4
Ferrocyanide (yellow prussiate of potash)—				
Pounds	5,027,264	6,165,406	[1]1,138,142	[1]18.5
Value	$683,277	$994,014	[1]$310,737	[1]31.3
All other	$107,389	$129	$107,260	83,147.3
Wood distillation:				
Alcohol, wood—				
Crude—				
Gallons	6,684,871	4,191,379	2,493,492	59.5
Value	$2,161,813	$1,660,061	$501,752	30.2
Refined—				
Gallons	5,162,346	3,038,218	2,124,128	69.9
Value	$3,129,486	$2,297,008	$832,478	36.2
Acetate of lime—				
Tons	52,571	43,413	9,158	21.1
Value	$1,474,982	$981,286	$493,696	50.3
Charcoal—				
Bushels	25,420,055	17,155,440	8,264,615	48.2
Value	$1,205,273	$726,809	$478,464	65.8
All other	$365,179	$10,452	$354,727	3,393.9
Fertilizers:				
Superphosphates—				
From minerals, bones, etc.—				
Tons	768,858	925,008	[1]156,150	[1]16.9
Value	$7,557,257	$8,492,360	[1]$935,103	[1]11.0
Ammoniated—				
Tons	775,987	142,898	633,089	443.0
Value	$12,901,057	$2,449,388	$10,451,669	426.7

[1] Decrease.

TABLE 6.—*Quantity and value of products, with amount and per cent of increase: 1905 and 1900*—Continued.

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Fertilizers—Continued.				
Complete—				
Tons	1,329,149	1,454,389	[1] 125,240	[1] 8.6
Value	$25,673,511	$25,796,143	[1] $122,632	[1] 0.5
All other—				
Tons	397,295	299,910	97,385	32.5
Value	$4,435,755	$4,276,794	$158,961	3.7
Bleaching materials:				
Hypochlorites—				
Tons	5,946	2,143	3,803	177.5
Value	$137,196	$115,608	$21,588	18.7
All other	$622,079	$376,478	$245,601	65.2
Electro-chemicals	$6,146,879	$1,305,368	$4,841,511	370.9
Dyestuffs:				
Natural [2]—				
Pounds	50,516,953	49,019,074	1,497,879	3.1
Value	$1,904,107	$2,658,008	[1] $753,901	[1] 28.4
Artificial [3]—				
Pounds	24,681,085	11,168,308	13,512,777	121.0
Value	$2,469,100	$2,256,678	$212,422	9.4
Tanning materials:				
Natural—				
Ground or chipped—				
Pounds	43,062,350	49,002,037	[1] 5,939,687	[1] 12.1
Value	$314,291	$465,956	[1] $151,665	[1] 32.6
Extracts—				
Pounds	181,187,192	62,012,788	119,174,404	192.2
Value	$2,948,561	$1,259,007	$1,689,554	134.2
Artificial [4]—				
Pounds	49,584,429	2,454,084	47,130,345	1,920.5
Value	$1,904,379	$65,155	$1,839,224	2,822.8
Paints and varnishes:				
Pigments—				
White lead, dry—				
Tons	31,198	58,051	[1] 26,853	[1] 46.3
Value	$2,877,109	$4,211,181	[1] $1,334,072	[1] 31.7
Lead oxides—				
Tons	24,867	25,380	[1] 513	[1] 2.0
Value	$2,591,772	$2,550,340	$41,432	1.6
Lamp and other blacks—				
Pounds	20,298,385	7,519,345	12,779,040	169.9
Value	$639,950	$420,037	$219,913	52.4
Fine colors—				
Pounds	7,780,330	4,080,902	3,699,428	90.7
Value	$1,076,853	$1,028,754	$48,099	4.7
Iron oxides and other earth colors—				
Pounds	48,745,978	33,772,256	14,973,722	44.3
Value	$332,616	$324,902	$7,714	2.4
Dry colors [5]—				
Tons	68,061	83,867	[1] 15,806	[1] 18.9
Value	$4,286,412	$4,428,028	[1] $141,616	[1] 3.2
Pulp colors, sold moist—				
Pounds	25,505,482	20,060,935	5,444,547	27.1
Value	$931,131	$861,531	$69,600	8.1
Paints—				
In oil or paste [6]—				
Tons	174,218	153,239	20,979	13.7
Value	$19,942,072	$17,603,127	$2,338,945	13.3
Already mixed for use—				
Gallons	22,386,206	16,900,350	5,485,856	32.5
Value	$20,454,256	$14,870,685	$5,583,571	37.5
Varnishes—				
Oil and turpentine—				
Gallons	17,162,719	14,286,758	2,875,961	20.1
Value	$15,702,997	$14,337,461	$1,365,536	9.5
Alcohol—				
Gallons	1,569,362	563,212	1,006,150	178.6
Value	$2,199,213	$943,069	$1,256,144	133.2
Pyroxylin—				
Gallons	215,887	204,069	11,818	5.8
Value	$283,783	$237,012	$46,771	19.7
Japan, lacquers, and liquid dryers	$3,348,653	$3,085,254	$263,399	8.5
All other	$17,278,518	$3,017,152	$14,261,366	472.7
Explosives:				
Gunpowder—				
Tons	107,910	61,657	46,253	75.0
Value	$8,919,460	$5,310,351	$3,609,109	68.0
Nitroglycerin—				
Pounds	7,935,936	3,618,692	4,317,244	119.3
Value	$1,620,117	$783,299	$836,818	106.8
Gun cotton or pyroxylin—				
Pounds	340,637	369,499	[1] 28,862	[1] 7.8
Value	$202,322	$189,623	$12,699	6.7
Dynamite—				
Tons	65,460	42,923	22,537	52.5
Value	$12,900,193	$8,247,223	$4,652,970	56.4

[1] Decrease.
[2] Includes logwood and other extracts and ground and chipped wood.
[3] Includes mordants, iron liquor, red liquor, turkey red oil, sizes, gums, and dextrin.
[4] Includes chrome tannage solution and other tanning liquids and tannic acid.
[5] Comprises all other dry pigments than those enumerated above.
[6] Includes white lead in oil.

TABLE 6.—*Quantity and value of products, with amount and per cent of increase: 1905 and 1900*—Continued.

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Explosives—Continued.				
Smokeless powder—				
Pounds	6,009,855	2,973,126	3,036,729	102.1
Value	$3,938,073	$1,655,948	$2,282,125	137.8
All other	$150,798	$850,453	[1] $699,655	[1] 82.3
Plastics:				
Pyroxylin	$2,857,093	$1,970,387	$886,706	45.0
All other	$1,898,668	$129,013	$1,769,655	1,371.7
Essential oils:				
Natural—				
Pounds	462,667	838,688	[1] 376,021	[1] 44.8
Value	$1,023,937	$701,173	$322,764	46.0
Witch hazel—				
Gallons	797,700	110,260	687,440	623.5
Value	$367,873	$54,649	$313,224	573.2
Artificial	$65,250	$54,460	$10,790	19.8
Compressed and liquefied gases:				
Anhydrous ammonia	$1,173,184	$448,157	$725,027	161.8
Carbon dioxide	$1,343,966	$696,164	$647,802	93.1
All other	$274,209	$70,690	$203,519	287.9
Fine chemicals:				
Alkaloids—				
Ounces	4,494,525	4,054,478	440,047	10.9
Value	$2,925,789	$1,750,503	$1,175,286	67.1
Gold salts—				
Ounces	59,969	12,347	47,622	385.7
Value	$449,864	$120,696	$329,168	272.7
Silver salts—				
Ounces	1,743,882	1,606,108	137,774	8.6
Value	$683,761	$627,252	$56,509	9.0
Platinum salts—				
Ounces	19,068	8,112	10,956	135.1
Value	$175,682	$61,400	$114,282	186.1
Chloroform—				
Pounds	616,670	396,540	220,130	55.5
Value	$165,604	$98,070	$67,534	68.9
Ether—				
Pounds	871,394	263,238	608,156	231.0
Value	$440,240	$129,876	$310,364	239.0
Acetone—				
Pounds	1,300,395	1,638,715	[1] 338,320	[1] 20.7
Value	$161,320	$178,666	[1] $17,346	[1] 9.7
All other	$4,162,137	$1,435,465	$2,726,672	190.0
General chemicals:				
Glycerin—				
Pounds	18,791,997	15,383,798	3,408,199	22.2
Value	$2,345,205	$2,012,886	$332,319	16.5
Cream of tartar—				
Pounds	11,553,660	10,620,000	933,660	8.8
Value	$2,263,872	$2,081,500	$182,372	8.8
Epsom salts—				
Pounds	17,658,535	7,559,809	10,098,726	133.6
Value	$159,517	$57,966	$101,551	175.2
Sodium phosphates—				
Pounds	12,018,815	3,478,350	8,540,465	245.5
Value	$243,822	$104,554	$139,268	133.2
Tin salts—				
Pounds	10,676,941	4,677,471	5,999,470	128.3
Value	$1,092,980	$470,159	$622,821	132.5
All other	$21,947,072	$18,935,201	$3,011,871	15.6

[1] Decrease.

The increase of $79,663,140 in the aggregate value of products indicates that the condition of the industries grouped under chemicals and allied products was, on the whole, most prosperous in the census year 1905. Nevertheless, in the case of 18 of the products enumerated in Table 6, a decrease was reported either in quantity or in value, or both, at the census of 1905 as compared with that of 1900. In some cases these decreases were not actual, but merely due to the manner of tabulation; as in many instances establishments classified under this heading in 1900 have been transferred in 1905 to other classifications because of a change in their principal product. The coal tar products may be cited as an example. Through the growth of the manufacture of tarred paper and other materials of this class the value of these materials has come, in several establishments, to exceed that of the coal tar distillery products and the chemicals made from them in these same establishments, and thus establishments which at the census of 1900 were classified as engaged in the manufacture of coal tar products were, at the census of 1905, classified as engaged in the manufacture of roofing and roofing materials. In such instances it is endeavored, when possible, to obtain from the returns of these establishments the quantity and value of the subsidiary coal tar products reported, and to combine these figures with those from the establishments in which coal tar products were the principal products, so as to give as complete a view as possible of the special industry. The results of this method as applied to this and other industries are set forth further on, where the different subindustries are treated in detail.

The decreases in some items shown in Table 6 may be ascribed to an increase in the practice of using within an establishment products of its manufacture in the manufacture of other products. Thus the decrease in the quantity and value of natural tanning materials, ground or chipped, is more than offset by the increase in the quantity and value of the extracts, which indicates that establishments which formerly sold their natural tanning material in the ground or chipped condition are now using much of it in the preparation of tanning extracts, and thereby securing the additional profit and advantage which results from further manufacture. The reduction in the quantity and value of dry white lead, as produced for sale, may also be due partly to establishments engaged in the corrosion of lead extending their operations to grinding this white lead in oil before offering it for sale, and thereby converting the pigment into a paint. Cases which arise, such as the two mentioned, will also be considered in the detailed discussion of the subclasses.

TABLE 7.—*Products consumed in establishments where manufactured, with amount and per cent of increase: 1905 and 1900.*

KIND.	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Sulphuric acid, tons	968,445	764,355	204,090	26.7
Nitric acid, pounds	62,116,306	32,123,221	29,993,085	93.4
Mixed acids, pounds	75,337,623	20,902,371	54,435,252	260.4
Acid phosphate, tons	884,211	839,966	44,245	5.3
Charcoal, bushels	12,183,896	1,719,675	10,464,221	608.5
Ether, pounds	2,742,154	1,193,264	1,548,890	129.8
Lead oxides, pounds	13,589,147	2,080,374	11,508,773	553.2
Nitrate of ammonia, pounds	2,552,472	158,307	2,394,165	1,512.4
Nitroglycerin, pounds	44,077,828	31,661,806	12,416,022	39.2
Pyroxylin, pounds	2,938,266	1,964,345	973,921	49.6
White lead, dry, tons	77,793	65,811	11,982	18.2
All other products consumed, tons	2,561,666	272,560	2,289,106	839.9

Table 7 shows that at the census of 1905, as compared with that of 1900, there was an increased consumption of products in the establishments in which they were manufactured, in the case of every substance mentioned in the table. The amount of increase was greatest in the case of sulphuric acid and least in the case of pyroxylin. The percentage of increase was greatest in the case of nitrate of ammonia and least in the case of acid phosphate. The increases recorded were undoubtedly all due to active business conditions and an improved demand for these products, except perhaps in the case of charcoal. In this instance certain establishments making charcoal for use in blast furnaces by wood distillation methods were, at the present census, by the operation of the Census rule for classification, transferred to the group "chemicals and allied products" from the group "iron and steel and their products" or the group "lumber and its remanufactures," where they were placed at the census of 1900.

The figures of Table 7 are of special interest when considered in connection with those of Table 6. Thus, for instance, the returns for lead oxides and white lead, dry, given in Table 7, confirm the opinion that the decreases shown for these products in Table 6 were due largely to their increased consumption in further manufacture in the establishments where they were originally manufactured.

CLASS I. A.—SULPHURIC, NITRIC, AND MIXED ACIDS.

Sulphuric acid, which has been known to man since the eighth century, and which has been manufactured on a commercial scale in the United States since 1793, is so extensively used in the manufacture of other chemical products that the statistics for its production have been regarded as a safe criterion by which to gauge the activity of a country in chemical manufactures. Nitric acid was manufactured in this country as early as 1834. Mixed acids, which are mixtures of sulphuric and nitric acids in various proportions, came into commercial use about 1860, and the consumption of them for the manufacture of nitroglycerin, gun cotton, picric acid, and a large number of organic nitrates and nitro-substitution bodies has grown rapidly.

The classification "sulphuric, nitric, and mixed acids" is adopted for the first time at the present census, the industry having now attained such magnitude and significance as to warrant it. The statistics for sulphuric acid have been collected separately at each census, beginning with the census of 1870, and at the censuses of 1890, 1900, and 1905 the quantities and values of each of the important commercial grades of the acid were also ascertained. The statistics for nitric and mixed acids were first collected separately at the census of 1900. The statistics for the three acids named were presented in the special report on chemicals and allied products for 1900 in conjunction with those for muriatic, boric, acetic, lactic, citric, tartaric, and other acids, under the heading "acids." The returns for 1900 were, however, so recorded that it has been possible to separate accurately the returns for sulphuric, nitric, and mixed acids from those for the other acids reported, so that a comparison of the statistics for these three acids for the last two censuses may be made. These statistics are summarized in Table 8, which gives only the statistics of establishments engaged primarily in the manufacture of the products in question.

TABLE 8.—*Sulphuric, nitric, and mixed acids—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	32	34	[1]2	[1]5.8
Capital	$12,761,920	$13,981,506	[1]$1,219,586	[1]8.7
Salaried officials, clerks, etc., number	308	298	10	3.4
Salaries	$556,106	$388,346	$167,760	43.2
Wage-earners, average number	2,447	2,356	91	3.9
Total wages	$1,505,406	$1,327,549	$177,857	13.4
Miscellaneous expenses	$712,953	$414,978	$297,975	71.8
Materials used, total cost	$4,972,838	$4,033,238	$939,600	23.3
Pyrites—				
Tons	197,847	197,459	388	0.2
Cost	$967,207	$953,680	$13,527	1.4
Sulphur—				
Tons	23,044	24,858	[1]1,814	[1]7.3
Cost	$479,529	$459,102	$20,427	4.4
Nitrate of soda—				
Tons	27,406	29,301	[1]1,895	[1]6.5
Cost	$1,143,280	$974,429	$168,851	17.3
All other materials	$2,382,822	$1,646,027	$736,795	44.8
Products, total value	$9,052,646	$8,596,390	$456,256	5.3
Sulphuric acid, 50° Baumé—				
Tons	467,614	452,942	14,672	3.2
Value	$4,286,312	$4,071,848	$214,464	5.3
Nitric acid—				
Pounds	30,306,555	20,402,570	9,903,985	48.5
Value	$1,446,471	$1,028,266	$418,205	40.7
Mixed acids—				
Pounds	42,812,894	42,301,319	511,575	1.2
Value	$1,222,295	$1,109,758	$112,537	10.1
All other products	$2,097,568	$2,386,518	[1]$288,950	[1]12.1

[1] Decrease.

Although the total number of establishments primarily engaged in the manufacture of sulphuric, nitric, and mixed acids, the capital employed, the quantities of sulphur and nitrate of soda used, and the value of "all other products" were less at the census of 1905 than at that of 1900, a healthy growth is indicated by the fact that there was an increase in all the other items. The relative increase in yields especially indicates improvement in operation.

The products included in Table 8 are those only which are produced for sale, and by establishments in which they constitute the principal product. A better idea of the industry may be gained by combining with the figures given those for the acid produced by establishments in which it constitutes a subsidiary product, and also those for acid which is produced and consumed in the same establishment in further manufacture, giving to this "consumed" acid the average value per unit of its grade so as to obtain a total value for the product. Among establishments of this kind may be mentioned chemical works in which various other acids, bases, salts, or other compounds are produced having a value greater than the sulphuric, nitric, or mixed acids produced for sale, or which consumed one or more of these acids in further manufacture; fertilizer works where sulphuric acid is extensively produced and used in making superphosphates; explosive factories where the sulphuric and nitric acids produced are converted into mixed acids and consumed in the manufacture of nitroglycerin or gun cotton and other cellulose nitrates; petroleum refineries where the sulphuric acid produced is consumed in refining oil; and smelting works where sulphuric acid is obtained from the sulphur fumes. This method has been adopted in treating of sulphuric acid so that comparisons may be made showing the growth in the production at the different censuses.

Sulphuric acid.—The census of 1870 was the first at which separate statistics were given for sulphuric acid, and then only for the number of establishments and the total value of the product. From evidence since obtained it is believed that these statistics are deficient, and that at that time there were probably 25 establishments in operation, yielding a product of over $1,000,000 in value. At the census of 1880 the total quantity of sulphuric acid was also reported, as well as its value and the number of establishments producing it.

TABLE 9.—*Sulphuric acid—number of establishments and quantity and value of products: 1870 to 1905.*

CENSUS.	Establishments.	Quantity (tons).	Value.
1905	[1]149	1,642,262	$15,174,886
1900	[2]127	1,352,730	14,247,185
1890	105	692,389	7,679,473
1880	49	154,383	3,661,876
1870	4	(3)	212,150

[1] Includes 117 establishments engaged primarily in the manufacture of other products.
[2] Includes 93 establishments engaged primarily in the manufacture of other products.
[3] Not reported.

TABLE 10.—*Sulphuric acid—increase and per cent of increase in quantity and value of products: 1870 to 1905.*

CENSUS PERIOD.	INCREASE.		PER CENT OF INCREASE.	
	Quantity (tons).	Value.	Quantity (tons).	Value.
1900 to 1905	289,532	$927,701	21.4	6.5
1890 to 1905	949,873	7,495,413	137.2	97.6
1880 to 1905	1,487,879	11,513,010	963.8	314.4
1870 to 1905	(1)	14,962,736	(1)	7,052.9
1890 to 1900	660,341	6,567,712	95.4	85.5
1880 to 1890	538,006	4,017,597	348.5	109.7
1870 to 1880	(1)	3,449,726	(1)	1,626.1

[1] Not reported.

Sulphuric acid is produced in several grades: (1) 50° Baumé, or chamber acid, containing on an average 51.04 per cent of SO_3; (2) 60° Baumé, containing on an average 63.7 per cent of SO_3; (3) 66° Baumé, known as oil of vitriol, containing on an average 76.35 per cent of SO_3; and (4) oleum, which consists of SO_3 dissolved in a sulphuric acid, containing 97 to 98 per cent of H_2SO_4. Pure pyrosulphuric acid contains 89.89 per cent of SO_3. The commercial article, called "oleum," usually contains 30 per cent of free SO_3, or a total of 87.14 per cent of free and combined SO_3. Beginning with the census of 1890 the statistics for the separate grades have been collected, and it thus becomes possible to show more definitely the condition of the industry at the different censuses, although the sum total of all the grades gives but an incomplete statistical view of the industry. It is also possible to reduce all the grades to a common basis, as, for instance, to the basis of 50° Baumé, or chamber acid. For this purpose the quantity given for 60° Baumé is multiplied by the factor 1.25; that given for 66° Baumé, by the factor 1.50; and that given for oleum, by the factor 1.71.

TABLE 11.—TOTAL QUANTITY AND VALUE OF SULPHURIC ACID, BY GRADES: 1890 TO 1905.

GRADE.	1905			1900			1890		
	Quantity (tons).	Value.	Value per ton.	Quantity (tons).	Value.	Value per ton.	Quantity (tons).	Value.	Value per ton.
Total reduced to 50° Baumé acid	[1] 1,869,437	....	....	[2] 1,548,123	....	$9.20	[3] 783,569	....	....
Total	1,642,262	$15,174,886	....	1,352,730	$14,247,185	....	692,389	$7,679,473	....
50° Baumé	1,169,141	8,314,646	$7.11	953,439	7,965,832	8.35	504,932	4,307,067	$8.53
60° Baumé	48,688	581,523	11.94	17,012	246,284	14.47	10,190	122,940	12.06
66° Baumé	411,165	5,917,699	14.39	382,279	6,035,069	15.78	177,267	3,249,466	18.33
Oleum	13,268	361,018	27.20	....	....	....	....	....	....

[1] Includes 968,445 tons, with an assigned value of $7,232,675, consumed in establishments where manufactured; and also sulphuric acid produced by establishments engaged primarily in the manufacture of other products.
[2] Includes 764,355 tons, with an assigned value of $7,032,066, consumed in establishments where manufactured; and also sulphuric acid produced by establishments engaged primarily in the manufacture of other products.
[3] Includes 290,768 tons, for which no value was assigned, consumed in establishments where manufactured; and also sulphuric acid produced by establishments engaged primarily in the manufacture of other products.

Comparing the total quantities reduced to the common basis of 50° Baumé, it appears that the increase for 1900 over 1890 was 764,554 tons; and for 1905 over 1900, 321,314 tons. The per cent of increase for 1900 over 1890 was 97.6; and for 1905 over 1900, 20.8. The value per ton for each grade has been consistently lower at each census except for the 60° Baumé. For this grade a higher value was reported at the census of 1900 than at that of 1890, but the value reported at the census of 1905 is less than that for 1890, and is in harmony with the values reported for the other grades at the present census. This progressive reduction in the cost of sulphuric acid is a matter of prime importance, since this acid is used to so large an extent in the manufacture of other products.

Oleum appears for the first time in any census at the census of 1905. This is due to the fact that it is readily produced by the contact process, which was described in detail in the 1900 report on chemicals and allied products, and which had then but recently been made commercially operative and introduced into this country.

The geographic distribution of the manufacture of sulphuric acid is shown in Table 12, which includes all establishments, making it either as a principal or as a subsidiary product, reported at the censuses of 1900 and 1905.

Establishments manufacturing sulphuric acid were reported from 25 states at the census of 1900, and 26 at that of 1905. At the census of 1900 New Jersey held first rank in the number of establishments, Georgia second, Maryland and South Carolina third, and New York and Pennsylvania fourth. Each of the remaining states reported less than 10 establishments in operation. At the census of 1905 Georgia held first rank, and was followed by Pennsylvania, New Jersey, South Carolina, and New York, in the order named.

TABLE 12.—*Sulphuric acid—number of establishments, by states and territories: 1905 and 1900.*

STATE OR TERRITORY.	1905	1900
United States	[1] 149	[2] 127
Alabama	7	3
Arizona	1	1
California	8	7
Colorado	1	1
Connecticut	2	2
Florida	1	1
Georgia	20	15
Illinois	3	2
Indiana	3	2
Kansas	3	....
Louisiana	3	3
Maine	....	1
Maryland	9	12
Massachusetts	4	4
Michigan	3	1
Mississippi	1	1
Missouri	....	1
New Jersey	13	18
New York	10	11
North Carolina	7	6
Ohio	9	3
Pennsylvania	16	11
Rhode Island	1	1
South Carolina	11	12
Tennessee	4	3
Texas	1	....
Virginia	7	5
Wisconsin	1	....

[1] Includes 117 establishments engaged primarily in the manufacture of other products.
[2] Includes 93 establishments engaged primarily in the manufacture of other products.

None of the remaining states reported 10 establishments in operation. Maine and Missouri each reported 1 establishment in operation at the census of 1900, but none at the census of 1905, while Kansas, which reported 3 establishments, and Texas and Wisconsin, which reported 1 establishment each at the census of 1905 did not report any at the census of 1900. At the census of 1900, out of the total number of establishments reported, 95, or 74.8 per cent, were located in states bordering on the Atlantic ocean or the Gulf of Mexico, and at the census of 1905, of the establishments reported, 97, or 65.1 per cent, were so located.

TABLE 13.—*Sulphuric acid—quantity of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
United States	Tons. 1,869,437	Tons. 1,548,123
North Atlantic	768,647	734,669
South Atlantic	540,593	520,575
North Central	349,906	153,979
South Central	141,107	87,665
Western	69,184	51,235

An increase is shown in each of the divisions, the largest increase, 195,927 tons, having occurred in the North Central division, and the smallest, 17,949 tons, in the Western; while the greatest percentage of increase was that for the North Central.

The census of 1900 was the first at which statistics were given with any detail as to the kinds, quantities, and values of the principal materials. At that census there were reported, as having been used in the manufacture of sulphuric acid, 633,837 tons of pyrites, having a value of $3,101,075, and 70,288 tons of sulphur, having a value of $1,396,975.

At the census of 1905 there were reported 707,326 tons of pyrites, having a value of $3,895,905, and 47,861 tons of sulphur, having a value of $1,022,644. This represents an increase in pyrites, for 1905 as compared with 1900, of 73,489 tons, or 11.6 per cent, in quantity and $794,830, or 25.6 per cent, in value, and a decrease in sulphur of 22,427 tons, or 31.9 per cent, in quantity and $374,331, or 26.8 per cent, in value.

The quantity of nitrate of soda used in the manufacture of sulphuric acid can not be directly ascertained, for the reason that in establishments producing sulphuric acid it is used for other purposes also, varying with the nature of the establishment, as, for example, in making nitric acid, fertilizers, gunpowder, dynamite, or saltpeter; and for the further reason that the nitrate used for all purposes in a single establishment is reported in gross. Analysis of returns, however, shows that on the average 1 part of nitrate is used to every 100 parts of 50° Baumé acid produced. Bearing in mind that no nitrate is used in the contact processes, it is estimated that in 1900 there was used in making sulphuric acid 15,481 tons of nitrate of soda, and in 1905, 18,467 tons. The ratio of nitrate to total acid will probably decrease greatly in the future.

In the report on sulphuric acid for the census of 1880 it was stated that there were then 3 establishments in the United States burning pyrites, from which it is inferred that the other 46 were burning brimstone, as sulphur is usually styled in this industry. In the census report for 1890 no mention is made of the kind of materials used. At the census of 1900 there were 77 establishments burning pyrites only, 31 burning brimstone only, 17 burning both pyrites and brimstone, and 2 producing the acid from the roaster gases in zinc smelting. At the census of 1905 there were 114 establishments burning pyrites only, 19 burning brimstone only, 10 burning both pyrites and brimstone, 5 producing acid from the roaster gases in zinc smelting, 1 producing acid from the roaster gases in copper smelting, and 5 engaged in the recovery from spent or sludge acid. Two of the pyrite plants were also engaged in the recovery of spent acids.

The total amount of recovered acid included in the product for 1905 was approximately 73,346 tons. It is probable that the amount of sulphuric acid recovered, or regained, during the census year was much greater than this, for in many establishments, such as explosives factories, it has been the practice to recover and reuse the acid again and again, and the acid so recovered is not reported. This practice is, however, now being supplanted by that of rebuilding the spent acid with oleum. At the census of 1900 the quantity of acid reported as produced in zinc smelting was 58,828 tons, having a value of $424,670; and at the census of 1905 the quantity so reported was 94,032 tons, having a value of $576,060. This represents a gain for 1905 over 1900 of 35,204 tons, or 59.8 per cent, in quantity and of $151,390, or 35.6 per cent, in value.

The increase between 1900 and 1905 in the number of establishments burning pyrites was 30, or 31.9 per cent; while for those burning pyrites only it was 37, or 48.1 per cent. The decrease for the same period in the number of establishments burning brimstone was 19, or 39.6 per cent; while for those burning brimstone alone it was 12, or 38.7 per cent.

At the census of 1905 the average yield for 105 establishments burning pyrites only was 211 pounds of sulphuric acid, reduced to 50° Baumé, for 100 pounds of pyrites. At the census of 1900 the average for the 39 works for which data are available was 206 pounds of acid for 100 of pyrites. The theoretical yield of chamber acid is given later. In practice 240 pounds have been obtained. At the census of 1905 the average yield for 15 establishments burning brimstone only was 432 pounds of sulphuric acid, reduced to 50° Baumé, for 100 pounds of brimstone. At the census of 1900 the average for the 20 works for which data are available was 402 pounds of acid for 100 pounds of brimstone. The theoretical yield of chamber acid is given later. In practice 446 pounds have been obtained. In the report on this industry for 1900 attention was called to the large use of sulphur in the United States, while practically no brimstone acid was being made in England or on the continent of Europe. The statistics for the present census indicate that our manufacturers are coming into conformity with European practice.

The large use made of pyrites and of sulphur in the sulphuric acid industry and the continued growth of this industry make it proper to inquire into the extent to which these raw materials are available.

TABLE 14.—*Pyrites produced in, and imported into, the United States: 1895 to 1904.*[1]

YEAR.	PRODUCED.		IMPORTED.[2]	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1895	99,549	$322,845	190,435	$673,812
1896	115,483	320,163	200,168	648,396
1897	143,201	391,541	259,546	747,419
1898	193,364	593,801	252,773	717,813
1899	174,734	543,249	269,868	1,077,061
1900	204,615	749,991	322,484	1,055,121
1901	[3]241,691	1,257,879	403,706	1,415,149
1902	[3]207,874	947,089	440,363	1,650,852
1903	[3]233,127	1,109,818	420,410	1,636,450
1904	[3]333,542	3,460,863	422,720	1,533,997

[1] United States Geological Survey, "Mineral Resources of the United States, 1904."
[2] Iron pyrites containing 25 per cent or more of sulphur and not more than 3.5 per cent of copper.
[3] Includes production of natural sulphur.

The chief sources of the supply of pyrites imported into the United States are the celebrated Rio Tinto and Tharsis mines of the Huelva district in Spain; the San Domingo mine at Pomaron, Portugal; and the Tilt Cove mines of Pilleys Island, Newfoundland. The residue from the roasting or burning of pyrites is known as pyrites cinders. Sometimes the pyrites contain gold, silver, or other valuable metals in sufficient quantity to warrant treatment to recover these values, and as the sulphur present renders such ores refractory, it is the practice in some instances to send them to sulphuric acid works to be burnt, the cinders then being returned. Under such circumstances no cost is assigned to the pyrites by the sulphuric acid works. Pyrites cinders is useful in smelting acid ores, as the contact mass in certain processes of making sulphuric acid, and in the manufacture of pigment and of copperas; it is also sometimes used as an iron ore in the blast furnace for making pig iron. In 1900 there were returned 62,701 tons of pyrites cinders, having a value of $105,631, and in 1905, 163,276 tons, having a value of $200,940. It is evident that but a small portion of the actual product is utilized.

Pure pyrite contains 53.3 per cent of sulphur. The pyrites commonly used for making sulphuric acid contain from 43 to 48 per cent. When the ore contains over 35 per cent of sulphur it can be ignited and, with a proper supply of air combustion, will continue until the greater part of the sulphur contents are burned, for there is sufficient heat generated by the process to maintain it. Such is not the case when the amount of sulphur in the ore is less than 35 per cent, and additional fuel is required with these low-grade ores.

The statistics for sulphur produced in this country from 1901 to 1904 are combined with those for pyrites, because the sulphur is largely the product of a single mine, and it is desired to avoid showing individual operations. The remainder of the sulphur used for all purposes is imported.

TABLE 15.—*Sulphur imported and entered for consumption in the United States: 1895 to 1904.*[1]

YEAR ENDING DECEMBER 31—	CRUDE.		FLOWERS OF SULPHUR.		REFINED.		Total value.
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	
1895	121,286	$1,546,481	581	$12,888	229	$4,379	[2]$1,613,754
1896	138,168	1,967,454	665	13,266	447	8,226	[2]2,172,629
1897	136,563	2,395,436	....	....	5,342	58,637	2,454,073
1898	151,225	2,891,767	507	14,548	12,772	163,609	3,069,924
1899	140,182	2,484,801	335	9,917	1,016	28,485	2,523,203
1900	166,825	2,917,172	628	17,437	259	8,385	2,942,994
1901	174,160	3,256,990	748	20,201	301	10,715	3,287,906
1902	170,601	3,334,002	738	19,954	41	3,694	3,357,650
1903	188,990	3,649,756	1,854	52,680	189	7,254	3,709,690
1904	127,996	2,462,360	1,332	39,133	204	9,776	2,511,269

[1] United States Geological Survey "Mineral Resources of the United States, 1904."
[2] Includes lac sulphur and other grades not otherwise provided for, but not pyrite.

It has been estimated that if the rate of increase in the consumption of pyrites and sulphur which obtained between 1893 and 1903 be maintained the amount of sulphur required in the United States in 1913 in the form of elemental sulphur or of sulphur bearing materials would amount to 1,045,875 long tons. As similar activity in manufacture is noted in several European countries, there is already a call for new sources of supply of raw materials. Fortunately there are many sulphur bearing materials, some of which are used as sources of the metals.

Table 16 presents the names of several of the more commonly occurring sulphur bearing minerals, with their formulas, and the number of tons of "real" sulphuric acid and of chamber acid which theoretically may be produced from a ton of each mineral when pure.

TABLE 16.—*Tons of real sulphuric acid and of chamber acid theoretically produced by a ton of each of the minerals specified.*

MINERAL.	Formula.	Real sulphuric acid.	Chamber acid.
Sulphur	S	3.06	4.93
Pyrite	$Fe\,S_2$	1.63	2.62
Marcasite	$Fe\,S_2$	1.63	2.62
Pyrrhotite	$Fe_{11}\,S_{12}$	1.18	1.90
Sphalerite	$Zn\,S$	1.01	1.63
Chalcopyrite	$Cu\,Fe\,S_2$	1.08	1.73
Bornite	$Cu_3\,Fe\,S_3$	0.86	1.38
Chalcocite	$Cu_2\,S$	0.62	1.00
Galenite	$Pb\,S$	0.41	0.66

Of the minerals named, sulphur, pyrite, and marcasite have long been used for making sulphuric acid. In the report for 1900 the use of sulphur for this purpose was traced back to Basilius Valentinus, living in the fifteenth century. The first proposal to use pyrites for this purpose is credited to an Englishman named Hill,[1] a patent for the process having been granted him in 1818. Little use was made of it until 1838, when the Sicilian government sold the monopoly of the export sulphur to a French firm, and the price of

[1] George Lunge, Manufacture of Sulphuric Acid and Alkali, edition 1903, Vol. I, pages 36 to 38.

crude brimstone was nearly trebled. Pyrites were found so satisfactory a substitute that they have steadily grown in favor ever since.

Pyrrhotite has come into use practically since the last census. Its value was demonstrated at Sault Ste. Marie, with Canadian ores, and the results were so satisfactory that works have been erected in which to utilize the pyrrhotite ores of Virginia. Pyrite, marcasite, and pyrrhotite, in the condition in which they occur as ores, are all embraced in pyrites.

Sphalerite is used as a source of zinc, and at each of the last two censuses sulphuric acid has been reported as having been produced in the process of zinc smelting. Pure zinc sulphide contains 32.9 per cent of sulphur, but the ores may range down to 18 per cent. In roasting these lower grade ores fuel is required in addition to that furnished by their sulphur contents. When this was added directly, as in earlier practice, the roaster gases were so dilute as to make the recovery of the sulphur difficult, but by roasting in muffles in such a manner as to keep the roaster gases separate from the fire gases, it has become possible to utilize the whole of the sulphur contents of the ore in vitriol chambers, and with the introduction of the contact process, it has even become feasible to recover it from the more highly diluted gases. As early as 1855 there was erected at Stolberg, Germany, a Hasenclever furnace by which the roaster gases from sphalerite, or zinc blende, could be converted into sulphuric acid.

Chalcopyrite, bornite, and chalcocite are copper ores. In 1905 a small amount of sulphuric acid was reported as having been produced in the process of copper smelting. The burner gases from copper smelting are quite lean in sulphur, yet as long ago as 1872 they were used at Altenau, Germany, in making sulphuric acid. By the use of a contact process their utilization becomes still more feasible. The Census report on mines and quarries for 1902 states that 11,780,064 tons of copper ores were mined in that census year, and it is well known that a large percentage of them were sulphur bearing ores.

No reports of sulphuric acid production have been eceived from any processes of smelting lead ores. Referring to galenite, Lunge says:[1] "Galena is probbly nowhere worked in such a way as to extract its ılphur in the shape of sulphuric acid. The purest ılena contains only 13.4 per cent of sulphur." The ensus report on mines and quarries for 1902 states at 132,330 tons of nonargentiferous lead ore were ined in that census year. The greater part of this was lphide ore. In addition, 9,787,804 tons of gold and ver ores were reported as being treated in that census ar, much of which consisted of sulphurets, the sulphur from all of which was evidently lost in treatment. By Salom's process of electrolyzing galenite, however, hydrogen sulphide is obtained, and this may be converted into sulphuric acid.

According to W. D. Harkins,[2] the amount of material of industrial value given out in smelter smoke in the United States is often enormous. The analysis of the smoke of one smelter showed an approximate daily output in smoke of 55,000 pounds of arsenic trioxide, 1,500 to 2,000 tons of sulphur dioxide, 150 tons of sulphur trioxide, 6,000 pounds of zinc, 5,000 pounds of copper, 6,000 pounds of lead, and 5,000 pounds of antimony. From private communications it is learned that 1 establishment is daily liberating into the atmosphere 850 tons of sulphur in various states of combination, and that another, in a widely different section of the country, is sending off in its smoke approximately 237,500 tons of sulphur dioxide per annum. It has been estimated[3] that a half million tons of sulphuric acid could be produced annually from the sulphur in the fuel burned in London.

This sulphur is not only wasted, but the emanations from smelters render the atmosphere noxious to man and other animals, and seriously affect the vegetation for considerable distances about the smelters. This has repeatedly led to litigation. So long ago as 1864 the owners of the works at Freiberg, Germany, were compelled to pay upward of $14,000 damages on account of the emanations from their works. The recovery and utilization of these gases and fumes will not only abate the evils to which they give rise, but will greatly increase the available supply of the sulphur compounds and other substances which are much used in our industries.

The Tennessee Copper Company has recently erected a plant for making acid from the gases of its smelting furnaces at Copperhill, Tenn., which are now operated on the pyrite principle. It has been determined that these gases average about 6 per cent in sulphur dioxide, and when the plant is in full operation their quantity will enable the production of upward of 700,000 tons of sulphuric acid of 50° B. per annum.[4]

Other sources of sulphur are found in the spent oxides from gas works, the waste liquors of Le Blanc soda works and of ammonia works, and in petroleum, such as the oils of Lima, Ohio, and of Canada. According to Pennock,[5] the hydrogen sulphide recoverable from by-product coke ovens is sufficient, when oxidized, to supply nearly one-half the sulphuric acid required in converting the ammonia into sulphate. According to Mabery,[6] "probably 50 tons of sulphur daily is a conservative estimate of the amount extracted from Ohio oil and burned off into the atmosphere." The

[1] Manufacture of Sulphuric Acid and Alkali, edition 1903, Vol. I, e 85.

[2] Science, 1907, vol. 25, page 407.
[3] Nature, 1907, vol. 76, page 110.
[4] The Mineral Industry, 1906, vol. 15, page 708.
[5] Journal of American Chemical Society, 1906, vol. 28, page 1257.
[6] Ibid., page 432.

sulphur may be obtained from sulphur bearing petroleum in the form of hydrogen sulphide which can be burned to sulphuric acid. This method is practiced to some extent in the United States, but until it becomes more general the product must appear in census statistics as being produced from sulphur.

The sulphur gases obtained by the burning of pyrites and other sulphurets are usually impure because of the other minerals naturally occurring in the ore. As pointed out in the report for 1900, in the contact process there described, these gases are purified before being brought into the presence of the contact mass. In the chamber process it has been customary to use these gases as produced and then to purify the sulphuric acid when it was specially desired. According to Schatterbeck,[1] several hundred tons of arsenic sulphide, which is obtained in our chemical works in purifying sulphuric acid, are thrown away every year in the United States, yet our imports of arsenic compounds have for several years past amounted to from 6,000,000 to 8,000,000 pounds, having a value of from $243,380 to $416,525.

In the Census report for 1900 it was pointed out that owing to the contact process for the manufacture of sulphuric acid having been made a commercial success by the Badische Aniline und Soda Fabrik, a formidable competitor to the long used chamber process had been developed. As a result, the period since 1900 has been marked by much activity in endeavors to improve the chamber process and to devise contact processes that are independent of the Knietsch process. The improvements in the chamber process consist largely in a reassembling, proportioning, and arranging of the chambers, with the introduction of dust chambers, fans, and intermediate towers, and the use of atomized water in place of steam. A notable departure from previous practice is found in the Meyer's tangent system. The chambers in this system are cylindrical in form, with the entrance pipe for the burner gases so placed that the gases enter the top of the chamber tangentially, and travel along the periphery in a downward spiral, leaving the chamber by an opening near the bottom. By this means a higher efficiency for unit volume of chamber is obtained, and greater compactness of plant results. Hence the cost of installation and interest, and the area required for the plant are materially diminished. According to Guttmann,[2] "the production of acid for a given chamber space is with ordinary chambers now frequently 3 kilos of H_2SO_4 per cubic meter, but with the intensified working one arrives at 4 kilos. With atomized water and fans in ordinary chambers 5.84 kilos have been obtained. A set of Meyer's chambers, without other improvements, produces 4 kilos. * * * With fans and atomized water a Meyer set will probably reach 8 kilos and more; at any rate the first chamber of the system, which is not worked to its full capacity, produces 10 kilos, and more." Further, in comparing the chamber processes with contact processes, he says: "The conclusion is therefore justified, that a factory burning about 100 tons of pyrites per week, and having a chamber plant, equipped with all recent improvements, can successfully compete with a contact plant for even the strongest sulphuric acid in the market."

According to Lunge,[3] there are six contact processes now in use, styled respectively, Badische, or Knietsch, Höchst, Grillo, Mannheim, Freiberg, and Rabe, about which, through patent specifications, publications, or special communications, considerable detail is known, and several others which have been kept secret. In the Badische, Höchst, Grillo, and Mannheim processes the conversion of SO_2 into SO_3 is rendered practically complete by contact action, while in the Freiberg and Rabe processes the contact action is supplemented by lead chambers for working up the residual gases. The Grillo process is known in this country as the Schroeder process. Of the processes named by Lunge, five appear to be in use in the United States—the Knietsch, Schroeder, Mannheim, Höchst, and Rabe, while the American inventions of J. B. F. Herreshoff are also used. The Knietsch was described at length in the report for 1900, and it may suffice to add that in this system the unit is one having a capacity for treating 5,000 tons of 50 per cent ore a year. The Schroeder process was made the subject of a symposium before the New York Section of the Society of Chemical Industry in February, 1903, and from the report[4] of this symposium it appears that the process is distinguished by the use of a contact mass composed of soluble salts, principally sulphates, carrying the platinum. According to this report the following advantages are claimed for this method:

(1) The contact mass is easily regenerated, hence the kiln gases do not need to be purified as perfectly as if working with platinized insoluble vehicles.

(2) The calcined crusts are very porous, so that the contact mass made from them offers much less resistance to the gases passing through them than the tightly packed asbestos formerly used.

(3) The catalytic action of the contact mass made from soluble salts is far superior to that of platinized insoluble carriers, and the contents of the platinum in the contact mass, which were from 8 to 10 per cent of the weight of the asbestos in the old Schroeder plates, have been decreased to one-tenth of 1 per cent without reducing the efficiency of the contact material.

At present (1903) there are 23 Schroeder plants built or building—7 in Germany, 2 in Russia, 1 in Poland, 1 in Italy, 2 in France, 1 in Chile, 1 in Mexico, 2 in South Africa, and 6 in the United States. Some are using blendes, some pyrites, some brimstone, and one a

[1] United States Geological Survey, "Mineral Resources of the United States," 1905.

[2] Journal of Society of Chemical Industry, 1903, page 1334.

[3] Manufacture of Sulphuric Acid and Alkali, edition 1903, vol. 1, page 1012.

[4] Journal of Society of Chemical Industry, 1903, vol. 22, page 348.

low-grade gold ore. Some of the ores are quite free from objectionable impurities, while others are very impure, which necessitates different methods of purification.

The cost of the plant is less than that of a chamber and concentrating plant of the same capacity.

The advantage of the contact process is greater the stronger the acid made, the cost being the same per unit of sulphur for all strengths. For acid stronger than 60° B. it is cheaper than chambers; but for 50° B., and perhaps for 60° B., it has at present but little, if any, advantage.

One application of the process that promises to be of great importance is its use in connection with chamber plants to make strong acid, in place of concentrating in the usual manner. A plant is now being built for this purpose, and there is every reason to believe that it will show a marked economy, both in first cost and in operating expenses.

The Mannheim process was described by Wilke[1] before the New England Section of the Society of Chemical Industry in December, 1905, as follows:

This process is based on the following fundamental principles:

First. To use the heat of the ordinary roasting process for carrying on the catalytic action of the oxide of iron upon the sulphurous acid.

Second. The purification of the burner gases is a dry process. In all other processes the gases are washed and have to be dried again.

Third. The conversion or catalytic oxidation of that part of the sulphurous acid which passed through the iron contact, but had not been converted, is brought about by means of the waste heat of the burner gases.

Fourth. The whole process is carried on by moving the gases by means of exhausters only.

The roast gases leave the kilns at a temperature of about 700° C. This is the proper temperature necessary in the iron oxide to produce the conversion or catalytic action to transform the sulphurous acid into sulphuric anhydride. The iron oxide, at the above-mentioned temperature, forms iron arsenate, with the arsenious acid which is contained in the roast gases. If roast gases are taken at the temperature of the furnace through the oxide of iron, a large proportion of the sulphurous acid (50 to 60 per cent) is converted into sulphuric anhydride, while the arsenic contained in these roast gases combines with the oxide of iron.

Water contained in the gases to be converted reduces the catalytic property of the iron oxide. It is therefore necessary to produce the roast gases with dried air. The drying of the air necessary for the process is accomplished with sulphuric acid which is produced in the process.

The roast gases are produced in a furnace which is protected with an air-tight iron shell against any entrance of moist atmospheric air. The air necessary for the roasting process passes through towers which are scrubbed with sulphuric acid and is then conducted through air-tight pipes entering the furnace or kilns below the grate bars. The dry and hot roast gases so obtained are conducted to a shaft which is attached to the furnace and filled with oxide of iron (pyrites cinders). In this shaft part of the conversion takes place; that is, part of the sulphurous acid is converted into sulphuric anhydride, while at the same time the arsenic obtained in the roast gases is retained.

The roast gases therefore are subjected to a dry purification, and are considerably reduced in their contents of sulphurous acid. After the sulphuric anhydride which is formed in this first part of the process has been absorbed, the rest of the sulphurous acid contained in the gases can be converted into sulphuric anhydride by means of a very small amount of platinum. To do this, it is necessary to remove any small quantities of sulphuric acid (monohydrate) which have not been absorbed. This is accomplished by passing the gases through layers of porous material which is not affected by sulphuric acid. The main part of the sulphuric acid which is carried over mechanically is eliminated or retained in this way. The purified gases are now allowed to pass through layers of granulated basic blast-furnace slag.

[1]Journal of Society of Chemical Industry, 1906, vol. 25, page 4.

The gases which have passed through the iron contact mass contain sufficient heat to reheat the filtered gases to the temperature necessary for catalytic action in the platinum contact.

It would be possible to utilize this heat by giving it off to the filtered gases. But the sulphuric acid (monohydrate) must be carried along in the form of vapor. The heat, therefore, must not be reduced too much to keep the monohydrate in a gaseous state. The heat given off in the heater located over the iron contact is not sufficient to raise the filtered gases to the temperature necessary to carry on catalytic action in the platinum contact. It is, therefore, necessary to have a small coal fire to raise these gases to their proper temperature.

The platinum contact apparatus must be built in such a way that it does not offer much resistance to the passage of the gases, in order to move them with an ordinary exhauster. This is accomplished by using a number of platinized asbestos nets, the meshes of which are such that the resistance in the whole apparatus does not represent more than the pressure of a column of water about 30 millimeters high. In constructing the platinum contact apparatus in this way, it is possible to exchange a single element during the process in the course of a few minutes without interruption. In this process it is possible to have a conversion of the roast gases up to 95 per cent.

The first plant in the United States was erected in 1903, in the works of the Schoellkopf, Hartford, and Hanna Company, in the city of Buffalo, N. Y. This plant consisted then of one unit with a capacity of about 1,600 tons of sulphuric acid or its equivalent. The original plant has since been enlarged to four times its original capacity. Besides this plant, four other firms have adopted this process, and there are now in use twenty-two units with a capacity of about 35,000 tons, and in the course of construction, ten more units with a capacity of 16,000 tons. This is a total capacity of over 50,000 tons per year. This has been accomplished in a little over two years since the process has first been introduced here.

This process does not require complicated or delicate pieces of apparatus, a staff of scientific men, nor any special apparatus for the purification of the roast gases, as this is done in the furnace itself. The amount of fuel consumed and motive power required is smaller than in any other known process, and the plant can be built up gradually on account of the units being small and being easily arranged in groups. The cost of repairs is very low.

According to Falding (V. Internationaler Kongress für Angewandte Chemie, 1904, vol. 1, page, 768), the following sulphuric acid plants were completed or in course of construction in the United States between 1900 and 1903:

Contact process plants.

NAME AND LOCALITY.	Process.
New Jersey Zinc Co., Mineral Point, Wis.	Schroeder.
New Jersey Zinc Co., Hazard, Pa.	Schroeder.
Peyton Chemical Co., Cal.	Schroeder.
Repauno Chemical Co., near Wilmington, Del.	Schroeder.
Dupont Powder Co., near Wilmington, Del.	Schroeder.
Harrison Bros. & Co., near Philadelphia, Pa.	Schroeder.
United Zinc & Chemical Co., Argentine, Kans.	Frasch converter.
——— Buffalo, N. Y.	Mannheim.
General Chemical Co., near New York, two plants.	(1)

[1] Inquiry has developed the fact that the General Chemical Company is operating a large number of contact plants, and that as rapidly as its chamber systems wear out it is replacing them by contact plants. This company operates under the Herreshoff patents and it also owns and utilizes the Knietsch, Höchst, and Rabe patents. This company expresses great satisfaction with the working of its contact processes and finds that the acid thus produced from pyrites is substantially free from iron and is superior to brimstone acid in its freedom from arsenic.

Chamber process plants.

NAME AND LOCALITY.	Equipment.	Chamber capacity (cubic feet).
Total		6,400,000
Richmond Guano Co., Richmond, Va.	Four intermediate towers.	178,000
E. Frank Coe & Co., Barren Island, N. Y.		225,000
Southwest Chemical Co., Argentine, Kans.	Fifteen Gilchrist columns and fans.	435,000
Lazaretto Guano Co., Baltimore, Md.	Nine Gilchrist columns and fans.	336,000
Western Chemical Co., Denver, Colo		450,000
Meridian Fertilizer Co., Meridian, Miss.	Pratt system	143,000
Bussey & Sons, Columbus, Ga	Pratt system	90,000
Greenville Fertilizer Co., Greenville, S. C.		135,000
Virginia-Carolina Chemical Co., Memphis, Tenn.		135,000
Anderson Fertilizer Co., Anderson, S. C.		124,000
Georgia Chemical Works, Rome, Ga		206,000
Philip Carey Manufacturing Co., Lackland, Ohio.		158,000
E. Rauh Sons Fertilizer Co., Indianapolis, Ind.	Two Gilchrist columns	101,000
Jackson Fertilizer Co., Jackson, Miss.	Three Gilchrist columns.	220,000
Scott Bros. Fertilizer Co., Elkton, Md		83,000
C. H. Dempwolf & Co., York, Pa.		170,000
A. P. Brantley Sons Co., Blackshear, Ga.		101,000
Virginia State Fertilizer Co., Lynchburg, Va.	Four intermediate towers.	148,000
Graselli Chemical Co., Birmingham, Ala.		400,000
Jarecki Chemical Co., Cincinnati, Ohio		140,000
Detroit Chemical Co., Detroit, Mich	Five Gilchrist columns	173,000
Federal Chemical Co., Nashville, Tenn.	Thirteen Gilchrist columns.	278,000
Southern States Fertilizer Co., Savannah, Ga.	Pratt system	130,000
Virginia-Carolina Chemical Co., Dothan, Ala.	Hoffman	100,000
Ohio Farmers Fertilizer Co., Columbus, Ohio.	Hoffman	204,000
Armour Fertilizer Co., Atlanta, Ga.		166,000
Virginia-Carolina Chemical Co., Savannah, Ga.	Hoffman intensifier	120,000
Merrimac Chemical Co., Boston, Mass		202,000
Sayles Bleacheries, Saylesville, R. I.		10,000
Bowker Fertilizer Co., St. Bernard, Ohio.		141,000
T. P. Shepard & Co., Providence, R. I.		140,000
Virginia-Carolina Chemical Co., Albany, Ga.		160,000
Standard Chemical and Oil Co., Troy, Ala.		150,000
F. S. Royster Guano Co., Columbia, S. C.	Seven Gilchrist columns.	173,000
Griffith & Boyd	Meyer Tangential	75,000
Virginia-Carolina Chemical Co., Greenville, S. C.		200,000

Sulphuric acid is probably used for a greater variety of purposes, especially in the chemical arts, than any other substance. According to Lunge,[1] the principal applications are the following:

I. *In a more or less dilute state* (say from 144° Tw. downwards). For making sulphate of soda (salt cake) and hydrochloric acid, and therefore ultimately for soda ash, bleaching powder, soap, glass, and innumerable other products. Further, for superphosphates and other artificial manures. These two applications probably consume nine-tenths of all the sulphuric acid produced. Further applications are for preparing sulphurous, nitric, phosphoric, hydrofluoric, boric, carbonic, chromic, oxalic, tartaric, citric, acetic, and stearic acids; in preparing phosphorus, iodine, bromine, the sulphates of potassium, ammonium, barium (*blanc fixe*), calcium (*pearl-hardening*); especially also for precipitating baryta or lime as sulphates for chemical processes; sulphates of magnesium, aluminum, iron, zinc, copper, mercury (as intermediate stage for calomel and corrosive sublimate); in the metallurgy of copper, cobalt, nickel, platinum, silver; for cleaning copper, silver, etc.; for manufacturing potassium bichromate; for working galvanic cells, such as are used in telegraphy, in electroplating, etc.; for manufacturing ordinary ether and the composite ethers; for making or purifying many organic coloring matters, especially in the oxidizing mixture of potassium bichromate and sulphuric acid; for parchment paper; for purifying many mineral oils, and sometimes coal gas; for manufacturing starch, sirup, and sugar; for the saccharification of corn; for neutralizing the alkaline reaction of fermenting liquors, such as molasses; for effervescent drinks; for preparing tallow previously to melting it; for recovering the fatty acids from soapsuds; for destroying vegetable fibers in mixed fabrics; generally, in dyeing, calico printing, tanning, as a chemical reagent in innumerable cases; in medicine against lead poisoning, and in many other cases.

II. *In a concentrated state.* For manufacturing the fatty acids by distillation; purifying colza oil; for purifying benzene, petroleum, paraffin oil, and other mineral oils; for drying air, especially for laboratory purposes, but also for drying gases for manufacturing processes (for this, weaker acid also, of 140° Tw., can be used); for the production of ice by the rapid evaporation of water in a vacuum; for refining gold and silver, desilvering copper, etc.; for making organo-sulphonic acids; manufacturing indigo; preparing many nitro compounds and nitric ethers, especially in manufacturing nitroglycerin, pyroxylin, nitrobenzene, picric acid, and so forth.

III. *As Nordhausen fuming oil of vitriol* (*anhydride*). For manufacturing certain organo-sulphonic acids (in the manufacture of alizarin, eosin, indigo, etc.); for purifying ozokerite; for making shoe blacking; for bringing ordinary concentrated acid up to the highest strength as required in the manufacture of pyroxylin and other purposes.

It is of value to know the extent to which sulphuric acid is used in the more important industries in which it is employed, and an attempt has been made to ascertain this by an investigation of the data of the census of 1900. For purposes of comparison the various grades of acid occurring have been reduced to a common standard of 50° Baumé. The results of this investigation are set forth in Table 17.

TABLE 17.—*Quantity of sulphuric acid consumed for specific purposes: 1900.*

	Tons.
Total domestic production	1,548,123
Purposes for which consumed:	
Fertilizer manufacture	803,358
Petroleum refining	181,782
Pickling iron and steel	125,000
Alum manufacture	71,426
Mixed acids manufacture	63,059
Textile industry	50,000
Muriatic acid manufacture	48,750
Nitric acid manufacture	47,348
Acetic acid manufacture	17,814
Ammonium sulphate manufacture	13,908
Explosives manufacture	13,500
Blue vitriol manufacture	10,645
Epsom salt manufacture	2,773
Storage batteries	2,640
Tartaric acid manufacture	1,503
Iron liquors manufacture	1,220
Boric acid manufacture	707
Zinc sulphate manufacture	415
All other purposes	92,275

The first and largest item for the separate industries is the amount actually returned, as "materials used" and as "products consumed," by the fertilizer establishments. The second is estimated from the amounts reported[2] at the censuses of 1880, 1890, and 1905, since no report was recorded for 1900. The third is estimated from the statement of F. J. Falding,[3] in 1905, that "about 150,000 tons of 60° Baumé acid are used yearly in the iron and steel industry for pickling sheets, wire, etc., previous to galvanizing or tinning,

[1] Manufacture of Sulphuric Acid and Alkali, edition 1903, pages 1169 and 1170.

[2] Census of Manufactures, 1905, Bulletin 70, page 11.

[3] Journal of Society of Chemical Industry, 1905, vol. 25, page 403.

and this must contain less than 0.002 per cent of As." Most of the other figures were obtained by stoichiometrical calculation from the quantities of the given products returned. It has been the endeavor to make the estimates conservative and to avoid duplication. Possibly an error may exist in the item of alum, owing to the use of ammonium sulphate or of sodium sulphate from nitric or hydrochloric acid manufacture, or of natural potassium sulphate, in the manufacture of the product named, but the quantity of sulphuric acid required for the aluminum sulphate produced is large. It is to avoid duplication that certain industries, known to make use of large quantities of sulphuric acid, do not appear in the list. An example of this is found in the manufacture of dyestuffs, which is omitted, because the sulphuric acid of this industry is already accounted for in the nitric and mixed acids placed on the list. Accepting the figures of this list as fairly approximate, it appears that the sulphuric acid used in the fertilizer industry at the census of 1900 constituted 51.9 per cent of the total quantity of sulphuric acid produced in that census year. The sulphuric acid used in petroleum refining formed 11.7 per cent, and that used in pickling iron and steel 8.1 per cent, or these three industries together consumed 71.7 per cent of the total. This is lower than the estimates usually given, and may arise from the fact that in this investigation the acid of all grades has been reduced to a common basis, as the sulphuric acid used in the fertilizer industry is 50° Baumé acid, so that if the strong acid used in many other industries had not been so reduced for purposes of comparison, the acid used in the fertilizer industry would have appeared to form a larger percentage of the total.

Nitric acid.—Nitric acid, the second substance in this subclass, has been known from early times. The first description of its production, so far as is now known, appeared in 778, in the writings of Geber, who made it by distilling niter (potassium nitrate) with copper sulphate and alum. Raymond Lullius, in the thirteenth century, gave directions for making it by distilling niter with sulphate of iron. Soon afterwards Glauber obtained it by distilling niter with oil of vitriol. Nitric acid of 1.375 specific gravity, known as gilder's aqua fortis, and made by this method, sold in England in 1771 for 57 cents per pound. Nitric acid was manufactured at Philadelphia by Carter and Scattergood in 1834. It is to-day made commercially by distilling sodium nitrate with sulphuric acid, though other methods are now competing for recognition.

The quantity and value of the total amount of nitric acid manufactured, including that produced as a subsidiary product and that produced and consumed in the same establishment, was ascertained at the census of 1900, the value assigned that produced and consumed in the same establishment being the average value per unit for that reported for the acid produced for sale. Proceeding in the same way for the census of 1905, a comparison may be instituted between the returns for each census. This is shown in Table 18.

TABLE 18.—*Nitric acid—quantity and value of products: 1905 and 1900.*

	CENSUS.		Increase.	Per cent increase.
	1905	1900		
Quantity, pounds	[1] 108,380,387	[2] 63,084,722	45,295,665	71.8
Value	$5,232,527	$2,964,700	$2,267,827	76.5
Value per pound	$0.048	$0.047		

[1] Includes 62,116,306 pounds, with an assigned value of $2,981,583, consumed in establishments where manufactured.
[2] Includes 32,123,221 pounds, with an assigned value of $1,509,791, consumed in establishments where manufactured.

The increase in value per pound may have arisen from the increased cost of nitrate of soda, or from the fact that a larger quantity of the higher grade acid was produced. The Census form of inquiry does not specify the different grades of nitric acid, and all of those returned are embraced in a common total in the above statistics.

In 1900 it was estimated that to produce the total amount of nitric acid reported at that census there would have been required 43,841 tons of nitrate of soda and 47,348 tons of sulphuric acid, and there would have been 52,609 tons of niter cake produced as a by-product. Using the same proportions for the returns at the census of 1905, there would have been required 75,319 tons of nitrate of soda and 81,344 tons of sulphuric acid, and there would have been produced 90,383 tons of niter cake as a by-product. These results are necessarily but approximations, because, as mentioned above, the many different commercial grades of nitric acid are all combined in the figures used, and because the different methods employed give different yields.

TABLE 19.—*Nitric acid—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	41	38
California	7	4
Colorado	1	1
Connecticut	1	2
Illinois	1	1
Indiana	3	2
Kansas	1	
Massachusetts	3	3
Maryland	1	
Michigan	1	1
Missouri		1
New Jersey	9	12
New York	4	4
Pennsylvania	6	4
Ohio	3	2
Rhode Island		1

Table 19 shows a total gain of 3 establishments. At both censuses New Jersey ranked first and California second. Pennsylvania, which shared the second place with California and New York in 1900, in 1905 fell to the third place, while New York became fourth.

Nitric acid is usually manufactured by heating sodium nitrate with sulphuric acid in iron retorts. The reactions taking place are probably somewhat complex,[1] but the initial and final stages may be represented by the equations:

(a) $2NaNO_3+H_2SO_4=Na_2SO_4+2HNO_3$, or

(b) $NaNO_3+H_2SO_4=NaHSO_4+HNO_3$.

If the proportions of the materials used be such that the first equation holds, the temperature which obtains must be very high in order that it may be realized, and as a consequence the nitric acid produced may be partly decomposed before it leaves the retort. This results in a diminished yield, and a product high in nitrogen oxides, and therefore discolored. Moreover, the normal sodium sulphate which remains solidifies in the retort and is difficult to remove. If, on the contrary, the proportions of the materials be those indicated in the second equation, too much sulphuric acid would be required for economic operation, unless the nitric acid works were carried on in connection with soda or muriatic acid works where the sodium hydrogen sulphate could be used in a "salt cake" furnace.

As a rule the proportions of the materials put into the retort are such as to produce a mixture of the two sodium sulphates which remains liquid at the final temperature employed, so that, after the nitric acid has been formed and distilled from the retort, the niter cake may be run off from the retort.

The sodium nitrate used is purified Chile saltpeter containing, when dried, from 98 to 99 per cent of $NaNO_3$, and should be free from sodium chloride in order that the nitric acid may not be contaminated with hydrochloric acid. The sulphuric acid used differs with the strength of the nitric acid sought. For nitric acid above 1.38 specific gravity, 66° Baumé sulphuric acid is used; but for weaker grades, sulphuric acid from the lead pan evaporation, of about 1.7 specific gravity. The size of the charge employed in different factories varies necessarily with the quantity of acid required, but charges of over 2,000 pounds of nitrate with somewhat more than an equal weight of sulphuric acid are now not uncommon.

The retorts used most commonly have been cylindrical in form. They are set in a horizontal position and partly inclosed in brickwork above a grate. More recent forms approach the shape of a short cylinder or inverted cone. They are set in a vertical position and entirely inclosed in brickwork, so that the flame may play all about them. The horizontal retorts are provided with a manhole, and the vertical with a tube, through which the molten niter cake may be run off.

A system long used for condensing the nitric acid vapors from the retort is that of passing them through a series of air-cooled earthenware Woulfe bottles, or *bombonnes,* and finally to a coke tower, fed with water or concentrated sulphuric acid to dissolve the vapors which have escaped condensation. Usually no water is placed in the Woulfe bottles unless a weak acid is required. Sometimes the Woulfe bottles are arranged in step-like positions, called *en cascade,* so that the acid vapors may enter the system in the opposite direction from that in which the condensed acid is flowing down.

Guttmann has constructed a nitric acid condensing apparatus of vertical earthenware pipes, having very thin walls, and joined at the top by 180° bends of the same material. These pipes open at the bottom into a slightly inclined collecting pipe of earthenware, which is divided by diaphragms into sections joined by U-tubes passing under the diaphragms. These diaphragms force the acid vapors to pass up one pipe and down the next in order to traverse the system. The system of pipes may be air cooled or water cooled, and thereby the acid vapors are rapidly condensed. The inventor also introduces an injector, fed with compressed air, immediately behind the exit tube from the still, and thus the nitric acid vapors are rapidly drawn off and mixed with hot air.

Hart's condensing apparatus consists of a series of superposed glass or earthenware tubes, slightly inclined to the horizontal, which starts from one vertical standpipe and ends in another. Jets of water are allowed to play upon the tubes from above, which by evaporation cools the nitric acid vapors within the inclined tubes.

In the Greisheim process a reflux cooler, consisting of a Rohrmann stoneware worm immersed in water kept at a temperature of about 60° C. by the heat of the operation itself, is placed behind the retort so that the acid vapors are partly condensed, while the nitrogen oxides pass on to a tower where they are condensed or converted and recove ed. Through this modification a very pure colorless nitric acid may be made in one operation.

Rohrmann and Lunge have devised plate towers, or columns, which take the place of coke towers, and consist of large stoneware cylinders filled with perforated plates of the same material, of such form and so disposed, one above the other, as to condense and concentrate rapidly the vapors rising in the column. Such towers are not only more efficient than coke towers, but, as coke reduces nitric acid, they give better yields.

Valentiner's process is one in which a vacuum is produced in the retort and condensing apparatus during the distillation of the nitric acid.

All of these processes are in use in this country in different establishments. The results of the operation of Valentiner's apparatus, which has been installed in this country since the taking of the census of 1900, are set forth in Table 20.

[1] Journal of American Chemical Society, 1900, vol. 23, page 489.

TABLE 20.—RESULTS OF NITRIC ACID DISTILLATION OBTAINED WITH THE FIRST TWO VALENTINER VACUUM APPARATUS INSTALLED IN THE UNITED STATES: 1904.

DATE OF RUN.	CHARGE.						Theoretical yield in pounds of 100 per cent nitric acid (pounds).	Recovered acid as 100 per cent nitric acid (pounds).	Per cent of theory.
	Niter.		Sulphuric acid.		Nitric acid.				
	Pounds.	Per cent.	Pounds.	Per cent.	Pounds.	Per cent.			
February 27	2,175	97.7	2,466	95.8			1,574	1,559	99.0
February 29	2,200	97.3	2,466	95.6			1,587	1,609	101.3
March 1	2,200	97.3	2,466	95.6			1,587	1,537	96.8
March 2	2,200	98.5	2,560	93.5			1,605	1,596	99.4
May 7	2,200	96.3	2,430	96.0			1,569	1,544	98.4
May 8	2,200	96.3	2,400	96.0			1,569	1,554	99.0
May 12	2,200	96.3	2,383	93.5			1,569	1,565	99.7
May 13	2,200	96.3	2,383	93.5			1,569	1,553	99.1
May 14	2,319	96.3	2,475	93.5			1,657	1,649	99.5
May 16	2,200	96.3	2,383	93.5			1,569	1,538	98.1
May 17	2,200	96.3	2,383	93.5			1,569	1,564	99.7
May 18	2,200	96.3	2,465	93.5			1,569	1,551	98.9
June 4	2,200	96.8	2,600	96.0	923	71.3	2,236	2,208	98.7
June 6			1,935	96.0	2,735	79.2	2,166	2,153	99.4
June 19			2,350	93.5	2,086	62.5	1,304	1,300	99.7

The first twelve distillations were made with niter and sulphuric acid of different strengths. The thirteenth was a distillation with niter and sulphuric acid, but charging at the same time some weak and dirty nitric acid. The fourteenth and fifteenth distillations were redistillations of weak and dirty nitric acid with sulphuric acid only. Ninety per cent of the yield was obtained as nitric acid of 93 to 96 per cent, with five-tenths of 1 per cent and less of nitrous acid. By redistillation in the same apparatus, the nitric acid was purified and concentrated to a strength of 96 to 98 per cent, with less than one-tenth of 1 per cent of nitrous acid.

Although for a long time sodium nitrate has been practically the sole commercial source of nitric acid, yet in the last five years many attempts have been made to obtain it in other ways. Ostwald has sought to produce it from ammonia and air by a contact process. This would necessitate a supply of cheap ammonia in order that the manufacture may be carried on profitably. Frank proposes to make this ammonia from calcium cyanamid prepared from atmospheric nitrogen.

The atmosphere in which the earth is enveloped consists of 79.2 per cent of nitrogen and 20.8 per cent of oxygen by volume. Its depth is such that, calculating from the pressure it exerts, it is estimated that the air existing above each acre of ground contains approximately 33,880 tons of free nitrogen. Naturally many have realized what important results would follow if a means could be devised by which this nitrogen could be made to combine with the oxygen with which it is intermingled in the atmosphere. As early as 1775 Priestley noted that nitrogen compounds were formed when electric sparks were passed through the air, and not long after Cavendish produced saltpeter by absorbing air, so treated, in caustic potash solution. Although many subsequent observations along this line were made by Berthelot, Lord Rayleigh, and many others, no method for accomplishing this end which appeared in the least promising was devised until Bradley and Lovejoy were, on September 30, 1902, granted United States patents for a method and apparatus. Their process, which was tried by the Atmospheric Products Company of Niagara Falls, N. Y., consisted in producing in the air a flaming electric arc of minimum volume by the rapid rotation of electrodes carrying high tension currents. While nitric acid was thus produced, the process proved too costly, and the experiments ceased.

Since then Birkeland and Eyde have devised a process which has been put into operation at Nottoden, Norway. In their device the flaming arcs produced by high tension currents are made to move to and fro through the atmosphere in the apparatus by exposure to the attraction of powerful magnets. This apparatus is characterized by a narrow air chamber through which air is passed, and within which the electrodes, placed near together, are arranged between the poles of a strong magnet and at right angles to these poles. A disk-shaped or deflected electric arc is thus obtained perpendicular to the lines of force of the magnetic field. Three such furnaces at Nottoden, using 500 kilowatts and 5,000 volts, give deflected arcs about 3 feet in diameter. This process has been operated on a very considerable scale. According to O. N. Witt,[1] the daily production now amounts to 1,500 kilos of anhydrous nitric acid, and an output of 500 to 600 kilos of nitric acid per kilowatt year can be regularly maintained. It is evident that Witt's figures simply set forth the nitric acid content of the product actually obtained, for the weak nitric acid which is directly produced in the atmosphere about the electric discharges must be combined with a basic radical in order to be recovered. For this purpose the nitrogen compounds formed are absorbed in water in towers, the weak acid being exposed repeatedly to the nitrogen oxides until it attains a strength of 50 per cent. The

[1] Journal of Society of Chemical Industry, 1905, vol. 28, page 699.

incompletely oxidized nitrogen oxides which leave the absorption towers are passed through milk of lime and then over quicklime, and are thereby converted chiefly into calcium nitrite. This is treated with the nitric acid, through which calcium nitrate is formed and nitrous acid set free. The latter is then oxidized to nitric acid and sent to the absorption towers. The calcium nitrate has been offered in commerce for use as a fertilizer, but, as the normal salt is extremely deliquescent and therefore troublesome, it is now converted into the more permanent basic calcium nitrate by the addition of more quicklime or of calcium sulphate. To obtain nitric acid of merchantable strength this calcium nitrate must be distilled with sulphuric acid, but there are difficulties in the way, such as the formation of calcium sulphate that is not easily fusible. Thus far no commercial nitric acid seems to have been formed by this process.

Notwithstanding that processes for the direct production of nitric acid from atmospheric nitrogen have not yet been made commercially successful, the necessity for other sources of supply is so pressing and increasing that this problem will probably be solved before the next census.

Niter cake, the by-product of this industry, is known also as "*sal enixum*," "Sally Nixon," and "cylinder cake." Its composition approaches that of sodium hydrogen sulphate or sodium bisulphate, but it frequently carries considerable adherent sulphuric acid. It generally contains from 25 to 30 per cent of "free acid" or "bisulphate acid," calculated as SO_3, and only traces of nitrate. Much of this material has in the past been thrown on the dumps, greatly to the injury of neighboring water courses and of surrounding vegetation, but it may be utilized in many ways. By fusing it with common salt the latter reacts with the excess sulphuric acid in the niter cake to form hydrochloric acid, which distills off and leaves the residue composed entirely of salt cake. By treating phosphate rock with niter cake, superphosphate, mixed with sodium sulphate, is produced. By reaction of a solution of niter cake in water with lime water, calcium sulphate, which may be used as a pigment in paint making or as a filler in paper making, is produced, together with Glauber's salt. Other instances occur in which the excess acid in niter cake may be used in substitution for the more costly sulphuric acid, and its use is extending.

Mixed acids.—Mixed acids, produced by mixing sulphuric acid with nitric, have been used in this country on a considerable commercial scale since the gun cotton and nitroglycerin industries were established, and their use has become common in other chemical industries. The statistics of this industry were reported separately only at the census of 1900 and at the present census. By assigning to the acid reported as produced and consumed the same value per unit as that found for the acid reported as produced for sale, the comparison set forth in Table 21 may be made.

TABLE 21.—*Mixed acids—quantity and value of products: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Quantity, pounds	[1] 140,668,959	[2] 135,610,095	5,058,864	3.7
Value	$4,142,147	$3,535,431	$606,716	17.2
Value per pound	$0.029	$0.026	....	....

[1] Includes 75,337,632 pounds, with an assigned value of $2,184,791, consumed in establishments where manufactured; and also the mixed acids produced in establishments engaged primarily in the manufacture of other products.
[2] Includes 93,241,276 pounds, with an assigned value of $2,424,273, consumed in establishments where manufactured; and also the mixed acids produced in establishments engaged primarily in the manufacture of other products.

The data presented in Table 21 show that this industry is steadily growing and that the larger part of the material is produced in establishments in which it is consumed in further manufacture. This fact tends to make it difficult to secure complete returns of the industry, for while manufacturers' books usually show records of the materials purchased, the stock on hand, and the products sold, they often may fail to show the materials produced and consumed in further manufacture. This may explain the decrease in amount of produced and consumed mixed acids that was returned at the census of 1905 as compared with that for 1900. The decrease, however, may be but partly due to this cause, for during the period since 1900 the practice of rebuilding the spent acids for further use has been greatly extended. Hence while from the standpoint of use and of the quantity of material nitrated the quantity of mixed acids employed may have increased largely, yet as the larger portion of this rebuilt acid is used over and over again, the total quantity used in the industry may have been less.

TABLE 22.—*Mixed acids—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	32	22
California	6	3
Connecticut	....	1
Illinois	2	....
Indiana	2	2
Kansas	1	....
Massachusetts	1	4
Michigan	1	1
New Jersey	9	7
New York	7	1
Pennsylvania	1	1
Ohio	2	2

There has been an increase in the total number of establishments at the census of 1905 as compared with 1900 of 10, or 45.5 per cent. New Jersey has ranked first at both censuses, and is followed at the census of 1905 by New York and California in the order named. No other state has at this census shown more than two establishments.

Table 23 shows the distribution of this industry, based on the output of the different geographic divisions at the censuses of 1900 and 1905.

TABLE 23.—*Mixed acids—quantity of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
	Pounds.	*Pounds.*
United States	140,668,959	135,610,095
North Atlantic	96,400,122	49,834,129
North Central	29,400,758	31,055,966
Western	14,868,079	54,720,000

Although there was an increase of 46,565,993 pounds in the North Atlantic division, yet in the North Central and Western divisions there was a decrease due undoubtedly to the operation of the causes set forth above in the discussion of Table 21.

Mixed acids, as used in the various industries and for different purposes, vary in their relative contents of nitric and of sulphuric acid. As an example there may be cited the following:

Percentage composition of various mixed acids.

MANUFACTURE.	H_2SO_4.	HNO_3.
Nitroglycerin	61.9	34.5
Gun cotton	78.6	21.0
Pyrocellulose	57.0	28.2
Pyroxylin for plastics	66.0	17.0
Pyroxylin for smokeless powder	56.0	29.0

These percentages are generally approximations, and the data are given in terms of real sulphuric and nitric acids. There are other compositions used in the coal tar dye industry and other industries, but by far the largest amount is consumed in the manufacture of nitroglycerin. It may therefore be fairly assumed that the average composition of the entire quantity of mixed acid is approximately 62 per cent of H_2SO_4 and 30 per cent of nitric acid, the remainder consisting of water, nitrogen oxides, and impurities. Proceeding in this way it would appear that at the census of 1900 there were used in the making of mixed acids 63,059 tons of 50° Baumé sulphuric acid and 20,342 tons of nitric acid, and that at the census of 1905 there were used for this purpose 65,411 tons of 50° Baumé sulphuric acid and 21,100 tons of nitric acid.

Mixed acids are manufactured by mixing sulphuric and nitric acids, of the strength and in the proportions required for the purpose to which the product is to be put. The mixture takes place in iron tanks, and is promoted by stirring with paddles or with compressed air.

The method of rebuilding, or regenerating, mixed acids, which is in use at the United States Naval Smokeless Powder Factory at Indian Head, Md., has been described by G. W. Patterson.[1] At this factory the acid is used in making a cellulose nitrate which must contain 12.5 per cent of nitrogen and be soluble in a mixture of two volumes of ethyl ether and one volume of 95 per cent ethyl alcohol.

The allowed limits of variation in this product are so small that every detail in the nitrating process requires to be carefully checked and accounted for. The exact strength of the nitrating acids is most important, and every batch of acid must conform to a certain standard. The acids used for the manufacture of this grade of nitrocellulose are a mixture of approximately 56 per cent of H_2SO_4, 29 per cent of HNO_3, and 15 per cent of H_2O. With such a mixture, it is the usual practice to regenerate the spent acids by the addition of a mixture of strong sulphuric and nitric acids, this mixture being given the name of fortifying acid.

* * * All handling of mixtures of nitric and sulphuric acid is carried on in cylindrical steel tanks, connected by heavy 2½-inch pipes, one pipe for receiving acid, the other for delivering. Iron cocks on these pipes control the flow of acid. Compressed air at 20 pounds pressure is used entirely for mixing and transfer of acid. The air pipes are 1 inch in diameter, and in tanks, where mixing is done, the pipe is extended inside the tank and along its entire length just clearing the bottom. The end of the pipe is plugged and a row of holes drilled in the underside of the pipe forms an air chamber of the pipe, allowing the air to escape along its entire length simultaneously. A tank 23 feet 6 inches long and 5 feet in diameter holds conveniently 42,000 pounds of mixed acid; one 35 feet long and 6 feet in diameter holds 90,000 pounds. Each tank is provided with a 1-inch vent hole through a flange in the top. When air pressure is to be applied to the tank this hole is closed by a wooden plug.

The tanks are arranged close together in a battery, two of the 90,000-pound tanks for spent acids; 8 of the 42,000-pound tanks for mixed acid, fortifying acid, and 98 per cent sulphuric acid; one 42,000-pound tank mounted on a platform scale as a weighing tank is connected by permanent 2½-inch pipe to the other tanks, as it is found that a 15-feet lead of pipe is sufficient to prevent any influence on the weighing.

Spent acid having been collected in a tank to the amount of 85,000 to 90,000 pounds, it is mixed by blowing air through it for one hour, sampled, and carefully analyzed. The proper quantities of fortifying acid and sulphuric acid or nitric acid, as the case may be, to be added, are calculated; 34,000 pounds of the spent acid are transferred to the weighing tank, and the other necessary acids are then transferred to the weighing tank. Air pressure is now put on the weighing tank and the whole charge transferred to a mixing tank, where it is mixed one hour by blowing air. Analyses of the mixed acid invariably agree with the calculation. Two important requirements are necessary for accurate work: (1) The weighing tank must have an inside air pipe to give a preliminary mixing and to entirely clear the tank of acid; (2) If less than one-half a tank of acid is being mixed, the circulation is not so good, and a longer time is required to mix the charge, up to one hour and a half or two hours. An air pressure of 20 pounds will transfer 1,000 pounds of acid per minute.

* * * The number of times that a spent acid may be regenerated appears to be unlimited, provided the amount of N_2O_4 does not exceed the limit of 5.5 per cent. The acid at present in use in the factory has been regenerated at least 150 times and remains practically unchanged. The amount of suspended nitrocellulose in the spent acid under normal conditions is less than 0.01 per cent, while the total iron present calculated as Fe is only 0.025 per cent. During the winter months there is a slight but constant decrease in lower oxides in the spent acid, while in the summer months they increase. The nitrocellulose in suspension in mixed acids is continually decomposing, and if allowed to stand undisturbed, entirely disappears.

* * * The fortifying acid contains 44 per cent H_2SO_4, 48 to 49 per cent HNO_3, and 0.2 to 2 per cent N_2O_4, with a total acidity of 94 per cent. In preparing this acid, the precaution is taken to have a

[1] Bericht V. Internationaler Kongress für Angewandte Chemie, 1904, Vol. II, page 474.

sufficient amount of nitric acid contained, so that no nitric acid, as such, must be added to the spent acid for regeneration. It is analyzed by the same methods as are used for other mixed acids, and must contain only traces of chlorine and no metallic salts, except salts of iron. This acid is handled and treated in exactly the same way as mixed acids of less strength.

CLASS I. B.—OTHER ACIDS.

The subclass "other acids" includes all of the substances appearing in commerce which are styled acids by the chemist, except sulphuric, nitric, and mixed acids. At the census of 1900 the quantities and values of the hydrochloric, boric, acetic, tartaric, tannic, and gallic acids reported were set forth separately. The quantities and values of the lactic and citric acids reported were combined in the presentation, since there were less than three independent establishments reporting these products. As our industries expand and become more diversified, the number of different acids for which returns may be separately published will undoubtedly increase, for new and useful purposes to which they may be applied in the arts are frequently being discovered.

TABLE 24.—*"Other acids"—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	11	13	[1]2	[1]15.4
Capital	$4,857,350	$2,360,787	$2,496,563	105.8
Salaried officials, clerks, etc., number	123	69	54	78.3
Salaries	$208,316	$90,440	$117,876	130.0
Wage-earners, average number	692	446	246	55.2
Total wages	$428,989	$265,715	$163,274	61.4
Miscellaneous expenses	$203,390	$69,770	$133,620	191.5
Cost of materials used	$1,605,649	$945,955	$659,694	69.7
Value of products	$2,726,487	$1,848,348	$878,139	47.5

[1] Decrease.

From Table 24 it appears that though there has been a decrease in the number of principal establishments in this subclass, due probably to the products being more frequently manufactured in establishments where other substances having a larger value are also produced, yet in every other item there has been a marked increase. The percentage of increase in miscellaneous expenses and cost of materials has been far greater than in value of products; and the percentage of increase in salaries much greater than that in wages.

Muriatic acid.—Muriatic acid, in some respects the most important member of this subclass, has been known also as spirit of salt, chlorhydric acid, and hydrochloric acid. It is a solution of hydrogen chloride, HCl, in water, and occurs in commerce in various strengths. Basil Valentine, in the fifteenth century, was the first to describe its preparation, producing it by heating a mixture of common salt and green vitriol, although Geber, whose work was accomplished in the second half of the eighth century, made use of *aqua regia*, which is a mixture of hydrochloric and nitric acids. It is a curious point in chemical history that muriatic acid, which at present is so cheap, and which has at times been considered almost worthless, was in Glauber's time (1604 to 1668) the most costly of the mineral acids.[1]

The condition of the muriatic acid industry as such is ascertained by combining the returns from all establishments in which it was manufactured either as a principal or subsidiary product together with the figures for that consumed in further manufacture, the latter being given the same value per unit as was found for the former. The results are set forth in Table 25.

TABLE 25.—*Muriatic acid—quantity and value of products: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Quantity, pounds	[1]188,538,396	[2]134,229,012	54,309,384	40.5
Value	$1,730,231	$1,173,900	$556,331	47.4
Value per pound	$0.009	$0.009	....	....

[1] Includes 61,035,714 pounds, with an assigned value of $549,321, consumed in establishments where manufactured; and also the muriatic acid produced in establishments engaged primarily in the manufacture of other products.

[2] Includes 17,553,903 pounds, with an assigned value of $157,985, consumed in establishments where manufactured; and also the muriatic acid produced in establishments engaged primarily in the manufacture of other products.

The marked increase shown in the amount produced and consumed indicates that in this industry, as in those previously discussed, there is a healthy tendency to realize the profit which accrues from further elaboration of the products of a chemical industry.

The quantity of muriatic acid given in the table includes all grades. The ordinary muriatic acid of commerce contains 40 per cent by weight of dry hydrogen chloride. Assuming the entire product reported in 1900 to be of this grade, there would have been required for its production about 41,427 tons of common salt and 54,582 tons of 50° Baumé sulphuric acid, while there would have been produced 52,624 tons of salt cake. For the quantity returned in 1905 there would have been required 59,700 tons of salt and 78,659 tons of 50° Baumé sulphuric acid, while there would have been 75,836 tons of salt cake produced. The above calculation is based on the further assumption that the acid was produced entirely by the action of sulphuric acid on common salt, for if niter cake were used with the common salt it would not only replace the sulphuric acid, but also a part of the salt required for the production of the quantity of salt cake desired. No definite information is at hand as to the extent to which niter cake is used in this industry, but there are indications which suggest that upward of 20 per cent of the common salt may be thus replaced, and of course a lesser amount of sulphuric acid.

[1] E. von Meyer, History of Chemistry, 1891, page 507.

TABLE 26.—*Muriatic acid—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1]36	[2]31
California	4	3
Colorado	1	1
Connecticut	....	1
Illinois	1	3
Indiana	1	2
Kansas	1	....
Maryland	1	....
Massachusetts	3	2
Michigan	3	1
Missouri	....	1
New Jersey	5	6
New York	5	4
Pennsylvania	9	5
Ohio	2	2

[1] Includes 25 establishments engaged primarily in the manufacture of other products.
[2] Includes 18 establishments engaged primarily in the manufacture of other products.

From Table 26 it appears that there has been an increase of 5 in the number of establishments, or 16.1 per cent. Pennsylvania, which was second in rank in 1900, passes to the first place, while New York, which was third, now shares second place with New Jersey, which was first in 1900. California now ranks third. No other of the states reports more than 3 establishments.

Table 27 shows the geographic distribution of the industry according to the quantity of the output at the censuses of 1900 and 1905.

TABLE 27.—*Muriatic acid—quantity of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
	Pounds.	*Pounds.*
United States	188,538,396	134,229,012
North Atlantic and South Atlantic	121,125,924	89,257,974
North Central	61,861,453	37,495,038
Western	5,551,019	7,476,000

From Table 27 it appears that there has been an increase in every one of the divisions presented except in the Western. There appears no evident cause for this exception.

Muriatic acid is manufactured by heating common salt with sulphuric acid or with niter cake. The roasting is carried on in salt cake furnaces of either the form known as the "open roaster," which consists of a cast-iron pan and a reverberatory hearth, or the "closed roaster," in which the pan and hearth are inclosed in a brick or fire clay muffle in order to prevent the soot and dust from the fire reaching the acid vapors and mingling with them. During the second stage of the process, when sulphuric acid is used, or throughout it, when niter cake is used, the charge must be constantly stirred to prevent "crusting," or adhering to the hearth. This has been accomplished by the use of a "rabble" worked by hand, but in the more modern Mactear furnace it is effected by a mechanical device. The acid vapors are absorbed in water. Formerly, and to-day still to some extent, this was done by the passage of the vapors through Woulfe bottles, placed *en cascade* and leading to a coke tower. The Lunge-Rohrmann plate tower will largely replace both, especially when combined with long cooling pipes exposed to the air, so that the vapors may be cooled before coming in contact with the water. A recent device for absorbing the vapors is found in the Cellarius tourill, or jar.

The results of a year's run with air cooling, using salt containing from 97 to 98 per cent of sodium chloride, is shown in Table 28.

TABLE 28.—*Muriatic acid produced with Cellarius jars during a twelve months' run.*

MONTH.	Salt (pounds).	20° acid produced (pounds).	Yield per 100 pounds of salt.
September	205,926	431,992	209.8
October	229,416	456,156	198.8
November	215,309	397,370	184.6
December	213,688	412,660	193.1
January	250,654	490,490	195.7
February	197,802	390,337	197.3
March	187,160	355,605	190.0
April	101,560	190,740	187.8
May	245,858	469,396	190.9
June	226,311	442,054	195.3
July	210,080	405,556	193.0
August	218,196	416,699	191.0

Acetic acid.—Acetic acid, as considered in the census returns, does not include the dilute acetic acid, produced by the fermentation of diluted alcoholic liquids or by the oxidation of alcohol, and known as vinegar. The grades of acetic acid found in commerce contain from 28 to 90 per cent of real acetic acid, and, unlike the other liquid acids in commerce, it is graded by its real acetic acid contents instead of by its specific gravity, because a 50 per cent solution of acetic acid possesses about the same specific gravity as anhydrous acetic acid.

This acid, in the form of vinegar, was known to the ancients. It is mentioned by Moses in Numbers vi, 3. Hippocrates employed it in medicine. Hannibal is said to have softened rock by fire and vinegar during his passage over the Alps. Acetic acid in its more concentrated form was known to Geber and to Stahl as being produced by the distillation of verdigris, which is an acetate of copper. It is to-day made by distilling brown or gray acetate of lime with concentrated muriatic acid, or sodium acetate with sulphuric acid.

TABLE 29.—*Acetic acid—quantity and value of products: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Quantity, pounds	[1]29,506,021	[2]27,875,222	1,630,799	5.9
Value	$597,235	$446,326	$150,909	33.8
Value per pound	$0.02	$0.016	....	....

[1] Includes 2,431,741 pounds, with an assigned value of $28,635, consumed in establishments where manufactured; and also acetic acid produced in establishments engaged primarily in the manufacture of other products.
[2] Includes 1,214,667 pounds, with an assigned value of $19,434, consumed in establishments where manufactured; and also acetic acid produced in establishments engaged primarily in the manufacture of other products.

This comparison shows that the acetic acid industry is characterized by the same tendency as that pointed out in industries already presented, for while the increase in the total quantity of acetic acid is but 5.9 per cent, the increase in that produced and consumed is 100.2 per cent.

TABLE 30.—*Acetic acid—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	12	14
Illinois	...	2
Maryland	1	...
Massachusetts	3	2
Missouri	...	2
New Jersey	5	2
New York	1	3
Pennsylvania	2	3

From Table 30 it appears that the number of establishments returned as producing acetic acid was smaller by 2 in 1905 than in 1900. Nevertheless both the quantity and value of the product for 1905 were larger than for 1900.

All other acids.—Table 31 contains the returns for all acids not already presented, by quantity and value, for the censuses of 1905 and 1900.

TABLE 31.—*Minor acids—number of establishments and quantity and value of products: 1905 and 1900.*

ACID.	1905			1900		
	Number of establishments.	Quantity (pounds).	Value.	Number of establishments.	Quantity (pounds).	Value.
Boric	7	6,956,896	$527,190	3	2,684,935	$198,212
Citric	4	2,265,631	598,718	[1] 3	[1] 3,886,382	[1] 335,297
Hydrofluoric	6	2,932,358	151,218	4	698,000	34,890
Lactic	3	2,906,555	158,911	(2)	(2)	(2)
Phosphoric	9	991,050	68,541	(3)	(3)	(3)
Pyroligneous	5	11,240	1,432	(4)	(4)	(4)
Tannic	3	715,500	195,136	5	282,515	135,662
Other acids[5]	7	...	975,551	11	...	1,151,819

[1] Includes lactic.
[2] Included in citric.
[3] Less than 3 establishments; included in "other acids."
[4] None reported.
[5] Includes gallic, salicylic, stearic, and tartaric acids in 1905 and 1900, and phosphoric and oleic acids in 1900.

The figures of Table 31 are only for acids produced for sale and do not include such as were consumed where produced.

The statistics for acids imported from 1891 to 1905 are given in Table 32. The data have been compiled from Commerce and Navigation of the United States, published by the Bureau of Statistics.

TABLE 32.—ACIDS—IMPORTS FOR CONSUMPTION: 1891 TO 1905.

YEAR ENDING JUNE 30—	SULPHURIC ACID, OR OIL OF VITRIOL (N. E. S.).[1]		SULPHURIC ACID.[1]		BORACIC ACID.						CHROMIC ACID.		CHROMIC AND LACTIC ACID.	
					Commercial.		Pure.		All kinds.					
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	15,377	$836	...	...	152,093	$7,975	39,394	$2,906	475,378	$30,138	{ ... 506	$1,587 155	} ...	...
1892	8,277	478	8,735	$339	...	...	...	...	701,625	39,418	426	156	...	...
1893	634	43	8,735	1,033	...	...	...	...	771,775	40,568	3,318	609	...	...
1894	17,053	405	400	32	...	...	...	...	292,900	19,282	5,048	824	...	...
1895	12,574	186	7,459	461	...	...	...	...	925,154	42,056	4,461	707	...	...
1896	36,798	475	48,759	1,606	...	...			555,769	21,899	2,440	409	...	...
1897	3,200	43	59,729	4,074	...	...	...	...	548,603	19,494	2,708	430	...	...
1898	25,350	786	2,725	40	134,707	4,053	244,073	7,994	...	45,265	6,720	906	64,066	$4,917
1899	40,175	1,874	...	...	...	...	436,958	14,303	...	56,428	...	...	23,969	4,843
1900	34,944	972	...	...	...	...	466,879	17,467	...	53,625	...	...	34,741	6,044
1901	77,492	2,312	1,628	23	...	...	...	...	648,994	23,485	...	...	46,993	9,881
1902	132,491	2,427	...	...	...	...	...	...	795,024	29,779	...	...	58,782	10,860
1903	307,687	4,317	...	...	...	...	...	...	783,987	29,651	...	...	84,918	8,339
1904	63,400	1,383	4,480	51	...	...	...	...	721,532	29,651	...	...	82,900	9,184
1905	288,630	4,145	570	6	...	...	...	...	660,150	23,626	...	...	68,732	8,481

YEAR ENDING JUNE 30—	CITRIC ACID.		TARTARIC ACID.		OXALIC ACID.		SALICYLIC ACID.		TANNIC ACID OR TANNIN.		ALL OTHER ACIDS.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	45,197	$15,482	1,511	$468	2,743,222	$200,595	...	...	659	$239	1,350,710	$380,054
1892	80,034	27,461	10	5	2,209,940	150,529	...	...	564	216	1,024,580	347,510
1893	13,315	4,633	130	39	2,464,443	143,194	260,027	$254,022	1,443	597	685,677	175,637
1894	5,502	1,810	113	32	2,783,876	159,026	252,332	231,946	794	287	835,215	134,665
1895	8,895	2,480	355	88	2,889,513	189,506	196,974	140,197	1,500	597	1,798,417	228,430
1896	39,671	12,521	212	66	3,164,969	219,630	335,354	138,013	1,745	681	1,027,235	240,522
1897	73,133	18,158	225	71	3,602,124	246,200	616,187	201,980	3,144	1,296	3,040,325	223,458
1898	4,323	1,108	455	128	3,747,041	242,276	92,943	28,688	2,335	927	...	45,265
1899	65,190	16,659	23,298	5,737	3,981,768	246,027	185,358	57,192	3,697	1,371	...	56,428
1900	60,354	14,213	954	252	4,990,123	275,747	240,687	89,175	1,415	671	...	53,625
1901	76,805	23,038	1,068	299	5,622,909	300,879	222,270	76,786	2,007	1,092	...	42,838
1902	74,712	21,085	1,483	377	5,678,139	301,675	219,127	57,852	1,938	1,116	...	61,286
1903	12,338	3,544	5,950	1,482	5,363,646	257,289	78,266	19,012	1,847	918	...	27,026
1904	5,546	1,461	849	215	6,726,159	329,836	32,759	7,305	5,855	2,829	...	23,793
1905	2,778	728	446	132	7,906,886	360,951	7,455	2,302	7,652	3,108	...	37,404

[1] From the value given, this would appear to be fuming sulphuric acid.

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Class II.—Sodas.

This class comprises soda ash, including white alkali and refined alkali; sal soda, including natural soda, mild mineral alkali, soda crystals, washing soda, and crystallized sodium carbonate; bicarbonate of soda, including bread soda, saleratus, sodium bicarbonate, and sodium hydrogen carbonate; caustic soda, including soda lye and sodium hydroxide; and borax, including borax glass, lime and sodium borates, and sodium biborate. Salt cake, or anhydrous sodium sulphate, and sodium silicate may be included here when products of a soda establishment. In addition to the original establishments, there are those in which soda ash is converted into sal soda and bicarbonate of soda, and those of the compounders or packers who give an added value to soda lye or the carbonate.

The term "soda" has acquired in use a variety of meanings. In the laboratory the term has been used in the past to designate the sodium oxide or hydroxide. In technology it has long been used to designate the normal sodium carbonate; yet the mixture of normal and acid carbonates found in nature is styled natural soda, and the industry in which soda ash, normal and acid sodium carbonates, and caustic soda are manufactured is called the soda industry.

Soda was known to the ancients and was used by them in making glass. They may have obtained it in the form of natural soda, for this exists in the waters of many lakes or in the residues from them. Up to a recent date[1] 5,000 tons of natural soda have been exported annually from Alexandria, Egypt. Or they may have obtained it by extracting the ash of seaweeds and marine plants with water and evaporating to dryness. These remained the only sources of soda until the latter part of the eighteenth century, when Le Blanc, stimulated by a prize offered by the French Academy about 1775, followed out the proposal of Duhamel de Monceau to prepare soda from common salt. This he accomplished by acting upon the salt with sulphuric acid, obtaining hydrochloric acid and sodium sulphate, and then converting the sodium sulphate into carbonate by fusing it with lime and coal. This process became established on a sound commercial footing when introduced into England by Losh in 1814.

[1] Wagner's Manual of Chemical Technology, 1892, page 309.

At the time the Le Blanc process was before the French tribunal, it was placed in competition with a process offered by Fresnel, which was based on the reaction taking place when a solution of common salt is brought in contact with a solution of ammonium carbonate, by which sodium hydrogen carbonate, or bicarbonate of soda, and ammonium chloride are formed; but Fresnel's process was rejected because at that time no method for the recovery of ammonia was known. It was revived by H. G. Dyar and J. Hemming in England, about 1838, and was tested on a considerable scale, but failed of success because of mechanical difficulties. These were finally overcome by Ernest Solvay, a Belgian, who made the process a commercial success in 1863. To-day the Le Blanc and Solvay processes are the chief sources of soda, though some is made from cryolite, and caustic soda is obtained in the electrolysis of common salt.

Saleratus, which is bicarbonate of soda, was reported at the census of 1860 as being manufactured in this country in 11 establishments, the product having a value of $1,176,000. For 1870, 4 establishments were returned, with a product valued at $231,647. At the census of 1880 and at each subsequent census the statistics for soda products have been made a feature in the special report on chemicals and allied products.

Table 33 shows an actual increase for 1905 over 1900 in every item. The increases in capital and value of products were especially noteworthy, being over $7,000,000 in each case, while the increase in value of products was more than double that in cost of materials. The largest proportional increase was in miscellaneous expenses, while the next largest was in number of salaried officials.

TABLE 33.—*Sodas—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	39	38	1	2.6
Capital	$22,728,369	$14,951,960	$7,776,409	52.0
Salaried officials, clerks, etc., number	784	370	414	111.9
Salaries	$1,046,891	$521,492	$525,399	100.7
Wage-earners, average number	5,981	5,788	193	3.3
Total wages	$3,310,216	$2,503,203	$807,013	32.2
Miscellaneous expenses	$2,150,469	$979,759	$1,170,710	119.5
Cost of materials used	$8,255,037	$5,331,823	$2,923,214	54.8
Value of products	[1]$18,466,504	[1]$11,073,406	$7,393,098	66.8

[1] Includes "all other products."

Table 34 shows that from 1880 on there has been a steady growth in both the quantity and value of the sodas produced. The percentage of increase in quantity was, up to 1905, greater than that in value, but at the present census this condition was reversed. In the figures for 1905 and 1900 borax and "all other products" were omitted from the list in order to make the statistics fairly comparable with those for the earlier censuses.

TABLE 34.—*Sodas—quantity and value, with per cent of increase: 1880 to 1905.*

CENSUS.	Number of establishments.	Quantity (tons).	Value.	PER CENT OF INCREASE.	
				Quantity.	Value.
1905	[1]63	734,209	$13,357,983	14.8	30.5
1900	[1]50	639,541	10,237,944	284.0	88.5
1890	32	166,562	5,432,400	727.4	526.9
1880	3	20,130	866,560	....	....

[1] Includes establishments engaged primarily in the manufacture of other products.

TABLE 35.—SODAS—QUANTITY AND VALUE OF PRODUCTS, WITH AMOUNT AND PER CENT OF INCREASE: 1890 TO 1905.

KIND.	CENSUS.			INCREASE.		PER CENT OF INCREASE.	
	1905	1900	1890	1900 to 1905	1890 to 1905	1900 to 1905	1890 to 1905
Total:							
Tons	734,209	639,541	166,562	94,668	567,647	14.8	340.8
Value	$13,357,983	$10,237,944	$5,432,400	$3,120,039	$7,925,583	30.5	145.9
Bicarbonate of soda:							
Tons	68,867	68,856	30,339	11	38,528	(1)	127.0
Value	$1,135,610	$1,332,765	$2,009,800	[2]$197,155	[2]$874,190	[2]14.8	[2]43.5
Caustic soda:							
Tons	86,840	166,783	16,501	[2]79,943	70,339	[2]47.9	426.3
Value	$3,185,959	$3,170,280	$661,114	$15,679	$2,524,845	0.5	381.9
Sal soda:							
Tons	59,548	63,249	72,322	[2]3,701	[2]12,774	[2]5.9	[2]17.7
Value	$831,869	$875,243	$1,581,766	[2]$43,374	[2]$749,897	[2]5.0	[2]47.4
Soda ash:							
Tons	518,954	390,603	47,400	128,351	471,554	32.9	994.8
Value	$8,204,545	$4,859,656	$1,179,720	$3,344,889	$7,024,825	68.8	595.5

[1] Less than one-tenth of 1 per cent.

[2] Decrease.

The figures of Table 35 show that while there was an increase in the total quantity and value of sodas produced at each census as compared with the previous one, there was at the census of 1900, as compared with that of 1890, a decrease in the total value of the bicarbonate of soda and also in the quantity and value of the sal soda. At the census of 1905 there was a decrease in the value of the bicarbonate of soda, and in both the quantity and value of the sal soda. These decreases are largely due to the increased use of these substances in the establishments in which they are produced. In such a summary as Table 35, if the produced and consumed products were included, the figures would be duplicated, for the other sodas are as a rule produced from the bicarbonate or the soda ash. Therefore, with the increased practice of soapmakers, wood pulp manufacturers, and others of causticizing soda ash and using the caustic soda produced in the manufacture of soap or wood fiber, the quantity produced for sale would be likely to be reduced. As explained in the report for 1900, the decrease in the production of sal soda is due to the increasing use of soap powders and other specially prepared washing materials.

At the census of 1890 sodas manufactured from natural soda were reported to the amount of 10,964,390 pounds, having a value of $124,783; and at the census of 1900, 20,420,000 pounds, valued at $106,600. At the census of 1905 the number of establishments reporting was not sufficient to permit of the statistics being published separately, but they are incorporated with soda ash in the data of Tables 36 and 37 for each census enumerated.

At the census of 1900, 7 establishments reported a product of 11,756,000 pounds of borax, having a value of $541,160. At the census of 1905, 7 establishments reported 41,764,000 pounds of borax, having a value of $2,122,808. This does not include the borax which was produced and consumed in the same establishments in the further manufacture of boric acid or other products.

TABLE 36.—*Sodas—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	63	[1]55
California	6	6
Colorado	1	
Illinois	4	4
Indiana	3	2
Kansas	1	
Maryland	1	1
Massachusetts	3	1
Michigan	5	3
Missouri	2	2
Montana	1	
New Jersey	7	3
New York	9	12
Nevada	2	5
Ohio	4	1
Pennsylvania	8	9
Rhode Island		1
Virginia	1	1
Wisconsin	4	4
Wyoming	1	

[1] Includes 5 establishments producing "soda products," but no "sodas."

From Table 36 it appears that at the census of 1905 as compared with the census of 1900, the establishments of the soda industry have increased 8 in number, or 14.5 per cent. The relative positions of New York and Pennsylvania remained unchanged in 1905, the former still ranking first and the latter second among the states. New Jersey, however, advanced from seventh to third place, with California fourth and Michigan fifth. No other state or territory reported as many as 5 establishments in 1905.

TABLE 37.—*Sodas—value of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
United States	[1]$19,785,385	[1]$10,922,536
North Atlantic and South Atlantic	10,512,852	6,559,295
North Central	8,745,382	3,694,436
Western	527,151	668,805

[1] Includes products other than sodas reported by establishments engaged primarily in this industry; and also the sodas produced by establishments engaged primarily in the manufacture of other products.

The figures of Table 37 show an increase in the value of sodas in all divisions shown except in the Western, the greatest increase being in the North Central. The decrease shown in the Western division can not be accounted for except perhaps by the fact of the existence of small establishments working natural soda or borax deposits as neighborhood industries, which would not under the rule be included in the establishments enumerated at the last census.

Up to the date of the commercial success of the Le Blanc process for making soda, potash, or "vegetable alkali," was much cheaper and more largely used than soda, or "mineral alkali." Since the development of the Le Blanc process the reverse has held true. Singularly, notwithstanding that the United States has been a large consumer of sodas, and that muriatic acid, and, on further treatment, chlorine and bleaching powder, are side products of the Le Blanc process, it never secured a firm foothold in this country.

The ammonia-soda process, on the other hand, has become a factor in our industries. The first to experiment with this process in the United States were Herman and Hans Frasch, who located a plant at Bay City, Mich., about 1880, but the enterprise was not a success and the plant was abandoned some two or three years later. In 1881 the Solvay Process Company, of Solvay, near Syracuse, N. Y., and Delray, near Detroit, Mich., was organized under the laws of the state of New York. According to Pennock,[1] the following plants in the United States were in 1900 engaged in manufacturing sodas by chemical methods as distinguished from electrolytic methods: The Solvay Process Company at Syracuse, N. Y., and Detroit, Mich.; the Michigan Alkali Company at Wyandotte, Mich.; the Mathiesson Alkali Company at Saltville, Va.; and the Pennsylvania Salt Company at Natrona, Pa. Between 1900 and 1903 the plant of the Columbia Chemical Company was installed at Barberton, Ohio, and the Frasch process at Cleveland, Ohio. All of these plants used the ammonia-soda process except the Pennsylvania Salt Company, which produced its sodas from cryolite.

In the operation of the ammonia-soda process a purified and concentrated salt brine is saturated with ammonia. This brine is then sent through iron

[1] Bericht V. Internationaler Kongress für Angewandte Chemie, 1904, vol. 1, page 661.

towers, where it encounters carbon dioxide gas, resulting in the formation of bicarbonate of soda, which separates out in crystals, while the liquid containing the ammonium chloride formed by the reaction, together with some ammonium carbonate and the residue in the brine, passes on and is collected for subsequent use.

The bicarbonate of soda, after wringing and washing in a centrifuge, is dried in an atmosphere of carbon dioxide and may be sold as bicarbonate, or it is calcined and converted into soda ash. When the soda ash is dissolved in warm water and the hot solution is allowed to stand until all sediment is deposited, large crystals of quite pure sal soda will be deposited as the solution cools. If the soda ash solution be treated with lime water, calcium carbonate will be formed and precipitated, while sodium hydroxide or caustic soda will remain in solution and may be obtained as a solid by evaporation of the solution. In the Hewitt and Mond, or Loewig's process the soda ash may be fused with iron oxide forming sodium ferrate, which is easily decomposed by warm water into caustic soda and ferric oxide. Pure iron ore or pyrites cinder may be used in this process.

Since the common salt used in the ammonia-soda process must be in solution, natural brine supplies this requirement in the most economical way. By reference to the bulletin on salt it will be noticed that most of the establishments cited above from Pennock's article are located near salt deposits, where natural salt brine, or that formed by sinking shafts to salt deposits and dissolving the salt in place, is cheaply obtained.

Since ammonia is so largely used in this industry, soda works are frequently operated in conjunction with by-product coke ovens. Much of the combined and free ammonia in the liquid running off from the bicarbonate of soda crystals in the carbonating tower is, however, recovered for further use by heating the liquid alone or with lime. Such repeated utilization must be taken into account in any attempt to estimate the quantity of ammonia used in this industry.

The carbon dioxide used for carbonating is originally obtained by calcining limestone, but much of it is recovered when calcining the bicarbonate of soda to soda ash, and from the treatment of the ammoniacal solution from the carbonating tower. Carbon dioxide might be obtained from the burning of coke or coal, but as quicklime is needed both in caustic soda manufacture and in the ammonia recovery process, it is necessary to calcine limestone.

The lime is recovered partly in a salable condition, either as crystallized calcium sulphate, used as a filler in paper making and for weighting cloth, under the names of "crown filler" and "pearl hardening," or as calcium chloride, which is used in the brine tanks of ice machines.

In his address[1] before the Congress of Applied Chemistry, Ernest Solvay reviewed the history of the soda industry and presented the data for the total production of sodas from 1850 to 1902, set forth in Table 38, but with the metric tons converted into short tons and the francs into dollars.

TABLE 38.—*World's production of sodas: 1850 to 1902.*

YEARS.	Total quantity produced (tons).	Produced by the Le Blanc process (tons).	Produced by the ammonia process (tons).	Average selling price per ton taken at the factory in Europe.
1850	165,345	165,345	....	$135.10
1863	330,690	330,690	....	86.85
1864 to 1868	413,363	412,260	331	77.20
1869 to 1873	496,035	492,728	2,865	54.04
1874 to 1878	578,708	545,639	33,069	54.04
1879 to 1883	744,053	600,754	149,913	32.81
1884 to 1888	881,000	479,501	402,340	23.16
1889 to 1893	1,127,653	429,897	697,756	22.20
1894 to 1898	1,377,875	492,109	1,085,765	21.23
1902	1,940,048	165,345	1,744,703	21.23

Thorp describes the manufacture of sodas by the cryolite process as follows:[2]

The ground cryolite is mixed with powdered limestone, and calcined at a red heat. Carbon dioxide escapes, and a mixture of calcium fluoride, sodium oxide, and sodium aluminate remains. On lixiviating this mixture with water another sodium aluminate is formed and goes into solution, leaving the calcium fluoride as an insoluble residue. The solution of sodium aluminate is then decomposed according to the third reaction, by passing into it purified limekiln gases, or the furnace gases of the calcining operation. Hydrated alumina is precipitated, while sodium carbonate remains in solution. Sal soda may be made by evaporating the solution, and was formerly the chief source of bicarbonate for culinary and medicinal purposes. If carried to complete dryness and calcined, a high grade of soda ash is obtained. By causticizing, it yields a very excellent caustic.

The by-products aluminum hydroxide and calcium fluoride are used in the alum and glass industries, respectively.

Soda ash appears in the market as 58 per cent, dense 58 per cent, 48 per cent, special 48 per cent, and 36 per cent; caustic soda, as high test 76 per cent, 74 per cent, 70 per cent, special 70 per cent, 60 per cent, and special 60 per cent; soda crystals, as monohydrate crystals, 49.8 per cent, and snow flake crystals, 40.9 per cent; and bicarbonate of soda, as pure bicarbonate, 99 per cent, for baking soda, and anchor dust, which is an inferior grade used as a source of carbon dioxide in charging "soda water." The percentages refer to the Na_2O contents in each case except that of the bicarbonate, where it refers to $NaCO_3$. In the census returns no cognizance is taken of these many grades, so that the figures given for any item in the tables are the gross amount for all grades.

Sodas are used in glassmaking. Thus at the census of 1890[3] there were reported as used by this industry 96,777 tons of soda ash and 38,092 tons of salt cake; at the census of 1900, 157,779 tons of soda ash and 53,257 tons of salt cake; and at the census of 1905,[4]

[1] Bericht V. Internationaler Kongress für Angewandte Chemie, 1904, vol. 1, page 108.

[2] Outlines of Industrial Chemistry, 1905, page 96.

[3] Twelfth Census, Manufactures, Part III, page 983.

[4] Census of Manufactures, 1905, Bulletin 57, page 46.

215,462 tons of soda ash. They are used in soap-making, 53,777 tons of soda ash and 71,551 tons of caustic soda, having been reported as used in this industry at the census of 1905.[1] Soda ash, caustic soda, and salt cake are used in the treatment of wood in the manufacture of wood fiber. The statistics of consumption are not at hand, but at the census of 1900,[2] 94,042 tons, and at the census of 1905,[3] 120,978 tons of soda wood fiber were reported as having been purchased for use in paper making. According to Griffin and Little,[4] with indirect steam in rotaries, about 700 gallons of a liquor, containing from 6 to 9 per cent of NaOH, are used to a cord of wood, while upright digesters require considerably more. As the liquors from the digesters are treated so as to recover their soda contents for further use, it is difficult to estimate the quantity of sodas actually used in the wood pulp industry, but it is large. There is a great variety of other uses to which sodas are put, but the three industries named are the largest consumers.

The natural soda industry was described with much detail in the special report on chemicals and allied products at the census of 1900.

The borax industry is closely associated with the natural soda industry since both substances, or at least boron compounds from which borax may be obtained, are found as residues in arid regions. In fact, deposits of a mixture of natural soda, common salt, and borax are known in California as "borax beds." According to Bailey[5] borax was first discovered in the United States on January 8, 1856, by Dr. John A. Veatch, on evaporating water from the Tuscan springs, Tehama county, Cal. Bailey describes the development of the industry as follows:

California in 1849 started the gold mining industry in the United States, and fifteen years later followed it with the establishment of the borax industry. The 12 tons made at Borax Lake, on the margin of Clear Lake, in Lake county, were the first produced on the American continent.

The young industry thrived for the next four years, although the maximum output of 220 tons in one year would seem small now.

The next three years, 1869, 1870, and 1871, were dark years for those watching the growth of the youngster, for the supply of the pure crystals in the blue mud of the famous little lake had given out, and an unruly artesian well had ruined the waters of the lake by diluting them beyond the profit point.

The deposits of Lake Hachinhama, on the opposite side of Clear Lake, exhausted themselves in yielding 140 tons in 1872.

The prospectors, however, had been aroused to interest in the mineral that was worth over $600 per ton and "only had to be shoveled up to be ready for the market," and discoveries in the deserts of California and Nevada followed each other with bewildering rapidity.

In 1873 San Bernardino county began her big record with the production of 515 tons from the so-called borax "marshes," or the "dry lakes" of the desert. Inyo county soon followed in lively rivalry, and the high water mark of the early years was reached in 1876, when 1,437 tons were produced, worth at that time over $312,000. From 1880 to 1888 the production increased slowly but steadily from 609 to 1,405 tons in a year. The year 1887 saw the suspension of work on the "marsh" beds, and the establishment of works on "colemanite" or borate of lime ores, in the Calico district, San Bernardino county. Since the discovery of these beds, large establishments have been erected in Alameda, near San Francisco, at Marion and Daggett, and at Bayonne, N. J., for the treatment of borates, and the production has risen from 1,405 tons in 1888 to 25,837 tons in 1900. The discoveries in Kern and Ventura counties also led to the establishment of boric acid manufacturing by the Stauffer Chemical Works of San Francisco, and the making of borax by the Chas. Pfizer & Co. works of New York.

When borax was first made in California, in 1864, the value of the refined article was 39 cents per pound, or $780 per ton. In spite of the discovery in Lake county, the price, while gradually declining, did not fall below 30 cents until 1873, when the borax "marshes" of San Bernardino county produced over 1,000,000 pounds, worth 24⅘ cents per pound, or $496 per ton.

The next year, 1874, saw the price fall to 14⅕ cents per pound, or $284 per ton, and the decline continued until 1879, when it stood at 9 cents per pound, or $180 per ton. From 1880 to 1883 the price varied from 12¼ to 14¾ cents per pound, or from $245 to $295 per ton. Prices in New York varied more widely than on the Western coast, as may be noted from one incident of many that might be quoted. In January, 1883, a tariff law was enacted that went into force in July of that year. During this six months, while imports were free from duty, 2,500 tons of boric acid, equivalent to 3,500 tons of borax, were imported. This, added to the large accumulations of the home manufacturers, caused the price to drop to 4½ cents per pound in New York, or less than the cost of production.

On the Coast, the result was that the producers combined and waited for living prices. From 1888 to 1894 the price stood still, practically, ranging from 6 to 7½ cents per pound, or from $120 to $150 per ton. Since that time the value of the refined article has been 5 or 6 cents per pound on the Coast, and about a cent higher in the East.

Owing to the establishment of the immense works in New Jersey, the shipments to the East are mainly in the form of crude borates, worth from $20 to $35 per ton, according to purity. The depression in prices, owing to rivalry between companies competing for the market, has been done away with, and the industry has outlived the disturbing features incident to youth, and has finally settled to a more certain and stable basis.

While the margin of profit is too small to permit the working of any but the most favorably located and economically handled deposits, yet the prevailing low prices are evidently causing an increased consumption of borates in the arts and manufactures in which they have been employed, and new uses are being continually found for the various compounds of boric acid. In this extended and ever growing consumption, the manufacturers find their compensation for low prices.

He further describes the process of preparing commercial borax as follows:

Every year has seen some improvement made in the industry in the way of more perfect appliances and processes. The process at first used in Lake county consisted in boiling the borax and crystallizing it in small pans holding from 2 to 3 gallons each; and the plant that produced the first 12 tons in 1864 consisted of some 4,000 such pans. The processes at the period when the "marsh" beds were worked consisted of boiling the crude material in large iron tanks and then running the solution into wood or iron settling tanks, the crude borax obtained being purified by recrystallization.

In the Calico district the colemanite ore is treated as follows at Marion: Low-grade ores, that were formerly rejected, are roasted in a Holthoff-Withey furnace, with two hearths having a capacity of 100 tons a day, six oil burners furnishing the heat. Colemanite when mildly heated is reduced to a fine powder, which is bolted, sacked, and shipped to the company's works at Bayonne, N. J.,

[1] Census of Manufactures, 1905, Bulletin 57, page 43.
[2] Twelfth Census, Manufactures, Part III, page 1030.
[3] Census of Manufactures, 1905, Bulletin 57, page 38.
[4] The Chemistry of Paper Making, page 162.
[5] Saline Deposits of California, page 36.

where the "flour" is boiled with soda to form borax. Any pandermite ore present is not affected by the heat and is lost in the waste, known locally as "dry bone." This waste often amounts to 50 per cent of the "flour" secured.

At Bayonne the huge machinery is driven by sets of independent electric motors. The crude colemanite reaches the works in sacks, as shipped from this state. It is first coarse-crushed on the ground floor of the works, and then conveyed to a Griffin mill, which reduces it to the fineness of flour. It is then carried by a screw conveyor to the foot of an elevator, which raises it to the first floor. Here it is dropped into a 100-ton tank and boiled with water. After boiling, it is drawn into settling tanks on the second floor, where the clear solution is run back to crystallizing vats on the first floor, the sediment being raised by a centrifugal pump to a tank on the third floor, and thence into a filter press of 50 pounds per square inch, the pulp receiving finally, however, double that pressure. The liquor drawn from the press goes back to the settling tank, and the refuse cakes go to the dump.

The crystallizing vats are of sheet iron 20 feet long by 6 feet wide and 6½ feet deep. Two-inch iron pipes are laid across the top of the vats, from which wires 5 feet long and 0.25 inch in diameter hang into the vats. As the solution cools, the borax crystallizes upon the wires and on the sides and bottoms of the vats. After crystallization, the mother liquor is pumped out and used again as a solvent, and the borax crystals removed. The crystallized borax is raised to the fourth floor to crushing rolls and screens and sorted into three sizes, viz: (1) Refined crystals; (2) refined screenings; (3) granulated borax. The granulated borax is then dried by hot air, in an inclined rotary cylinder; then pulverized in a cyclone pulverizer; then caught in dust chambers; and finally barreled for the market.

It is found that while the borax from the wires in the vat is pure, that from the sides and bottom has to be redissolved and refined.

The statistics of imports are from "Commerce and Navigation of the United States," published by the Bureau of Statistics, Department of Commerce and Labor.

TABLE 39.—SODAS—IMPORTS ENTERED FOR CONSUMPTION: 1891 TO 1905.

YEAR ENDING JUNE 30—	SODA ASH.		SAL SODA.		CAUSTIC SODA.		ALL OTHER SALTS OF SODA.		BORAX.		BORATES OF LIME OR SODA, OR OTHER BORATE MATERIAL.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	[1] 354,744,335	$4,382,917	(2)	(2)	78,743,976	$1,874,700	18,136,888	$118,713	10,725	$1,062	414,151	$17,681
1892	[1] 339,057,006	4,496,597	(2)	(2)	64,741,106	1,598,903	22,348,570	167,634	3,970	426	40	6
1893	388,910,183	4,855,098	27,531,554	$238,029	57,485,106	1,344,525	47,664,938	297,761	11,230	1,327	543,967	13,659
1894	256,293,395	2,520,921	16,893,760	120,794	38,987,832	850,753	14,829,622	104,800	1,812	225	441,066	11,427
1895	300,599,257	2,367,109	28,761,108	167,325	57,653,959	1,044,809	11,803,171	141,070	612,730	26,429	4,234,361	105,604
1896	251,067,856	1,950,981	17,966,996	84,423	61,713,044	1,071,169	9,090,367	149,248	11,376	796	4,307,100	104,952
1897	162,585,074	1,241,321	18,875,029	82,695	66,476,152	1,147,763	3,919,339	67,684	2,209	249	6,946,205	171,101
1898	87,809,619	589,714	8,851,011	40,266	29,697,185	476,032	21,400,585	225,628	42,407	2,541	1,381,175	31,726
1899	45,444,305	310,742	4,224,680	20,905	18,405,272	252,297	23,891,135	317,032	35,228	2,755	1,161,808	24,903
1900	78,571,870	648,450	6,624,314	31,072	11,429,989	177,857	23,632,374	314,425	136,610	5,960	36,266	3,594
1901	34,451,228	307,298	5,191,350	28,229	5,119,099	106,248	16,757,354	178,205	501,136	18,291	84,200	7,491
1902	27,636,757	262,106	3,560,460	21,084	4,297,850	100,557	15,422,281	276,239	849,088	26,865	121,686	10,746
1903	24,688,625	232,201	4,083,961	23,298	2,657,751	66,176	17,705,615	281,505	72,479	4,441	206,839	13,841
1904	19,563,349	188,750	3,705,930	20,855	2,945,709	74,072	10,550,404	278,333	72,888	5,464	122,848	11,021
1905	17,930,376	166,279	2,901,544	18,344	2,190,820	54,474	10,044,341	230,570	192,950	13,002	27,056	1,157

[1] Includes sal soda.

[2] Not reported separately.

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CLASS III.—POTASHES.

The class of potashes comprises stone-ash (known also as crude potash and lump potash), which is a mixture of caustic potash, potassium carbonate, and potassium sulphate with organic and various kinds of inorganic matter; potash, or black salts, or black flux, which is the unrefined potassium carbonate produced by calcining stone-ash or argols, or wine lees; and pearlash, or white flux, which is refined potassium carbonate. The term "potash" has also long been used to designate caustic potash, known also as vegetable alkali, potassium hydrate, or hydroxide, but as here used the term is more comprehensive. Caustic potash is properly included here with the potassium carbonate, as caustic soda was with the sodium carbonates under "sodas." Were any potassium hydrogen carbonate or bicarbonate of potash to be reported, the data for it would be entered under this class.

A detailed description of the American process for the production of potashes from the ashes of plants, together with a resumé of the processes in use abroad, and of those proposed for use in the production of potashes from various sources, was given in the special report on chemicals and allied products for the census of 1900. It is evident from the nature of the operations and the character of the materials used in the American process that, in a majority of instances, the industry is a neighborhood industry, and hence one which does not come within the scope of the census of 1905. Statistics for production, however, were taken within the states, and it therefore becomes possible to present their results in comparison with those presented separately at each census beginning with that of 1850. The quantity and value of the potashes reported at each census from 1850 to 1905 are set forth in Table 40.

TABLE 40.—*Potashes—quantity and value of products: 1850 to 1905.*

CENSUS.	Number of establishments.	PRODUCT.		Average price per pound.
		Pounds.	Value.	
1905	[1] 39	1,811,037	$104,655	$0.058
1900	[1] 67	3,864,766	178,180	0.046
1890	75	5,106,939	197,507	0.039
1880	68	4,571,671	232,643	0.051
1870	105	....	327,671	....
1860	212	....	538,550	....
1850	569	....	1,401,533	....

[1] Includes establishments engaged primarily in the manufacture of other products.

The statistics in Table 40 show a constant decrease in the total value of the product since 1850 and a steady decrease in the quantity of the product since 1890. This seems quite reasonable, in consideration of the destruction of the forests during recent years, and the resulting decrease in the quantity of ashes readily available for the manufacture of potashes; also in consideration of the decrease in the native fertility of the soil, with which has come an inclination to return potash to the soil as it occurs in the ashes rather than to extract and market it; and also in consideration of the cheapening of soda or hard soaps and increased facilities for bringing them to agricultural communities, whereby the temptation to extract potash from ashes for the manufacture of potash or soft soaps is lessened. These causes, combined with the comparative cheapness of foreign potashes, tend to destroy the domestic industry. The data of Table 40 indicate that the industry is a waning one, and that it may come to be of so slight importance as not to warrant separate consideration in subsequent censuses, unless other causes, recently set in operation, shall revive it in another form.

Although potassium occurs in considerable quantities in India saltpeter, in orthoclase feldspar, and in many other minerals which have long been used for many purposes in the arts, yet up to about the middle of the nineteenth century the ashes of plants were practically the sole source of supply of potashes. In the beginning of that century Stassfurt, in Germany, was noted for its salt works, in which salt was produced by the evaporation of natural brine obtained, by pumping, from driven salt wells. With the utilization of rock salt deposits in various localities the price of salt was reduced to such a point that the Stassfurt works ceased to yield their former large revenue to the Prussian Government, and with a view of making them again valuable the Government began boring for rock salt in this locality in 1839. In 1857 a shaft, which was begun in 1852, reached at a depth of 1,080 feet a stratum of rock salt, but in doing so it passed through a heavy deposit of so-called "abraumsalze," or refuse salts, which consisted largely of compounds of potassium and magnesium, which were then considered worthless.[1] This deposit is now, and has long been, the chief source of the potashes and the potassium salts of commerce. These native Stassfurt potash salts consist of the minerals carnallite, which is a magnesium potassium chloride; sylvite, which is potassium chloride; and kainite, which is a magnesium potassium chloride containing also magnesium chloride.

As early as 1861 patents were granted to A. Frank for the extraction of potassium chloride from the abraum salts, and since then a variety of processes of extraction have been invented and put into use. By treating this potassium chloride with sulphuric acid, limestone, and coal, as Le Blanc treated sodium chloride, potassium carbonate is obtained. By means of a process analogous to the ammonia-soda process, potassium chloride being used in place of sodium chloride and trimethylammonium carbonate in place of ammonium carbonate, potassium hydrogen carbonate, or bicarbonate of potash is obtained. By causticizing these carbonates with lime, caustic potash is obtained.

The Stassfurt deposit of potassium salts has been explored since its discovery and it has been found to cover an area of about 100 square miles. The stratum of carnallite, which is the most abundant and commercially most important, is from 50 to 150 feet in thickness. This deposit continues to be the chief source of the world's supply of potassium salts, except the nitrate, and the mining of them and their conversion into potashes and other commercial salts gives employment to a large force of men. It is stated that these German mines, and the chemical works connected with them, employ 10,000 miners, 15,000 laborers, and 800 chemists and technical experts, besides a large clerical force.[2]

Consideration is now being given to deposits of potassium salts within the territory of our own country, and this subject is discussed at length by William M. Courtis, who says:[3]

[1] Potash in Agriculture, The German Kali Works, page 5.
[2] Mineral Industry, 1907, Vol. XV, page 659.
[3] Ibid., page 663.

There are several large and well-known supplies of surface potash in this country, which could be utilized in the event of the imports of the United States being entirely cut off, but at present they are remote from railroads, in the desert portion of this country, and the cost of working would be prohibitive. These deposits are largely mixed with soda salts and would require washing, and this would be costly. The salts consist of sulphates and nitrates only, the chloride not having been found in any quantity. It is probable that with so many surface indications, occurring where conditions are similar to those of the Stassfurt district, boring on a large scale would supply information which would eventually lead to the discovery of a bed similar to that of Germany, but it would require a large expenditure for blind boring. However, in Germany the surface indications were so slight that the immense deposits were not discovered until a comparatively few years ago, and then only by accident.

Since the census of 1900 a new method for the manufacture of caustic potash from potassium chloride has been put in operation in this country. This is described as follows:[1]

The Roberts Chemical Company, of Niagara Falls, electrolyze potassium chloride. At the cathode caustic potash is produced and hydrogen is set free, while at the anode chlorine is set free. The quantities of hydrogen and chlorine are in equivalent proportions, so that they may be combined to form hydrochloric acid. This is done by the Roberts Chemical Company, the two products of which are, therefore, hydrochloric acid and caustic potash. In the September issue of Things Chemical, of the Charles E. Sholes Company, who are the sales agents of the Roberts Chemical Company, it is pointed out that on account of its method of production, this hydrochloric acid can not contain the ordinary impurities of muriatic acid unless they were expressly and intentionally added. Its only impurity is a small amount of free chlorine, which gives it a pale yellow color. The acid is of special interest to manufacturers of fine chemical products, gas mantles, cereals and foodstuffs (where there must be no arsenic), high grade and fancy leathers, and in general, for all purposes where quality is of more importance than a slightly increased first cost. The electrolytic caustic potash is made in three forms: Fused (solid), in drums of 100, 200, and 800 pounds; broken, in drums of 100, 250, 500, and 1,000 pounds; and caustic potash solution, in drums of 325, 650, and 1,350 pounds. The solid and broken grades analyze not less than 85 to 87 per cent KOH and 10 to 15 per cent carbonate and chloride of potassium. The solution contains 45 to 47 per cent KOH. Caustic potash is now very largely used in electroplating shops for removing grease from metallic surfaces before plating. In the laundry a dilute solution of caustic potash is an excellent "builder," for the soap will remove all grease and produces excellent suds, without injury to the fabric. Soapmakers use caustic potash especially for all the finest soaps, whereas caustic soda is used for the common grades.

Another direction in which the potash industry tends to develop is in the production of potashes from the potash or orthoclase feldspar and from other minerals containing potassium. Several inventions for the extraction of potash from these minerals have been patented, the latest patent, No. 851922, of April 30, 1907, having been granted Dr. Allerton S. Cushman, assistant director of the United States road material laboratory, for a process for the extraction of potash, soda, and other soluble bases from ground rocks. This is described as follows:[2]

Feldspathic or other potash bearing rock is ground to fine powder, slimed with water, and placed inside of a suitable wooden container, which is then set inside of another larger vessel. Water is now placed in the outer vessel and electrodes inserted, so that the inner or slime chamber becomes connected with the positive pole, and the outer chamber with the negative pole. A current of electricity from a dynamo is then turned on. When this is done the potash, soda, and other soluble bases are partially set free from the combinations with alumina and silica in which they exist in the feldspathic rocks.

Under the influence of electrolysis the soluble bases pass through the wooden partition and the water in the outer vessel becomes alkaline, owing to the accumulation of potassium and sodium hydroxide. The electrical resistance of the cells arranged in this way is so high that only a small fraction of an ampere passes through under a potential of 110 volts. After a certain percentage of the alkali has been extracted in this manner, the action slows down, and it has been found necessary to devise methods to accelerate the action.

Doctor Cushman has discovered two methods for accelerating the decomposition of the rock slime and hastening the extraction of the potash: (*a*) By a suitable grinding or churning arrangement the slime in the inner chamber can be kept in a continual agitation, which causes the necessary reactions to go on more rapidly. (*b*) If a small quantity of hydrofluoric acid is added to the slime a very great acceleration in the rate of decomposition and extraction is obtained, and it is possible in a reasonably short time to make a complete extraction of all the potash contained.

If instead of caustic potash it is desired to make various salts of potash such as are in ordinary use for fertilizers and other purposes, that is, nitrate, sulphate, chloride, and phosphate, the corresponding acids—nitric, sulphuric, hydrochloric, and phosphoric—are fed in a dilute form into the outer or so-called cathode chamber, fast enough to neutralize the caustic alkali as it forms. By varying the amount of acid added, the resistance of the cell can be controlled and the decomposition of the rock carried on under the best and most economic conditions.

The consumption of potash or pearlash in the glass industry of the United States was, at the census of 1890,[3] 2,544,978 pounds, valued at $135,047, and at the census of 1900,[3] 4,406,211 pounds, valued at $186,847. The quantity of potash used in the soap industry at the census of 1905[4] was 4,453,800 pounds, valued at $191,933, but this does not include the quantity of potash produced and consumed in the same establishments in the manufacture of soft soap. These are two of the industries in which the largest quantities of potashes are used.

Table 41 shows the imports and exports of potashes and ashes as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

[1] Electrochemical and Metallurgical Industry, 1906, Vol. IV, page 382.

[2] The Chemical Engineer, 1907, Vol. V, page 21.
[3] Twelfth Census, Manufactures, Part III, page 983.
[4] Census of Manufactures, 1905, Bulletin 57, page 43.

TABLE 41.—IMPORTS OF POTASHES, ASHES (WOOD) AND LYE OF, AND BEET ROOT ASHES, ENTERED FOR CONSUMPTION; AND DOMESTIC EXPORTS OF POTASHES AND PEARLASHES: 1891 TO 1905.

YEAR ENDING JUNE 30—	IMPORTS OF BICARBONATE OF POTASH.		IMPORTS OF CARBONATE OF POTASH.				IMPORTS OF CAUSTIC OR HYDRATE OF POTASH.				Imports of ashes (wood) and lye of, and beet root ashes (value).	DOMESTIC EXPORTS OF POTASHES AND PEARLASHES.	
			Crude or black salts.		Refined.		Not including refined, in sticks or rolls.		Refined, in sticks or rolls.				
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.		Pounds.	Value.
1891....	76,828	$4,344	[1] 6,207,419	$219,557	....	....	1,882,461	$84,429	9,145	$1,106	$42,624	430,582	$24,432
1892....	40,759	2,290	8,745,268	309,585	....	....	1,810,604	79,649	56,075	3,035	54,855	1,307,634	99,566
1893....	74,983	3,903	10,115,017	329,895	....	....	2,338,868	99,177	9,513	1,781	76,306	634,421	31,775
1894....	2,716	168	[1] 8,130,975	262,818	....	....	[2] 1,471,511	62,671	36,510	1,877	74,050	650,261	29,205
1895....	117,674	7,401	11,602,272	364,506	....	....	[2] 3,015,361	123,798	1,305	194	77,708	664,876	30,188
1896....	71,350	3,457	12,439,180	401,819	....	....	[2] 3,322,261	135,826	....	....	67,393	969,874	41,208
1897....	303,447	15,053	7,501,497	229,029	420,513	$24,727	[2] 4,011,996	165,735	....	....	66,423	511,830	21,727
1898....	115,711	5,936	15,844,374	471,919	22,941	727	[2] 3,354,245	125,591	15,577	2,119	62,206	869,841	33,202
1899....	132,431	7,239	16,018,889	437,675	637,587	16,783	3,454,739	132,331	36,055	3,643	59,970	745,433	29,676
1900....	162,798	9,666	21,191,258	625,922	2,968,051	87,987	3,612,595	157,842	23,297	2,715	66,453	1,273,905	49,566
1901....	73,770	5,054	18,888,612	627,601	3,448,249	112,783	3,840,777	180,277	86,798	7,195	76,306	1,043,817	56,072
1902....	56,970	3,625	18,671,566	624,042	3,869,549	125,445	4,118,079	191,281	33,518	4,526	88,096	1,363,355	62,529
1903....	19,130	1,518	11,130,789	141,033	17,689,935	507,219	4,499,555	193,350	31,632	3,853	76,156	1,193,258	60,376
1904....	93,769	4,778	8,193,872	224,396	13,586,306	397,104	4,810,993	194,839	36,048	4,879	62,641	1,027,181	56,800
1905....	76,983	4,504	7,166,569	218,816	13,687,083	440,139	5,269,804	217,041	22,313	2,537	60,713	542,832	30,156

[1] Fused.

[2] Includes some refined admitted free.

CLASS IV.—ALUMS.

The class of alums comprises potash, ammonia and soda alums, and all other double sulphates of aluminum with the alkali metals, or their isomorphs, such as chrome alum; burnt alum, known also as dried alum and alumen exsiccatum, or ustum; porous alum, which is effloresced soda alum, or else the product obtained by mixing soda ash with alum cake; aluminum sulphate; concentrated alum, which is crystallized aluminum sulphate; alum cake, which is crude aluminum sulphate; alumino-ferric cake, which is alum cake containing a considerable amount of iron; and aluminum hydrate, or hydroxide.

Statistics for the alum industry have been reported separately at each census beginning with that of 1880. At the census of 1900 the quantity and value of each of the chief varieties of alums were also set forth.

TABLE 42.—*Alums—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	8	4	4	100.0
Capital	$11,836,933	$5,553,313	$6,283,620	113.2
Salaried officials, clerks, etc., number	87	27	60	222.2
Salaries	$135,226	$64,328	$70,898	110.2
Wage-earners, average number	2,559	1,496	1,063	71.1
Total wages	$1,331,776	$773,356	$558,420	72.2
Miscellaneous expenses	$467,113	$214,997	$252,116	117.3
Cost of materials used	$2,583,173	$1,318,906	$1,264,267	95.9
Value of products[1]	$5,058,395	$2,882,421	$2,175,974	75.5

[1] Includes "all other products."

Table 42 presents the statistics for the principal establishments only. An increase is shown in every item, the largest per cent of increase being in the number of salaried officials, clerks, etc., and the next largest being in miscellaneous expenses.

TABLE 43.—ALUMS—QUANTITY AND VALUE: 1880 TO 1905.

CENSUS.	Establishments.	Quantity (pounds).	Value.	INCREASE.			PER CENT OF INCREASE.		
				Establishments.	Quantity (pounds).	Value.	Establishments.	Quantity (pounds).	Value.
1905	17	225,543,308	$2,956,844	4	40,898,011	$440,424	30.8	22.1	17.5
1900	13	[1] 184,645,297	[1] 2,516,420	3	90,647,289	899,710	30.0	96.4	55.7
1890	10	93,998,008	1,616,710	4	54,780,283	808,545	66.7	139.7	100.0
1880	6	39,217,725	808,165	....	....	....	....	....	....

[1] Includes 5,177,826 pounds, with an assigned value of $69,844, consumed in establishments where manufactured; and also the alum reported by establishments engaged primarily in the manufacture of other products.

The data of Table 43 shows, when the industry is considered as a whole as well as when only the operation of the principal establishments is considered, that there has been an increase in every item at each succeeding census, and that the industry was in a flourishing condition at the census of 1905. A comparison of the increases at the various periods shows that while the greatest percentage of increase in every item occurred in the interval from 1880 to 1890, the largest actual increase in both quantity and value occurred in the interval from 1890 to 1900. It is to be observed that the data for 1900 includes the quantity and value of alum which was produced and consumed. No information on this point is available for 1905.

TABLE 44.—*Kinds of alum—quantity and value of products: 1905 and 1900.*

KIND.	1905		1900	
	Pounds.	Value.	Pounds.	Value.
Total	225,543,308	$2,956,844	179,467,471	$2,446,576
Ammonia alum	3,467,104	59,774	6,580,373	102,308
Burnt alum	15,858,335	364,328	6,628,914	174,600
Concentrated alum	80,919,272	972,892	103,016,815	1,062,547
Potash alum	10,307,154	156,448	14,200,393	215,004
Soda alum	82,050	4,923	9,399,550	228,500
Alum cake	19,496,047	161,906	4,048,655	34,047
Other alums	95,413,346	1,236,573	35,592,771	629,570

The data of Table 44 shows that a larger proportion of the alums returned at the census of 1905 is included under the heading "other alums" than at the census of 1900, and that there has been a decrease in every other item, except in the quantity and value of burnt alum and of alum cake, items which show marked increases. The greatest decrease is in the quantity and value of soda alum, but, as pointed out in the special report for 1900, this is often included under burnt alum; there is reason for this, since as sold it does not usually contain the water of crystallization, which is characteristic of the crystallized alums. Some manufacturers contend that soda alum, which is known in trade as "C. T. S.," or "cream of tartar substitute," is not an alum, and accordingly they may have reported it under "all other products." This would reduce the total quantity and value of alums and may be an additional means of explaining why the increases shown for the industry at the census of 1905 are not proportionate to those shown at the census of 1900.

TABLE 45.—*Alums—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1]17	[1]13
California	1	....
Illinois	3	1
Massachusetts	3	3
Michigan	1	1
New York	2	2
Ohio	1	....
Pennsylvania	6	6

[1] Includes 9 establishments engaged primarily in the manufacture of other products.

Table 45 shows the same number of establishments in operation at the censuses of 1905 and 1900 in every state except Illinois, where there has been a gain of 2 establishments, and California and Ohio, in each of which 1 plant has been established. Pennsylvania stands first at each census. Massachusetts stands second at each, being joined in this place at the census of 1905 by Illinois. No other state had more than 2 establishments at either census.

TABLE 46.—*Alums—value of products, by states: 1905 and 1900.*

STATE.	1905	1900
United States	$2,956,844	$2,446,576
Pennsylvania	1,479,340	1,411,652
Massachusetts	270,614	306,754
Illinois	481,754	(1)
All other states [2]	725,136	728,170

[1] Included in "all other states."
[2] Includes in 1905 California, Michigan, New York, and Ohio; in 1900, Illinois, New York, and Michigan.

Table 46 shows that at each census Pennsylvania stood first in the value of alums produced and "all other states" second. It also shows for the later census a decrease in the value of the product for Massachusetts, and an apparent decrease for "all other states," but as the value of the product from Illinois was reported separately at the census of 1905, while it was included in the item "all other states" for 1900, the only real decrease is in the returns for Massachusetts.

In the census year 1900 there were used in the manufacture of alums, including those produced and consumed, 39,000 tons of bauxite, valued at $263,850; 5,000 tons of cryolite, valued at $110,000; 2,000 tons of sodium sulphate, in the form of salt cake or niter cake, valued at $4,100; 755 tons of soda ash, valued at $8,744; 360 tons of ammonium sulphate, valued at $21,900; 477 tons of potassium sulphate, valued at $19,600; and 71,426 tons[1] of sulphuric acid, in the manufacture of which were used 3,323 tons of sulphur (valued at $66,000), 28,358 tons of pyrites (valued at $133,282), and 720 tons of sodium nitrate (valued at $25,200). In 1905 there were used in this industry 53,246 tons of bauxite, valued at $423,643; 4,867 tons of aluminum hydrate, or hydroxide, valued at $223,882; 4,141 tons of sodium sulphate, valued at $11,627; 8,657 tons of soda ash, valued at $162,394; 179 tons of ammonium sulphate, valued at $11,165; 1,288 tons of potassium sulphate, valued at $55,951; and 80,672 tons of sulphuric acid of 50° Baumé, in the manufacture of which were used 38,233 tons of pyrites (valued at $187,341) and 807 tons of sodium nitrate (valued at $32,280).

Table 47 shows the imports of alums and materials for alum making as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

[1] Recalculated from ascertained yields in practice.

TABLE 47.—ALUMS, CRYOLITE, AND BAUXITE—IMPORTS FOR CONSUMPTION: 1891 TO 1905.

YEAR ENDING JUNE 30—	ALUMS.		CRYOLITE.		BAUXITE.			
					Bauxite, crude.		Aluminum hydrate or refined bauxite.	
	Pounds.	Value.	Tons.	Value.	Pounds.	Value.	Pounds.	Value.
1891	4,652,985	$58,863	7,129	$95,405				
1892	4,140,916	59,336	8,298	76,350				
1893	4,572,923	73,806	8,459	111,796				
1894	1,838,728	30,831	12,756	170,215				
1895	2,983,682	46,815	8,685	116,273				
1896	5,525,825	86,371	7,024	93,198				
1897	5,301,544	96,529	3,009	40,056	8,722,074	$14,915		
1898	2,787,639	36,099	10,788	144,178			2,092,082	$60,194
1899	1,601,829	14,244	5,529	79,455	7,722,000	14,168	2,955,339	92,019
1900	2,186,266	19,354	5,878	78,658	6,850,000	11,413	3,474,421	109,574
1901	2,120,119	21,179	6,167	82,533	33,526,000	63,597	5,584,477	199,950
1902	1,970,961	18,217	4,653	61,116	29,418,000	52,245	1,448,505	53,557
1903	1,865,006	17,321	7,565	104,178	33,534,240	56,861	1,520,273	50,132
1904	1,465,709	13,501	6,332	84,359	38,609,160	62,452	1,656,635	55,826
1905	2,395,071	23,600	998	17,707	19,100,000	32,813	16,291	1,388

CLASS V.—COAL TAR PRODUCTS.

The class of coal tar products comprises the materials obtained by the distillation of coal tar, known as coal tar distillery products, which include pitch, creosote oil, dead oil and other tar oils, benzol (benzene), toluol, xylol, naphthalene, anthracene and other coal tar hydrocarbons, phenol (carbolic acid), cresol, naphthol, resorcin, or resorcinol, and other coal tar tertiary alcohols, and aniline, toluidine, xylidine, and other coal tar amines; and chemicals made from coal tar distillery products, which include the aldehydes, acids, ketones, salts, and various other so-called benzene derivates. These cover the so-called coal tar dyes, which appear also under "dyestuffs," and many nitro-substitution compounds and synthetic preparations, which appear again under "essential oils" or "fine chemicals." There is a further duplication in that many establishments in which coal tar is distilled consume part of the product in the further manufacture of roofing felt, roofing paper, and roofing preparations which belong either in the class of "roofing and roofing materials" or of "paints." These duplications are necessary in order to show the condition of the industry as a whole. In view of these facts it is evident that the classifying of the coal tar products presents very serious difficulties and that for this industry there will necessarily be at the different censuses variations in the statistics.

TABLE 48.—*Coal tar products—comparative summary, with amount and per cent of decrease: 1905 and 1900.*

	CENSUS.		Decrease.	Per cent of decrease.
	1905	1900		
Number of establishments	6	15	9	60.0
Capital	$837,991	$2,095,363	$1,257,372	60.0
Salaried officials, clerks, etc., number	41	84	43	51.2
Salaries	$65,802	$152,817	$87,015	57.0
Wage-earners, average number	129	514	385	74.9
Total wages	$70,972	$257,838	$186,866	72.5
Miscellaneous expenses	$114,389	$190,041	$75,652	39.8
Cost of materials used	$538,617	$1,341,561	$802,944	59.9
Value of products	$820,309	$2,227,544	$1,407,235	63.2

Table 48 shows a decrease in every item for 1905 as compared with 1900, the greatest percentage of decrease being in the average number of wage-earners and in wages paid, and the least in miscellaneous expenses. The cause of the decreases is due chiefly, if not entirely, to the fact that establishments which in 1900 produced coal tar distillery products as their principal product and roofing materials as a subsidiary product, in 1905 produced roofing materials as their principal product, and were thus taken out of the class of coal tar products establishments. It is pointed out, in the special report on this industry for the census of 1900, that tarred felt and tarred paper, in which part of the material produced from the coal tar was consumed in further manufacture, were produced to the value of $442,529.

Statistics for this industry were first reported separately at the census of 1880, since which time they have been reported separately at each census. As no data are at command by which to ascertain the quantity of the coal tar products which were produced and consumed, these statistics show only the totals of those products produced for sale.

TABLE 49.—*Coal tar products—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1] 39	[2] 22
California	1	1
Illinois	1	
Louisiana		1
Maine	3	
Massachusetts	3	2
Michigan	1	
Minnesota		1
Missouri	3	3
New Jersey	8	2
New York	8	3
Ohio	3	2
Pennsylvania	6	6
Rhode Island	1	
Tennessee	1	1

[1] Includes 33 establishments engaged primarily in the manufacture of other products.
[2] Includes 7 establishments engaged primarily in the manufacture of other products.

Table 49 shows that there has been an increase of 17 in number, or 77.3 per cent, for the establishments in the United States for 1905 as compared with 1900, the increases for the individual states reporting in 1900 being 6 in New Jersey, 5 in New York, and 1 in Ohio, while Maine reports 3 establishments and Illinois, Michigan, and Rhode Island 1 each for the first time at the census of 1905. Louisiana and Minnesota which reported 1 establishment each in 1900 did not report any in 1905. At the census of 1900 Pennsylvania stood first in the number of establishments, with Missouri and New York sharing second place. No other state returned more than 2 establishments. At the census of 1905 New Jersey and New York shared first place, Pennsylvania occupied second, and Maine, Massachusetts, Missouri, and Ohio shared third. No other state returned more than 1 establishment.

TABLE 50.—*Coal tar products[1]—value, by states: 1890 to 1905.*

STATE.	1905		1900		1890
	Number of establishments.	Value of products.	Number of establishments.	Value of products.	Value of products.
United States	39	$3,984,821	22	$1,421,720	$687,591
District of Columbia					20,000
Georgia					20,000
Maine	3	30,051			
Massachusetts	3	175,978			
Missouri	3	284,637	3	415,600	
New Jersey	8	1,664,136	(2)	(2)	330,200
New York	8	926,329	3	44,016	138,324
Ohio	3	463,001	(2)	(2)	
Pennsylvania	6	375,757	6	396,759	168,180
All other states	[3] 5	64,932	10	565,345	10,887

[1] Showing value of coal tar products only.
[2] Included in "all other states."
[3] Includes in 1905 California, Illinois, Michigan, Rhode Island, and Tennessee; in 1900, California, Louisiana, Massachusetts, Minnesota, New Jersey, Ohio, and Tennessee; in 1890, Massachusetts and Tennessee.

The rank of the states at the different censuses, as determined by the value of products, has varied in an erratic manner. New Jersey, which ranked first in 1890 and again in 1905, was classified under "all other states" in 1900; Missouri, which ranked first in 1900, took the fifth place in 1905; and Pennsylvania, which ranked second in 1900, passed to the fourth place in 1905; New York, which ranked third in 1890 and in 1900, rose to the second place in 1905; Ohio, which had not been reported separately at any previous census, took the third place in 1905. At each census the largest portion of the product has been reported from the Middle Atlantic states.

Coal tar is produced in the destructive distillation of bituminous coal, and is therefore a by-product of the coal gas industry and, when by-product ovens are used, of the coke industry. The unit of measure used in treatises on this material is sometimes gallons and sometimes tons. But since a gallon of coal tar weighs, on an average, 10 pounds, it is a simple matter to convert the quantities given in one of these units into terms of the other. At the census of 1900[1] it was estimated that the quantity of coal tar produced in the gas industry in this country was 67,094 tons, and the quantity of water gas tar produced, 222,868 tons. At the census of 1905[2] the quantity of tar reported was 67,515,421 gallons, or 337,577 tons. This includes both the coal tar from the straight coal gas process, and the water gas tar produced chiefly in carbureting the water gas. As the two processes are often carried on in conjunction, it is not a simple matter for the producers to give separate returns for them, and hence a combined return was received. Assuming, however, that the ratio of each approximated that reported for the census of 1900, which was closely 23 of coal gas tar to 77 of water gas tar, the amount reported for the census of 1905, in the gas industry, was equivalent to 77,643 tons of coal tar and 259,934 tons of water gas tar. In the coke industry, at the same census, the quantity of coal tar reported was 26,223,323 gallons, or 131,117 tons.[3] There was therefore available in the United States in 1905, 208,760 tons of coal tar as compared with 119,438 tons in 1900, and 468,694 tons of coal and water gas tar as compared with 342,306 tons in 1900. It is to be noted that at the later census the coal tar production from coke ovens exceeded that from coal gas plants. The amount of coal tar reported as used in the United States at the census of 1900 was 110,023 tons, and at the census of 1905, 127,756 tons; at the later census there were also reported as used 117,459 tons of oil gas tar.

Among the products of this industry reported at the census of 1905 were 61,100 tons of pitch, valued at $800,862; 577,750 gallons of refined coal tar, valued at $22,704; 18,750 gallons of ready mixed paints, valued at $5,621, these three products evidently having been made from coal tar pitch and light distillate; 288,817 gallons of creosote oil, valued at $17,546; 17,175 tons of oils, including light, heavy, and dead oils, and probably some creosote oil, valued at $308,830; coal tar distillery products, probably comprising some of the foregoing, valued at $7,613; 5,872,360 pounds of coal tar dyes, valued at $2,348,189; and 2,391,866 pounds of chemicals made from coal tar distillery products, including salicylic acid and its derivatives, saccharine, and phenol preparations and derivatives, valued at $569,024. It is believed that many of these are lost in the classifications "druggists' preparations" and "patent medicines and compounds." At the census of 1900 the chemicals made from coal tar distillery products were valued at $205,047. Pyridine and its homologues, some of these chemicals, are used for denaturing alcohol, and, as the Commissioner of Internal Revenue has ruled that alcohol denatured by their use may be used tax free in the arts and manufactures and for domestic purposes, it is reasonable to suppose that in subsequent census returns these substances may be enumerated as separate items.

[1] Twelfth Census, Manufactures, Part IV, page 549.

[2] Census of Manufactures, 1905, Bulletin 57, page 42.
[3] Census of Manufactures, 1905, Bulletin 65, page 17.

A comparison of the coal tar reported as used in the manufacture of coal tar products, with the coal tar produced in the coal gas and coke industries, shows that in 1900 there was used in the manufacture of coal tar products 92.1 per cent of the entire amount produced, and in 1905 but 61.2 per cent; at the latter census the amount of oil gas tar used nearly equaled that of the coal tar. These figures indicate that other and increasing uses for coal tar than that of converting it into coal tar products are being found, such for instance as employing it for fuel in internal combustion engines of the Diesel type. Despite these uses, however, our resources for tar are by no means exhausted; it is estimated that in 1905, 28 per cent of the tar produced in by-product coke works was consumed as fuel in the works, and it is shown in the bulletin on coke for 1905,[1] that had all the coal which was coked in that census year been coked in by-product ovens, at the average rate of yield which obtained for the coal actually so coked, there would have been produced 295,273,173 gallons, or 1,476,366 tons, of coal tar from that source alone. There is therefore no lack of coal tar for our industries. In fact, the difficulty of profitably disposing of that now produced is a large factor in delaying the erection of additional by-product coke plants. Nor is there yet any restriction on the amount of benzene and its homologues available for use in the aniline dye industry, for, besides that which occurs in the coal tar, a considerable amount, which might be utilized, is allowed to pass off in the gas from by-product ovens. Of the 10,000 cubic feet of gas produced from a ton of coal, 6,500 cubic feet are required in the coking process. This gas contains three-fourths of 1 per cent of benzene and its homologues, which may be removed by washing the gas with petroleum, or coal tar oil; the product thus obtained is a benzolized oil containing from 2 to 3 per cent of benzene. On distillation a crude benzene light oil is obtained which contains only slight quantities of impurities, such as carbon disulphide, hydrogen sulphide, thiophene, and naphthalene, which by purification and redistillation yields a 100 per cent pure benzene,[2] suitable for converting into aniline. The extraction of the benzene and its homologues does not seriously affect the heating value of the gas, and is now being practiced to some extent. At the census of 1905 the volume of gas reported as produced and consumed in by-product ovens was 16,232,309 thousand cubic feet. The volume which would have been produced had all of the coal which was coked in that year been coked in by-product ovens is estimated at 183,025,147 thousand cubic feet.

The statistics given in Tables 48 and 50 show that the manufacture of coal tar products in the United States is an important and a growing industry, yet when compared with the same industry in Germany it sinks into insignificance.

[1] Census of Manufactures, 1905, Bulletin 65, page 18.
[2] Journal of American Chemical Society 1906, Vol. 28, page 1254.

Table 51 sets forth the imports of coal tar and of coal tar products from 1896 to 1905, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

TABLE 51.—*Coal tar and coal tar products—imports for consumption: 1896 to 1905.*

YEAR ENDING JUNE 30—	COAL TAR, CRUDE AND PITCH.		Coal tar products not medicinal and not colors or dyes (value).[1]	Preparations of coal tar except medicinal, colors and dyes, and products of, not specially provided for (value).
	Barrels.	Value.		
1896	139,976	$288,750	(2)	$313,943
1897	111,534	258,900	(2)	373,224
1898	89,346	158,589	$228,037	134,416
1899	26,704	60,500	393,602	221,101
1900	80,047	165,072	397,780	274,946
1901	39,062	104,547	383,559	342,116
1902	28,390	84,410	368,098	496,928
1903	57,114	141,822	425,069	544,176
1904	38,277	83,323	391,645	522,242
1905	46,057	114,500	468,352	645,830

[1] These preparations are known as benzol, toluol, naphthalin, xylol, phenol, cresol, toluidine, xylidin, cumidin, binitrotoluol, binitrobenzol, benzidin, tolidin, dianisidin, naphthol, naphthylamin, diphenylamin, benzaldehyde, benzyl chloride, resorcin, nitrobenzol, and nitrotoluol.
[2] Not reported separately.

CLASS VI.—CYANIDES.

The class of cyanides comprises potassium cyanide (cyanide of potash, or white prussiate of potash), sodium cyanide, and other simple cyanides including "cyan-salt," which is a mixture of potassium and sodium cyanides; potassium ferrocyanide (yellow prussiate of potash) and potassium ferricyanide (red prussiate of potash); the cyanates, ammonium and potassium sulphocyanates (thiocyanates or sulphocyanides), and other sulphocyanates; and cyanamids.

TABLE 52.—*Cyanides—comparative summary, with amount and per cent of decrease: 1905 and 1900.*

	CENSUS.		Decrease.	Per cent of decrease.
	1905	1900		
Number of establishments	6	12	6	50.0
Capital	$342,233	$1,250,941	$908,708	72.6
Salaried officials, clerks, etc., number	7	20	13	65.0
Salaries	$12,538	$36,475	$23,937	65.6
Wage-earners, average number	113	376	263	69.9
Total wages	$72,768	$190,568	$117,800	61.8
Miscellaneous expenses	$71,332	$173,133	$101,801	58.8
Cost of materials used	$348,490	$1,283,949	$935,459	72.9
Value of products	$586,581	$1,769,736	$1,183,155	66.9

The statistics of Table 52 show a decrease in every item, the greatest in amount being in value of products and the greatest percentage in cost of the materials used and in capital. This comparison is made between those establishments only in which the cyanides are the principal products. Since in 1900, several establishments produced a notable amount of subsidiary products, part of this reduction may be accounted for through these subsidiary industries outgrowing the cyanide industry in such establishments, and thereby carrying these establishments into another Census classification.

A better idea of the condition of the industry at the census of 1905 may be gained by bringing together the quantity and value of the cyanides produced either as a principal or as a subsidiary product, and comparing these results with similar ones for the census of 1900, the first census at which the cyanides were reported separately.

TABLE 53.—*Cyanides—quantity and value of products, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Quantity, pounds	11,196,318	8,460,989	2,735,329	32.3
Value	$1,710,823	$1,595,505	115,318	7.2
Value per pound	$0.153	$0.189		

The statistics of Table 53 show an increase in each item reported, though the increase in value is relatively less than the increase in quantity. The cyanide process for the extraction of precious metals from their ores was first made commercially successful in 1890. Its introduction into this country was slow at first, but very rapid after its utility was once demonstrated. In 1905 there were 132 establishments operating in the United States in which the cyanide process was used. When the rapid increase in the use of cyanides for this purpose and the constant increase in their use in the textile and paint industries are considered, and especially when, as shown in Table 56, it is found that the imports for consumption of cyanide of potash and of yellow prussiate of potash were less in 1905 than in 1900, while the imports of red prussiate of potash were but slightly greater, it is believed that the statistics available at the census of 1905 do not fairly represent the condition of the cyanide industry. There are probably two reasons to account for this: The first, that possibly some manufacturers, instead of making separate returns for the cyanides which they produced for sale or used in further manufacture, have reported them under "all other products;" and the second, that possibly some of the larger consumers, such as those engaged in the manufacture of printed fabrics, or paints, or inks, have begun the manufacture of the cyanides consumed by themselves in further manufacture, and, in cases where this manufacture is, relatively to the principal product of the establishment, of very minor importance, it has been found difficult to secure separate returns.

TABLE 54.—*Cyanides—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1] 11	[2] 18
Maryland		1
Massachusetts	1	1
Michigan	1	
Missouri	1	3
New Jersey	1	6
New York	2	
Ohio	2	3
Pennsylvania	3	4

[1] Includes 5 establishments engaged primarily in the manufacture of other products.
[2] Includes 6 establishments engaged primarily in the manufacture of other products.

Table 54 shows a decrease of 7, or 38.9 per cent, in the number of establishments of all classes manufacturing cyanides at the census of 1905 as compared with that of 1900. The largest decrease is in New Jersey, which returned 6 establishments in 1900 and but 1 in 1905. The other decreases are 2 in Missouri, and 1 each in Maryland, Ohio, and Pennsylvania. At the census of 1900 New Jersey ranked first and Pennsylvania second. At the census of 1905 Pennsylvania ranked first, with 3 establishments, while New York and Ohio each had 2 establishments.

TABLE 55.—*Cyanides—value of products,[1] by states: 1905 and 1900.*

STATE.	1905	1900
United States	$1,710,823	$1,595,505
New Jersey		1,053,472
Pennsylvania	434,770	303,245
Ohio		86,852
All other states[2]	1,276,053	151,936

[1] Includes value of cyanides only.
[2] Includes in 1905 Massachusetts, Michigan, Missouri, New Jersey, New York, and Ohio; in 1900, Louisiana, Tennessee, Ohio, California, Minnesota, Massachusetts, and New Jersey.

The statistics of Table 55 show that New Jersey, which is included in "all other states" in 1905, returned 66 per cent of the total value of products in 1900. In both Pennsylvania and "all other states" there is an increase at the later census. The increase in "all other states" is due partly to the fact that the statistics for New Jersey and Ohio, which in 1900 were set forth separately, can not be shown in 1905, because less than 3 establishments reported. It is worthy of note, considering the extent to which the cyanides are used in metallurgical processes in the far West, that their manufacture is largely confined to the Eastern states.

At the census of 1900 there were reported[1] as used in this industry, 9,315,080 pounds of potassium carbonate, valued at $279,602; 3,456 tons of hoofs and of horn waste, valued at $87,502; 19,417 tons of scrap leather, valued at $150,213; 1,200 tons of spent iron oxide from gas works, valued at $3,000; 300,000 pounds of sodium, valued at $93,183; 2,400 bushels of lime, valued at $480; scrap iron, valued at $9,520; and 2,401,180 pounds of potassium ferrocyanide.

At the census of 1905 there were reported as used 9,981,700 pounds of potassium carbonate, valued at $215,664; 1,279,447 pounds of sodium carbonate, valued at $5,037; 13,478 tons of scrap leather, valued at $87,253; 3,248 tons of spent iron oxide, valued at $25,146; 2,478,966 pounds of sodium; 40,034 bushels of lime, valued at $6,112; 175 tons of scrap iron, valued at $7,000; and 54,966 pounds of potassium ferrocyanide, valued at $7,695.

Among the cyanides reported at the census of 1900[1] there were 6,165,407 pounds of potassium ferrocyanide, valued at $994,014, and 2,317,280 pounds of so-called potassium cyanide, valued at $601,491. At the census of 1905 there were reported produced, 5,027,264

[1] Twelfth Census, Manufactures, Part IV, page 553.

pounds of potassium ferrocyanide, valued at $683,277; 78,584 pounds of potassium cyanide, valued at $17,438; and 6,197,470 pounds of sodium cyanide, valued at $923,210.

At a meeting of the Fifth International Congress of Applied Chemistry held in Berlin in 1903, Mr. George Beilby said that the whole "turnover" of the European trade at its best, in the cyanide industry, did not exceed $2,919,000 a year, and that the total net profit in the best year was probably under, rather than over, $486,650. He estimated that the consumption of European-made cyanide throughout the world, not counting that exported to America, was normally about 5,500 tons per annum, while the capacity of the then existing works in Germany, France, and Great Britain was 12,600 tons, and with the then proposed additions would soon be 15,700 tons per annum. He said also that on account of the congestion of the European market during the two or three previous years, relief had been sought through exports to America at a low price. He referred to the new industrial sources of the cyanides, such as the "Schlempe," or residue of the beet root molasses refineries, which through Bueb's process had been made to yield a gas very much richer in ammonia and hydrocyanic acid than coal gas; to the improved processes for the production of the cyanides and ferrocyanides from coal gas; to the improved Gelée process for the production of ammonium sulphocyanide from carbon disulphide and ammonia, and its further conversion into ferrocyanide; and to the Siepermann and his own process for obtaining cyanide from potassium carbonate, charcoal, and ammonia. At the same Congress, Dr. F. Rössler traced the development of the synthetic processes of manufacture. Descriptions of all these processes are given in great detail in the recently published book of Robine and Lenglen.

The most important discovery in the cyanide industry, in the interval which has elapsed since the last census, is in the manufacture of calcium cyanamid, or lime nitrogen, by the process of Frank and Caro, which consists practically of the passage of nitrogen over heated calcium carbide, for in this is found a practical and economical process for the fixation of atmospheric nitrogen, a further use for calcium carbide, and a valuable and very extensive field for the utilization of liquid air; while the product itself is a valuable fertilizer, which may be used directly as such. Furthermore, by very simple means a considerable number of useful chemicals may be produced from it, among which may be mentioned potassium and other cyanides, ammonia and ammonium sulphate or other ammoniacal salts, urea, guanidin, dicyandiamid, and nitric acid. Since this process was discovered, between 8,000 and 9,000 gross tons of lime nitrogen have been manufactured by it, and for more than a year past a plant having a capacity of 3,750 gross tons per year has been in operation at Piano d'Orta, Italy. This plant is engaged in enlarging its capacity to 15,000 gross tons per year, while other plants having a combined capacity of 26,250 gross tons per year are under construction in Europe. There is little doubt but that this industry will have been established in this country by the time of the taking of the next census, and that its stimulating effect on related industries will be noted.

Table 56 shows the imports of cyanides from 1891 to 1905, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

TABLE 56.—*Cyanides—imports for consumption: 1891 to 1905.*

YEAR ENDING JUNE 30—	YELLOW PRUSSIATE OF POTASH.		RED PRUSSIATE OF POTASH.		CYANIDE OF POTASH.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	2,223,154	$368,366	35,826	$10,650	....	....
1892	1,302,632	232,058	35,933	11,111	....	....
1893	1,047,910	206,259	16,679	5,743	....	....
1894	599,103	114,826	11,125	3,339	....	....
1895	878,727	161,009	26,703	7,593	....	....
1896	1,056,562	157,457	30,390	8,579	....	....
1897	3,252,931	359,037	59,087	14,893	16,232	$4,190
1898	1,340,305	132,508	77,246	18,674	549,097	120,252
1899	1,809,089	204,974	62,697	15,211	1,102,780	253,613
1900	1,771,394	224,274	53,716	12,954	2,064,974	444,703
1901	1,609,358	218,909	30,262	7,357	2,029,994	475,833
1902	594,295	66,756	47,200	11,355	3,054,254	595,587
1903	1,315,051	119,859	57,169	13,757	3,019,462	549,628
1904	1,736,564	156,275	55,624	13,508	1,513,849	279,204
1905	1,165,192	103,193	60,699	14,453	1,624,372	260,208

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CLASS VII.—WOOD DISTILLATION.

The class of wood distillation comprises wood alcohol (methyl alcohol), both crude and refined, acetate of lime (calcium acetate), both brown and gray, acetate of soda, acetic acid, charcoal, formaldehyde, acetone, pyroligneous acid, pyrolignite of iron, dye liquors, wood creosote, wood oil, wood tar, wood ashes, spirits of turpentine, as produced by the distillation of wood, pine oil, red liquor, wood preservative, tar oil, and pine tar. Naturally spirits of turpentine and rosin, with other products, obtained from the distillation of the exuded turpentine of the long leaf pine are reported under the classification of "turpentine and rosin."

TABLE 57.—*Wood distillation—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	141	102	39	38.2
Capital	$10,506,979	$6,729,127	$3,777,852	56.1
Salaried officials, clerks, etc., number	301	235	66	28.1
Salaries	$297,528	$213,025	$84,503	39.7
Wage-earners, average number	2,272	1,556	716	46.0
Total wages	$1,066,786	$700,484	$366,302	52.3
Miscellaneous expenses	$631,437	$368,305	$263,132	71.4
Cost of materials used	$4,847,770	$3,455,015	$1,392,755	40.3
Value of products	$7,813,483	$6,001,023	$1,812,460	30.2

Table 57 shows a marked increase in every item, the largest percentage of increase being in the item of miscellaneous expenses. A more significant increase is in the item of capital, which shows nearly double the percentage of increase that the value of products does. A part of this increase is due to the introduction into the South and West of distillation processes for the treatment of pine wood and stumpage.

Statistics for this industry were reported separately at the census of 1880 and have been reported separately at each subsequent census. The figures given in 1880 were for crude wood alcohol, acetate of lime, and charcoal, and for purposes of comparison the figures for these items are shown in Tables 58 and 59 for each census. Since 1880, following the general trend of the development of chemical manufactures, a number of establishments manufacturing these crude products have used the crude alcohol for the production of refined alcohol, which is the form in which this product is offered for sale. In the process of refining, the crude alcohol is reduced in volume by about 20 per cent. To ascertain the total volume of crude alcohol produced by wood distillation processes at any given census, it is necessary, not only to add together all of the crude alcohol produced as a subsidiary product, but also to include that which is consumed in the wood distillation establishments in further manufacture. Frequently this is not reported, but, knowing the volume of refined alcohol produced, the volume of the crude alcohol can be determined with a close approach to accuracy by multiplying the quantity of refined alcohol by 1.25. Such a method of procedure was followed at the census of 1890, and has been followed at each subsequent census.

TABLE 58.—WOOD DISTILLATION—CRUDE PRODUCTS: 1880 TO 1905.

CENSUS.	Number of establishments.	WOOD ALCOHOL (CRUDE).		ACETATE OF LIME.		CHARCOAL.	
		Gallons.	Value.	Pounds.	Value.	Bushels.	Value.
1905	129	[1] 8,282,286	[1] $2,672,507	110,383,997	$1,527,733	[2] 40,944,190	[2] $2,038,514
1900	93	4,945,963	1,976,986	86,826,000	981,286	17,154,302	726,672
1890	53	1,116,075	688,764	26,778,415	315,430		
1880	17		86,274	6,593,009	156,892		31,770

[1] Includes 1,468,028 gallons, with an assigned value of $470,546, consumed in establishments where manufactured.
[2] Includes 11,026,978 bushels of charcoal, with an assigned value of $551,349, consumed in establishments where manufactured.

TABLE 59.—WOOD DISTILLATION—CRUDE PRODUCTS, INCREASE AND PER CENT OF INCREASE: 1880 TO 1905.

KIND.	INCREASE.						PER CENT OF INCREASE.					
	1900 to 1905		1890 to 1900		1880 to 1890		1900 to 1905		1890 to 1900		1880 to 1890	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Wood alcohol (crude), gallons	3,336,323	$695,521	3,829,888	$1,288,222		$602,490	67.5	35.2	343.2	187.0		698.3
Acetate of lime, pounds	23,557,997	546,447	60,047,585	665,856	20,185,406	158,538	27.1	55.7	224.2	211.1	306.2	101.0
Charcoal, bushels	23,789,888	1,311,842					138.7	180.5				

Table 59 shows an increase in every item at each census, indicating a constant progress in every branch of the industry.

Table 60 shows that the number of establishments has increased by 39, or 35.1 per cent, in 1905 as compared with 1900, the greatest increase in any one state being in Georgia, which reported 9 in 1905 as compared with none in 1900. The increase in Michigan was 7, in South Carolina 5, and in New York, North Carolina, and Pennsylvania 4 each. It will be observed that a large part of the gain is to be credited to the Southern states.

TABLE 60.—*Wood distillation—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1] 150	[1] 111
Alabama	1	....
Connecticut	1	1
Delaware	....	1
Florida	4	....
Georgia	9	....
Indiana	....	1
Kentucky	1	....
Louisiana	2	....
Massachusetts	2	4
Michigan	13	6
Minnesota	1	....
Mississippi	1	....
Missouri	1	....
New York	32	28
New Jersey	2	4
North Carolina	7	3
Ohio	....	1
Pennsylvania	64	60
South Carolina	5	....
Tennessee	....	1
Vermont	2	1
Washington	1	....
Wisconsin	1	....

[1] Includes 9 establishments engaged primarily in the manufacture of other products.

Ranked by the number of establishments, Pennsylvania stood first at each census, New York second, and Michigan third. Georgia in 1905 stands fourth, North Carolina fifth, South Carolina sixth, and Florida seventh. No other state reported more than 2 establishments.

TABLE 61.—*Wood distillation—value of crude products,[1] by states: 1905 and 1900.*

STATE.	1905	1900
United States	$6,538,769	$3,833,266
Georgia	78,313	....
Michigan	1,343,163	505,069
New York	1,222,383	786,252
North Carolina	74,501	18,409
Pennsylvania	3,127,350	2,339,536
South Carolina	15,419	....
All other states	677,040	184,000

[1] Includes crude products manufactured by establishments engaged primarily in the manufacture of other products.

At the census of 1900 Pennsylvania ranked first in the value of its crude products, New York second, and Michigan third. At the present census Pennsylvania ranks first, Michigan second, and New York third. At the census of 1900 the value of the crude products of Pennsylvania, New York, and Michigan amounted to $3,630,857, and constituted 94.7 per cent of the total for the United States, while at the census of 1905 it amounted to $5,692,896, and constituted 87.1 per cent of the total.

At the census of 1900 there were 9 establishments reporting the production of the crude material and the refining of the alcohol in the same factory. These establishments produced 637,856 gallons of refined alcohol, valued at $370,513; 5,124,000 pounds of acetate of lime, valued at $54,928; and 2,726,120 bushels of charcoal, valued at $114,663. At the census of 1905 the number of establishments thus reporting was 8, which produced 1,210,736 gallons of refined alcohol, valued at $503,884; 10,718,089 pounds of acetate of lime, valued at $110,517; and 9,275,543 bushels of charcoal (including 3,035,100 bushels produced and consumed) valued at $536,926.

The quantity of wood used in this industry at the census of 1900 was 490,939 cords, valued at $1,241,972, or an average of $2.53 per cord. Of this, 3,134 cords, valued at $7,822, consisted of soft wood, namely, long leaf pine. The quantity of wood used at the census of 1905 was 1,049,503 cords, valued at $3,755,627, or an average of $3.58 per cord. Of this, 31,431 cords, valued at $112,742, consisted of soft wood, principally long leaf pine. It was estimated in 1900, on the assumption that one man could cut on the average 1½ cords of wood per day, that the cutting of the wood required for the wood distillation industry for that year gave employment to 3,273 men for one hundred days each. The cutting of the wood required for the census year 1905 at the same rate would have given employment to 6,997 men for one hundred days each.

Up to the census of 1900 the wood distillation industry was confined to the distillation of the hardwoods, but at the census of 1900, 4 establishments were reported as being engaged in the distillation of pine wood, and at the census of 1905, 31 establishments were reported as being so engaged. The products of the distillation of pine wood are so unlike those of hardwoods that the statistics of the two industries should be reported separately. This was not done in the report on chemicals and allied products at the census of 1900, because the quantity and value of such products were relatively insignificant, but the growth of the industry requires that this now be done.

TABLE 62.—*Pine wood distillation products: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Value.	Quantity.	Value.
Total	....	$376,874	....	$31,148
Wood alcohol, gallons	18,000	1,800	62,238	7,570
Pyroligneous acid, gallons	277,500	8,005	12,296	316
Turpentine spirits, gallons	409,685	176,521	....	....
Tar, gallons	1,292,983	75,923	....	....
Tar oil, gallons	176,849	8,076	170,960	13,677
Charcoal, bushels	342,320	25,046	1,138	137
All other kinds	....	81,508	....	9,448

Table 62 shows an increase of $345,726, or of 1,109.9 per cent in the total value of products for 1905 as compared with 1900, and an increase also in every separate item for which a comparison is made except in the quantity and value of the wood alcohol and in the value of tar oil. Furthermore, an increased number of products is shown for 1905 as compared with 1900, which indicates a marked improvement in manufacturing methods and a more complete utilization of the distillation product.

Table 63 shows that the increase in the quantity of refined wood alcohol at the census of 1900 over that of 1890 was 2,871,798 gallons, or 1,726.4 per cent, and that the increase at the census of 1905, as compared with that of 1900, was 2,879,013 gallons, or 94.8 per cent, in quantity, and $1,158,727, or 50. 4 per cent, in value.

The quantity of lime used at the census of 1900 was 524,508 bushels, valued at $86,635, or an average of $0.165 per bushel, and at the census of 1905, 811,902 bushels, valued at $120,181, or an average of $0.148 per bushel.

TABLE 63.—*Production of refined wood alcohol: 1890 to 1905.*

CENSUS.	Number of establishments.	Gallons.	Value.
1905	15	5,917,153	$3,455,625
1900	18	3,038,140	2,296,898
1890	4	166,342	....

The quantity of caustic soda returned as used at the census of 1900 was 1,270,846 pounds, valued at $33,717, and at the census of 1905, 346,150 pounds, valued at $4,158. This very considerable shrinkage is believed to be due to the failure of refiners to make separate returns for this item of materials used. Chloride of lime, sulphuric acid, and muriatic acid were also reported at each census among the materials used, but the quantities were not sufficiently large to warrant them being presented separately.

In addition to the principal products of this industry there were returned at the census of 1900 as subsidiary products 182,446 gallons of pyroligneous acid, valued at $9,481; 308,400 gallons of dye liquors, valued at $29,440; and sundries, such as wood, creosote, wood oil, ashes, and tar to the value of $71,452. Many of these substances returned at the census of 1905 are accounted for in Table 61, the pine distillation industry having increased so greatly since 1900 as to warrant separate presentation. But there were also returned from the hardwood distillation in 1905 as subsidiary products 6,600 gallons of pyroligneous acid, valued at $566, and 55,960 gallons as produced and consumed; also 63,100 gallons of pyrolignite of iron, valued at $4,446; 22,000 gallons of red liquor, valued at $2,150; 28,000 gallons of iron liquor, valued at $345; 388,760 bushels of wood ashes, valued at $18,305; 62,700 pounds of acetone, valued at $6,897; and creosote to the value of $209.

The methods of manufacture followed in this industry were described in the report on chemicals and allied products for the census of 1900. The chief development of the intervening period has been in pine wood distillation in which processes for the utilization of pine stumps and of pines killed in the extraction of turpentine have been sought. Many of the establishments have failed to make a commercial success of this industry because of their inability so to conduct the process as to keep the products of the destructive distillation of the wood separate from the spirits of turpentine, but apparently this problem has now been solved satisfactorily, and the resources of the country in spirits of turpentine have been increased materially.

Table 64 gives the exports and imports of wood distillation products from 1891 to 1905, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

TABLE 64.—*Wood distillation products—exports and imports: 1891 to 1905.*

YEAR ENDING JUNE 30—	EXPORTS.				IMPORTS.	IMPORTS FOR CONSUMPTION.	
	Wood alcohol.		Acetate of lime.		Charcoal (value).	Acetic or pyroligneous acid.	
	Gallons.	Value.	Pounds.	Value.		Pounds.	Value.
1891	....	....	....	....	$56,020	10,946	$1,036
1892	....	....	....	....	48,029	12,280	2,302
1893	....	....	....	....	51,634	18,421	2,795
1894	....	....	....	....	40,249	22,244	3,959
1895	....	....	....	....	20,272	92,889	8,938
1896	....	....	....	....	42,970	....	....
1897	....	....	....	....	32,106	....	....
1898	385,938	$199,230	37,496,288	$537,856	2,404	127,949	9,776
1899	727,062	414,875	48,987,511	700,900	(1)	202,838	14,467
1900	540,799	320,306	47,790,765	776,413	(1)	292,891	19,189
1901	919,504	476,582	61,296,544	1,101,037	(1)	291,801	21,182
1902	626,925	338,619	60,488,509	962,265	(1)	139,028	14,629
1903	833,629	452,892	59,449,811	987,067	(1)	125,983	11,623
1904	1,194,466	585,359	64,256,945	1,103,389	14,844	142,620	9,262
1905	1,097,451	603,385	55,170,131	1,245,776	478	141,662	18,058

[1] Not reported separately.

CLASS VIII.—FERTILIZERS.

The class of fertilizers comprises superphosphate (acid phosphate), which is a mixture of the hydrated mono-calcium tetra-hydrogen, and di-calcium di-hydrogen phosphates with hydrated calcium sulphate; double superphosphate, which is hydrated mono-calcium tetra-hydrogen phosphate; ammoniates or substances containing nitrogen; ammoniated superphosphate, which is a mixture of ammoniates with superphosphate; complete fertilizers, which consist of mixtures of superphosphate, potash salts, and ammoniates; bones, tankage, and offal; ground bone; fish scrap; cottonseed meal; basic calcium nitrate; and cyanamid, or lime nitrogen. A comparison of the substances above enumerated with the materials used indicates that several of the substances are identical. This arises from the fact that each of these substances, as used in the manufacture of compounded fertilizers, possesses of itself fertilizing properties, and is sometimes used as fertilizer. This is true even of phosphate rock, which, under some circumstances is ground fine and applied to the soil, also of the phosphatic slag, Thomas slag, or Belgian phosphate, produced in the basic process of manufacturing steel, and of gypsum, or plaster. Where such substances are reported as being manufactured for sale as fertilizers, they are entered in this classification, together with special compositions not provided for above, under "all other fertilizers." Frequently they belong to the class of products consumed in further manufacture in the establishment where they were produced.

TABLE 65.—*Fertilizers—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	400	422	[1] 22	[1] 5.2
Capital	$69,023,264	$60,685,753	$8,337,511	13.7
Salaried officials, clerks, etc., number	1,618	1,712	[1] 94	[1] 5.5
Salaries	$1,940,712	$2,124,972	[1] $184,260	[1] 8.7
Wage-earners, average number	14,201	11,581	2,620	22.6
Total wages	$5,142,147	$4,185,289	$956,858	22.9
Miscellaneous expenses	$4,919,824	$3,734,285	$1,185,539	31.7
Cost of materials used	$39,343,914	$28,958,473	$10,385,441	35.9
Value of products	$56,632,853	$44,657,385	$11,975,468	26.8

[1] Decrease.

The data of Table 65 shows an increase in every item for 1905 as compared with 1900, except in those of the number of establishments, the number of salaried officials, clerks, etc., and the amount of salaries paid. As all the other items increased by from 13.7 to 35.9 per cent, there appears to have been consolidations in this industry in the interval which has elapsed since the census of 1900. The largest absolute increase appears in the value of products, and the largest percentage of increase, in cost of materials used.

TABLE 66.—*Fertilizers*[1]*—quantity and value of products, with amount and per cent of increase: 1905 and 1900.*

KIND.	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Superphosphates:				
Tons	[2] 1,670,978	[3] 1,480,414	190,564	12.9
Value	[2] $16,495,206	[3] $13,575,393	$2,919,813	21.5
Ammoniated superphosphates:				
Tons	781,354	143,648	637,706	443.9
Value	$13,020,825	$2,462,888	$10,557,937	428.7
Complete fertilizers:				
Tons	1,603,847	1,478,826	125,021	8.5
Value	$31,305,057	$26,318,995	$4,986,062	18.9
All other fertilizers:				
Tons	419,803	327,522	92,281	21.9
Value	$4,826,656	$4,723,430	$103,226	2.2

[1] Not including cottonseed meal.
[2] Includes 884,211 tons of superphosphates, with an assigned value of $8,674,110, consumed in establishments where manufactured.
[3] Includes 543,406 tons of superphosphates, with an assigned value of $4,983,033, consumed in establishments where manufactured.

From Table 66 it is seen that by far the largest increase in quantity and in value of the different kinds of fertilizers was in ammoniated superphosphates, which have increased in both respects more than 400 per cent. The marked relative increase in the value of complete fertilizers is brought out strikingly by the percentage column, an increase in quantity of only 8.5 per cent being accompanied by an increase in value of 18.9 per cent. Besides compounded fertilizers not provided for under ammoniated superphosphates or complete fertilizers, ground gypsum, marl, phosphate rock, bones or slag, wood ashes, leached and unleached, and other such materials are included under "all other fertilizers." Evidently much of such material which is produced and used escapes census enumeration, and returns under this heading will necessarily lack uniformity at the different censuses.

TABLE 67.—*Fertilizers—number of establishments,*[1] *by states and territories: 1905 and 1900.*

STATE OR TERRITORY.	1905	1900
United States	[2] 553	[3] 475
Alabama	21	21
Alaska	1	....
California	20	9
Colorado	3	....
Connecticut	11	9
Delaware	9	11
District of Columbia	4	7
Florida	8	7
Georgia	57	45
Illinois	25	12
Indiana	22	16
Iowa	6	1
Kansas	11	3
Kentucky	6	4
Louisiana	4	6
Maine	4	3
Maryland	41	42
Massachusetts	15	10
Michigan	2	1
Minnesota	8	1
Mississippi	5	3
Missouri	7	4
Nebraska	5	1
Nevada	1	....
New Jersey	28	30
New York	31	37
North Carolina	28	20
Ohio	24	28
Oregon	2	1
Pennsylvania	56	66
Rhode Island	2	1
South Carolina	20	24
Tennessee	12	5
Texas	4	2
Virginia	39	42
Washington	4	1
West Virginia	2	2
Wisconsin	4	....
Wyoming	1	....

[1] Does not include establishments making cottonseed meal.
[2] Includes 153 establishments engaged primarily in the manufacture of other products.
[3] Includes 53 establishments engaged primarily in the manufacture of other products.

Table 67 shows an increase in the number of establishments in 27 states and a decrease in 10, the actual increase for the whole United States being 78. The increase in Illinois was 13, in Georgia 12, and in California 11. There was a decrease of 10 in Pennsylvania; of 6 in New York; and of 4 each in Ohio and South Carolina. Georgia, which held the second place in 1900, takes the first place in 1905, and Pennsylvania, which held the first place in 1900, drops to second place. Maryland, Virginia, New York, and New Jersey now hold third, fourth, fifth, and sixth places, respectively. North Carolina passes from the ninth place to the sixth, sharing this place with New Jersey in 1905. Illinois rises from the eleventh to the seventh place and Indiana from the tenth to the ninth. Ohio falls from the sixth to the eighth place. Alabama falls from the eighth to the tenth place. California rises from the fourteenth to share with South Carolina, which falls from the seventh to the eleventh place. Massachusetts rises from the thirteenth to the twelfth and Tennessee from the seventeenth to the thirteenth place. Connecticut remains in the fourteenth place, sharing it, at the census of 1905, with Kansas, which has risen from the nineteenth place. Delaware falls from the twelfth to the fifteenth place, and Florida from the fifteenth to the sixteenth, sharing this place with Minnesota, which has risen from below the line of less than 3 estabishments. Missouri rises from the eighteenth to the seventeenth place.

Kentucky retains the eighteenth place, but shares it at the present census with Iowa, which has risen from below the line. Mississippi retains the nineteenth, but shares it with Nebraska, which has risen from below the line. Maine falls from the nineteenth to the twentieth. The District of Columbia has fallen from the fifteenth place, Louisiana from the sixteenth place, sharing the twentieth place with Texas and Washington, which rise from below the line, and with Wisconsin, which first appears at this census. Colorado, which also first appears at this census, occupies the twenty-first place. At the census of 1900 there were 25 states in which there were 3 or more establishments and 9 states in which there were less than 3. At the census of 1905 there were 32 states in which there were 3 or more and 7 states in which there were less than 3 establishments.

Although a consideration of the returns of the establishments primarily engaged in the manufacture of fertilizers as set forth in the comparative summary in Table 65 indicates that there has been a concentration of the industry in the interval from 1900 to 1905, yet when the inquiry is extended so as to include also those establishments which manufacture fertilizers as a secondary product, it becomes evident that this industry has, as a fact, become more widely diffused.

Table 68 shows that at both censuses the South Atlantic division leads in both quantity and value of products, with the North Atlantic second, the South Central third, and the North Central fourth. At the census of 1900 the product of the Western division exceeded that of "all other states" in value but was less in quantity. At the census of 1905 the product of the Western division stood fifth in both quantity and value.

TABLE 68.—*Fertilizers—quantity and value of products, by states and geographic divisions: 1905 and 1900.*

STATE OR DIVISION.	1905		1900	
	Quantity (tons).	Value.	Quantity (tons).	Value.
United States	3,591,771	$56,973,634	2,887,004	$42,097,673
North Atlantic division	709,875	12,320,747	685,893	11,978,666
Maine	4,613	74,991	1,828	27,902
Massachusetts	82,598	1,972,988	83,733	2,108,575
Connecticut	19,506	609,705	11,077	313,610
New York	106,010	1,695,949	164,266	2,610,435
New Jersey	285,613	4,523,675	247,144	3,820,189
Pennsylvania	211,535	3,443,439	177,845	3,097,955
South Atlantic division	1,924,623	28,039,923	1,531,688	19,462,816
Delaware	13,673	225,348	49,942	634,213
Maryland	523,493	6,715,402	386,133	5,213,925
District of Columbia	(1)	(1)	3,859	76,480
Virginia	250,877	3,902,938	258,474	3,325,542
North Carolina	181,330	2,865,501	139,582	1,727,270
South Carolina	254,408	3,498,127	388,572	4,657,275
Georgia	629,250	9,242,836	278,982	3,331,469
Florida	71,592	1,589,771	26,144	496,642
North Central division	405,236	7,487,078	258,726	4,349,157
Ohio	149,855	2,262,711	103,814	1,562,638
Indiana	30,022	447,158	11,668	238,161
Illinois	155,602	2,758,473	104,120	1,842,300
Wisconsin	1,419	31,081	(2)	(2)
Minnesota	7,503	156,749	(1)	(1)
Iowa	5,686	121,540	(1)	(1)
Missouri	17,078	369,547	8,753	156,115
Nebraska	16,750	545,369	(1)	(1)
Kansas	21,321	794,450	30,371	549,943
South Central division	512,482	8,001,153	352,778	5,053,564
Kentucky	32,137	541,553	17,315	295,520
Tennessee	159,593	2,663,062	93,054	1,464,788
Alabama	163,221	2,367,258	139,282	1,944,283
Mississippi	60,372	933,877	37,704	492,772
Louisiana	88,916	1,289,659	65,423	856,201
Texas	8,243	205,744	(1)	(1)
Western division	28,160	867,383	22,131	636,687
California	28,160	867,383	22,131	636,687
All other states [3]	11,395	257,350	35,788	616,783

[1] Included in "all other states."
[2] Not reported.
[3] Includes in 1905 Alaska, Colorado, District of Columbia, Michigan, Nevada, Oregon, Rhode Island, Washington, West Virginia, and Wyoming; and in 1900, Iowa, Michigan, Minnesota, Nebraska, Oregon, Rhode Island, Texas, Washington, and West Virginia.

TABLE 69.—FERTILIZERS—NUMBER OF ESTABLISHMENTS AND QUANTITY AND VALUE OF PRODUCTS, WITH AMOUNT AND PER CENT OF INCREASE: 1860 TO 1905.

CENSUS.	Number of establishments.	Quantity (tons).	Value.	INCREASE.			PER CENT OF INCREASE.		
				Number of establishments.	Quantity (tons).	Value.	Number of establishments.	Quantity (tons).	Value.
1905	553	3,591,771	$56,973,634	78	704,767	$14,875,961	16.2	24.7	35.3
1900	475	2,887,004	42,097,673	83	988,198	6,577,832	21.2	52.0	18.5
1890	392	1,898,806	35,519,841	114	1,171,353	15,598,441	41.0	161.0	78.3
1880	278	727,453	19,921,400	152	....	14,106,282	120.6	....	242.6
1870	126	....	5,815,118	79	....	4,923,774	168.1	....	552.4
1860	47	....	891,344	....	....	....	....	....	....

The statistics of Table 69 show a constant increase in every item. As compared with the returns for 1860 the product has at the census of 1905 increased $56,082,290, or 6,291.9 per cent in value, and as compared with the returns of the census of 1880, which is the first at which the quantity is recorded, it has increased 2,864,318 tons, or 393.7 per cent, in quantity.

Table 70 sets forth the materials used in the principal establishments only, at the censuses of 1900 and 1905, together with the amount and per cent of increase.

TABLE 70.—*Fertilizers*[1]*—quantity and cost of principal materials used, with amount and per cent of increase: 1905 and 1900.*

KIND.	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Fish:				
Thousands	923,305	458,963	464,342	101.2
Cost	$880,142	$183,542	$696,600	379.5
Kainit:				
Tons	190,493	54,700	135,793	248.3
Cost	$1,891,073	$520,833	$1,370,240	263.1
Limestone:				
Tons	20,281	7,158	13,123	183.3
Cost	$10,731	$7,322	$3,409	46.6
Phosphate rock:				
Tons	888,571	787,927	100,644	12.8
Cost	$4,244,554	$3,554,174	$690,380	19.4
Pyrites:				
Tons	342,962	288,778	54,184	18.8
Cost	$2,020,759	$1,466,285	$554,474	37.8
Sulphur:				
Tons	4,210	12,728	[2]8,518	[2]66.9
Cost	$92,234	$268,670	[2]$176,436	[2]65.7
Lime:				
Bushels	22,131	13,130	9,001	68.6
Cost	$3,475	$887	$2,588	291.8
Potash salts:				
Tons	122,107	....	....	....
Cost	$3,606,701	$3,098,400	$508,301	16.4
Nitrate of potash:				
Tons	1,160	884	276	31.2
Cost	$39,039	$32,156	$6,883	21.4
Nitrate of soda:				
Tons	42,213	19,518	22,695	116.3
Cost	$1,760,432	$709,841	$1,050,591	148.0
Wood ashes:				
Bushels	17,083	....	....	....
Cost	$2,050	....	....	....
Sulphuric acid:				
Tons	197,865	231,527	[2]33,662	[2]14.5
Cost	$1,084,304	$1,355,382	[2]$271,078	[2]20.0
Superphosphate:				
Tons	320,559	286,898	33,661	11.7
Cost	$2,912,010	$2,176,245	$735,765	33.8
Ammoniates:				
Tons	125,888	....	....	....
Cost	$2,445,051	....	....	....
Ammonium sulphate:				
Tons	10,540	3,678	6,862	186.6
Cost	$600,856	$186,609	$414,247	222.0
Common salt:				
Tons	2,406	481	1,925	400.2
Cost	$13,245	$2,211	$11,034	499.1
Cottonseed meal	$2,376,448	$167,410	$2,209,038	1,319.5
Bones, tankage, etc	$5,094,149	$9,766,735	[2]$4,672,586	[2]47.8

[1] Includes materials used in principal establishments only.
[2] Decrease.

The statistics presented in Table 70 show an increase in every item except in the quantity and value of sulphur, in the quantity and value of sulphuric acid, and in the value of bones, tankage, etc. Sulphur is used in the fertilizer industry in the manufacture of sulphuric acid, which is consumed in the manufacture of superphosphate from bones or from phosphate rock, and, as pointed out when discussing the manufacture of sulphuric acid under Class I, it is good practice to substitute pyrites for sulphur in the manufacture of the same, especially when it is to be used in the manufacture of superphosphate. Inspection of the table shows that while there was a decrease of 8,518 tons in the quantity of sulphur used, there was an increase of 54,184 tons in the quantity of pyrites used. The decrease in the quantity and value of the sulphuric acid purchased is accompanied also by a decrease in the quantity and value of the sulphuric acid produced for sale by these principal establishments, for, while in 1900 there were reported as thus produced 2,816 tons of 66° Baumé acid, valued at $50,004, and 66,952 tons of 50° Baumé acid, valued at $387,921, in 1905 there were reported as thus produced but 337 tons of 66° Baumé acid, valued at $9,521, and 23,997 tons of 50° Baumé acid, valued at $185,327. These statistics together with those for pyrites and sulphur combine to show that the practice of consuming in further manufacture the sulphuric acid made is increasing. The decrease in the value of the bones, tankage, etc., used may be partly accounted for by the separate presentation of the statistics for ammoniates at the census of 1905. As bones and tankage furnish phosphorus and nitrogen, the decrease in this item as regards its phosphorus contents is offset by the increase in the quantities of fish and phosphate rock used, and as regards its nitrogen contents, by the increase in the quantities of nitrate of potash, nitrate of soda, ammonium sulphate and cottonseed meal used. It is probable that much of the blood and bone tankage is now prepared for marketing by drying and pulverizing, and sold for use as a fertilizer without further compounding.

It should be definitely borne in mind that the materials enumerated in Table 70 are only those which were reported as used in principal establishments, while the statistics for production given in Table 66 include both the products of establishments in which the manufacture of fertilizers is a primary industry and those in which it is a secondary industry. But in establishments such as those engaged in slaughtering and meat packing, which alone returned at the census of 1905 a product of 211,137 tons of complete fertilizers, valued at $4,397,626, and 157,937 tons of fertilizing material, such as tankage, valued at $2,806,435, the materials used in the fertilizers other than the animals from which the blood, tankage and offal were obtained, formed so small a proportion of the whole that they were not enumerated separately and therefore could not be directly ascertained for insertion in Table 70. It is true that in the past complete fertilizers have averaged 8 parts of superphosphates to 2 parts of potash salts and 2 of ammoniates, the proportions being based upon the phosphorus, potassium, and ammonia contents or equivalents, but as in recent years there has been an increasing demand for compositions of the ratio of 10 : 2 : 2 any estimate of the quantity of these substances used must be quite rough, especially as by ammoniates in this connection all substances containing nitrogen are meant.

The quantities of materials available for use may be indicated by the fact that the by-product coke industry produced 15,773 tons of ammonium sulphate in 1905, while the principal fertilizer establishments used but 10,540 tons. In the same year the cottonseed-oil factories produced $27,428,762 worth of cottonseed meal and cake, while the principal fertilizer establishments used but $2,376,448 worth, or less than one-tenth of the total production.

The slaughterhouse fertilizing materials are marketed in three grades known to the trade as "blood," which is merely dried blood containing approximately 14 per cent of nitrogen; "tankage No. 1," containing approximately 8.2 per cent of nitrogen; and "tankage No. 2," containing nearly 5.8 per cent of nitrogen.

Table 71 gives the imports of fertilizers for the years 1890, 1900, and 1905 as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

Table 71.—FERTILIZERS—IMPORTS FOR CONSUMPTION: 1890 TO 1905.

YEAR ENDING JUNE 30—	PHOSPHATE, CRUDE OR NATIVE.		KIESERITE, KYANITE, OR CYANITE, AND KAINITE.		GUANO.		BONE DUST OR ANIMAL CARBON AND BONE ASH, FIT ONLY FOR FERTILIZING PURPOSES.		APATITE.		ALL OTHER SUBSTANCES, NOT ELSEWHERE SPECIFIED.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1890	31,179	$309,764	62,871	$422,225	8,432	$111,811	3,219	$59,059	126	$1,297	21,277	$333,109
1900	14,075	86,763	133,244	762,493	4,765	58,474	1,968	30,189	333	4,019	99,169	745,724
1905	131,196	753,004	240,790	1,143,296	34,431	545,354	5,551	89,110	98	1,276	130,149	1,973,588

Class IX.—Bleaching Materials.

The class of bleaching materials comprises chlorine, chloride of lime (chlorinated lime, bleaching powder), chloride of soda (chlorinated soda, solution of chlorinated soda, liquor sodae chloratae, Labarraque's solution, eau de Labarraque), and other hypochlorites, hydrogen dioxide (peroxide), sodium, magnesium, calcium, barium, and other dioxides (peroxides), sulphur dioxide or sulphurous acid, sulphites, and sodium, potassium, calcium, and other bisulphites (hydrogen or acid sulphites).

With the progress of invention in chemical manufacture many of these substances have come to be manufactured by the aid of electricity, and when so made they are grouped under Class X. They are, however, included in the discussion of Class IX when it is sought to ascertain the total quantity and value of the bleaching materials manufactured, the number of establishments engaged in the manufacture, and the geographic distribution of the industry considered as a whole.

Table 72 gives a comparative summary of the bleaching materials industry at the censuses of 1900 and 1905, together with the amount and per cent of increase, those establishments only being considered in which bleaching materials are the principal product, and in which they are made by processes other than by the aid of electricity.

Table 72.—*Bleaching materials—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	9	5	4	80.0
Capital	$221,874	$95,713	$126,161	131.8
Salaried officials, clerks, etc., number	54	10	44	440.0
Salaries	$60,339	$12,734	$47,605	373.8
Wage-earners, average number	66	66	....	....
Total wages	$38,049	$31,893	$6,156	19.3
Miscellaneous expenses	$67,352	$8,388	$58,964	703.0
Cost of materials used	$160,547	$37,096	$123,451	332.8
Value of products	$418,730	$104,801	$313,929	299.5

The statistics of Table 72 show an increase in every item except that of the number of wage-earners for 1905 as compared with 1900, the large gain of $313,929 being reported for value of products. The greatest proportional increase is found in miscellaneous expenses and the smallest in total wages.

Table 73 sets forth the quantity and value of the bleaching materials produced at the censuses of 1900 and 1905, together with the amount and per cent of increase. The figures for bleaching materials manufactured as a subsidiary product are included.

Table 73.—*Bleaching materials—quantity and value of products, with amount and per cent of increase: 1905 and 1900.*

KIND.	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Hypochlorites:				
Tons	19,588	10,979	8,609	78.4
Value	$535,835	$462,949	$72,886	15.7
Hydrogen dioxide:				
Pounds	4,370,614	588,335	3,782,279	642.9
Value	$413,221	$63,754	$349,467	548.1
Sulphur dioxide:				
Pounds	[1] 8,725,124	[2] 684,000	8,041,124	1,175.6
Value	[1] $45,983	[2] $9,493	$36,492	384.4
Bisulphites:				
Tons	6,223	1,461	4,762	325.9
Value	$110,155	$34,486	$75,669	219.4
Chlorine, pounds	[3] 15,670,000	8,784,000	6,886,000	78.4
All other products, value	$98,396	$26,643	$52,163	195.8

[1] Includes 8,684,000 pounds, with an assigned value of $45,526, consumed in establishments where manufactured.
[2] Includes 333,415 pounds, with an assigned value of $4,667, consumed in establishments where manufactured.
[3] Consumed in establishments where manufactured.

The statistics of Table 73 show that the largest actual increase at the census of 1905 as compared with that of 1900 was in the quantity of hypochlorites produced, although in percentage of increase this item is the lowest. The greatest percentage of increase in quantity produced was reported for sulphur dioxide, the largest part of which product was, however, consumed in further manufacture in the establishments where produced. In values reported the greatest actual increase as well as the largest percentage of increase was in the production of hydrogen dioxide. It is also to be noted that all of the chlorine reported in the table was produced and consumed.

TABLE 74.—*Bleaching materials—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1]33	[2]26
Illinois		3
Maryland	1	
Massachusetts	4	
Michigan	2	1
Missouri	2	2
New Jersey	3	3
New York	11	10
Ohio	3	1
Pennsylvania	7	6

[1] Includes 24 establishments engaged primarily in the manufacture of other products.
[2] Includes 21 establishments engaged primarily in the manufacture of other products.

The statistics of Table 74 show a net gain of 7 in number of establishments in 1905 as compared with 1900, or 26.9 per cent. Illinois, which reported 3 establishments in 1900, reported none in 1905, while Massachusetts, from which no establishments were returned at the census of 1900, reported 4. New York ranked first in the number of establishments at each census, and Pennsylvania second. Massachusetts, which appears for the first time at this census, held third place. No other state reported more than 3 establishments at either census.

Table 75 shows, for the establishments manufacturing bleaching materials either as a principal or subsidiary product, the quantity and value of the materials used as reported at the censuses of 1900 and 1905, together with the increase and per cent of increase.

TABLE 75.—*Bleaching materials—quantity and cost of principal components used, with amount and per cent of increase: 1905 and 1900.*

KIND.	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Salt:				
Tons	[1]15,713	9,055	6,658	73.5
Cost	[1]$38,141	$19,105	$19,036	99.6
Lime:				
Bushels	[2]358,074	158,561	199,513	125.8
Cost	[2]$30,600	$20,532	$10,068	49.0
Caustic soda:				
Tons	324	168	156	92.9
Cost	$13,175	$7,618	$5,557	72.9
Manganese dioxide:				
Pounds	84,444	93,000	[3]8,556	[3]9.2
Cost	$1,200	$1,325	[3]$125	[3]9.4
Muriatic acid:				
Tons	251	227	24	10.6
Cost	$6,275	$4,325	$1,950	45.1
Soda ash:				
Tons	733	974	[3]241	[3]24.7
Cost	$15,353	$23,368	[3]$8,015	[3]34.3
Potash:				
Tons	11	7	4	57.1
Cost	$1,084	$420	$664	158.1
Sulphur:				
Tons	2,171	171	2,000	1,169.6
Cost	$45,526	$4,000	$41,526	1,038.2
Barium dioxide:				
Tons	218	74	144	194.6
Cost	$53,849	$16,540	$37,309	225.6
Phosphoric acid:				
Pounds	[4]551,206	74,490	476,716	640.0
Cost	[4]$104,286	$14,898	$89,388	600.0
Bleaching powder:				
Tons	55	44	11	25.0
Cost	$1,500	$1,570	[3]$70	[3]4.5
Metallic sodium, pounds	[4]180,000	92,600	87,400	94.4

[1] Includes 13,020 tons of salt from brine or the by-product of other industries having an estimated cost of $29,823.
[2] Includes 9,864 bushels of lime, having an estimated cost of $592, consumed in other manufacture.
[3] Decrease.
[4] Estimated.

From Table 75 it will be seen that there is an increase in every item except in the quantity and value of manganese dioxide, the quantity and value of soda ash, and the value of bleaching powder. The manganese dioxide is used with muriatic acid in making chlorine bleach, such as the chloride of soda from soda ash, and is of minor importance, particularly as electrolytic chlorine is now being produced most abundantly and cheaply, while the product may also be obtained easily from bleaching powder. The decrease in cost of bleaching powder has no significance when the small quantities used are considered.

The greatest increase in quantity is found in phosphoric acid, the next greatest in lime, and the third in salt. The greatest increase in cost is found in phosphoric acid, the next greatest in sulphur, the third in barium dioxide, and the fourth in salt. The greatest percentages of increase are found in the quantity and cost of sulphur and the next greatest in the quantity and cost of phosphoric acid, while barium dioxide rank third.

TABLE 76.—*Bleaching materials—value of products, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1]$1,158,064	[1]$592,658
Illinois		42,399
Massachusetts	41,746	
New Jersey	46,595	39,171
New York	799,521	407,327
Ohio	13,774	(2)
Pennsylvania	37,761	15,878
All other states[3]	218,667	87,883

[1] Includes value of products consumed in establishments where manufactured.
[2] Included in "all other states."
[3] Included in 1905, Maryland, Michigan, and Missouri; in 1900, Michigan, Missouri, and Ohio.

The statistics of Table 76 show that New York ranked first at each census in the value of products. New Jersey passed from the third place in 1900 to the second place in 1905, displacing Illinois, which did not report any production of bleaching materials at the last census. Massachusetts, which appeared in 1905 for the first time, ranked third. The returns for the state of Illinois at the census of 1900 were from establishments in which bleaching materials were packed. At the census of 1905 the reports from such establishments were included under another category.

From the returns it appears that all of the bleaching powder was made from electrolytic chlorine produced from salt. The principal competing process is that in which the salt is first decomposed by the Le Blanc method for producing soda products, forming hydrochloric acid, which is then oxidized to set its chlorine free. Although the latter is the older process and was well and widely established, yet, according to Hasenclever,[1] of the 260,000 tons of bleaching powder, representing the world's production in 1905, one-half was produced electrolytically. The total production of bleaching powder in Germany in 1905

[1] Journal of Society of Chemical Industry, 1907, vol. 25, page 1011.

was 60,000 tons, of which 65 per cent was prepared electrolytically from potassium chloride.

Although, through the discoveries of Knietsch, liquid chlorine has been made an article of commerce and is found extremely useful and convenient in many industries and for laboratory purposes, and although efforts are also being made to find new avenues for the disposal of the chlorine output of this country, yet at no census has there been any return made of liquid chlorine as a product.

The most novel advance in this industry since the census of 1900 is perhaps that found in the development of the dioxides or peroxides and their derivatives. The preparation, properties, and uses of sodium dioxide were set forth to some extent in the report on chemicals and allied products at the census of 1900. Harold J. Turner[1] has devised a very ingenious method for utilizing this material as a source of oxygen.

The action of water on fused sodium peroxide is one of the most convenient and elegant methods for the preparation of oxygen for laboratory or lecture purposes. The liberation of the gas is so lively, however, that a specially constructed generator is usually required to enable one to control the evolution of it. To prepare a small quantity, the most efficient method is the decomposition of the substance by means of water of crystallization. A mixture of equal parts of fused sodium peroxide and crystallized sodium sulphate or carbonate, upon being gently warmed, evolves oxygen in a steady stream, under perfect control of the operator. A 10-gram piece of "oxone" readily evolves, by this process, 4 liters of oxygen. The oxygen is 99 per cent pure, perfectly odorless, tasteless, and colorless. Within the last few months calcium carbide has been decomposed by a like process, known as the Atkins system, with the production of the so-called "sun gas," which is being developed by the Sun Gas Company, of London.

Fused sodium dioxide is now put upon the market under the trade name of oxone. This product has a specific gravity of 2.43; it is hard, but not brittle, and is capable of being cast into any convenient shape; it can be easily transported, without detriment or any mechanical or chemical change, and can be stored and protected from moisture, without any danger or risk of deterioration. Upon contact with water oxone liberates pure oxygen gas, just as calcium carbide in water liberates acetylene gas. The amount of gas thus yielded averages 2.2 cubic feet per pound, or 60 liters reduced to normal pressure and temperature, which corresponds to 322 times the volume of the body. The oxygen evolved is of 99 to 100 per cent purity, the only impurity consisting of a slight vapor caused by the energy of reaction, which is easily absorbed by passing the gas through water, thus furnishing an absolutely pure material. This chemical, furthermore, has the property of absorbing carbon dioxide and moisture, a quality which, combined with its oxidizing capacity, makes it an ideal disinfectant and air purifier. Oxone is sold in the following shapes: In crude form, in 2-pound and 10-pound tins, and in bulk; in cartridges, in boxes of 20, generating 7 to 8 gallons of pure oxygen gas; and in square cakes, 16 in one tin, for calcium lights, averaging 160 liters of oxygen gas.

The use of oxone for the purpose of making confined spaces habitable has been carefully studied by G. F. Brindley and R. von Foregger,[2] who find that one kilogram of oxone would enable a man to live for five hours and twelve minutes in a supply of air sufficient for a single respiration.

Even more novel, possibly, is the manufacture on a commercial scale of other peroxides and their derivatives.

TABLE 77.—*Peroxides now offered in commerce, other than sodium peroxide.*

KIND.	Per cent of peroxide.	Per cent of available oxygen.	Volumes of active oxygen compared with one volume of water.	Method of packing.
Peroxide of calcium	70–85 CaO_2	16–18	120	½-lb. tins and upward.
Peroxide of magnesium	25–32 MgO_2	7–9	60	½-lb. tins and upward.
Peroxide of zinc	50–60 ZnO_2	8–10	70	½-lb. tins and upward.
Peroxide of strontium	90–95 SrO_2	12–12.75	90	½-lb. tins and upward.
Perborate of sodium	100 $NaBO_3+4H_2O$	9–10	70	½-lb. cartons. 1-lb. cartons. 25 and 50 lb. kegs.
Perborate of zinc		7–8	55	½-lb. tins and upward.
Perborate of magnesium		9–10	70	½-lb. tins and upward.

The peroxides named in Table 77 are active bleaching agents and hence efficient disinfectants. The various compounds, however, differ in solubility in water and hence in the rate at which they evolve ozone. Because of their relative insolubilities and slow rate of reaction, calcium and magnesium peroxides have come to be used to some extent, either alone or in admixture with other substances, for tooth powders, the ozone set free or hydrogen peroxide formed serving to cleanse and purify the teeth.

Table 78 sets forth the imports of chloride of lime, or bleaching powder, for the years 1891 to 1905, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

TABLE 78.—*Chloride of lime, or bleaching powder—imports: 1891 to 1905.*

YEAR ENDING JUNE 30—	Pounds.	Value.
1891	107,475,715	$1,429,509
1892	110,748,289	1,839,640
1893	120,811,918	2,213,121
1894	81,610,463	1,507,076
1895	100,456,774	1,644,835
1896	104,053,877	1,579,358
1897	99,274,138	1,375,560
1898	114,232,578	1,421,920
1899	113,107,250	1,159,271
1900	136,403,151	1,464,019
1901	110,960,523	1,371,028
1902	130,251,696	1,788,354
1903	107,827,117	1,126,666
1904	99,085,386	772,532
1905	96,119,711	776,281

[1] Dry Method for the Generation of Oxygen from Sodium Peroxide. American Chemical Journal, vol. 37, No. 1, January, 1907, page 106.

[2] Report of Experiments with Fused Sodium Peroxide for the Regeneration of Air in Submarines. Ninth General Meeting of the American Electrochemical Society, Ithaca. N. Y., May 1, 2, and 3, 1906.

Class X.—Chemicals Produced by the Aid of Electricity.

This classification appeared for the first time in the special report on chemicals and allied products for the census of 1900. In the comparatively short time that has elapsed since electricity was first practically employed in the manufacture of chemicals, many new and advantageous processes have been found, which have resulted not only in the more economical production of substances already obtained by other methods, but also in the addition of some hitherto unknown to commerce. With the constant progress of discovery and invention in this field it is to be expected that the industry will show an ever widening range in the substances produced, as well as a steady increase in the quantity and value of its products. At the present time these products include, commercially, aluminum, bromine, carbon (in its allotropic form of graphite or plumbago), lead, phosphorus, silicon, and sodium among elementary substances; ferrochrome, ferromanganese, ferrosilicon, and the titanium, tungsten, and vanadium compositions among alloys; and adamite (fused corundum), alundum (artificial corundum), barium hydroxide, calcium carbide, carbon disulphide (bisulphide), carborundum (silicon carbide), caustic soda (sodium hydroxide), hydrochloric acid, litharge and other lead oxides, potassium chlorate (chlorate of potash) potassium hydroxide (caustic potash), siloxicon, and white lead among compound substances.

In this report all establishments producing the above substances, as described, by electricity are included under the present classification. Furthermore, there are establishments in which the direct products of these electrical processes, such as bromine, chlorine, carborundum, hydrogen sulphide, phosphorus, sodium, and the like are partly or wholly consumed on the premises in which they are produced in the further manufacture of potassium bromide, bleaching powder, graphite, sulphuric acid, phosphorus acids, sodium cyanide, sodium and other dioxides, or other substances, and such establishments are also included here, although other establishments which use their original product to produce the same final product, but without the aid of electricity, are classified elsewhere.

Table 79.—*Electro-chemicals—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	Census.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	20	13	7	53.8
Capital	$11,495,537	$9,170,750	$2,324,787	25.4
Salaried officials, clerks, etc., number	245	88	157	178.4
Salaries	$345,475	$134,033	$211,442	157.8
Wage-earners, average number	2,082	733	1,349	184.0
Total wages	$1,111,850	$374,836	$737,014	196.6
Miscellaneous expenses	$1,457,191	$293,608	$1,163,583	396.3
Cost of materials used	$2,442,596	$900,554	$1,542,042	171.2
Value of products	$7,048,246	$2,036,261	$5,011,985	246.1

The statistics of Table 79 show an increase in every item, the value of products making the substantial gain of $5,011,985, or more than doubling. The greatest proportional increase is presented in miscellaneous expenses, and the next in the value of products. In considering Table 79 it should be noted that the statistics for 1905 include those for the manufacture of aluminum, while in 1900 the returns for this industry were presented under another heading. It must also be pointed out that these figures give but a partial indication of the extent to which electricity is employed in chemical processes of manufacture. The returns from the recovery of gold, silver, copper, iron, and other strictly metallurgical products are included in other categories, while no report at all is made of the oxygen and hydrogen which some establishments manufacture extensively for the purpose of employment in producing high temperatures, or of the bleaches which textile establishments produce for their own use exclusively; and other exceptions could probably be found.

Table 80.—*Electro-chemicals—number of establishments, by states: 1905 and 1900.*

State.	1905	1900
United States	[1]21	[1]14
Connecticut	.....	1
Maine	1	1
Michigan	4	1
New Hampshire	.....	1
New York	14	10
Virginia	1	.....
West Virginia	1	.....

[1] Includes 1 establishment engaged primarily in the manufacture of other products.

New York ranked first at each census in the number of establishments engaged in this industry, reporting two-thirds of the total number returned in 1905. At the census of 1905 Michigan reported 4 establishments. No other state returned more than 1 establishment at either census. This overwhelming supremacy of New York is a consequence of the fact that hitherto the electro-chemical industry has depended primarily for its success on cheap and abundant supplies of water-power, such as are found at Niagara Falls. With the improvements in the efficiency of internal combustion engines, however, through which producer gas, the surplus gas from by-product coke ovens, and the waste gases from blast furnaces may be utilized economically, and with the constant inventions through which other sources of energy in nature may be made use of, it is reasonable to expect a wider distribution of this industry in the future. Indeed it seems possible that other hitherto unused sources of energy may be available at the present time, since it appears by no means impracticable to employ hydrogen sulphide, sulphur vapors, and other combustible gases as the fuel in internal combustion engines and then to utilize their products of combustion in further manufacture.

TABLE 81.—*Electro-chemicals—value of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
United States	$7,068,246	$2,045,535
North Atlantic	6,037,533	1,852,279
North Central	827,583	(1)
All other divisions	203,130	193,256

[1] Included in "all other divisions."

Out of the total value of products returned at the census of 1900, New York reported $1,836,606, or 89.8 per cent; while at the census of 1905, out of the total of $7,068,246, that state also reported substantially all shown for the North Atlantic division.

TABLE 82.—*Electro-chemicals—quantity and cost of principal materials used, with amount and per cent of increase: 1905 and 1900.*

KIND.	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Alumina and bauxite:				
Tons	14,164	....	....	....
Cost	$591,563	....	....	....
Carbons, cost	$230,744	$32,121	$198,623	618.4
Coal and coke:				
Tons	19,125	11,614	7,511	64.7
Cost	$97,281	$46,229	$51,052	110.4
Lime:				
Bushels	1,309,716	(1)	(1)	(1)
Cost	$133,333	(1)	(1)	(1)
Ores, chrome and iron:				
Tons	3,459	....	....	....
Cost	$54,539	....	....	....
Phosphate rock and other minerals:				
Tons	6,189	3,364	2,825	84.0
Cost	$44,437	$24,812	$19,625	79.1
Potassium salts:				
Tons	3,908	1,900	2,008	105.7
Cost	$200,008	$80,097	$119,911	149.7
Salt:				
Tons	13,175	(1)	(1)	(1)
Cost	$30,259	(1)	(1)	(1)
Sodas:				
Tons	1,717	(1)	(1)	(1)
Cost	$72,188	(1)	(1)	(1)
All other materials, cost	$338,522	$247,300	$91,222	36.9

[1] Included in "all other materials."

The statistics of Table 82 show an increase in the case of each substance presented separately at both censuses, the largest increase in quantity being found in coal and coke and the next in phosphate rock. The greatest increase in cost among the materials enumerated is found in carbons and the next in potassium salts. This latter includes muriate of potash and potash salts. The percentages show some exceptionally large increases, but this is a necessary consequence in an industry which came into existence but a short time before the census of 1900 and at the census of 1905 had just attained to a respectable importance. It may cause remark that coal, coke, and charcoal, which are usually used as fuels, appear as materials used, but as a fact carbon, in one of these various forms, enters as one of the components into the production of calcium carbide, carbon disulphide, carbon tetrachloride, carborundum, and other carbon compounds.

As already indicated, Niagara Falls, N. Y., is to-day the chief seat of the electro-chemical industry and it has held this rank since the industry was introduced into this country. On the occasion of the holding of the International Electrical Congress in September, 1904, a guide[1] for visitors from abroad attending the congress and visiting Niagara Falls was prepared under the auspices of the American Institute of Electrical Engineers, from which it appears that in 1904 there were two companies, the Niagara Falls Hydraulic Power and Manufacturing Company and the Niagara Falls Power Company, both situated on the American side of the Niagara river, engaged in transforming the energy of the water into electricity, while three companies were then engaged in developing plants on the Canadian side for the purpose. The Niagara Falls Hydraulic Power and Manufacturing Company established its first station for supplying electricity for commercial purposes in 1881, and it was here that the public distribution of electricity from Niagara Falls began. In 1904 current was being supplied from its power house to the Pittsburg Reduction Company for use in the isolation of aluminum; to the National Electrolytic Company for the manufacture of chlorate of potash; and to the Acker Process Company for the manufacture of caustic soda, bleaching powder, tetrachloride of tin (known to the trade as bichloride of tin), oxide of tin, tin crystals, and carbon tetrachloride. The Niagara Falls Power Company supplied current to the Pittsburg Reduction Company; to the Carborundum Company for the manufacture of silicon carbide and silicon; to the Union Carbide Company for the manufacture of calcium carbide; to the Electrical Lead Reduction Company for the manufacture of spongy lead, litharge, red lead, and white lead; to the International Acheson Graphite Company for the manufacture of graphite, graphite paint, and graphitized electrodes; to the Roberts Chemical Company for the manufacture of caustic potash and hydrochloric acid; to the Norton Emery Wheel Company for the manufacture of alundum; and to the Niagara Research Laboratories, where new electro-chemical processes are tested on a large scale and with a view to their commercial form until factory conditions are determined.

There appear to have been other establishments making electro-chemical products at Niagara Falls that are not enumerated in the publication just mentioned. Taking into account all the establishments, it is reported that the average consumption of electric energy in the electro-chemical industries of Niagara Falls was, at the census of 1900, 15,161 kilowatts and, at the census of 1905, 37,910 kilowatts. The peak load figures were naturally higher than this, being about 50 per cent greater at the census of 1900 and about 23 per cent greater at that of 1905. It is reasonable to expect, as the manufacture of electro-chemicals increases in magnitude and operating methods are perfected, that the percentage of difference between the average and the peak load will be a diminishing quantity.

[1] The Niagara Falls Electrical Handbook.

Table 83, taken from The Mineral Industry,[1] sets forth the quantity and value of the aluminum produced, imported, exported, and consumed in the United States from 1897 to 1906.

[1] The Mineral Industry, vol. 15, page 11.

TABLE 83.—ALUMINUM—PRODUCTION, IMPORTS, EXPORTS, AND CONSUMPTION: 1897 TO 1906.

YEAR.	PRODUCTION.			IMPORTS.			Exports (value).	Consumption (value).
	Pounds.	Value.	Per pound.	Crude. Pounds.	Crude. Value.	Manufactures (value).		
1906	14,350,000	$5,166,000	$0.36	770,713	$154,292	$1,866	$364,251	$4,957,907
1905	11,350,000	3,632,000	0.32	530,429	106,108	33	290,777	3,015,364
1904	7,700,000	2,233,000	0.29	515,416	128,350	478	166,876	2,494,952
1903	7,500,000	2,325,000	0.31	498,655	139,298	4,273	157,187	2,311,384
1902	7,300,000	2,284,590	0.31	745,217	215,032	3,819	116,052	2,387,389
1901	7,150,000	2,238,000	0.31	564,803	104,168	5,580	183,579	2,164,169
1900	7,150,000	2,288,000	0.32	256,559	44,455	5,989	281,821	2,056,623
1899	6,500,000	2,112,500	0.33	53,622	9,425	7,828	291,515	1,838,238
1898	5,200,000	1,690,000	0.33	60	30	13,840	238,997	1,474,268
1897	4,000,000	1,400,000	0.35	1,822	1,082	3,647	(1)	1,404,729

[1] Not reported.

Continuing, The Mineral Industry says:

Aluminum is now a strong competitor with copper and other metals, and doubtless the increase in the price of copper has been instrumental, on this account, in the rise in price of aluminum which occurred during 1906. However, the fact that the demand is far in excess of production is the chief reason for the present high price of aluminum. The amount of aluminum consumed is limited only by the number of furnaces which are now in operation, and by the capacity of the dynamos which operate the furnaces.

The Pittsburg Reduction Company (now the Aluminum Company of America) was the only producer. It owns large bauxite deposits in Georgia, Alabama, and Arkansas, obtaining, however, most of its ore from Saline county in the latter state. It has done a large amount of stripping and development work at its mines at Bauxite, Ark., also is just completing there a new crushing, grinding, and drying plant, and has built a railroad called the Bauxite and Northern, connecting all of its mines in that region with the Chicago, Rock Island and Pacific Railroad and the Missouri Pacific and Iron Mountain systems. This company has realized that reserve stores of bauxite are as essential to the welfare of a large aluminum company as reserves of iron ore are to a great steel corporation, and it has accordingly spent large sums of money in purchasing bauxite lands both in the eastern district—Georgia and Alabama—and in Arkansas.

Concerning the production of pure alumina, this company has enlarged to great dimensions its chemical plant at East St. Louis. The process used is the same as heretofore, but the capacity of the plant has been increased several times. The power for the plant is furnished by condensing turbine engines; the evaporating plant is the most complete and largest of its kind ever built.

The carbons used in the reduction are now manufactured entirely by this company, being baked in electrically heated furnaces patented by Charles M. Hall. The old plant for making carbons, at the upper Niagara works, has been practically torn down and rebuilt to three times its previous capacity; the buildings are of steel, with traveling cranes and every up-to-date conveying appliance; the new plant has an equipment and capacity equal to that of any other carbon electrode plant in the world.

The rolling and sheet mills of the company have been correspondingly enlarged; a new mill for this purpose is in course of construction at Niagara Falls. This is of reinforced concrete, and when finished will be one of the largest and most complete sheet rolling mills in America.

The work thus done by this company within the last three years, in plants and processes entirely outside of the reduction of the metal, has been on a scale which, remembering the former infancy of the aluminum industry, may be properly characterized as stupendous. The investments thus made in these accessory enterprises have amounted to several millions of dollars.

The reduction plants of this company, at Niagara Falls, Massena, N. Y., and Shawenegan Falls, Quebec, Canada, are all in process of being greatly enlarged. At Niagara Falls, the lower plant, using power supplied from the canal of the Niagara Falls Power and Manufacturing Company, which has heretofore been reported as of 12,000 horsepower capacity, has been increased by the building of a very large plant to use 45,000 horsepower, consisting of five units of 9,000 horsepower each. Two of these units (18,000 horsepower) will be in operation by May, 1907, and the whole plant in June, 1907. At Shawenegan Falls, the company is quadrupling its already large capacity and expects the new plant to be finished ready for operation in April, 1907. This plant is nominally controlled by the Northern Aluminum Company, which is a subsidiary company of the American company, and manufactures aluminum chiefly for export; it is expected that this increased capacity will exceed the demands for export, but the company is intent upon providing reserve facilities equal to all possible demands of the near future. At Massena, the company has purchased the entire plant of the St. Lawrence River Power Company, with its canal and power house of 40,000 horsepower capacity, and is actively preparing to dredge out the canal to double this capacity. One of the largest of modern dipper dredges and the most powerful elevator dredge ever built have been installed ready to commence operations as soon as the winter is over. The complete dredging plant has cost over a million dollars. A new power house for this enlarged capacity will be started in 1907, and eight large water wheels, to absorb the capacity of the first canal, have been purchased and will be placed in position in the old power house within a few months. The output of this plant in 1907 will be from two to three times the output of 1906.

Bradley's United States Patent No. 168148, covering the production of aluminum from a molten electrolyte by the action of the internally generated electrical heat of the decomposing current and without the aid of external heat, was confirmed by the United States circuit court of appeals, and this patent holds until February, 1909. Hall's original patent, covering the electrolysis of a melted bath of double fluoride of aluminum and a more positive metal, as a solvent for alumina, expired on April 2, 1906, and as such is now the property of the public, but it must be operated by externally applied heat.

Aluminum[1] is largely supplanting phosphide of copper as a deoxidizer in brass and bronze, in which it acts by reducing the oxides of copper, zinc, or tin with which the metal may be contaminated. A small excess of aluminum does not injure the metal so much as a small excess of phosphorus. Care must be taken, however, not to cast the alloy immediately after using the deoxidizer, since the alumina formed must be given an opportunity to rise out of the metal and enter the slag. If this is not done, the quality of the metal may be injured by the intermingled alumina. With pure copper used for electrical purposes, silicon is found superior as a deoxidizer to aluminum, because the silica formed is less infusible, tends to unite with copper oxide to a fusible slag, and thus gets out of the melted metal quicker and more completely, leaving it with higher electric conductivity.

Dr. Hans Goldschmidt, the inventor of the process of reducing metallic oxides by powdered aluminum, has recently patented improvements in his method of obtaining fluid iron at high temperature for welding purposes. In place of aluminum as the sole reducing agent acting upon iron oxide, producing the difficultly fusible alumina, he uses a granulated alloy of calcium and aluminum, or a mixture of these two metals in granular form. This alloy gives a very high thermal effect, higher even than aluminum alone, while the heat of formation of the aluminate of lime slag is also utilized, and the slag is much more fusible than alumina alone.

According to The Mineral Industry, volume 15, page 28—

The manufacture of alundum was begun by the Norton Emery Wheel Company, of Worcester, Mass., in 1904. It is an artificial product formed in the electric furnace from bauxite, and is used as an abrasive. Its chemical composition is exactly the same as that of natural corundum. The production of alundum has been as follows: In 1904, 4,020,000 pounds, valued at $281,400; in 1905, 3,612,000 pounds, valued at $252,840; in 1906, 4,331,233 pounds, valued at $303,186.

Before the invention of the electric furnace, artificial abrasives suitable for grinding purposes were unknown, and manufacturers necessarily depended upon natural products, chiefly corundum, emery, and garnet. Briefly, the process of making alundum consists in taking the mineral bauxite (oxide of aluminum), purifying it and melting in an electric furnace into a large homogeneous mass. Upon cooling, this molten fluid solidifies and crystallizes in solid masses of alundum of great purity and uniformity.

The bauxite is heated in large preliminary furnaces to drive off its combined water and is then melted directly in electric furnaces of special design. There are 11 electric furnaces installed at the company's plant at Niagara Falls, N. Y., each furnace being capable of producing three tons of alundum per twenty-four hours. The temperature at which the bauxite melts into a homogeneous mass is estimated at between 6,000 and 7,000 degrees Fahrenheit.

After the large masses of molten bauxite have cooled in the furnace, the fusion is broken up by crushers and passed through rolls to reduce the product to various sizes of grain, which are finally graded by passing through sieves of different mesh in preparation for manufacture into grinding wheels and blocks, polishing stones, etc.

Alundum is much harder than the correspondingly natural product, corundum, represented by the sapphire or ruby, and alundum powder is used for cutting and drilling rubies and sapphires for watch jewels, but its chief use is in the manufacture of "artificial emery" grinding wheels, as they are called.

Many new applications of carborundum have recently been made in the arts, but notwithstanding its varied uses in the mechanical, chemical, and metallurgical fields its application as an abrasive is still of chief importance and consumes the major part of the production.

In this field a development of great interest is the application of carborundum to the marble industry. The methods of cutting, dressing, and polishing marble are now in a process of rapid and complete revolution owing to the use of carborundum wheels. A complete line of machinery has been developed for the various operations of coping, countersinking, molding, rubbing, and polishing, which largely dispenses with the old style machine tools and also with skilled labor. The molding machine equipped with carborundum wheels is capable of removing stock at the rate of 60 cubic inches per minute. The carborundum drum rubber displaces five of the old style rubbing beds.

The methods of beveling plate glass have undergone radical changes and one operator is now able to bevel 6,500 feet per day, using in this time 10 pounds of carborundum grains. The use of carborundum has long been general throughout the granite industry and its introduction in the marble and glass industries naturally follows and promises equally important economies.

Carborundum paper is now being introduced in the woodworking trades, where it displaces garnet paper, and into the hat trade, in competition with fine flint paper for pouncing and finishing hats. The paper industry now utilizes carborundum in the form of blocks for the construction of bedplates in the beaters and for the lining of Jordan engines. It assists in refining the pulp.

Carborundum applied to nonslipping stair treads, carriage treads, and to nonslipping horseshoes has been made the subject of several recent patents. This branch of the trade consumes an important amount of product. Carborundum is being introduced for the same purpose in the construction of cement pavements and sidewalks.

Amorphous carborundum, or as it is commercially called, carborundum fire-sand, is now widely used as a refractory material, and the methods of using it in the form of bricks and various furnace linings have been the subject of a large number of patents both in this country and abroad. This product occurs in the carborundum furnace immediately outside the crystalline zone and contains carbon, silicon, and oxygen in the form of various compounds representing the partial reduction of silica by carbon. It is used in lining crucible furnaces for melting brass and also in the later designs of tilting brass furnaces, especially in those burning crude oil fuel. It resists severe flame action as do few refractory materials available to the furnaceman. The material is ground to the fineness of about No. 20 mesh and is mixed according to the following formula: Carborundum fire-sand, 70 parts; fire clay, 15 parts; silicate of soda, 52° B., 8 parts; water, 7 parts. This mixture is tamped in place and slowly dried. When subjected to furnace temperatures it burns into a strong refractory body. Amorphous carborundum is one of the few refractories which can withstand the heat of the powdered coal flame. Fire bricks made from carborundum are now on the market and have given favorable results in the arches of copper reverberatory furnaces and also in boiler furnaces where special smoke consuming devices are used. The use of both crystalline and amorphous carborundum for the manufacture of zinc retorts is increasing, especially among foreign smelters, and many hundreds of tons were exported for this purpose during 1906. The best results are obtained by making the inner lining of the retort of carborundum and the exterior of fire clay. W. A. McAdam (British patent No. 16168, July 17, 1906) uses powdered carborundum in molds for the casting of aluminum and obtains a rapid chilling of the metal, which increases its tensile strength.

Carborundum has found important use as a resistance material, especially in the manufacture of resistance rods for lightning arresters. In one method of manufacture the rods are made up from a mixture of plastic clay, powdered carborundum, graphite, etc., and are fired in a potter's kiln. The rods are then glazed throughout their length to prevent the absorption of moisture and the ends are electroplated or otherwise treated to provide good electrical contact to the terminals. These rods are generally made in small sizes, from 6 to 10 inches long, and are used to protect circuits of comparatively low voltage. For high potential lines rods made of No. 40 to 60 carborundum grains with a vitrified porcelain binder

[1] The Mineral Industry, vol. 15, page 23.

are giving satisfactory service for potentials of 60,000 volts. These rods are 6 feet in length and 3 inches in diameter. When measuring the electrical resistance of the rods no readings can be obtained with the ordinary Wheatstone bridge. When, however, they are subjected to a potential of 10,000 volts current readings are obtained which indicate a resistance of from 120,000 to 150,000 ohms. Siemens Brothers, of Charlottenburg, in a recent patent propose to make electric resistance rods and anodes for electrolytic baths from a mixture of silicon carbide and silicon. Another inventor makes resistance rods for heaters, rheostats, and the like, using carborundum with a vulcanized rubber bond.

A carborundum wireless detector was developed in 1906 by Gen. H. H. C. Dunwoody of the American DeForest Wireless Telegraph Company and is being used in a large number of the company's installations. The device consists of a minute fragment of carborundum held in place between two metallic terminals or conductor plugs of copper or brass.

As a result of several years' research work, Prof. H. C. Parker and W. G. Clark brought out in 1906 the Helion lamp. The filament of this lamp is formed by subjecting a heated carbon filament to vapors of silicon, whereby there is produced a conductive compound of silicon and carbon, which doubtless coincides chemically with the silicon carbide. The Helion lamp is claimed to have remarkable life and efficiency, surpassing in this respect the new tantalum and tungsten lamps.

The calcium carbide industry has been given a marked impetus by the invention of the Frank and Caro process for the manufacture of calcium cyanamid from calcium carbide and atmospheric nitrogen, which has already been felt abroad and which will probably be shown statistically in the report of the next census. According to The Mineral Industry[1] the production of calcium carbide in the United States is now controlled by the Union Carbide Company, operating at Niagara Falls and at Sault Ste. Marie, as the only other producer is operating on a small scale and is involved in litigation.

The utilization of electrolytic chlorine in the manufacture of carbon tetrachloride has so cheapened the cost of this very useful article that since 1900 it has passed from the category of rarely occurring chemicals found in laboratories to that of the commonly occurring bodies applied to common uses.

Carbon tetrachloride is a heavy, colorless, transparent liquid with an agreeable and aromatic odor. Its specific gravity is 1.604 and one gallon weighs 13.3 pounds. It is noninflammable, noncombustible, and nonexplosive, and its vapor extinguishes flame. Its boiling point is 77° C. It can be evaporated off completely without residue. It is insoluble in water, in alcohol containing less than 75 per cent by volume of absolute alcohol, and in glycerin. It is freely soluble in acetone, glacial acetic acid, oleic acid, ethyl and amyl alcohol, chloroform, carbon disulphide, benzole, benzine, ether, aniline oil, spirits of turpentine, petroleum and all petroleum oils, and fixed and volatile oils.

Carbon tetrachloride is one of the greatest of solvents. It dissolves oils, fats, resins, wax, gutta-percha, ceresin, spermaceti, paraffin, stearin, varnish, asphaltum, pitch, balsams, coal tar, pine tar, rubber, salicylic acid, carbolic acid, iodine, bromine, iodoform, bromoform, menthol, thymol, camphor, naphthalene, sulphur chloride, soda and potash, soaps, ammonia, and numerous other chemicals and products. It is not acted upon by either strong acids or alkali. As an extracting medium, it has found wide application in the extraction of fats and oils from oil seeds, oil cake, animal tankage, wool, wool and cotton waste, and other oil and fat bearing materials. They are extracted pure, absolutely free from residual solvent and contaminating odor, taste, or "chemical smell," and the extracted materials may be produced absolutely free from solvent and with no odor or taste imparted to them.

Oil cake extracted with carbon tetrachloride is a feeding stuff of excellent quality, better than unextracted cake, in which the high oil content is worthless and generally considered objectionable. It is very much better than cake extracted with other solvents, which, because of the residual solvent, usually is of poor taste, and has an objectionable physiological action on cattle, so that material extracted with such other solvents has to be used for purposes which command a much lower price.

Its remarkable solvent properties make it an extremely valuable constituent in rubber and gutta-percha cements and in the rubber and gutta-percha industries, likewise in the lacquer, varnish, and paint remover industries, and for innumerable other purposes of similar nature.

A carbon tetrachloride solution of sulphur chloride is a vulcanizing agent of great value.

It is a very excellent cleansing agent, as it does not affect in the least the most delicate fabrics, including silk, satin, wool, cotton, lace, feathers, etc., and the most delicate shades of color are not injured in the slightest degree when carbon tetrachloride is properly applied. It is therefore of peculiar value for dry cleaning and cleansing establishments, which have heretofore used naphtha and benzine.

Aside from its advantage as a solvent it has the additional advantage of being fireproof, noninflammable, and nonexplosive, and therefore eliminates the extreme fire insurance premiums which are charged when benzine, benzole, naphtha, and similar solvents are used. In a suitable apparatus the loss of carbon tetrachloride is very minute, so that many important economies in operation are permitted, and the products produced by its use command higher selling prices as well as open and larger markets. Garments cleaned with tetrachloride of carbon do not have an offensive smell, as they may have when cleaned with benzine, naphtha, or gasoline. Carbon tetrachloride can be mixed with turpentine, naphtha, gasoline, benzine, benzole, etc., so as to render these products noninflammable and nonexplosive at an ordinary temperature, and is therefore of decided importance to those who are obliged to use considerable quantities of the solvents named.

[1] The Mineral Industry, vol. 15, page 89.

Carbon tetrachloride is packed in steel drums holding approximately 215 pounds, 650 pounds, and 1,350 pounds, and also in 10-gallon, 5-gallon, 2-gallon, and 1-gallon cans, weighing approximately 140 pounds, 68 pounds, 27 pounds, and 14 pounds, respectively.

A recent development of scientific interest is the use of the electric furnace in the process of melting quartz or rock crystal, which is a pure form of silica occurring in nature, for it becomes possible by this means to produce, for use in chemistry and physics, vessels which endure high temperatures without melting, great variations in temperature without cracking, and the corrosive action of the larger number of concentrated acids.

According to Dr. L. H. Baekeland,[1] a marked improvement has been effected in the manufacture of alkaline hydroxides and chlorine by the electrolysis of alkali chlorides through the use of the cell invented by Clinton P. Townsend. This has been worked on a commercial scale at the Niagara plant of the Development and Funding Company, which has an average daily capacity of 5 tons of caustic soda and 11 tons of high-grade bleach, and the results have been so encouraging that the plant is about to be increased to fourfold this capacity. The form of the cell is such that the anode space contains saturated brine while the cathode compartment contains kerosene oil. On account of the difference in specific gravity between the two liquids there is a hydrostatic pressure from the anode compartment toward the cathode compartment. Even if the level of the two liquids be the same, there is a tendency on the part of the brine in the anode compartment to press through the diaphragm and flow into the kerosene. If the electric current be turned on, the percolating brine becomes cathode liquid and carries caustic hydrate. The strength in caustic will increase according to the number of amperes which are sent through the cell. Furthermore, each drop of liquid as soon as it traverses the diaphragm runs through the perforations of the anode plate and acquires a globular shape, by a capillary phenomenon, produced on contact with the kerosene oil. This provokes a rapid separation of the aqueous liquid, so that every drop as soon as it forms detaches itself rapidly, sinks to the bottom of the oil, and accumulates in a small caustic pocket. This puts it entirely outside of the zone of possible chemical or physical action. A goose-neck tube drains this liquid from the supernatant oil, and thereby avoids its accumulation in quantities more than desired. The inflow and outflow of the brine at the anode compartment are so regulated as to maintain a steady level. By a simple contrivance this level can be increased or decreased at will, thus controlling the hydrostatic pressure on the inside of the anode compartment. This gives a simple means of increasing the rate of percolation, and thereby producing stronger or weaker caustic liquor, in accordance with the density of the electric current.

The first diaphragms used in the Townsend cell were made of asbestos paper, but this necessitated delicate handling, and the expense for renewals was considerable. During the last fourteen months the whole plant has been operated with diaphragms after Baekeland's patent. These latter consist of a woven sheet of asbestos cloth, the pores of which are filled with a special mixture of oxide of iron, asbestos fiber, and colloid iron hydroxide. The latter material produces a sort of binder for the asbestos fiber and the oxide of iron; its function is somewhat similar to that of rosin or glue size in the manufacture of asbestos paper, but it has a great advantage over organic sizes, in that it does not become gummy in contact with sodium hydrate. The mixture is applied with a brush and painted on as ordinary paint. Whenever a diaphragm has to be renovated the surface is simply scrubbed and washed with water; a new coat of paint is applied, and after this is dry the diaphragm is again ready for use. This process has only to be repeated at long intervals, and requires but a few minutes. A diaphragm may not require repainting for several months. Even when impure or unsettled brine is used the painting has to be done only about once in five weeks.

If the cells are run with proper care, the Acheson graphite anodes used last an astonishingly long time. In some experiments where cells were operated with especial attention, corrosion was so slight that delicate scratches which had been made with the point of a needle on the surface of the anodes showed very distinctly and with no alteration after several months of continuous operation. Even under the worst conditions the anodes only require partial renewal after one year of continuous hard service.

The strength of the caustic liquor produced in the Townsend cell can be regulated at will by increasing or decreasing percolation in conjunction with the strength of the current. By reducing percolation, cathode liquor containing 250 grams of NaOH per liter or more can be produced. In practice it is found advantageous to produce liquor containing about 150 grams of NaOH per liter. Such liquor carries also about 213 grams of salt. The latter is separated by evaporation from the caustic lye and is used over again.

Among notable suggestions relative to the utilization of sodium is the proposition to use it as a substitute for copper in electric conductors, since sodium has the greatest conductivity per unit of weight of any of the common metals. Mr. Anson G. Betts[2] constructed such a conductor in January, 1906, by filling lengths of 1½-inch wrought iron pipe with molten sodium and, when the sodium was solidified, screwing the lengths together to form a line. For the same conductivity the price of the complete sodium conductor

[1] "The New Electrolytic Alkali Works at Niagara Falls"—Electro-Chemical and Metallurgical Industry, 1907, vol. 5, page 209.

[2] Electrical World, 1906, vol. 48, page 914.

is much below that of copper cables,[1] being in small sizes not more than 50 per cent and in large sizes not more than 20 per cent of the cost of copper. For instance, a half-inch wrought iron pipe filled with sodium has a capacity of 109 amperes, and costs about 3½ cents per foot, against 8½ cents for a copper line of the same capacity. A 6-inch sodium conductor would carry 8,130 amperes, the cost of the line being about $1.40 per linear foot, as compared with $6.30 per linear foot for copper. These figures were estimated on the basis of 7½ cents per pound for sodium and 16 cents per pound for copper.

Another product of electro-chemical establishments, which consumes surplus chlorine, is sulphur chloride, which is a yellowish red, oily liquid, having a specific gravity of 1.709, and mixes in all proportions with carbon tetrachloride, benzol, carbon disulphide, etc., also with petroleum or naphtha. It is used in the cold or dip process of vulcanizing rubber; in the preparation of rubber substitutes, artificial drying oils, linseed oil substitutes from menhaden, and fish oils, corn oils, etc., and for the thickening of oils, rapid manufacture of printers' ink, and other manufacturing and special purposes. It is sold in lead-lined steel drums holding about 675 pounds and 1,300 pounds, respectively, in 5-gallon boxed jugs, and in 1-pound and 5-pound bottles.

Other developments worthy of special note in this industry are found in the electric smelting of iron ore for the production of iron and steel, there being in 1906 five electric smelting furnaces for this purpose in the United States and Canada, furnaces of the induction type of Colby, Kjellin, and Heroult being used; in the manufacture of phosphorus, since the nodules of wavellite found with iron and manganese ores, in the clay deposits near Carlisle, Pa., are mixed with apatite and used as a source of phosphorus; in the manufacture of graphite, since Acheson has been able to produce a form which remains suspended indefinitely in lubricating oil, thus forming an ideal lubricant; and in the manufacture of barium hydroxide and silicide, for which considerable commercial uses are being found.

TABLE 84.—*Plumbago—imports entered for consumption: 1891 to 1905.*

YEAR ENDING JUNE 30—	Tons.	Value.
1891	10,135	$509,809
1892	13,511	726,648
1893	14,207	866,309
1894	7,935	410,819
1895	7,051	208,935
1896	11,891	384,554
1897	12,459	321,355
1898	11,154	472,401
1899	15,970	1,081,859
1900	20,597	2,345,294
1901	13,077	929,986
1902	16,081	963,356
1903	18,354	1,247,584
1904	13,302	991,134
1905	13,676	915,306

[1] Daily Consular and Trade Reports, 1907, No. 2797, page 14.

Table 84 sets forth the imports of plumbago for the years 1891 to 1905, inclusive, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

CLASS XI.—DYESTUFFS.

The class of dyestuffs comprises natural dyestuffs, including logwood, fustic, quercitron, cochineal, lac dye, kermes, gambier, Persian berries, curcuma, Brazil wood, madder, cutch, and yellow oak bark, the ground and chipped wood, bark, or berries of these natural dyestuffs, and extracts such as logwood extract; artificial dyestuffs, such as the aniline, phenol, azo, quinoline and anthracene colors, synthetic indigo, the so-called coal tar dyes, special compositions or mixtures of dyes, and mineral dyes used in printing, such as chrome yellow, orange and green, iron buff or nankin yellow, prussian blue, ultramarine, and manganese brown; mordants such as myrobalans, valonia, divi-divi, chestnut, nutgalls, oak and hemlock bark, the ground product and the extracts of these materials, special mordanting liquids containing inorganic compounds, and assistants such as turkey red oil, iron liquor (black liquor, pyrolignite of iron), red liquor (aluminum sulpho-acetate), gums, dextrins, and sizes.

TABLE 85.—*Dyestuffs—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	51	44	7	15.9
Capital	$7,507,837	$6,279,877	$1,227,960	19.6
Salaried officials, clerks, etc., number	193	165	28	17.0
Salaries	$348,318	$236,084	$112,234	47.5
Wage-earners, average number	816	1,093	[1]277	[1]25.3
Total wages	$476,041	$580,605	[1]$104,564	[1]18.0
Miscellaneous expenses	$426,327	$379,238	$47,089	12.4
Cost of materials used	$3,471,236	$3,725,149	[1]$253,913	[1]6.8
Value of products	$5,277,523	$5,637,464	[1]$359,941	[1]6.4

[1] Decrease.

The statistics of Table 85 show an increase in the number of establishments and of salaried employees, and in the amount of capital, salaries, and miscellaneous expenses for 1905 as compared with 1900, but they show a decrease in every other item, the largest decrease appearing in the value of products and the next largest in the cost of materials used; while the largest decrease in per cent appears in the average number of wage-earners and the second largest in the total wages paid. As the dyeing and printing industries have prospered and should therefore consume more rather than less dyestuffs at the later census, it would appear that, following the course of industrial development so strongly emphasized in this census, the dye and print works have manufactured a large part of the dyestuffs which they have consumed in the manufacture of their finished products, in place of purchasing them from other manufacturers as formerly.

TABLE 86.—*Dyestuffs—quantity and value of products: 1905 and 1900.*

KIND.	1905		1900	
	Pounds.	Value.	Pounds.	Value.
Total	72,421,670	$5,666,416	60,729,671	$6,523,618
Artificial dyestuffs	10,640,910	2,665,134	7,698,435	2,280,899
Ground and chipped wood	9,033,867	83,166	(1)	(1)
Gum and dextrin	6,366,351	223,326	(1)	(1)
Iron liquor	2,120,968	45,316	3,344,568	32,065
Mordants	5,154,330	246,432	734,000	85,466
Natural dyestuffs	31,755,886	1,766,273	48,245,628	3,435,808
Red liquor	(1)	(1)	707,040	7,340
Sizes	7,349,358	223,326	....	....
All other dyestuffs	....	413,443	....	682,040

[1] Not reported separately.

The statistics of Table 86 show an increase in the total quantity but a decrease in the total value of the products for 1905 as compared with 1900. The separate items of the table show an increase in every item which appears at both censuses except in the quantity and value of natural dyestuffs, the quantity of iron liquor, and the value of all other dyestuffs. It is believed that much of the dextrin is manufactured as a subsidiary product in another industry which does not report it separately, and therefore it is not given separately in Table 86.

TABLE 87.—*Dyestuffs—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1] 61	[2] 60
Connecticut	2	2
Florida	....	1
Illinois	2	2
Maine	3	1
Maryland	1	....
Massachusetts	15	15
New Jersey	12	8
New York	8	20
North Carolina	1	....
Pennsylvania	6	7
Rhode Island	8	2
South Carolina	1	2
Vermont	....	1
West Virginia	1	1
Wisconsin	1	....

[1] Includes 10 establishments engaged primarily in the manufacture of other products.
[2] Includes 16 establishments engaged primarily in the manufacture of other products.

Table 87 shows that the total number of establishments has increased by but 1, and that there have been some marked changes in the different states, New York decreasing 12 in number, while Rhode Island has gained 6, New Jersey 4, and Maine 2. Massachusetts ranks first at the census of 1905, New Jersey second, New York and Rhode Island third. It is interesting to note that this industry is practically confined to the states of the North Atlantic division.

The statistics of Table 88 show a decrease for 1905 as compared with 1900 in the total value of the product and in the value of the product of every state except New Jersey, for which comparative statistics are set forth. New Jersey, which ranked fourth at the census of 1900, ranks first at that of 1905. The statistics for Rhode Island and Maine are presented separately for the first time at the present census.

TABLE 88.—*Dyestuffs—value of products, by states: 1905 and 1900.*

STATE.	1905	1900
United States	$5,666,416	$6,523,618
Maine	30,051	(1)
Massachusetts	863,496	1,377,822
New Jersey	1,925,473	899,468
New York	1,611,244	2,098,402
Pennsylvania	489,167	906,564
Rhode Island	513,006	(1)
All other states [2]	233,979	1,241,362

[1] Included in "all other states."
[2] Includes in 1905, Connecticut, Illinois, Maryland, North Carolina, South Carolina, Vermont, West Virginia, and Wisconsin; in 1900, Connecticut, Florida, Illinois, Maine, Rhode Island, Vermont, and West Virginia.

The statistics of Table 89 show a decrease in each item for natural dyestuffs set forth at both censuses, but an increase in each item for artificial dyestuffs. Sulphuric acid has decreased in quantity and increased slightly in value, while other acids have decreased in quantity and increased greatly in value, facts which indicate a greater consumption of the higher priced acids. Chemicals have increased in value, and salt in both quantity and value.

TABLE 89.—*Dyestuffs—quantity and cost of principal materials used: 1905 and 1900.*

KIND.	1905	1900
Logwood:		
Tons	45,556	51,955
Cost	$793,865	$1,084,746
Cutch:		
Pounds	85,786	798,508
Cost	$6,366	$61,697
Fustic:		
Tons	....	3,204
Cost	....	$51,585
Logwood extract:		
Pounds	264,394	2,364,792
Cost	$21,785	$163,408
Fustic extract:		
Pounds	5,099,880	....
Cost	$37,529	....
Aniline colors:		
Pounds	1,321,567	1,734,717
Cost	$636,617	$849,229
Other coal tar products:		
Pounds	13,950,842	1,417,325
Cost	$751,905	$333,317
Indigo:		
Pounds	96,500	109,034
Cost	$82,000	$125,069
Acids:		
Sulphuric—		
Pounds	1,173,989	1,222,357
Cost	$18,992	$18,750
Other acids—		
Pounds	2,995,946	4,135,328
Cost	$81,029	$54,298
Starch:		
Pounds	6,815,442	(1)
Cost	$173,103	(1)
Caustic soda:		
Tons	154	(1)
Cost	$8,366	(1)
Soda ash:		
Tons	1,885	(1)
Cost	$60,521	(1)
Sulphur:		
Tons	1,190	(1)
Cost	$24,699	(1)
Oils:		
Gallons	110,608	(1)
Cost	$38,265	(1)
Fats:		
Pounds	830,783	(1)
Cost	$46,642	(1)
Chemicals:		
Pounds	1,003,669	....
Cost	$30,110	$14,510
Salt:		
Tons	2,935	1,078
Cost	$9,790	$5,298
Alum:		
Pounds	(1)	291,400
Cost	(1)	$9,065

[1] Not shown separately.

The dyestuffs and tanning extracts industries are so closely associated that combined statistics have been compiled for them since the census of 1880 under the caption "dyestuffs and extracts." These statistics are set forth in Table 90 for each census from 1880 to 1905.

TABLE 90.—*Dyestuffs and extracts—comparison of statistics: 1880 to 1905.*

CENSUS.	Number of establishments.	Capital.	Number of wage-earners.	Value of products.
1905	98	$14,904,150	2,707	$10,893,113
1900	77	7,839,034	1,647	7,350,748
1890	62	8,645,458	2,111	9,292,514
1880	41	2,363,700	[1] 992	5,253,038

[1] Includes salaried employees.

The statistics of Table 90 show a constant increase in every item at each succeeding census except in the amount of capital, number of wage-earners, and value of products at the census of 1900, which show a decrease as compared with these items at the census of 1890. It is to be noted that the capital invested has increased to a greater extent than the value of the products, for while the former has increased from 1880 to 1905 to the amount of $12,540,450, or 530.5 per cent, the latter has increased but $5,640,075, or 107.4 per cent.

It has been said[1] that—

Almost the first industries established in the American colonies, after they were settled, and after they had taken measures to establish a food supply, were spinning and weaving, and dyeing came soon after. New dyestuffs were found here, and permanent dyehouses were established sooner than woolen factories. Butternut was a very common dye, but logwood and other substances prevented it from being used in any other than the most common work. Indigo, cochineal, annotto, quercitron, and Brazil wood were among those introduced from abroad shortly afterwards, and have stayed in use up to the present time. Mordants afterwards became known, and later mineral dyes. Within the lifetime of the present generation a new and exceedingly brilliant series of colors for dyeing has been evolved from coal tar. The industry of dyeing is now very widely spread. Nearly every mill devoted to textiles has a dyehouse, and there are many independent works throughout the country.

The year 1906 marked the fiftieth anniversary of the epoch making discovery by William Henry Perkin of the dyestuff "mauve," by which the foundation of the coal tar color industry was laid and a great stimulus was given to the study of organic chemistry. This anniversary was celebrated on an extensive scale throughout the civilized world, and honors, titles, and dignities were conferred on the discoverer.

The discovery, which was destined to have such far-reaching consequences, was made in the Easter vacation of 1856, while Perkin, then only a lad of 18 was working in a private laboratory he had fitted up in his father's house. The coloring matter was patented on the 26th of August of the same year, and in the early part of the following year the erection of the first coal tar color works was commenced at Greenford Green, near Harrow, England. Here mauve was soon produced in quantity and here also were manufactured later other coal tar dyestuffs, including artificial alizarin. From these small beginnings the industry has now grown to dimensions which neither the discoverer nor any man of his time could have foreseen. Not only has an enormous and highly scientific industry been established, which with its collateral branches has an output with an estimated value of upward of $100,000,000 per annum, but the dyeing and related industries have been subjected to a complete revolution by which empiric methods have been changed to scientific ones. Side by side with this technical progress and closely interrelated with it is the immense stimulus which the establishment and rapid growth of the coal tar industry have given to the study of pure organic chemistry, especially that of ring carbon compounds. The development of this industry has also exerted a large influence upon the entire chemical trade of the world, and directly given birth to several derivative industries, such as the manufacture of synthetic medicinal agents, antiseptics, synthetic perfumes, artificial sweetening materials, and explosives.

It is a curious fact to note that although French manufacturers promptly recognized the importance of Perkin's discovery and were, in fact, the first to put mauve colored calicos upon the English market, the manufacture of coal tar dyestuffs has passed almost wholly into the control of the manufacturers of Germany where it gives employment to thousands of workmen. It was stated at the Perkin Jubilee that there were at that time 700 distinct color dyestuffs produced from coal tar.

The first mention of the coal tar dyestuff manufacture in the United States was at the census of 1880, when 3 establishments were reported as producing 80,518 pounds of aniline dyestuffs, valued at $107,292.

At the census of 1905, 10,640,910 pounds of artificial dyestuffs, valued at $2,665,154, were reported as produced. Since these dyestuffs included products obtained by mixing purchased coal tar dyes to give desired shades or effects, products obtained by mixing extracts with coal tar dyes to form special compositions, and compositions formed from vegetable extracts and mineral substances, and since the total annual production of artificial dyestuffs throughout the world is in the neighborhood of $100,000,000, it is evident that the quantity and value of the dyestuffs produced from coal tar derivates or distillates in the United States is still relatively insignificant.

Schultz and Julius[2] in their Tabular Presentation of Artificial Organic Dyestuffs found in Commerce, published in 1902, give a list of 63 firms operating 88 establishments, then engaged in the manufacture of coal tar dyestuffs. Thirty-one of these establishments were in Germany, 19 in France, 13 in England,

[1] C. M. Depew, One Hundred Years of American Commerce, 1895, page 671.

[2] Gustave Schultz and Paul Julius, Tabellarische übersicht der im Handel befindlichen küntslichen Organischen Farbstoffe, Berlin, 1902.

6 in Russia, 6 in the United States, 6 in Switzerland, 3 in Holland, 2 in Belgium, and 2 in Italy. In this book 681 different dyestuffs are described which the authors found were prepared for sale and use. Two hundred and forty-five of these were granted the protection of patents in the United States. Out of these 681 different substances, only 20 are mentioned as being manufactured in the United States and of these 20, but 3 were protected by patents, so that we may say that the manufacture of artificial organic dyestuffs in this country is confined largely to those whose manufacture is open to all.

While there is no criticism to be made on Schultz and Julius' estimate, it would appear that the number of colors made in this country is larger now than in 1902, for in a circular received from one manufacturing establishment in 1906 there are enumerated 97 different colors: 49 acid colors, 33 basic colors, and 15 direct colors, divided among water soluble, alcohol soluble, and oil soluble colors, and in some instances there are as many as six grades of a given color.

Inspection of Table 91 shows that coal tar colors or dyes not specially provided for to the value of $5,635,-164 were imported into the United States in 1905. This value is larger than the value of any other item shown in the table and is more than twice the value of all the artificial dyestuffs reported as manufactured in the United States at the census of 1905.

As stated above, this industry is controlled by Germany. Considering the foreign trade alone of that country the value of the chemicals exported from Germany[1] in 1905 was $131,395,500, of which the artificial dyestuffs, valued at $48,665,000, constituted nearly 40 per cent. Among these were included aniline dyes, valued at $24,065,500, and alizarin and indigo, valued at $9,733,000. The extent of the development of this industry in Germany is further emphasized by the statement[1] that of the 31 aniline color works in Germany, the bulk of the trade is in the hands of 5 firms, forming two large combinations. The combined nominal capital of these 5 firms is nearly $24,332,500, and the net annual profits $9,733,000, 60 per cent of which is paid in dividends and the remainder of which is carried to depreciation. The average dividend of these aniline dye works has exceeded 20 per cent for many years, while the dividend paid by individual firms has in some cases exceeded 30 per cent. The Badische Anilin und Soda Fabrick began business in 1895 with 40 men; in 1905 it employed 7,251. Many of the reasons that have been advanced for the acquisition of the control of this industry by Germany are set forth in the prefatory remarks to the special report on chemicals and allied products at the census of 1900, and others will be found in revision of the Tariff Hearings before the Committee on Ways and Means, Fifty-first Congress, 1st session, 1890, pages 391 to 398, and Fifty-third Congress, 1st session, 1893, pages 22 to 26.

These remarks are strongly stated in a History of the Development of the Coal Tar Industry in the United States, prepared by Mr. J. F. Schoellkopf for presentation to Congress when the Wilson Tariff bill was under consideration. He has kindly permitted its use here, and as it has not been published heretofore and as there is much in it which is worthy of consideration in this connection, it is given below.

To properly understand the causes of the slow development of this industry in the United States, it will be advisable to give a short sketch of its inception and progress in Europe up to the present time.

Though Perkin began the manufacture of coal tar dyes in England in 1857, they were first produced on a considerable commercial scale in France, and at a later date their manufacture was taken up in Switzerland and Germany. But while the growth of this new branch of industry was not extraordinary in the first-named countries, the history of it in Germany reads like a fairy tale. One can truthfully say that Germany's greatness and present supremacy in the chemical arts dates from the time it actively engaged in the production of coal tar dyes. From practically nothing in 1862, the value of the output of the German factories had risen to $6,000,000 in 1874, to $10,000,000 in 1878, $12,500,000 in 1882, and to fully $17,000,-000 in 1890. This is in the face of the fact that the goods were not only vastly improved in quality, but also very materially cheapened in price; magenta for instance falling in this time from $300 per pound to 90 cents, and aniline blue from $800 per pound to $1.

Germany has a capital of at least $20,000,000 invested in the industry which gives employment to fully 15,000 hands directly and to at least as many more indirectly. The amount of chemicals and other material consumed by this industry is simply stupendous, one factory alone using 160,000 tons of coal annually. The main reason for this wonderful growth in Germany was probably the judicious cooperation of theory and practice, the working together of factory and university, which in no other country was carried out to the extent it was in Germany. During this period of rapid development, it is obvious, there could be no surplus of scientific or expert manual help to start factories of a similar nature in America. The chemists graduated from German universities who had chosen this branch of chemistry as their specialty immediately found remunerative employment in one of the home factories. No one thought of leaving the "Fatherland," and seeking his fortune elsewhere.

These conditions, however, changed radically about the year 1880. The universities and chemical schools had continued to grind out coal tar chemists in increasing numbers, until the home factories were no longer able to take care of all of them, and naturally they looked around for other fields of operation. At this time the United States apparently presented an inviting field. The consumption of colors was already large and constantly increasing. The import duty at that time was 35 per cent ad valorem and 50 cents per pound specific, which, taking into consideration the low price the dyes had reached, was ample protection. There were as yet no colors produced in this country, if one excepts the magenta turned out by the now extinct Albany Aniline Color Works. They produced a small quantity of poor magenta in a very crude way and had been doing this ten years back, without attempting to enlarge by adding new colors to their product. As stated above, America presented an inviting field and during the years 1880 to 1883 no fewer than 9 different plants for the manufacture of coal tar dyes were established. The prospect of becoming independent of other nations for our supply of these important colors was bright indeed until the passage of the tariff act of July 1, 1883. This act abolished the specific duty of 50 cents per pound, leaving an ad valorem duty of 35 per cent on coal tar colors, or dyes, and 20 per cent on coal tar preparations not

[1] J. T. Conroy, "The Chemical Trade of England and Germany," Journal, Society Chemical Industry, 1906, vol. 25, page 1011.

colors, or dyes. This left a net protection for the colors of nominally 15 per cent, but it will appear later that even this meager protection was completely neutralized through various circumstances.

The evil effects of this adverse tariff legislation showed itself almost immediately. No new factories were started and within one year after the new tariff took effect, 5 of those already established were forced to succumb and go out of business. The remaining 4 would have gladly followed their examples, but they had invested large sums of money in plant (the Buffalo factory having expended about $500,000 in this way), which would not have brought 10 cents on the dollar if sold. So they decided to continue to operate their factories, hoping for more favorable legislation in the future. But thus far they have always been bitterly disappointed in this. At every tariff revision this industry, which, if properly fostered, would be of such enormous importance to the chemical industry at large, has been treated in a most unfair and unkind manner. The parties interested have repeatedly asked for an increase of duty, which has as often been refused. They have asked for a decrease of duty on raw material, which has also been refused. As their raw materials are not made in this country, and never will be under existing conditions, it is not comprehensible why this latter request has not been granted. They finally petitioned Congress to change the phraseology of the paragraphs referring to coal tar colors and alizarin red, to prevent fraud and misunderstandings at the custom-house. But even this just request, which was recommended by the appraisers department in New York, was not acceded to.

It can be safely predicted that unless the policy of Congress toward this industry shows a decided change for the better very soon, it will soon entirely disappear in America. It is a well-known fact, that since 1883 the European factories, especially those in Germany, have been distributing ever increasing dividends, the earnings of the larger concerns for the past few years having amounted to over 50 per cent on their enormous capital invested. During all this time the industry in America has languished. The factories have been barely able to hold their own and as to making any profits or even interest on the capital invested, that was out of the question entirely.

The principal causes of the nondevelopment of the industry in America, under existing conditions, are as follows: First, high wages; second, greater first cost of plant and larger annual cost of wear and tear; third, higher cost of coal tar preparations and other chemicals and materials; fourth, high tax on alcohol for industrial purposes. Each of these causes will be discussed separately, and as to their correctness, each reader can judge for himself after perusing the following. All the statements made and the figures given are the results of actual experience and positive knowledge and are vouched for as absolutely correct.

First—High wages.—It must be taken into consideration that in works of this kind, besides the regular labor engaged in the production of colors, a number of mechanics are permanently employed such as engineers, machinists, carpenters, masons, pipe fitters, etc. This class of help is necessary to renew and keep the plant in repair and to carry out the frequent changes made necessary by improvements or changes in the processes. This class of labor forms quite an important item in the weekly pay roll. Its remuneration is from $2 to $3 per day of ten hours, while the same men in German factories receive but 75 cents per day of eleven hours. Ordinary labor in America costs $1.50 per day of ten hours, while the German manufacturers pay only 60 cents per day of eleven hours for similar help. To more clearly illustrate the advantage the foreign employer possesses over his American competitor in this respect, we give under "Exhibit A" the labor cost of an American coal tar dye factory, with a capacity valued at $25,000 per month, as compared with a factory of the same kind and size in Germany. From this exhibit it appears that to produce $25,000 worth of colors the American is obliged to pay directly for labor $4,110, while his German rival has the same work performed for but $1,798.20.

Second—Greater first cost of plant and larger annual cost of maintenance.—In America a plant designed for an output valued at $25,000 per month will cost:

For land and building	$100,000
For machinery, tools, etc	180,000
For working capital	200,000
Total	480,000

In Germany the same plant would cost at the outside:

For land and building	$75,000
For machinery, tools, etc	100,000
For working capital	140,000
Total	315,000

This shows a higher first cost for the American factory of $165,000, which at 6 per cent per annum amounts to an extra yearly charge of $9,900. If we allow 5 per cent for depreciation on buildings and 10 per cent for "wear and tear" on machinery, etc., we find that these items amount to $1,916.67 per month in America and to only $1,145.83 per month in Germany. See "Exhibit B."

Third—Higher cost of coal tar preparations and other chemicals and materials.—"Exhibit D" shows the kinds and quantities of raw materials used for producing $25,000 worth of coal tar dyes. It also shows their cost in Germany and in America under the present law, and under the proposed Wilson bill. This is the class of raw materials now principally used by the American manufacturers. "Exhibit C" shows prices of these products per 100 pounds in Germany, and in America under the present law, and under the proposed Wilson bill. From "Exhibit D" it appears that the materials used cost 22 per cent more here than in Germany under the present tariff and under the proposed Wilson bill would still cost 19.75 per cent more. Now as the Wilson bill places coal tar preparations on the free list, the small benefit shown requires some explanation. By referring to "Exhibit D" it will be observed that the coal tar preparations, aniline oil and aniline salt, which constitute 60 per cent in value of the materials used, are on the free list to-day and are therefore not cheapened by the Wilson bill. In fact, the only materials cheapened to any extent are the soda products and naphthol.

Fourth—High tax on alcohol for industrial purposes.—In America alcohol for industrial purposes costs about $2.25 per gallon. In Germany alcohol for industrial purposes costs only about 35 cents per gallon. It is obvious, therefore, that coal tar colors, requiring in their preparations the use of alcohol, can not be profitably made in the United States.

"Exhibit E" shows the total cost of producing and marketing $25,000 worth of coal tar dyes: First, when made in the United States under the McKinley tariff; second, when made in the United States under the proposed Wilson bill; third, when made in Germany and imported, including a duty of 35 per cent ad valorem. It is clearly shown that the German-made goods can be imported, and after paying a duty of 35 per cent, can be sold as low as the American-made colors. It is obvious, therefore, that if the duty on coal tar dyes is reduced below the present rate of 35 per cent, the American manufacturers will be quickly driven out of business. In preparing the Wilson bill the fact was not taken into consideration that the colors now being manufactured in America are made from free coal tar preparations, and that those paying a duty of 20 per cent can not be used. It was evidently taken for granted that coal tar preparations constituted the item of chief value in the make-up of coal tar dyes. We have shown, however, that they constitute only about one-third of the value of the finished product. The Wilson bill, by putting *all* coal tar preparations on the free list, will permit the use of a large number of products for the manufacture of a new line of dyes, but *only* if the duty of 35 per cent on colors is retained.

We repeat: The Wilson bill as it now stands means the extinction of every coal tar dye factory in the United States, even if the 20 per cent duty is honestly paid. But there is a paragraph in the free list, which in a short time will admit every important coal tar color absolutely free of duty. The paragraph referred to is No. 366 in section 2: "Alizarin, natural or artificial, and all colors or dyes, *commercially* known as alizarin colors, or dyes." Under this provision every color or dye of any importance will be rebaptized and become *commercially* known as alizarin color, or dye. Why any product should be admitted under its commercial name is incomprehensible and requires an explanation. This is a vicious attack on the American color industry, and if allowed to stand must be followed by disastrous results, no matter how high the duty on colors may *nominally* be.

If it be desirable to retain and develop the coal tar dye industry in America, the present duty of 35 per cent must not be disturbed. All coal tar preparations, not colors, or dyes, should be made free, and the words "and all colors, or dyes, commercially known as alizarin colors or dyes" should be stricken out of paragraph 366 of the Wilson bill.

EXHIBIT A.—*Table showing employees needed for a coal tar dye factory having a capacity valued at $25,000 per month.*

EMPLOYEES.	MONTHLY WAGES IN—	
	United States.	Germany.
Total wages per month	$4,110.00	$1,798.20
4 chemists	700.00	400.00
2 clerks	200.00	100.00
60 men	2,250.00	900.00
5 foremen	250.00	150.00
1 mason	75.00	19.50
2 carpenters	130.00	39.00
1 engineer	75.00	35.00
2 pipe fitters	120.00	39.00
1 blacksmith	45.00	19.50
2 night watchmen	110.00	39.00
2 teamsters	90.00	31.20
5 boys	65.00	26.00

EXHIBIT B.—*Table showing cost of coal tar plant designed for a monthly output valued at $25,000, also showing the monthly cost of depreciation of buildings and wear and tear of the machinery, etc.*

	COST OF PLANT IN—	
	United States.	Germany.
Total cost of plant	$480,000.00	$315,000.00
For land and buildings	100,000.00	75,000.00
For machinery, tools, etc	180,000.00	100,000.00
For working capital	200,000.00	140,000.00
Total monthly cost for depreciation and wear and tear	1,916.67	1,145.83
Depreciation per month on land and buildings at rate of 5 per cent per annum	416.67	312.50
Wear and tear per month on machinery at rate of 10 per cent per annum	1,500.00	833.33

EXHIBIT C.—*Table showing principal raw materials used in American color factories, giving prices for same here and in Germany.*

MATERIAL.	PRICE PER 100 POUNDS IN CENTS IN—		
	America.		Germany.
	Under McKinley tariff.	Under proposed Wilson bill.	
Sulphuric acid	85.0	85.0	38.0
Muriatic acid	100.0	100.0	25.0
Nitric acid	450.0	450.0	350.0
Common salt	17.5	17.5	12.5
Lime	33.0	33.0	25.0
Ice	10.0	10.0	10.0
Iron borings	60.0	60.0	45.0
Caustic soda	350.0	300.0	225.0
Soda ash	180.0	168.0	130.0
Nitrate soda	725.0	725.0	540.0
Zinc	450.0	395.0	300.0
Benzole	700.0	700.0	700.0
Aniline oil	1,350.0	1,350.0	1,250.0
Aniline salt	1,250.0	1,250.0	1,200.0
Beta naphthol	1,230.0	1,038.0	961.0
Benzoic acid	4,100.0	4,100.0	4,000.0

EXHIBIT D.—*Table showing the quantity and cost of raw materials used for the production of $25,000 worth of coal tar dyes.*

MATERIAL.	Pounds used.	COST IN—		
		America.		Germany.
		Under McKinley tariff.	Under proposed Wilson bill.	
Sulphuric acid	155,590	$1,237.51	$1,237.51	$553.25
Muriatic acid	47,730	477.30	477.30	119.33
Nitric acid	12,450	560.24	560.24	435.76
Common salt	150,000	262.50	262.50	188.50
Lime	5,280	17.60	17.60	13.20
Ice	27,000	27.00	27.00	27.00
Iron borings	450	2.70	2.70	2.01
Caustic soda	11,550	404.24	346.50	259.87
Soda ash	5,520	99.36	92.74	71.76
Nitrate soda	9,780	709.04	709.04	528.12
Zinc	6,000	270.00	237.00	180.00
Benzole	10,830	758.10	758.10	758.10
Aniline oil	61,200	8,262.00	8,262.00	7,650.00
Aniline salt	5,400	675.00	675.00	648.00
Beta naphthol	10,020	1,232.46	1,040.08	842.92
Benzoic acid	30	12.00	12.00	11.70
Total	518,830	15,007.05 122%	14,717.31 119.75%	12,289.52 100%

EXHIBIT E.—*Table showing total cost of producing $25,000 worth of coal tar dyes in America as compared with equal quantity produced abroad and imported.*

	COST WHEN MADE IN UNITED STATES—		Cost when made in Germany and imported.
	Under McKinley tariff.	Under proposed Wilson bill.	
Raw materials (see "Exhibit D")	$15,007.05	$14,717.31	$12,289.52
Depreciation and wear and tear (see "Exhibit B")	1,916.67	1,916.67	1,145.83
Expense for steam for power and heating	1,000.00	1,000.00	1,000.00
Incidentals	500.00	500.00	400.00
Labor (see "Exhibit A")	4,110.00	4,110.00	1,798.20
Total cost	22,533.72	22,243.98	16,633.55
Duty, 35 per cent ad valorem			5,820.34
Selling expense 10 per cent	2,500.00	2,500.00	2,500.00
Aggregate cost	25,033.72	24,743.98	24,953.89

Among the innovations in this industry that have come into special prominence since the census of 1900, although they originated much earlier, are the sulphur dyes. According to Matthews[1]—

The original representative of these colors was discovered a number of years ago, in 1873, by Croissant and Bretonniére, and it was given the name of "cachou de Laval." It was prepared in rather a peculiar manner by the fusion of organic vegetable matter, such as sawdust, etc., with sodium sulphide and sulphur. The resulting product was a porous, lumpy mass of a brownish black color and readily soluble in water, and decomposing in moist air with the liberation of some sulphuretted hydrogen. It was found that unmordanted cotton could be dyed by this substance a brown color, though the dyestuff, it is true, had but slight tinctorial properties compared with the other artificial dyes, yet the color obtained with it was very fast to washing. It was on account of its fastness that the new coloring matter received a considerable amount of attention. The general method of applying the dyestuff was to boil the cotton material in a solution containing the coloring matter together with a rather large proportion of common salt. This was for the purpose of forcing on the fiber more color, as otherwise it took a very large proportion of the dyestuff to produce any depth of color. Even under these conditions, however, the dyestuff does not exhaust from the first bath to any great degree. By after-treating the dyed color with a solution of potassium bichromate, the intensity of the color is somewhat enhanced and the general fastness of the

[1] Journal of the Franklin Institute, 1905, vol. 109.

dyestuff is improved. By a similar after-treatment of the color with bluestone or copper sulphate, the fastness of the dyeing to light appears to be somewhat increased.

It was also found that cachou de Laval when dyed on cotton acted as a mordant toward a large number of other coloring matters, such as most of the common basic dyes, the vegetable dyewoods, and the alizarin dyes. The shades obtained with the basic dyes, however, are not as fast to washing as the original cachou de Laval, also those with the vegetable dyewoods are not so fast to light; but the shades obtained in conjunction with the alizarin dyes are as a rule fast to both washing and light.

Owing to the small tinctorial powers of cachou de Laval, it never became of much commercial importance in dyeing. It was looked upon chiefly as a curiosity among the artificial dyestuffs, particularly on account of its peculiar method of manufacture.

A number of years passed before the sulphur dyes received any further development. It was not until about 1893 that the French chemist Vidal publicly announced his discovery of a black sulphur dyestuff which he called 'Vidal black.' This coloring matter was made by fusing para-amido-phenol with sulphur. The product obtained was of uncertain composition, but was found to yield black colors on unmordanted cotton, and was especially characterized by its great fastness. The dyestuff, however, was liable to decomposition on exposure to the air, and presented certain practical difficulties in dyeing so that at first it was not received with much favor. A number of years passed in the development and perfection of this coloring matter and a study of its properties and possibilities, until it had passed beyond the stage of experiment and finally attained commercial success. This led the attention of other dyestuff chemists, especially those of the large German color factories, to the investigation of the sulphur dyestuffs, with the result that great activity was soon displayed in the preparation of new colors, and the purification and modification of those already known. A large number of these dyes have appeared in trade during the past five or six years, and the range of colors has been so extended as to include various shades of black, brown, blue, green, olive, yellow, and orange colors; a red color among the sulphur dyes is still lacking, the nearest approach being the so-called orange, and certain very red shades of brown. All of these colors are applied in about the same manner and are only used on cotton, giving shades which are very fast, especially to washing and acids, and on this account are very desirable products.

The sulphur colors usually appear in trade in the form of blackish lumps, which are hygroscopic and rapidly deteriorate on exposure to the air, especially in the presence of moisture. On this account the dyestuff should be used up as soon as possible after the package is opened. Recently, however, some of these dyes have appeared in the form of dry powders and are not so hygroscopic, being mixed with some suitable dryer, and consequently are not so liable to deteriorate. The manufacturers also seem to be preparing these dyes in a much purer and more concentrated form so that their tinctorial power is considerably increased. The sulphur dyes nearly all smell more or less of sulphuretted hydrogen, especially when moistened or dissolved in water; they also, as a rule, contain more or less sodium sulphide.

Some of the sulphur dyes may be dyed directly on cotton with nothing but the solution of the coloring matter; in other cases, however, a considerable amount of sodium sulphide must be added to the dye bath for the purpose of bringing the dyestuff into proper solution; there is also added some soda ash for the purpose of correcting any hardness which may be present in the water and which would cause a precipitation of the coloring matter. In general, these dyes are applied in about the same manner, as regards the manipulation of the cotton materials, as when other dyes are employed. Care must be taken, however, in most cases, not to have any copper or brass fitting present in the dyeing vats, as the dyestuff is decomposed by these metals; iron and lead, however, may be used without danger. Some of the dyes require an after-treatment with certain metallic salts, especially potassium bichromate or copper sulphate, in order to yield the full development and fastness of the color. In their general fastness they far surpass the other colors available for cotton dyeing, and are comparable in fastness to indigo and aniline black. They are especially suited to the dyeing of material contained in cotton and woolen fabrics, where the cotton is dyed first and the wool is afterwards dyed in acid baths, as these colors will stand the treatment with hot acid baths. The dyestuff does not cause any injury to the cotton fiber, though the dyed goods should be carefully washed in order to eliminate all excess of sodium sulphide, the retention of which by the fiber would eventually cause a weakening; but beyond this the dyestuff itself does not weaken the goods. One drawback to these colors, however, is that in dyeing them the cotton is liable to become somewhat harsh to the feel, although the fiber may be softened by suitable treatment with oil or soap baths. The sulphur blacks are especially adapted for the dyeing of fast blacks of hosiery, as also are the brown colors, as the dyestuffs stand the repeated washings and the effect of the acid preparation to which the color of hosiery is subjected.

It is interesting to note the consumption of the products of the dyestuff industry at the different censuses. Fortunately this may be done with the aid of the following tabular statement from Bulletin 74 of the census of 1905,[1] which shows the cost of chemicals and dyestuffs used in all textile establishments (exclusive of shoddy and felt hat mills) and independent dyeing and finishing works in 1890, 1900, and 1905.

Cost of chemicals and dyestuffs used in all textile establishments: 1890 to 1905.

	1905	1900	1890
Total	$26,682,619	$25,392,573	$19,686,663
Independent dyeing and finishing establishments	10,587,319	10,667,621	8,407,693
Other textile establishments	16,095,300	14,724,952	11,278,970
Cotton manufactures [1]	4,573,375	5,718,107	4,266,773
Wool manufactures [2]	9,177,681	7,983,684	5,889,612
Hosiery and knit goods	1,677,252	1,023,161	564,053
Silk manufactures	666,992	(3)	558,532

[1] Includes cotton goods and cotton small wares.
[2] Includes worsted goods; woolen goods; carpets and rugs, other than rag; felt goods, and wool hats.
[3] Not reported separately in 1900.

Rather more than one-half, in value, of all the materials reported as consumed in 1905 by independent establishments consisted of chemicals and dyestuffs. Inasmuch as the value of such articles shows a positive decline since 1900, although the work done by these establishments, being of the same character and presumably divided as to the amount of each particular process in fairly similar proportions, has largely increased, it seems a reasonable inference that the average price of those materials decreased but that the quantities used increased.

Table 91 sets forth the imports of dyestuffs for consumption during the years ending June 30, 1891 to 1905, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

[1] Page 206.

Table 91.—DYESTUFFS—IMPORTS ENTERED FOR CONSUMPTION: 1891 TO 1905.

YEAR ENDING JUNE 30—	LOGWOOD.		EXTRACTS AND DECOCTIONS OF LOGWOOD AND OTHER DYEWOODS.		CAMWOOD.		FUSTIC.		ALL OTHER DYEWOODS.		CUDBEAR.	
	Tons.	Value.	Pounds.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Pounds.	Value.
1891	84,381	$1,842,954	3,282,227	$275,802	3	$220	9,100	$132,841	1,002	$28,969	402,241	$37,889
1892	60,297	1,233,592	4,227,017	325,576	29	3,339	8,490	125,067	2,527	50,131	276,690	24,597
1893	56,404	1,218,934	3,757,259	287,723	26	3,745	10,293	165,807	479	8,978	320,348	25,317
1894	53,709	1,313,376	2,817,451	196,397	70	5,770	7,765	126,309	347	4,426	151,121	12,666
1895	60,683	1,478,618	3,565,277	261,762	23	1,676	6,299	89,696	553	12,386	148,024	13,129
1896	66,074	1,522,069	4,910,176	287,120	50	3,748	6,832	90,389	1,155	18,583	118,517	9,256
1897	33,462	611,010	5,459,302	277,798	....	....	7,918	102,472	639	8,327	66,804	4,902
1898	46,977	744,135	3,664,623	232,986	....	....	9,923	137,666	2,726	33,475	66,795	4,795
1899	37,518	547,334	3,113,558	207,406	....	....	9,198	121,665	8,834	103,276	36,487	2,919
1900	48,190	628,464	3,420,276	227,527	1	161	4,440	60,886	20,967	205,351	61,305	3,944
1901	54,480	857,991	2,864,875	191,852	....	....	7,140	83,695	14,985	151,849	44,332	2,964
1902	53,625	774,796	3,221,606	219,208	....	....	4,353	59,562	11,128	101,188	60,909	3,779
1903	51,008	748,550	3,480,032	237,362	....	....	8,516	114,569	28,560	290,473	50,117	2,945
1904	48,491	663,572	3,121,218	269,228	....	....	4,618	51,011	28,799	313,262	55,250	3,558
1905	36,167	459,824	3,686,730	323,763	1	131	4,371	59,909	849	17,700	66,088	3,785

YEAR ENDING JUNE 30—	GAMBIER, OR TERRA JAPONICA.		CRUDE INDIGO.		INDIGO CARMINE.		EXTRACTS OR PASTES OF INDIGO.		Substitute indigo (value).	MADDER OR MUNJEET, OR INDIAN MADDER, GROUND OR PREPARED.		Orchil or orchil liquid (value).	Safflower and extract of saffron and saffron cake (value).
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.		Pounds.	Value.		
1891	27,610,594	$1,343,604	2,089,500	$1,600,865	28,175	$33,145	881,969	$58,288	$416	673,260	$39,806	$81,974	$44,598
1892	25,808,495	1,069,043	2,460,635	1,772,506	23,600	28,636	826,887	58,845	....	518,786	52,063	68,779	55,391
1893	35,762,646	1,305,468	3,226,314	3,137,511	29,687	35,304	1,317,835	101,347	2,793	653,779	61,720	64,928	27,697
1894	26,408,458	981,328	1,717,635	1,218,580	12,504	16,907	829,380	68,474	1,587	262,563	17,576	43,235	24,341
1895	29,022,603	963,255	3,411,539	1,940,250	26,173	33,405	605,750	57,317	187	329,477	18,541	59,317	16,462
1896	32,343,256	1,108,611	2,707,928	1,571,018	34,967	42,369	590,664	55,361	....	318,313	15,746	62,831	33,765
1897	31,349,555	959,501	3,010,005	1,586,309	52,192	59,182	469,729	51,153	....	292,462	12,963	38,965	38,022
1898	42,333,486	1,021,288	3,058,787	1,807,336	25,671	26,642	396,760	59,001	....	246,218	11,816	56,755	52,482
1899	38,123,478	754,497	3,127,182	1,698,583	17,505	17,172	254,531	23,324	....	280,081	12,298	45,494	32,477
1900	38,857,515	906,282	2,747,043	1,446,490	18,204	15,767	251,538	20,094	....	120,736	5,869	47,134	44,502
1901	26,811,197	824,444	3,139,063	1,402,894	11,061	9,789	181,168	12,292	....	178,872	11,329	31,937	42,502
1902	28,508,836	1,165,081	2,957,673	1,035,980	15,555	13,401	145,024	9,022	....	118,316	6,615	44,847	35,005
1903	42,719,254	2,042,036	4,532,021	1,202,342	22,206	17,190	168,484	12,912	....	153,171	9,706	63,438	43,554
1904	28,387,698	1,274,048	5,046,612	1,282,497	18,731	13,775	132,247	9,522	....	146,382	9,073	56,028	43,145
1905	32,192,891	1,112,660	4,830,955	873,781	24,304	18,529	126,070	8,649	....	58,218	3,841	44,205	60,132

YEAR ENDING JUNE 30—	COCHINEAL.		OIL OF ANILINE.		Salts of aniline (value).	ALIZARIN, NATURAL OR ARTIFICIAL, AND DYES COMMERCIALLY KNOWN AS ALIZARIN YELLOW, ORANGE, GREEN, BLUE, BROWN, AND BLACK, INCLUDING EXTRACT OF MADDER.		Coal tar colors or dyes, not specially provided for (value).	ALIZARIN ASSISTANT OR SOLUBLE OIL, OR OLEATE OF SODA, OR TURKEY RED OIL.		ALIZARIN ASSISTANT, ETC., ALL OTHER.		DEXTRIN, BURNT STARCH, GUM SUBSTITUTE, OR BRITISH GUM.	
	Pounds.	Value.	Pounds.	Value.		Pounds.	Value.		Gallons.	Value.	Pounds.	Value.	Pounds.	Value.
1891	86,797	$19,935	1,489,908	$299,662	$713,732	3,443,167	$674,101	$1,632,642	653	$437	1,325	$717	6,319,352	$212,968
1892	230,039	55,883	1,428,070	253,248	536,477	4,838,220	1,029,122	1,640,024	....	....	3,997	2,262	3,275,326	137,408
1893	215,512	52,572	1,211,818	163,539	432,134	5,729,221	1,125,506	2,322,258	....	....	2,901	1,157	4,650,215	161,430
1894	104,284	28,124	951,671	115,141	395,575	3,960,079	722,919	1,429,101	....	....	1,153	577	3,988,361	121,963
1895	130,205	37,285	1,315,934	143,426	548,110	5,287,720	870,383	2,739,933	92,158	25,735	....	....	....	....
1896	160,422	50,988	1,364,674	164,238	662,459	6,154,156	994,395	2,918,332	82,376	24,626	....	....	....	....
1897	137,261	41,943	....	....	812,884	6,169,018	1,023,425	3,163,182	....	....	....	....	4,874,656	124,719
1898	158,055	45,762	....	....	1,087,704	5,871,962	886,349	3,723,388	....	....	....	....	3,737,575	108,919
1899	97,563	23,207	....	....	743,130	5,226,452	700,786	3,900,099	....	....	....	....	3,402,474	99,056
1900	158,911	31,408	....	....	537,812	6,009,552	771,336	4,792,103	....	....	....	....	5,950,487	169,470
1901	114,414	20,414	1,530,950	143,268	589,535	4,046,986	713,392	4,034,171	....	....	....	....	5,692,395	164,120
1902	138,821	24,865	1,928,920	177,415	631,467	6,550,083	1,028,327	4,911,668	....	....	....	....	6,544,470	160,607
1903	112,714	24,215	1,899,933	167,976	789,553	4,307,428	660,464	5,252,611	....	....	....	....	6,532,764	149,637
1904	162,362	64,246	2,238,840	200,569	686,184	4,666,007	636,418	4,903,077	....	....	....	....	4,784,981	131,289
1905	84,332	36,876	2,362,480	209,385	712,925	4,076,573	625,076	5,635,164	....	....	....	....	4,000,102	128,779

Class XII.—Tanning Materials.

The class of tanning materials includes the ground, chipped, and comminuted products of oak, chestnut, chestnut oak and hemlock wood or bark, palmetto roots, sumac leaves, and the fluid or solid extracts from these materials or from quebracho wood and quercitron bark or other tannin-containing materials; tannic or gallic acid; and chrome tannage or other tannage solutions. The statistics presented in Table 92 show an increase in every item for the census of 1905 as compared with that of 1900, the largest increase in amount being in capital and the next largest in value of products. In common with most of the industries shown, the increase in capital is represented by a much larger percentage than the increase in value of products.

TABLE 92.—*Tanning materials—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	47	33	14	42.4
Capital	$7,396,313	$1,559,157	$5,837,156	374.4
Salaried officials, clerks, etc., number	168	64	104	162.5
Salaries	$260,472	$76,025	$184,447	242.6
Wage-earners, average number	1,891	554	1,337	241.3
Total wages	$788,451	$207,337	$581,114	280.3
Miscellaneous expenses	$518,033	$78,974	$439,059	556.0
Cost of materials used	$3,358,104	$1,020,763	$2,337,341	229.0
Value of products	$5,615,590	$1,713,284	$3,902,306	227.8

The statistics of Table 93 show an increase in every item for 1905 as compared with 1900 except in the quantity and value of ground bark, ground sumac, hemlock extract, and sumac extract, and in the value of "all other products." The largest increase in both quantity and value is found in the item of ground and chipped wood, in which there was an increase of 636,858,006 pounds, or 336.4 per cent in quantity and of $6,370,994, or 336.6 per cent in value, but it will be observed that these figures are based on reports of estimates of materials used. The next largest increase is found in oak and chestnut extract, in which an increase of 121,846,126 pounds, or 351.4 per cent, in quantity corresponds with an increase of $1,750,065, or 264.7 per cent, in value. As shown by the table the proportionate increases and decreases in quantity among the different products are remarkably consistent with the corresponding increases and decreases in value. It is believed that if the returns of the industry in tanning hides could be obtained in detail, the quantity of tanning materials, and especially of tanning liquors used, would be greatly increased, since many establishments in this industry manufacture their own tanning materials.

TABLE 93.—*Tanning materials—quantity and value of products: 1905 and 1900.*

KIND.	1905		1900	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Total	1,132,307,832	$13,943,190	424,120,026	$5,548,522
Ground bark	[1]74,847,272	[1]269,460	[2]136,380,000	[2]696,125
Ground and chipped wood	[3]826,147,006	[3]8,263,884	[4]189,289,000	[4]1,892,890
Ground sumac	5,129,333	65,630	9,528,800	114,660
Hemlock extract	18,833,450	406,619	35,591,329	572,882
Oak and chestnut extract	156,520,123	2,411,184	34,673,997	661,119
Sumac extract	4,093,619	95,958	4,349,742	103,085
Tannic acid	5,165,500	200,136	(5)	(5)
Tanning liquors	41,571,529	1,618,821	14,307,158	353,143
All other products	....	611,498	....	1,154,618

[1] Includes 36,553,420 pounds, with an assigned value of $18,277, consumed in establishments where manufactured; and also the tanning materials produced by establishments engaged primarily in the manufacture of other products.
[2] Includes 109,352,000 pounds, with an assigned value of $546,760, consumed in establishments where manufactured; and also the tanning materials produced by establishments engaged primarily in the manufacture of other products.
[3] Includes 825,181,300 pounds, with an assigned value of $8,251,813, consumed in establishments where manufactured; and also the tanning materials produced by establishments engaged primarily in the manufacture of other products.
[4] Estimated.
[5] Included in "all other products."

Table 94 shows that the principal increases in the number of establishments at the census of 1905 as compared with that of 1900 were in Virginia, North Carolina, and Tennessee, and the principal decreases in Pennsylvania and New York. Practically all of the gains were in the Southern states, which in 1905 contained more than half of the establishments of the country. Virginia ranked first in 1905, and Pennsylvania first in 1900.

TABLE 94.—*Tanning materials—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1]51	[2]47
California	2	2
Connecticut	1	......
Florida	2	1
Illinois	......	1
Kentucky	1	1
Maryland	......	2
Massachusetts	3	1
Michigan	1	1
New Jersey	7	8
New York	2	6
North Carolina	5	......
Pennsylvania	5	11
Tennessee	5	1
Virginia	13	8
West Virginia	4	4

[1] Includes 4 establishments engaged primarily in the manufacture of other products.
[2] Includes 14 establishments engaged primarily in the manufacture of other products.

Virginia and New Jersey, which shared the second place in 1900, passed to the first and second rank, respectively, at the census of 1905. North Carolina, which did not appear at the census of 1900, Pennsylvania, which stood first at that census, and Tennessee, which was in the sixth rank in 1900, now share the third place in rank. West Virginia has held the fourth rank at both censuses. Massachusetts has passed from the sixth to the fifth rank. California, which held the fifth, Florida the sixth, and New York the third place in 1900, now share the sixth place in rank. Connecticut, which did not appear in 1900, with Kentucky and Michigan, which both held the sixth place in 1900, now share the seventh place in rank.

TABLE 95.—*Tanning materials—value of products, by states: 1905 and 1900.*

STATE.	1905	1900
United States	$5,673,100	$3,108,872
Massachusetts	204,725	(1)
New Jersey	288,727	399,481
New York	(1)	301,756
North Carolina	634,128	....
Pennsylvania	482,862	753,182
Tennessee	720,255	(1)
Virginia	739,144	470,223
West Virginia	240,965	232,365
All other states[2]	2,362,294	951,865

[1] Included in "all other states."
[2] Includes in 1905 California, Connecticut, Florida, Kentucky, Michigan, and New York; in 1900, California, Florida, Illinois, Kentucky, Maryland, Massachusetts, Michigan, and Tennessee.

The statistics of Table 95 show that as measured by the value of products in the states which are reported separately at each census, Virginia, which stood second in rank at the census of 1900, stands first at the census of 1905. Tennessee, which was combined with "all other states" in 1900, now ranks second, and North Carolina, which did not appear at the census of 1900, ranks third. At the earlier census the value of the product of "all other states" exceeded that of any single state specially enumerated. This condition was still more marked at the census of 1905, notwithstanding the fact that the returns for Massachusetts and Tennessee were shown separately, because of the increase in the number of establishments in these states.

The table also shows for those states whose returns have been presented separately at each census that, while there has been an increase in the returns for Virginia and North Carolina, there has been a decrease in the returns for New Jersey and Pennsylvania. Inspection of the returns of the individual establishments shows that the decrease in New Jersey and Pennsylvania has been due to the growing remoteness of natural raw material.

TABLE 96.—*Tanning materials—quantity and cost of principal materials used: 1905 and 1900.*

KIND.	1905	1900
Hemlock, oak, and chestnut bark:		
Tons	98,468	93,104
Cost	$706,865	$436,071
Wood:		
Cords	247,295	27,813
Cost	$750,591	$86,728
Quebracho wood:		
Tons	4,904	(1)
Cost	$816,817	....
Sumac leaves:		
Tons	4,476	11,538
Cost	$93,959	$176,353
All other materials	$466,916	$155,469

[1] Included in "all other materials."

The statistics of Table 96 show an increase at each census for every item except sumac leaves, which show a decrease in both quantity and value. The general increase is in accordance with the increase noted in the value of products in Table 95.

It is evident when we consider the nature of this industry that a complete presentation of it can not be made for several reasons. In the first place, logwood and other materials of the dyestuff industry are used to a certain extent in treating leather, but as there is no information at command by which to determine what portion of the logwood is used in each industry, the whole has been accredited to dyestuffs. Some tanning materials, on the other hand, are used in dyeing textiles, and as in this instance also no separation can be effected, they are all included in the class now under treatment. This constitutes an offset in the bookkeeping. A more serious difficulty is met with in the production of tanning materials in tanning factories in which they are consumed in further manufacture.

The extent to which tanning materials from all sources are used in the manufacture of leather is shown in Table 97, the data being taken from Census Bulletin 57.

TABLE 97.—*Tanning materials used in the manufacture of leather: 1905 and 1900.*[1]

KIND.	1905	1900
Hemlock bark:		
Cords	1,000,328	1,170,131
Cost	$8,471,292	$7,347,242
Oak bark:		
Cords	422,269	445,934
Cost	$3,765,509	$3,174,995
Oak bark extract:		
Barrels	214,391	54,231
Cost	$2,300,395	$550,065
Quebracho extract	$2,490,487	$292,133
Chemicals	$2,847,441	$2,257,751
All other materials used in tanning	$5,154,870	$3,395,261

[1] Census of Manufactures, 1905, Bulletin 57, page 37.

Examination of the data given here shows that the statement made at the census of 1900 practically holds good to-day. It was as follows:[1]

The early tanners were conservative in adopting new processes. Various tannages and substitutes for oak and hemlock bark, which furnished all the tannin of former years, have come into wide use. Standard tannages are now made from hemlock and oak barks, from their extracts, from gambier, sumac, and quebracho, and from chemicals. Mechanical devices have shortened the time required for getting good results, but the tanner is constantly on the alert to secure something that will diminish the number of weeks he is compelled to wait while his hides are assimilating the liquors in which they are placed. Some such shortening process as that employed in the manufacture of kid or morocco is confidently anticipated by manufacturers of sole leather, calf, upper, etc. In the case of kid, hyposulphite of sodium added to the chromium compounds makes the tannage more permanent, while the desired results are obtained in a shorter time. To this discovery is due the sudden growth of a most important branch of leather manufacturing.

Notwithstanding the numberless inventions that have to do with the chemical side of tanning, hemlock and oak bark still furnish the great bulk of the material upon which the manufacturers of leather rely for their tannin. This is accounted for by the practically unlimited supply and the satisfactory results obtained through their use. Inventive genius has exhausted almost every expedient for getting the last particle of tanning material from the bark, so that, whereas not long ago a large percentage of tannin was lost to the manufacturer, he is now able to utilize practically all that the bark is capable of yielding.

The process of chrome tannage above referred to is described by Thorp[2] as follows:

Chrome tannage, or tawing with chromium salts, has been chiefly developed in this country and is now in general use here. The principle of the process consists in precipitating an insoluble chromium hydroxide or oxide on the fibers of a skin which has been impregnated with a soluble chromium salt, usually potassium bichromate; basic chromium chloride, chromium chromate, and chrome alum are also used. The skins, having been limed, unhaired, fleshed, bated, drenched, and scudded, are worked in a solution of potassium bichromate to which some common salt has been added, together with one-fourth to three-fourths of the theoretical amount of hydrochloric or sulphuric acid necessary to liberate all the chromic acid (CrO_3). After several hours, when the skin shows a uniform yellow color when cut through the thickest part, it is removed, the excess of water pressed out or drained away, and the

[1] Twelfth Census, Manufactures, Part III, page 716.
[2] Frank Hall Thorp, Outlines of Industrial Chemistry, 1905, page 540.

skin worked in a bath of sodium bisulphite ($NaHSO_3$), or thiosulphate, to which has been added some mineral acid to liberate the sulphur dioxide:

(1) $K_2Cr_2O_7+2\ HCl=2\ KCl+H_2O+2\ CrO_3$.

(2) $Na_2S_2O_3+2\ HCl=2\ NaCl+H_2O+S+SO_2$.

(3) $2\ CrO_3+3\ SO_2+3\ H_2O=3\ H_2SO_4+Cr_2O_3$.

The chromic acid is absorbed by the fiber and is later reduced in situ by the sulphurous acid. It is necessary to use a strong solution of the reducing agent, so that the reduction may be fully accomplished before the chromic acid has time to "bleed" from the skin. The strength of solutions recommended vary somewhat in the various processes, but are usually made from 10 to 30 grams per liter for the bichromate, and 30 to 50 grams for sodium thiosulphate. Calculated on the weight of the skin, from 4 to 9 per cent of bichromate, and about 15 per cent thiosulphate are usually employed. The amount of chromic acid fixed on the fiber is about 4 to 6 per cent, calculated as bichromate, $K_2Cr_2O_7$.

Chrome leather is tough and resists moisture very thoroughly. On this latter account, skins which are to be dyed should be introduced into the dye at once after reducing and washing, for if allowed to dry the dyeing is incomplete. The leather may be heated to 80° C. or more without injury, and hence can be dyed with some of the alizarin colors. It is a very rapid process, the time of steeping in the chrome bath being only a few hours and even less in the reducing bath. It is a very light tannage, and on thick skins has considerable tendency to contract the fiber, and so is not used for sole or upper leathers. It is chiefly employed for glazed kid, calf kid, and glove leathers. The tanned or colored skins are oiled and stuffed before drying.

Table 98 sets forth the imports and exports of tanning materials for the years ending June 30, 1891 to 1905, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

Table 98.—TANNING MATERIALS—IMPORTS FOR CONSUMPTION AND DOMESTIC EXPORTS: 1891 TO 1905.

YEAR ENDING JUNE 30—	IMPORTS.														DOMESTIC EXPORTS.
	Sumac, extract of.		Sumac, ground.		Sumac, unmanufactured.		Hemlock bark.		Hemlock extract.		Extracts other than hemlock.		Hemlock and other extracts (value).	Other articles in crude state used in tanning, not specially provided for (value).	Bark and extracts for tanning (value).
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Cords.	Value.	Pounds.	Value.	Pounds.	Value.			
1891	2,399,028	$77,152	11,412,297	$235,729	2,953,202	$65,802	57,255	$274,426	768,710	$14,958	3,310	$229	...	$2,603	$241,382
1892	1,902,089	68,853	10,822,614	225,891	2,841,200	60,657	53,019	256,346	...	...	12,973	408	...	1,918	239,708
1893	2,880,210	108,447	14,363,922	289,953	3,817,568	70,152	50,689	241,244	...	...	672	71	...	8,361	232,269
1894	1,277,609	54,535	8,315,551	191,333	970,207	21,427	46,173	212,350	...	...	...	...	...	10,630	271,236
1895	1,604,024	53,260	12,242,216	236,541	2,203,645	40,021	47,286	230,943	...	...	...	...	$3,470	16,629	290,362
1896	2,472,923	78,504	13,349,233	231,324	1,027,824	24,861	43,964	214,891	...	...	...	...	19,046	23,499	354,007
1897	2,907,521	84,150	18,530,104	245,992	2,117,439	30,554	...	...	...	...	...	...	...	...	241,979
1898	1,266,542	48,399	8,336,117	121,461	3,754,307	62,553	...	...	...	...	...	...	...	...	329,904
1899	1,133,662	38,709	14,156,344	202,605	3,011,810	42,297	...	...	...	...	...	...	...	...	369,693
1900	1,419,827	50,295	10,644,001	233,846	1,048,955	20,800	...	...	...	...	...	...	...	...	376,742
1901	1,613,178	52,105	9,935,746	179,801	1,422,822	26,138	16,749	65,313	...	...	...	...	...	46,739	386,238
1902	1,431,354	45,375	13,047,249	209,324	1,204,030	20,886	24,901	103,930	...	...	...	...	...	82,913	288,012
1903	1,356,020	50,681	13,659,289	199,290	1,131,629	16,553	17,041	75,283	...	...	...	...	...	56,592	239,786
1904	1,341,762	50,045	18,007,931	269,459	2,660,936	38,723	14,147	63,632	...	...	...	...	...	92,919	291,783
1905	1,213,494	38,572	16,413,560	235,403	3,745,016	51,162	13,492	64,098	...	...	...	...	...	157,612	552,909

Class XIII.—Paints and Varnishes.[1]

The products of this class embrace pigments, including dry white lead (basic lead carbonate, corroded lead, ceruse), sublimed white lead (basic, oxy-, or anhydrolead sulphate usually containing some zinc oxide), dry white zinc (zinc oxide, Chinese white), zinc lead white (composed of about equal parts of lead sulphate and zinc oxide), leaded zinc oxide (zinc oxide containing varying amounts of lead sulphate), lead oxides (litharge, lead monoxide, red lead, minium, orange lead, orange mine, orange mineral), lampblack and other carbon blacks (vegetable black, gas black, ivory black, animal black, Frankfort, German, or drop black, candle black, graphite, plumbago), barytes (barium sulphate, heavy spar, "sugar," blanc fixe), fine colors (artists' colors, including among others true vermilion, Chinese vermilion, cadmium yellow, true chrome green, cobalt green, cobalt blue, ultramarine blue, Chinese blue, ceruleum, umber, Vandyke brown, sepia, and bister), iron oxides and other earth colors (rouge, light red, Indian red, red oxide, Venetian red, purple oxide, scarlet red, burnt sienna, burnt umbers, and other colors obtained artificially from iron compounds or iron and other earthy minerals), dry colors (including all other pigments in the dry condition either simple or compounded), and pulp colors sold moist; paints, including white lead and other white pigments in oil, "paints in oil and in paste," and "paints in oil already mixed for use;" varnishes and japans, including oleoresinous varnishes, spirit varnishes, dammar and similar turpentine and benzine varnishes, pyroxylin varnishes, drying japans, dryers, baking japans and lacquers, and enamels, fillers, including liquid, paste, and dry fillers and putty; and water paints and kalsomine, including water paints dry or in paste, and water paints already mixed for use.

This classification, therefore, covers many forms of industry, such as the corroding of lead; roasting lead to form the oxides; volatilizing and oxidizing galena to form sublimed lead; distilling zinc and burning its vapors to produce zinc white; grinding and bleaching barite, heavy spar, cawk, or lead bloom to form barytes, or the artificial formation of barium sulphate to produce blanc fixe; thermolyzing hydrocarbons and other carbonaceous compounds to produce carbon blacks, the electric furnace production of artificial

[1] Including bone, ivory, and lamp black.

graphite; and the large number of chemical processes through which a great variety of colors are formed, the mechanical processes of grinding colors in oil or other vehicles to produce paint, and the physical process of dissolving gums in solvents to produce varnishes.

TABLE 99.—*Paints and varnishes—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	664	615	49	8.0
Capital	$77,149,357	$60,834,921	$16,314,436	26.8
Salaried officials, clerks, etc., number	4,455	3,731	724	19.4
Salaries	$5,725,941	$5,040,301	$685,640	13.6
Wage-earners, average number	11,833	9,782	2,051	21.0
Total wages	$6,368,767	$4,971,697	$1,397,070	28.1
Miscellaneous expenses	$9,720,791	$5,122,381	$4,598,410	89.8
Cost of materials used	$60,030,070	$44,844,229	$15,185,841	33.9
Value of products	$91,487,326	$69,922,022	$21,565,304	30.8

The statistics of Table 99 show an increase in every item, particularly noteworthy being those in value of products and in capital, $21,565,304 and $16,314,436, respectively. The largest proportional increase, 89.8 per cent, was in miscellaneous expenses, while cost of materials ranked next, the relative increase in this latter item slightly exceeding that in value of products. It is evident that there has been a material development in the industry since the last census, the increase in the value of products in particular reported for the five-year period at the census of 1905 being markedly greater than the corresponding increase in the ten-year period between the censuses of 1890 and 1900.

Table 100 shows, for the censuses of 1900 and 1905, the quantity and value of the different products of the paint and varnish industry, including bone, ivory, and lamp black, for all establishments where they were manufactured either as principal or subsidiary products, including also the quantity and value of such products as were consumed in processes of further manufacture in the same establishments where they were originally produced.

The statistics of Table 100 show an increase in every item except in the quantity of dry white lead, dry colors, and of liquid dryers, the value of iron oxides and other earth colors, and in both the quantity and value of paints in oil, in paste. In the case of both the dry colors and the liquid dryers the value has increased, which would indicate that superior and more efficient articles are being produced thereby rendering a smaller quantity adequate for a given amount of work. It may be mentioned that both of these products are used in the compounding of paints ready mixed for use, that they may therefore be consumed in such further manufacture in the establishment where originally produced, and that there is, as already pointed out, an increasing tendency on the part of manufacturers to pursue this practice; it has not, however, been possible in this investigation to ascertain definitely the quantities so used. The decrease in both the quantity and value of the paints in oil, in paste is more than offset by the increase in quantity and value of both white lead in oil and in paints ready mixed for use, which indicates a growing tendency on the part of the consumer to mix his colors at his convenience and to suit his own taste, or to use the ready mixed paints in preference to buying separately the colored paint in oil, in paste and the vehicle, and then compounding them for use.

TABLE 100.—*Paints and varnishes—quantity and value of products: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Value.	Quantity.	Value.
White lead, dry, tons	[1] 120,046	[1] $11,761,909	[2] 127,346	[2] $9,317,765
Oxides of lead, tons	[3] 36,663	[3] 4,001,775	[4] 32,233	[4] 2,958,184
Oxides of zinc, tons	58,743	4,330,394	37,557	2,718,700
Lampblack, pounds	20,298,385	640,701	7,670,931	425,028
Fine colors, pounds	8,030,330	1,091,853	3,898,447	1,009,096
Iron oxides and other earth colors, tons	[5] 24,723	[5] 342,816	17,454	367,987
Dry colors, tons	[6] 61,894	[6] 4,550,295	75,909	3,655,718
Pulp colors sold moist, pounds	25,505,482	931,131	20,060,935	861,531
White lead, in oil, tons	[7] 114,816	[7] 11,790,482	59,506	6,127,960
Paints in oil, in paste, tons	67,021	8,892,755	95,710	11,751,240
Paints ready mixed, gallons	22,755,018	20,771,387	17,437,311	15,302,481
Oil and turpentine varnishes, gallons	[8] 17,929,403	[8] 16,170,614	14,804,251	14,530,159
Alcohol varnishes, gallons	[9] 1,542,562	[9] 2,202,645	553,432	921,169
Pyroxylin varnishes, gallons	[10] 458,361	[10] 562,629	171,127	187,626
Liquid dryers, gallons	[11] 5,201,187	[11] 3,998,635	6,564,370	3,085,954
Liquid fillers, gallons	1,059,948	786,517	123,552	112,921
Putty, pounds	43,931,556	728,468	17,287,323	238,427
Water paints, dry or in paste, pounds	28,457,447	936,607	14,412,653	744,024
All other products	....	14,827,101	....	4,939,215

[1] Including 88,823 tons, with an assigned value of $8,882,300, consumed in establishments where manufactured.
[2] Including 68,811 tons, with an assigned value of $4,816,707, consumed in establishments where manufactured.
[3] Including 4,925 tons, with an assigned value of $492,500, consumed in establishments where manufactured.
[4] Including 1,040 tons, with an assigned value of $95,441, consumed in establishments where manufactured.
[5] Including 310 tons, with an assigned value of $6,200, consumed in establishments where manufactured.
[6] Including 619 tons, with an assigned value of $6,190, consumed in establishments where manufactured.
[7] Including 5 tons, with an assigned value of $500, consumed in establishments where manufactured.
[8] Including 605,684 gallons, with an assigned value of $466,377, consumed in establishments where manufactured.
[9] Including 2,200 gallons, with an assigned value of $3,432, consumed in establishments where manufactured.
[10] Including 5,800 gallons, with an assigned value of $6,670, consumed in establishments where manufactured.
[11] Including 843,682 gallons, with an assigned value of $649,635, consumed in establishments where manufactured.

In explanation of the falling off in the quantity of dry white lead reported in 1905, together with the large increase in the quantity of white lead in oil, it may be stated that it appears probable, after a careful scrutiny and checking of the returns for both censuses, that in 1900 a considerable quantity of white lead in oil may have been tabulated as "white lead, dry," for the reason that at that census many establishments returned white lead without indicating whether it was dry or in oil, or furnishing a criterion by which this fact could be definitely ascertained. As each of these substances was specifically called for in 1905, the separation has undoubtedly been made more completely in the present report.

A means of checking the figures for dry white lead is found in the quantity of pig lead used in the paint and varnish industry. Out of the total quantity reported, 40,011 tons were used in the manufacture of lead pipe, sheet lead, solder, and other manufactures of lead. By calculation based on the residue, the quantities reported for dry white lead have been confirmed.

Although Table 100 gives for the most part a reasonably accurate presentation of the paint and varnish industry so far as those products which are produced for sale are concerned, yet the actual manufacture of these substances for use is probably much greater. It is well known that large establishments engaged in the manufacture of cars and other structures on an extensive scale use large quantities of paint in the preservation and decoration of their products, and it is a sound policy for these establishments to manufacture a material which they consume so largely, but no means are at hand by which to determine the extent of this manufacture. Again it is known that litharge is used in the making of glass. In 1900[1] there were used for this purpose 8,386,106 pounds, costing $490,200, and in 1905, 9,613,649 pounds, costing $555,130. It has long been a practice in some glass works to manufacture there the litharge consumed in the making of the glass, and the item in Table 100 for oxides of lead contains the returns for such litharge in 1900, although not for 1905.

TABLE **101**.—*Paints and varnishes—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1] 712	[2] 652
Alabama	3	....
California	24	16
Colorado	5	3
Connecticut	14	11
Delaware	4	2
District of Columbia	1	2
Florida	1	....
Georgia	6	5
Illinois	66	55
Indiana	16	10
Iowa	5	6
Kansas	3	1
Kentucky	14	12
Louisiana	3	4
Maine	1	3
Maryland	13	16
Massachusetts	35	46
Michigan	19	17
Minnesota	6	7
Mississippi	1	1
Missouri	41	30
Nebraska	3	3
Nevada	1	1
New Jersey	53	60
New York	134	126
North Carolina	2	2
Ohio	77	67
Oregon	4	4
Pennsylvania	112	111
Rhode Island	5	6
Tennessee	4	6
Texas	2	5
Vermont	1	2
Virginia	4	2
Washington	6	3
West Virginia	11	....
Wisconsin	12	7

[1] Includes 48 establishments engaged primarily in the manufacture of other products.
[2] Includes 37 establishments engaged primarily in the manufacture of other products.

At both censuses New York ranked first, Pennsylvania second, and Ohio third in the number of establishments, New York and Pennsylvania both reporting over a hundred establishments at each census. In 1905 Illinois, which stood fifth at the census of 1900, exchanged places with New Jersey, which stood fourth, while a similar exchange occurred between Missouri and Massachusetts for the sixth and seventh places. California ranked eighth with 24 establishments. No other state reported 20 establishments at either census. The largest increase in the number of establishments was in Missouri and West Virginia, which reported a gain of 11 each. Twelve states and territories reported a decrease, the largest loss, 11 establishments, being shown for Massachusetts.

TABLE **102**.—*Paints and varnishes—value of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
United States	$98,804,910	$74,343,037
North Atlantic division	51,987,750	43,330,875
New England	3,888,090	4,009,504
Southern North Atlantic	48,099,660	39,321,371
South Atlantic division	1,614,425	934,288
Northern South Atlantic	1,323,752	748,610
Southern South Atlantic	290,673	185,678
North Central division	39,943,931	27,133,057
Eastern North Central	30,567,947	20,688,785
Western North Central	9,375,984	6,444,272
South Central division	1,770,765	1,039,985
Eastern South Central	1,570,290	860,053
Western South Central	200,475	179,932
Western division	3,488,039	1,904,832
Rocky Mountain and Basin and Plateau	666,519	309,775
Pacific	2,821,520	1,595,057

The statistics of Table 102 show an increase in the value of the products for 1905 as compared with 1900 in every main division and subdivision presented except in New England, in which there was a decrease of $121,414, or 3 per cent. The greatest actual increase in one of the main divisions, $12,810,874, is reported from the North Central division, followed by the North Atlantic with an increase of $8,656,875. The greatest proportional increase, 83.1 per cent, is found in the Western division followed by the South Atlantic with an increase of 72.8 per cent, although the absolute increase in these divisions is relatively small. At each census the North Atlantic division stood first in the value of products, reporting 52.6 per cent, or more than half of the total value returned in 1905, the Southern North Atlantic minor division alone reporting 48.7 per cent. The North Central division ranked second at both censuses, followed by the Western, South Central, and South Atlantic divisions in the order named.

Table 103 sets forth the quantities and values of the more important materials used in the manufacture of paints and varnishes, either as a principal or subsidiary product, as returned at the censuses of 1900 and 1905.

[1] Census of Manufactures, 1905, Bulletin 62, page 25.

TABLE **103.**—*Paints and varnishes—quantity and cost of principal materials used: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Cost.	Quantity.	Cost.
Alcohol, grain, gallons	59,064	$138,703	78,309	$175,907
Alcohol, wood, gallons	1,357,682	790,243	310,059	285,510
Barytes, natural and artificial, pounds	47,788,162	218,692	59,675,207	[1] 241,778
Benzine, gallons	13,306,420	1,276,578	10,081,945	1,045,488
Dry colors, pounds	151,986,244	5,322,157	....	4,258,959
Gums, pounds	37,712,476	4,329,031	36,533,632	3,470,695
Iron oxides and other earth colors, tons	63,610	518,950	20,993	[1] 337,733
Lead oxides, pounds	3,690,402	242,475	6,118,576	[1] 429,121
Linseed oil, gallons	20,642,781	7,904,978	16,157,117	7,495,196
Pig lead, tons	129,629	11,214,961	99,052	8,585,688
Turpentine, gallons	7,160,774	3,590,250	6,519,408	2,965,051
White lead, pounds	[2] 61,758,068	[2] 3,046,065	39,689,235	1,970,614
Whiting, pounds	46,598,424	332,836	10,690,441	55,157
Zinc white, pounds	65,408,503	2,814,710	45,178,276	[1] 2,531,037

[1] Included in "dry colors" in Twelfth Census Bulletin No. 210.
[2] Includes 342,014 pounds of white lead in oil, valued at $16,335.

The statistics of Table 103 show an increase in every item except the quantity and value of grain alcohol, of barytes, and of lead oxides. The marked increase in the quantity and value of the wood alcohol used indicates that it has been substituted for the more expensive tax-paid grain alcohol. At the same time, in the pyroxylin varnish industry, other cheaper solvents than grain alcohol have come into use. The decreases in the barytes and lead oxides have probably resulted also from the substitution of other pigments and dryers for these substances. The largest increase in quantity is found in the item of iron oxides and other earth colors, amounting to 42,617 tons, or 203 per cent; while the largest increase in value was that of $2,629,273, or 30.6 per cent, reported for pig lead. A comparison of the amount of pig lead returned in 1900 and 1905 with the dry white lead reported as produced at these censuses tends to confirm the statement previously made that in 1900 the statistics for dry white lead probably included a quantity of white lead in oil also.

The growth of the industry is brought out more clearly in Table 104, which shows the number of establishments, capital, number of employees (including both salaried employees and wage-earners), and value of products reported for the industry at each census from 1850 to 1905, inclusive. Establishments manufacturing paints or varnishes as subsidiary products are not included.

TABLE **104.**—*Paints and varnishes—comparative summary: 1850 to 1905.*

CENSUS.	Number of establishments.	Capital.	Number of employees.	Value of products.[1]
1905	664	$77,149,357	16,288	$91,487,326
1900	615	60,834,921	13,513	69,922,022
1890	546	46,945,797	10,973	55,264,711
1880	343	17,960,742	5,280	29,773,317
1870	224	13,949,740	3,504	22,512,860
1860	164	7,402,697	2,216	11,107,342
1850	68	3,217,100	1,579	5,466,052

[1] Includes custom work and repairing.

It will be observed that there has been a steady increase from census to census in every item shown in Table 104, and that there has been no abnormal growth in any one item as compared with the others. The increase in number of establishments is perhaps particularly noteworthy, as many industries showed a falling off in this item at the censuses of 1900 and 1905, as a result of the prevailing tendency to concentration.

Lead oxides and carbonate are found occurring as minerals in the earth and were known to the ancients. Minium was used as a rouge and white lead as a cosmetic by the Romans and Athenians. White lead was also used by the Romans as a body for their paints. Its manufacture was described by Theophrastus about 300 B. C., the method followed being to place sheets of lead in pots with vinegar or wine lees and allow them to stand, whereby, evidently through the action of the carbon dioxide of the air, the basic lead acetate first formed was converted into basic carbonate. This practice with some improvements appears to have been revived in Holland about the sixteenth century. This method is still known as the Dutch process, and is held to give a white lead of superior covering power which is especially valued as a basis for colored pigments in the manufacture of mixed paints.

The process as practiced in this country is described in a circular of the Sterling White Lead Company, as follows:

The pig, or metallic lead, is melted and cast into perforated disks called "buckles," 6 inches in diameter, which are put into pots containing about 1 pint of vinegar. These are placed in rooms holding ten layers, or tiers, 600 to 1,000 pots each. The pots are covered with boards, and layers of spent tan bark placed between each tier. The rooms, technically called "beds," are kept closed from three to four months. During this period the heat and carbonic acid gas generated by fermentation of the tan, together with the acid vapors, combine to corrode the lead into a white flaky substance. This, after it is crushed, screened, ground in water, and dried, forms the white lead of commerce, and is either sold in the dry state to mixed paint and color manufacturers, or ground in linseed oil and sold under corroder's brand for general painting purposes. The works comprise a corroding house 78 by 450 feet, containing 34 corroding beds with a capacity of 60 tons of pig lead each every one hundred days, with ample room for additional beds when required; an iron building containing the buckle machine, pig lead storeroom and machine shop; an iron boiler house equipped with three safety boilers of over 600 horsepower; an exceptionally solid mill building of brick and stone, 75 by 150 feet, four stories high, with a fine light and dry basement; an iron and frame building containing the oxide furnaces and plant, with a capacity of 1,200 tons of red lead and litharge annually; a bark-extracting plant sufficient to supply all the tan bark required for corroding; and a pumping house on the river bank equipped with a fine steam pumping engine. The corroding department is equipped for the "old Dutch" process exclusively (one hundred days' corrosion), but instead of the usual arduous and tedious method of charging and discharging the beds by hand, an electric traveling crane has been introduced. This crane, with a capacity of 3 tons, travels the entire length of the corroding beds, and is utilized for quickly and economically handling the charged pots, the tan bark, and the corroded product. With this crane it is possible to conduct all the work of charging in a much shorter time and with far fewer hands in proportion to tonnage than is possible in any other "old Dutch" process works in the world. The dust-proof separator has a capacity of 50 tons daily, and there are two double run water mills, with a combined daily capacity of 30 tons. These are run in connection with 14 cedar settling tanks holding about 100 barrels each. The drying rooms on the top floor are furnished with 17 pans with a present capacity for 150 tons a week, with room for additions if necessary. Of these pans, 6 are of the ordinary steam-jacket type, but these are soon to be replaced with new pans of the filter type, which are in exclusive use at this plant. The combined steam and filter drying pan is an invention of the Sterling Company. It comprises an inclined bed, with a false bottom of brass wire cloth covered with filtering fabric, underneath which lies a series of steam coils. Instead, therefore, of having to provide sufficient heat units to evaporate all the moisture from the pulp, only enough is consumed to evaporate the residue that can not be drawn off by gravity and filtration. The saving in coal consumption and in time is apparent at once. But the improvement is still more significant in its effectiveness as an additional washing process. With the ordinary drying pan any acetic acid retained in the pulp after settling remains in the finished product, but with these filter pans it is drained off to the last degree. The oil grinding plant comprises 10 double buhr mills, with a combined daily capacity of 2 carloads of ground lead, with mixers adequate to supply all the mills. The mills are all set on ponderous brick piers extending to solid foundations. An improvement over the ordinary practice with oil grinding consists in allowing all the ground lead to cool in tubs before packing. The mill is also equipped with a pulverizing machine in connection with the automatic packer for reducing the dry lead for barreling. The bark-extracting plant was established for the purpose of insuring a permanently adequate supply of tan for corrosion, as well as to control the quality of the tan provided. Chestnut oak bark is procured from the adjacent country, and the plant is similar to those installed at first-class tanneries, with a vacuum pan for reducing the extract.

Theoretically, 100 parts by weight of lead should yield 124.8 parts of lead carbonate, but in practice the yields vary from 106 to 117 parts of dry white lead. The dross, or skimmings, is used in further manufacture.

In addition to the Dutch process there are the English process, in which litharge is moistened with a solution of lead acetate and the mixture stirred by machinery in an atmosphere of carbon dioxide gas produced by the combustion of coke, and the French process, in which a current of carbon dioxide is passed through a solution of basic lead acetate; but neither of these appears to be in use in this country, though mention is made in literature, but without descriptions, of the use of "quick" processes. Quite a number of electrolytic processes for the production of white lead have been devised, but these do not appear in practice, either because the product is not satisfactory or the operating costs do not compete successfully with those of the older methods.

Sublimed white lead is a strictly American product, the process for its manufacture having been invented and patented by Messrs. E. O. Bartlett and George T. Lewis. This substance is an oxy- or anhydro- lead sulphate which is obtained, without grinding, in the form of an impalpable white powder, having a specific gravity of 6.2, high covering power and wearing qualities, and a high degree of resistance to blackening when exposed to the sulphur compounds occurring in fuel and sewer gases. Furthermore, as it is difficultly soluble, it is free from the poisonous properties which characterize many other lead compounds. The methods employed in its manufacture are described as follows:[1]

Viewed in the gross the process is most simple: The sulphide ore of lead (galena) is heated to the sublimation point and the heated vapors, taking up oxygen from the air, are transformed from the sulphide into the oxy-sulphate of lead. But in detail the transformation is not so easily or simply accomplished. To comprehend thoroughly, we must begin with the ore and follow it through the successive steps of manipulation. The "mineral," as it is called in miners' phrase, after being taken from the mine, is finely crushed, washed, and separated by a gravity process known as "jigging" from accompanying rock and other minerals. In this purified condition it is delivered to the works, where it is again crushed, sized, and inspected. The ores of this district are the purest in the world, and the Picher plant was located at Joplin because of this fact; nevertheless great care is taken in their preparation for the furnaces. The ore thus prepared is charged, with proper carbon fuel, into patent furnaces of different types specially constructed for the different stages of the process. In the last stage the charge is subjected to a heat sufficiently intense to vaporize the lead contents with sufficient access of air to oxidize it into a basic sulphate compound of lead. Powerful suction fans carry these volatilized vapors through a long series of sheet iron pipes or flues up around and through the famous "goose necks," the oxidation being completed during the progress, until the cooled and condensed white vapors of lead oxy-sulphate are finally collected in fabric condensers, which allow the gases of combustion to escape through their meshes. These condensers or collectors are in the form of long bags, hung perpendicularly in a large building, technically known as the "bag house." When it is remembered that in this process a pure lead pigment is carried in the form of vapor through a series of winding flues for a distance of practically 1,000 feet, until it is finally caught and retained in the fabric strainers (bags), it will be realized that the pigment particles must be in a fine state of subdivision. As a matter of fact these ultimate particles of dry sublimed white lead are so fine as to be practically formless—perfectly amorphous. Many pigments, especially those formed by slow processes of precipitation, corrosion, etc., are either crystalline or cryptocrystalline, to use the chemical term; but no other pigment, except lampblack, approaches sublimed lead in fineness and absence of structure; and there is no other pigment to which it can be compared in durability. The two are practically equal in this respect, though there are many instances in which the lettering painted with Picher Sublimed White Lead on a lampblack ground has remained intact after the ground had disappeared.

According to Joseph Hyde Pratt[2] the production of sublimed lead in the United States from 1902 to 1904 was as follows:

YEAR.	Quantity (pounds).	Value.
1904	12,954,000	$550,587
1903	8,592,000	386,640
1902	9,465,500	449,611

Another white pigment produced in this country by the oxidizing smelting of lead and zinc ores in a furnace of special design is known as zinc lead, and is composed principally of lead and zinc oxides. According to Pratt[3] the production in the United States from 1901 to 1904 was as follows:

[1] The Story of Picher Sublimed White Lead, pages 8 to 10.
[2] The Production of Mineral Paints in 1904, page 18.
[3] Ibid., page 19.

YEAR.	Quantity (tons).	Value.
1904	5,779	$404,530
1903	4,500	247,500
1902	4,000	225,000
1901	2,500	150,000

Zinc white, also known as Chinese white, is zinc oxide. According to Dudley,[1] it is produced as follows:

In Leclaire's process zinc is volatilized in retorts, and the hot vapors of metallic zinc issuing are met by a current of air, which completely oxidizes them. The resulting products of combustion are led through a series of pipes and chambers, where the zinc oxide is deposited in the shape of a flocculent, impalpable white powder. This method of production, commonly known as the "French process," was the only one in use until Samuel T. Jones, an American, invented, in 1850, a furnace for the direct sublimation of zincite into the oxide of zinc. Zincite, which occurred as an ore at Sterling Hill, N. J., was soon exhausted, and were it not for the invention of another American, Col. Samuel Wetherill, the paint trade would be dependent for zinc white entirely upon that produced by the more expensive and roundabout French process. Colonel Wetherill's invention consists in mixing the Franklinite ore, mined at Sterling Hill and Franklin, N. J., with finely divided anthracite coal and oxidizing it in a closed furnace, an air blast applied under a perforated grate supplying the necessary oxygen. The products of combustion are carried through a long series of pipes and condensing chambers, in which all the ingredients except the finely divided pure white zinc oxide are removed, the latter being finally collected in long muslin bags, through which the gases of combustion filter. By means of this process the all but inexhaustible deposits of Franklinite ore existing in Sussex county, N. J., were rendered available for the production of a high-grade zinc white, and a large proportion of this pigment as used in this country has its origin in these ore deposits.

Zinc white is not poisonous and is not blackened by contact with hydrogen sulphide or the vapors of other sulphides, a fact which was observed as early as 1779 by Courtois.

The lead oxides are obtained by roasting metallic lead in an oxidizing atmosphere on the hearth of a reverberatory furnace. To obtain litharge (PbO) the lead is oxidized in a current of air at a temperature sufficiently high to melt the oxide as it forms. To obtain red lead, or minium, the lead is oxidized at a temperature below the melting point of litharge in a "drossing" furnace. The mixture of unmelted PbO and particles of metallic lead are ground and levigated in water, the oxide sifted from the particles, and then roasted, with stirring in an oxidizing atmosphere, in a coloring furnace until the desired red color is obtained. Minium has the formula of Pb_2O_3 or Pb_3O_4. Orange mineral, which has an analogous formula but a paler color and a lower specific gravity, is obtained by roasting white lead or white lead skimmings in an oxidizing atmosphere. Orange mineral is used as a base, with eosin and other aniline colors, to produce artificial vermilion. Theoretically, 100 parts by weight of lead will yield 108 parts of litharge and 110 parts of red lead.

[1] Stanton Dudley, The Paint Question, page 9.

Lampblack is obtained by the imperfect combustion of turpentine, rosin, fats, grease, oils, coal tar, and gas through chilling the flames from their combustion, the lampblack being deposited as soot on the cold surfaces against which the flames impinge. It is made largely in this country from natural gas, this variety being known as gas black or carbon black. As produced by deposition of the soot on revolving plates or cylinders it forms one of the purest and most desirable varieties of lampblack. From 2,000 to 8,000 cubic feet of gas are required to produce 1 pound of black.

Barytes is obtained from the mineral heavy spar or tiff by grinding the cleaned and sorted mineral, bleaching it by boiling in acid until the iron and other staining constituents are removed and washing with distilled water, grinding again in buhr mills to the requisite fineness, and grading by elutriation in water. When manganese dioxide is present a special treatment with nitrate of soda, salt, and sulphuric acid is required. Off-colored barytes is used in compounding colored paints. Purified barytes mixed with an equal quantity of white lead produces Venice white; with one-fourth its quantity of white lead (Dutch white), and with an intermediate quantity Hamburg white. Forty parts of cream-floated barytes to 60 parts of zinc oxide produce a paint which has been used in canvasing hams to close the meshes of the canvas so as to prevent the ingress of insects and air. Barytes is used as a base in compounding many colored pigments. Blanc fixe is obtained as a fine white powder by precipitating a barium salt with aluminum or other sulphate. In the moist condition, containing from 25 to 30 per cent of water, it is used in paper making and cotton finishing. In the dry condition it is used as a base for coal tar colors in the preparation of colored pigments. Lithophone is a white pigment consisting of barium sulphate, zinc oxide, and zinc sulphide.

The individual substances constituting the fine colors, iron oxides and other earth colors, and dry colors are so numerous that their mere enumeration would fill a very considerable space. Moreover, many of them are produced in but small quantities and therefore can not be considered separately in the present report. Among the more important are true vermilion, produced by heating mercury with sulphur and treating the product with soda lye, or potash lye and potassium sulphide, or nitric acid, to improve the brilliancy or fire; cadmium yellow, prepared by treating the solution of a cadmium salt with hydrogen sulphide or ammonium sulphide; and chrome green. True chrome green is the chromium trioxide, Cr_2O_3, though some authors include under chrome green the chromium phosphate, $Cr_2P_2O_8$, also, notwithstanding that it is of inferior brilliancy. The former is made by calcining potassium bichromate with boric acid or ammonium chloride, or by precipitating the chromium hydroxide from it with caustic soda or sodium carbonate and then calcining the hydroxide; the latter is made by boiling a solution containing potassium bichromate, sodium phosphate, and sodium thiosul phate, when the chromium phosphate is precipitated out and is collected and calcined. Ultramarine is produced by calcining kaolin mixed with soda ash, sulphur, sodium sulphide, sodium sulphate, silica, and rosin. Fine colors are used by artists and in expensive work like the painting of coach bodies.

Iron oxides and other earth colors are artificially produced by calcining the material in its natural form so as to drive off water of constitution or hydration, or carbon dioxide, whereby the shade or color, and sometimes the condition of aggregation of the pigment, are changed. Venetian red and other iron oxides are also produced by precipitating, with lime, the liquors resulting from the pickling of iron or steel with sulphuric acid, and calcining the precipitate.

The term "dry colors" includes any dry pigment suitable for grinding in a medium for the production of paint. Such pigments are produced largely by grinding together their components, as, for example, brunswick green, which is a mixture of barytes, prussian blue, and chrome yellow. A considerable number, however, are produced by strictly chemical means. For example, to produce red shade prussian blue, a mixture of solutions of potassium ferrocyanide and copperas is boiled with sulphuric acid and nitrate of iron till complete oxidation is reached. After washing, solutions of aluminum sulphate and soda ash are added and the blue precipitate is collected, washed, and dried. Chrome yellow is obtained by precipitating lead acetate with potassium bichromate, and satin white by precipitating alum with lime water so as to produce a mixture of calcium sulphate and aluminum hydroxide. These are but a few among many examples. Dry colors are used as pigments in the manufacture of paints and of engraving and printing inks. To be well adapted for these purposes they must possess working quality, which comprises oil absorbing power, "tackiness," stretch, and capacity for being easily wiped off a plate when ground up with oil. The qualities depend mainly on the base used to etain the pigment or dye, but partly on the fineness f the material. The mixtures of an organic coloring atter with inorganic bases such as aluminum hyroxide are styled lakes.

Pulp colors are produced from much the same marials as dry colors, but they have the consistency of a astic watery pulp. They frequently contain a conderable percentage of clay, which imparts to them rtain desirable qualities, since they must be adapted r work on a spreading machine when mixed with ing. They are chiefly used in coloring window ades, book coverings, wall paper, and glazed paper.

Paints in oil properly include white lead in oil, since is may, like the paints, be used in painting after it s been extended by means of proper vehicles. The ef difference is that paints contain pigments and some turpentine in addition to white lead. A typical composition for paints in oil, in paste, is white lead 10 parts, linseed oil 22 parts, turpentine 2 parts, dry colors 66 parts. According to Hurst[1]—

The quantity of oil required to grind colors into the stiff paste in which they are now so largely sold varies very considerably with different pigments; some only require a comparatively small quantity of oil, others a relatively large quantity. Even with different samples of the same color the proportion will vary a little. Different color makers, too, use different proportions of oil and dry color in grinding. The following table will give some idea of the proportions usually adopted, which are essentially the same both for raw and for boiled linseed oil:

White lead	7½ per cent of oil
Zinc white	22 per cent of oil
Barytes	7 per cent of oil
Putty	18 per cent of oil
Black	27 per cent of oil
Brunswick green	11 per cent of oil
Red oxides	10 per cent of oil
Brunswick blue	11 per cent of oil
Oxford ocher	16½ per cent of oil
Burnt Turkey umber	29 per cent of oil
English umber	20 per cent of oil
Vandyke brown	40 per cent of oil
Siennas	37½ per cent of oil
Black in turps	55 per cent of oil

These figures are based on practical working, but, as mentioned above, are liable to vary a little from time to time.

Paints in oil already mixed for use are those in which linseed or other oil, turpentine or other volatile vehicle, dryer, and varnish or japan have been mixed in such proportions with the pigment as to render the product fit for immediate application. According to Heckel[2] the ready mixed paint industry began in this country about 1860. The proportions and kinds of materials used vary widely, but the following is a typical mixture:

White lead	6. 75 per cent
Lead oxide	17. 08 per cent
Linseed oil	27. 64 per cent
Turpentine	3. 75 per cent
Varnish	4. 78 per cent
Pigments	40. 00 per cent

This category, however, includes many other compositions such as anticorrosive and antifouling paints and roofing paints.

The term varnish embraces a large number of different substances, all of which are viscous liquids containing a volatile solvent or solvents which on evaporation leave behind coherent, flexible, and usually transparent films. The most important of these, because of their more extended use, are the varnishes which are made by dissolving resins, or so-called gums, in linseed oil, and thinning with turpentine. This is generally accomplished by melting the resin in a copper kettle over a fire, adding linseed oil, heating the mixture until the incorporation is complete and then, when partly cooled, thinning with turpentine.

[1] G. H. Hurst, Painters' Colors, Oils and Varnishes, London, 1896, page 353.

[2] Recent Mixed-Paint Literature, page 4.

The large number of such mixtures which are made is indicated by Sabin[1] in the following extract:

If 10 gallons of oil is added to the melted mass, weighing, let us say, 95 pounds, which results from melting 125 pounds of resin, the resulting varnish is said to be an 8-gallon varnish, because it contains 8 gallons of oil to every 100 pounds of resin originally taken. Similarly, 25 gallons of oil would make a 20-gallon varnish, and so on, the varnishes being designated by the proportion of oil to the hundred pounds of unmelted resin, and nothing is said about the turpentine which is, to some extent, a variable quantity. Of course this is purely a factory nomenclature. The purchaser knows the varnishes he buys by certain descriptive or trade names, and, as in every other business, a name which takes the public fancy is very valuable. Further, the varnish as it comes out of the kettle is not usually of the same composition as any varnish sold, because, in order to get certain qualities, it is necessary to mix varnishes made in different ways and of different resins. It will be obvious that if the maker has, for example, three tanks of 10-gallon varnishes, made respectively of Zanzibar, Kauri, and Manila resin, and also three tanks of 30-gallon varnishes made from the same resins, he is in a position to supply nine different kinds of 20-gallon varnish, each differing from the others in certain properties peculiar to each mixture, and also in price; making each of these mixtures from two tanks, and an indefinite number by mixing them in a more intricate manner.

It would be indeed remarkable if some of these 20-gallon mixtures were not better for some special purpose, or even for general use, than any possible 20-gallon varnish, made from a single resin, just as it comes from the kettle. It will also be obvious that an indefinite number of 12-gallon, 15-gallon, 18-gallon, 22-gallon, 25-gallon, and 28-gallon varnishes may be made from these same tanks, and if, in addition, the manufacturer has a set of tanks of 8-gallon, 16-gallon, and 20-gallon varnishes, each set representing, say, these same three resins, the number of possible combinations passes imagination. It is to be further remembered that varnishes are made with as little as 3 gallons of oil and as high as 60; that the more important resins are sold in from two to ten grades, and that the number of these resins is very great and is constantly increasing. It will be seen that a knowledge of the qualities of the various varnishes, and especially of their effect in mixtures, is of as much importance as knowing how to manipulate the materials in the kettle, and the expert, to be an expert, must be intimately and practically acquainted with the use to which the varnish is to be put and the way in which it is necessary to apply it, and how these uses and conditions vary. He should, therefore, have as the simplest foundation a good working knowledge of the furniture trade, of wagon and carriage building, of railway engines and coaches, of ship and boat construction, and of house painting and decoration. To these he may add the lesser trades and specialties, from the making of oilcloth to the japanning of hooks and eyes, as far as his natural abilities and acquired opportunities may allow.

As Chinese wood oil, or tung oil, corn oil, and other oils are used in place of linseed oil, and rosin oil, benzine, benzol, and other volatile solvents in place of turpentine, the number of oil and turpentine varnishes is enormous and the variety of materials employed in their manufacture is very large.

Spirit varnishes embrace turpentine varnishes, of which dammar varnish is an example; alcohol varnishes, of which shellac varnish is an example; and asphaltum varnishes, produced by dissolving asphalt in coal tar naphtha, carbon disulphide, and other solvents. Both grain and wood alcohol are used in making alcohol varnishes, the standard shellac varnish of the country being made with 1 pound of shellac to 1 gallon of 95 to 97 per cent alcohol, or about 1 part by weight of shellac to $1\frac{1}{2}$ parts by weight of alcohol. It is expected that a considerable use for denatured alcohol will be found in this industry.

Pyroxylin varnishes or lacquers are formed by dissolving pyroxylin in a mixture of volatile solvents. An example of such mixture, given by Sabin,[2] is 97 per cent of methyl alcohol, 65 parts; amyl alcohol, 25 parts; and amyl acetate, 10 parts; 16 ounces of pyroxylin being dissolved in 1 gallon of this mixture. Colors are dissolved in these varnishes, or pigments are ground up in them so as to be held in suspension in the liquid, and these latter are used as enamels. These varnishes are greatly improved for use with the brush by adding various resins to them, as the body is increased without increasing the viscosity. Pyroxylin varnishes are largely used in covering polished metal surfaces and enameled leather, and in coating incandescent mantles.

Drying japans and liquid dryers shade into one another. An example of a simple dryer is one which is made by heating 1 gallon of linseed oil with 4 pounds of a mixture of lead and manganese oxides, in which the lead oxide is in great excess, to a temperature of from 500° to 600° F. until saponification ensues, and then dissolving the resulting black colored compound in turpentine. Examples of solid dryers are found in litharge, lead acetate, and manganese borate.

Baking japans are hard black varnishes used for producing a glossy black and enamel-like surface on iron, tin, or other materials. Such a japan may be made by cooking asphaltum with linseed oil and thinning the resulting thick mass with turpentine. Lacquers are varnishes which are used for coating instruments and other objects made of brass, nickel, silver, and other bright metals or alloys to prevent their tarnishing. Such a lacquer may be produced by adding to a varnish composed of seed lac 2 parts, sandarac 4 parts, elemi 4 parts, and alcohol 40 parts, alcoholic tinctures of gamboge, dragon's blood, magenta, picric acid, Martin's yellow, or corallin. Enamels are varnishes holding the pigment in suspension. Fillers occur as liquid fillers, paste fillers, and dry fillers and are used to fill the pores of the wood to which the paint or varnish is to be applied, giving thereby a more even surface and economizing the paint or varnish. Fillers are also styled dopes. Liquid fillers are commonly solutions of rosin, but raw or boiled linseed oil may be used as such. An example of a paste filler is a mixture of pulverized quartz with a quick drying varnish. Putty, which is a mixture of whiting with oil, is used in filling holes and crevices before painting, but is also, and probably most largely, used in glazing.

Water paints and kalsomine embrace the mixtures made from lime or whiting, dry colors, size, and water. In making certain of these compositions it

[1] Alvah H. Sabin, The Industrial and Artistic Technology of Paint and Varnish, 1905, page 82.

[2] Alvah H. Sabin, The Industrial and Artistic Technology of Paint and Varnish, 1905, page 113.

was long ago found beneficial to add a certain proportion of milk. It has been found that the benefit was due to the casein in the milk, and as with the development of the creamery industry a large quantity of casein has become available, an extensive industry has grown out of its applications, chief among which is its use in cold-water paints. According to Scherer[1] it is only within a couple of decades that any extensive use has been made of casein for this purpose, though casein has been detected in old paintings. He gives many formulas for casein paints, among which that for "marble lime" color for outside work may be cited. This consists of—

Casein soluble in alkali	100 parts
Caustic lime, from marble	100 parts
Levigated chalk (whiting)	800 parts
Borax	1 part
Ultramarine	2 to 2.5 parts

Casein paints are met with in commerce in the form of paste or liquids, containing the casein in a dissolved condition, but more commonly as dry powders, containing the casein and an alkali in the dry form. When these powders are mixed with water the alkali is dissolved, and this acts as a solvent for the casein. This then forms compounds which become insoluble, after the paint is applied, by exposure to the air, thus holding the pigments on the surfaces to which they have been applied.

Table 105 sets forth the imports and exports of paints and varnishes, for the years ending June 30, from 1891 to 1905, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

TABLE 105.—*Paints, pigments, and colors, and varnishes, spirits, and "all other"—imports and domestic exports: 1891 to 1905.*

YEAR ENDING JUNE 30—	PAINTS, PIGMENTS, AND COLORS.		VARNISHES, SPIRITS, AND "ALL OTHER."			
	Imports (value).	Domestic exports[1] (value).	Imports.		Domestic exports.	
			Gallons.	Value.	Gallons.	Value.
1891	$1,439,127	$690,698	35,073	$97,298	153,365	$203,285
1892	1,372,052	709,857	38,737	101,692	215,266	293,059
1893	1,466,761	700,308	41,216	111,675	210,067	258,400
1894	980,715	825,987	20,337	54,746	226,760	282,278
1895	1,246,924	729,706	39,095	106,927	256,890	303,959
1896	1,309,041	880,841	40,644	105,551	335,979	362,975
1897	1,387,353	944,536	62,655	159,024	409,569	431,761
1898	1,065,088	1,079,518	32,848	79,702	398,841	422,693
1899	1,207,440	1,447,425	33,227	79,461	436,817	463,547
1900	1,535,461	1,902,367	43,743	103,985	588,545	620,104
1901	1,487,381	2,036,343	46,030	119,888	606,187	611,459
1902	1,603,181	2,096,379	47,703	127,583	619,024	607,685
1903	1,827,110	2,350,937	49,730	131,114	660,553	667,475
1904	1,674,193	2,756,581	39,771	105,898	713,147	726,585
1905	1,524,301	3,126,317	41,536	103,224	747,017	791,578

[1] Includes carbon black, gas black, lamp black, and oxide of zinc, prior to 1898.

CLASS XIV.—EXPLOSIVES.

This class of explosives embraces gunpowder (including blasting powder and all mechanical mixtures of inorganic nitrates with carbon or any carbonaceous substance which does not of itself possess explosive properties), chlorate powders, nitroglycerin, dynamite (including blasting gelatin, gelatin dynamite, and all explosives containing nitroglycerin which are used in blasting), gun cotton (including pyroxylin and all other cellulose nitrates and all nitric esters other than nitroglycerin used as explosives), nitrosubstitution compounds and the explosives of which they are components (joveite, arctic, masurite, and other safety explosives), smokeless powder (including cellulose nitrate-nitroglycerin, nitrosubstitution and all other high-powered powders used as propellants), and fulminates (such as mercury fulminate, fulminating silver, acetylides, hydrazotates and other detonants). Cundill's Dictionary of Explosives, published in 1895, gives the names of upward of one thousand explosives, and the number of explosives has been considerably increased since, but all that occur in commerce in this country are comprised in the above classification. Cartridges, detonators, fuses, and other devices containing explosives for use in guns and in blasting, are classed under "ammunition," while colored fires, rockets, railroad torpedoes, signal lights, and other devices of this nature are classed under "fireworks."

[1] Robert Scherer, Casein—Its Preparation and Technical Utilization, translated by Charles Salter, New York, 1906.

TABLE 106.—*Explosives—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	124	97	27	27.8
Capital	$42,307,163	$19,465,846	$22,841,317	117.3
Salaried officials, clerks, etc., number	1,289	768	521	67.8
Salaries	$1,797,050	$914,447	$882,603	96.5
Wage-earners, average number	5,800	4,502	1,298	28.8
Total wages	$3,308,774	$2,383,756	$925,018	38.8
Miscellaneous expenses	$1,657,665	$1,096,604	$561,061	51.2
Cost of materials used	$17,203,667	$10,334,974	$6,868,693	66.5
Value of products	$29,602,884	$17,125,418	$12,477,466	72.9

The statistics of Table 106 show an increase in every item for 1905 as compared with 1900, the largest increase in amount being in the item of capital, the next in the value of products, and the least in the item of miscellaneous expenses. The largest percentage of increase is found also in the item of capital and the second largest in the item of salaries.

TABLE 107.—*Explosives—quantity and value of products: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Value.	Quantity.	Value.
Gunpowder, pounds	10,383,944	$1,541,483	5,450,773	$614,290
Blasting powder, kegs[1]	8,217,448	7,377,977	4,774,948	4,780,903
Nitroglycerin, pounds	[2] 51,579,270	7,730,175	[3] 35,280,498	5,532,570
Dynamite, pounds	130,920,829	12,900,193	85,846,456	8,247,223
Gun cotton, pounds	[4] 5,905,958	2,435,805	[5] 2,988,176	1,473,619
Smokeless powder, pounds	7,009,720	4,406,477	3,053,126	1,716,101
All other explosives	....	190,948	....	6,493

[1] A keg contains 25 pounds of blasting powder.
[2] Including 43,643,270 pounds, with an assigned value of $6,110,058, consumed in establishments where manufactured.
[3] Including 31,661,806 pounds, with an assigned value of $4,749,271, consumed in establishments where manufactured.
[4] Including 5,522,796 pounds, with an assigned value of $2,209,118, consumed in establishments where manufactured.
[5] Including 2,139,834 pounds, with an assigned value of $1,069,917, consumed in establishments where manufactured.

The statistics of Table 107 show an increase in every item for 1905 as compared with 1900, the largest increase in value, $4,652,970, being for dynamite, and except for all other explosives the largest percentage of increase in value, 156.8 per cent, for smokeless powder. The largest increase in quantity, 86,062,500 pounds, is shown for blasting powder, and the next largest, 45,074,373 pounds, for dynamite, but the greatest percentage of increase in quantity, 129.6 per cent, is shown for smokeless powder.

A comparison of the statistics for 1900 as given here with those set forth in the report on chemicals and allied products for the census of 1900 shows apparent discrepancies, and it should be stated that it was found that in several of the returns for that census gunpowder and blasting powder were reported together. These returns have been analyzed and separated, with the result that the quantity and value of the gunpowder was found to be less, and the quantity and value of the blasting powder greater, than the published figures for 1900.

Again, at the census of 1900, when discussing in the text the subject of gun cotton or pyroxylin, the statistics for the cellulose nitrates used in the manufacture of pyroxylin plastics, varnishes, and collodion were included in the totals there given. As these cellulose nitrates are used for other purposes than the manufacture of explosives, and as they are of little or no value as explosives, they are omitted from the statistics of both censuses in Table 107.

Furthermore, the returns for 6 establishments manufacturing railroad torpedoes, fuses, and blasting caps, which were included in the statistics for 1900 under "all other explosives," were at the census of 1905 transferred to classifications other than "chemicals and allied products." The values returned for these products in 1900 have therefore been, in the present report, deducted from "all other explosives" and credited to "all other products." The result of these transfers in the accounts is to make the statistics for the two censuses as set forth in Table 107, much more strictly comparable.

The statistics presented in Table 108 show that this industry was represented in about half of the states of the country at the censuses of 1900 and 1905, and that more than half of the establishments at each census were in the states of Pennsylvania, Ohio, and New Jersey. The whole United States shows a gain of 30 in number of establishments, notwithstanding the fact that 6 establishments included in the list for 1900 have at the present census been classified under other categories. One of these was located in California, 1 in Illinois, 1 in Massachusetts, 1 in New Jersey, and 2 in Pennsylvania. The principal increases were in Ohio and West Virginia, each of which gained 7, and in Pennsylvania and Kansas, each of which gained 4. Pennsylvania ranked first at each census, and at the census of 1905 Ohio ranked second and New Jersey third.

TABLE 108.—*Explosives—number of establishments, by states and territories: 1905 and 1900.*

STATE OR TERRITORY.	1905	1900
United States	[1]130	[2]100
Alabama	3	2
California	6	7
Connecticut	1	1
Delaware	1	1
Illinois	5	3
Indian Territory	1	......
Indiana	7	6
Iowa	1	2
Kansas	5	1
Kentucky	1	......
Maine	1	1
Maryland	2	1
Massachusetts	1	2
Michigan	4	5
Missouri	4	1
New Jersey	11	10
New York	6	5
Ohio	16	9
Pennsylvania	40	36
Rhode Island	1	1
Tennessee	3	2
Vermont	1	1
Virginia	......	1
West Virginia	8	1
Wisconsin	1	1

[1] Includes 6 establishments engaged primarily in the manufacture of other products.
[2] Includes 3 establishments engaged primarily in the manufacture of other products.

The statistics of Table 109 show that the North Atlantic division has stood first in rank at each census, the North Central division second, the South Central and Western divisions combined third, and the South Atlantic division fourth, and that in the interval between 1900 and 1905 there has been an increase in every division in value of products. The greatest increase, $7,856,325, has been in the North Atlantic division and the next greatest, $3,416,620, in the North Central division.

TABLE 109.—*Explosives—value of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
United States	[1]$30,292,916	[1]$17,186,164
North Atlantic	15,035,556	7,179,231
South Atlantic	1,347,407	542,110
North Central	8,322,367	4,905,747
South Central and Western	5,587,586	4,559,076

[1] Includes products other than explosives reported by establishments engaged primarily in this industry; and also the explosives produced by establishments engaged primarily in the manufacture of other products.

The statistics of Table 110 show an increase in every item, the largest increase in quantity, 53,002 tons, being in mixed acids; the second largest, 44,510 tons, in nitrate of soda; and the third largest, 18,504 tons, in charcoal. The largest increase in any single item of cost, $2,705,691, is for nitrate of soda; the second largest, $1,307,663, for mixed acids; and the third largest, $1,113,108, for glycerin.

Pyrites appears among the materials used in this industry for the first time at this census, and its use marks the introduction into this country of the contact process for the manufacture of sulphuric acid, which is so extensively consumed in the manufacture of explosives. The marked increase in the quantity of nitrate of ammonia used, 3,202,058 pounds, or

539.1 per cent, indicates the marked increase in the quantity both of safety explosives manufactured, and of weak nitric acid residues utilized. It is to be noted that in some instances sulphate of ammonia is employed in place of the aqua ammonia or ammonia liquor mentioned in the table. The increase in the quantity of ether used, 2,167,341 pounds, most of which is produced in the establishments in which it is consumed, corresponds closely with the increase in the production of smokeless powder, particularly that portion of it used in the manufacture of military powders.

TABLE 110.—*Explosives—quantity and cost of materials used: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Cost.	Quantity.	Cost.
Alcohol, grain, gallons	850,560	$231,353	191,125	$99,166
Aqua ammonia, pounds	997,830	46,916	649,703	11,303
Charcoal, bushels	[1] 2,408,667	446,078	[2] 928,344	114,172
Cotton, pounds	4,515,787	443,998	1,771,221	103,971
Ether, pounds	[3] 3,425,245	479,494	[4] 1,257,904	88,053
Glycerin, pounds	24,561,527	3,129,665	16,983,918	2,016,557
Mixed acids, tons	[5] 92,598	3,093,429	[6] 39,596	1,785,766
Nitrate of ammonia, pounds	[7] 3,796,033	948,307	[8] 593,975	26,742
Nitrate of potash, tons	[9] 4,114	308,644	[10] 3,315	270,186
Nitrate of soda, tons	133,034	5,608,557	88,524	2,902,866
Nitric acid, tons	[11] 20,406	1,646,543	[12] 7,528	601,494
Pyrites, tons	12,256	67,261	....	....
Sulphur, tons	19,574	507,469	12,742	317,383
Sulphuric acid, tons	[13] 49,298	774,361	[14] 40,385	681,934
Wood, cords	5,628	38,780	600	4,800

[1] Includes 1,156,918 bushels, with an assigned value of $214,030, consumed in establishments where manufactured.
[2] Includes 118,419 bushels, with an assigned value of $14,210, consumed in establishments where manufactured.
[3] Includes 3,382,895 pounds, with an assigned value of $473,605, consumed in establishments where manufactured.
[4] Includes 1,222,704 pounds, with an assigned value of $85,589, consumed in establishments where manufactured.
[5] Includes 37,669 tons, with an assigned value of $2,260,129, consumed in establishments where manufactured.
[6] Includes 6,000 tons, with an assigned value of $270,180, consumed in establishments where manufactured.
[7] Includes 2,863,857 pounds, with an assigned value of $715,964, consumed in establishments where manufactured.
[8] Includes 483,975 pounds, with an assigned value of $21,779, consumed in establishments where manufactured.
[9] Includes 1,778 tons, with an assigned value of $133,385, consumed in establishments where manufactured.
[10] Includes 1,468 tons, with an assigned value of $119,642, consumed in establishments where manufactured.
[11] Includes 18,988 tons, with an assigned value of $1,519,040, consumed in establishments where manufactured.
[12] Includes 7,274 tons, with an assigned value of $583,125, consumed in establishments where manufactured.
[13] Includes 30,994 tons, with an assigned value of $526,898, consumed in establishments where manufactured.
[14] Includes 32,366 tons, with an assigned value of $548,222, consumed in establishments where manufactured.

Table 110 differs from other tables of materials used presented in this report in that the statistics for materials produced and consumed are included therein, but it appears that, with the exception perhaps of nitrate of potash, none of the substances enumerated in the table are produced for sale by these establishments, and therefore the statistics for these substances do not appear elsewhere.

Statistics for the explosives industry as a whole and for certain of its products have been reported and published at each census as far back as that of 1840, or from the date of the census at which the newer explosives first appeared for census enumeration. Table 111 presents a comparative summary of this industry from 1840 to 1905.

TABLE 111.—*Explosives—comparative summary: 1840 to 1905.*

CENSUS.	Number of establishments.	Capital.	Average number of wage-earners.	PRODUCTS.	
				Pounds.	Value.
1905	124	$42,307,163	5,800	363,748,097	[1] $28,204,51[illegible]
1900	97	19,465,846	4,502	218,272,834	[1] 16,552,01[illegible]
1890	69	13,539,478	2,353	98,645,912	10,993,13[illegible]
1880	54	6,585,185	1,340	(2)	5,802,0[illegible]
1870	36	4,099,900	973	(2)	4,237,5[illegible]
1860	58	2,305,700	747	(2)	3,223,0[illegible]
1850	54	1,179,223	579	(2)	1,590,3[illegible]
1840	137	875,875	496	8,977,348	(2)

[1] Not including "all other products."
[2] Not reported.

The statistics of Table 111 show an increase in every item from 1840 up to 1905 except in the item of establishments, which decreased in number from 1840 to 1870, but which have since constantly increased in number. The total quantity of the product has increased more rapidly than its total value, indicating a cheapening of the product. At the same time the increase in the capital has gone on at a greater rate than that of the value of products. An interesting feature disclosed by this comparison is that whereas in 1840 each man produced on an average 18,099 pounds of powder per year, in 1905 the average was 62,715 pounds, and this increase, which has resulted from the introduction of machinery, from organization, through which the work of each man is rendered more efficient, and from more continuous employment, has taken place in spite of the fact that the manufacture of the modern explosives involves much more complicated and delicate processes than the manufacture of gunpowder. On the other hand, in 1840 the entry "wage-earners" included the salaried employees, since, as a rule, at that time the owner of the establishment worked with his hands in the factory besides performing the duties of salesman and bookkeeper. A fairer condition for comparison in 1905 would follow by combining the salaried officials of that census with the employees. With this product as the divisor, it appears that in 1905 the product averaged 51,312 pounds per man per year.

TABLE 112.—*Gunpowder—quantity and value: 1840 to 1905.*

CENSUS.	Quantity (pounds).	Value.
1905	215,820,144	$8,919,460
1900	124,824,473	5,395,193
1890	95,019,174	6,740,099
1880	(1)	3,348,941
1870	(1)	4,011,839
1860	(1)	3,223,090
1850	(1)	1,590,332
1840	8,977,348	....

[1] Not reported.

The statistics of Table 112 as far as given show a steady increase in the quantity and value of the gunpowder returned at each census since that of 1840 except at that of 1880 and at that of 1900, when the total value of products was less than at the preceding censuses. The greatest increase in quantity, 90,995,671 pounds, and in value, $3,524,267, are found for the interval from 1900 to 1905, notwithstanding the fact that all previous intervals covered decades. At all times the term gunpowder, as used in this table, includes the nitrate-sulphur-charcoal powder used in blasting as well as in guns, and since 1857 it has included the nitrate of soda blasting powder as well as the nitrate of potash blasting powder.

TABLE 113.—*Nitroglycerin—quantity and value: 1870 to 1905.*

CENSUS.	Quantity (pounds).	Value.
1905	7,936,000	$1,620,117
1900	3,618,692	783,299
1890	(1)	(1)
1880	3,039,722	1,830,417
1870	(1)	225,700

1 Not reported.

The striking features of Table 113 are the remarkable increase in the quantity of nitroglycerin produced in 1905 as compared with the quantity produced in 1900, and the decrease in the selling price of the same from 1880 to 1900; the increase from 1900 to 1905 was more than 100 per cent. The slight increase in quantity from 1880 to 1900 was accompanied by a decrease in value of over 50 per cent. This marked fall in the selling price of nitroglycerin in recent years is characteristic of the products of many chemical industries.

TABLE 114.—*Dynamite—quantity and value: 1880 to 1905.*

CENSUS.	Quantity (pounds).	Value.
1905	130,920,829	$12,900,193
1900	85,846,456	8,247,223
1890	30,626,738	4,253,032
1880		622,671

The statistics of Table 114 show an increase in every item at each census as compared with the preceding one, the greatest increase in quantity, 55,219,718 pounds, being for the decade from 1890 to 1900, though the increase of 45,074,373 pounds for the five-year period from 1900 to 1905 is proportionately greater. The greatest increase in value, $4,652,970, is shown for the five-year period from 1900 to 1905—due probably to the increased production of gelatin dynamite, ammonia dynamite, and other high-grade explosives.

No marked change of importance is to be noted in the manufacture or composition of gunpowder or blasting powder, but the latter has new competitors in the compositions made by mixing finely divided metals, such as aluminum, or alloys, such as ferrosilicon, with potassium or sodium nitrate or other oxidizing agents. The fundamental conception of these explosive mixtures is not new, for it has long been known that finely divided iron and other metals furnished combustible components to such mixtures, but the metals and alloys now used were not then available.

A detail which has affected yield and cost in the dynamite industry is the introduction of ice machines for use in the manufacture of nitroglycerin. By the use of artificial refrigeration the yield of nitroglycerin from a given mass of acid is increased, the speed of nitration is increased, the danger attending nitration is decreased, and the use of second separators rendered unnecessary. Two methods of refrigeration may be used: (1) The direct expansion system in which compressed ammonia is sent directly through the coils, and (2) the brine system in which the ammonia is sent through the coils in a brine tank, and then the cooled brine is sent through the cooling coils in the nitrator or separator. The brine, or indirect, system is to be preferred, because in case of leakage in the nitrator the rise of temperature is less from the escape of a given mass of calcium chloride brine than it is from the escape of the same mass of ammonia; leakage of the calcium chloride brine is less likely to occur than is that of the compressed and liquefied ammonia; and less ammonia is required in the indirect than in the direct system; and because the indirect system is a better one for discontinuous use.

The quantities of acids and glycerin and the composition of the mixed acids vary somewhat in practice, but the advantage of artificial refrigeration may be illustrated by a concrete example in which the charge of mixed acid is 6,400 pounds, its composition being—

H_2SO_4	61.50 per cent.
HNO_3	34.50 per cent.
H_2O	4.00 per cent.

With such a charge, using the approved method of nitration without refrigeration, 880 pounds of glycerin may be nitrated, and 1,953.6 pounds of nitroglycerin obtained, while by using artificial refrigeration 928 pounds of glycerin may be nitrated and 2,115.84 pounds of nitroglycerin obtained, or an increased yield of 162.24 pounds. With glycerin at 11 cents per pound and nitroglycerin at 15 cents per pound, the increased profit from a single run is $19.05, or from four runs per day, which can easily be effected, $76.20. As a 30-ton machine can easily be installed for $12,000, and as the cost of operation including interest and 10 per cent depreciation will not exceed $6,000 per year, there is a marked advantage in artificial refrigeration.

At the same time the theoretical conditions of efficiency are not yet realized, for the charge of acid cited above is theoretically sufficient to nitrate 1,074.77 pounds of glycerin and to yield 2,651.31 pounds of nitroglycerin, or 535.47 pounds more than is obtained by artificial refrigeration. The yield may probably be brought more nearly to the theory by the employment of dried air in the injector of the nitrator.

It is well known that at times the separation of nitroglycerin from the emulsion in the acid mixture in which it is formed is extremely slow. Dr. Charles L. Reese alleges that this is due to the presence there of silicon compounds, and he overcomes this difficulty by the addition of a fraction of a per cent of sodium fluoride before nitration, thereby forming silicon fluoride which is eliminated by volatilization.

The spent acid from the manufacture of nitroglycerin treated in a denitrator yields nitric acid of 35° to 40° Baumé, which is used in the manufacture of ammonium nitrate, and by means of this apparatus and of concentrators 95 per cent of the sulphuric acid is now recovered, though 80 per cent was considered a good yield a few years ago. In other works it has become the custom to rebuild the spent acids, as pointed out in the discussion of mixed acids in this report.

According to Whitman Symmes,[1] the dynamites made by the 4 establishments on the Pacific coast have the following composition:

Percentage composition of various dynamites.

Total	100.0	100.0	100.0	100.0	100.0
Nitroglycerin	70.0	60.0	50.0	40.0	30.0
Wood pulp	20.0	16.5	14.0	11.2	4.2
Ground sodium nitrate	7.0	22.5	35.0	46.2	60.0
Middlings	....	....	....	2.2	5.8
Precipitated magnesium carbonate	3.0	1.0	1.0	0.4	....

	40 per cent gelatin dynamite.	Ammonium dynamite.	Stump powder.	Low powder.
Nitroglycerin	36.0	25.0	20.0	5.0
Cellulose nitrate	1.2	....	....	....
Nitrate of ammonia	(1)	20.0	....	....
Nitrate of soda	(1)	40.0	50.0	70.0
Wood pulp	(1)	15.0	5.0	....
Ground coal	(1)	....	20.0	18.0
Sulphur	(1)	....	5.0	7.0

[1] Dope as in ordinary dynamite.

The first five straight wood pulp dynamites are designated "70 per cent," "60 per cent" grade, etc., according to their nitroglycerin contents; whereas in the case of the gelatin and ammonium dynamites they are designated by a grade showing their supposed equivalency. Theory requires that the niter should be very finely ground in order to be intimately mixed in the dope, but practice shows that such powder packs into hard sticks which sometimes miss fire even with XXX caps, hence medium grinding is resorted to.

The most recent advance in the manufacture of cellulose nitrate has been found in the new process, invented by J. M. and W. T. Thomson, which has been introduced at the Waltham Abbey Factory, England.

The object of this invention[2] is the removal of the acids of nitration from the nitrated material after the action has been completed, and without the aid of moving machinery, such as presses, rollers, centrifugals, and the like. The invention consists in the manufacture of nitrated celluloses by removing the acids from the nitrated cellulose directly by displacement without the employment of either pressure or vacuum or mechanical appliances of any kind, and at the same time securing the minimum dilution of the acids. It was found that if water was carefully run on to the surface of the acids in which the nitrocellulose is immersed, and the acids be slowly drawn off at the bottom of the vessel, the water displaces the acid from the interstices of the nitrocellulose without any undesirable rise in temperature, and with very little dilution of the acids. By this process almost the whole of the acid is recovered in a condition suitable for concentration, and the amount of water required for preliminary washing is very greatly reduced. The apparatus which is used for the purpose consists of a cylindrical or rectangular vessel constructed with a perforated false bottom and a cock at its lowest point for running off the liquid. Means are also provided to enable the displacing water to be run quietly on to the surface of the nitrating acids. In a further patent J. M. Thomson and W. T. Thomson propose by use of alcohol to replace the water, used in washing nitrocellulose, and afterwards to remove the alcohol by pressing and centrifuging.

A notable change in practice in the manufacture of smokeless powder in the United States has been in the abandonment of the nitroglycerin-nitrocellulose powder by the Army, and the adoption of a straight nitrocellulose powder of definite nitrogen contents, thus bringing their practice into conformity with that of the Navy. In fact, the continued tendency in military powders is to approach more closely to the principle set forth by Munroe many years ago as governing the ideal smokeless powder, viz, that "it should be composed of a single chemical substance in a state of chemical purity."

The progress in smokeless sporting powder has been characterized by the adoption of a small-grained nitrocellulose powder which is gelatinized and then hardened throughout, in place of the grain that has heretofore been pretty generally in use, which was superficially gelatinized and hardened. The manufacture of such powder is carried on in a stationary vertical vessel of copper, which has cone-shaped ends. Around the lower end is a steam jacket, by which the contents of the vessel may be heated. A rotatable shaft extends downward through a stuffing box in the top of the vessel, or still, to a point near its bottom, and carries six arms extending across it, each arm being attached at its central point to the shaft and at points on the shaft about 8 inches apart, and the ends of the arms reach nearly to the wall of the still. Five of the bars are square in cross section and about 1 inch thick; the sixth bar, which is the upper one, is flattened out so as to form paddles, which slant in the direction of motion of the shaft in such a way as to smooth down the surface of the liquid that is placed in the still.

An orifice at the bottom of the still having been first closed, the vertical shaft carrying its horizontal stirrers is set in rotation and continued in rotation during the whole of the process at a speed sufficient to maintain the particles of gun cotton in mechanical suspension in the water, when the gun cotton and water are introduced into the still as hereinafter described.

Water in which 5 per cent of barium nitrate and 2 per cent of saltpeter have been dissolved is then pumped into the still, through a pipe provided for this purpose, until the still has been partly filled. Finely pulped wet gun cotton is then thrown into the still through an opening in the side of its upper part, this gun cotton not having been as yet subjected to the action of any

[1] Chemical Engineer, vol. 5, 1907, page 422.
[2] P. Gerald Sanford, Nitro-Explosives, 1906, page 73.

solvent. More water in which barium nitrate and saltpeter have been dissolved is then pumped into the still until the surface of the liquid in the still is about on a level with the upper stirrer-blades on the vertical shaft. The opening through which the gun cotton was inserted is now closed, and a previously formed emulsion of from 25 to 50 per cent of amyl acetate in water containing barium nitrate and saltpeter in solution is pumped into the still.

The material now begins to granulate and the progress of the granulation is observed by withdrawing a little of the mixture through a small orifice near the bottom of the still. When granulation has been effected throughout the mass, which is within about five minutes after the introduction of the emulsion into the still was begun, steam is turned into the jacket surrounding the lower portion of the still. The heating due to the steam is continued for a period of five or six hours, and during this time the amyl acetate is distilled and passes over, with the vapors from the heated water, into a reservoir, where the water is separated from it.

After the amyl acetate is thus removed, a gate valve in the bottom of the still is opened and the mixture of water and granulated powder is drawn off into a draining tank. After draining it is dried, sized, blended, and packed. The strength and the amount of the emulsion used depend upon the amount and quality of the gun cotton; the best proportions are ascertained by experience. The length of time the heating is maintained depends upon the amount of amyl acetate used and the temperature of the steam in the steam jacket.

The still may measure about 6 feet and 3 inches from its bottom to the upper stirrer-blades and about 5 feet in diameter in its cylindrical portion. In such a vessel the usual charge of gun cotton is 450 pounds, to which is added the dust or very small grains from previous granulations, making a total charge of upward of 700 pounds. The finished powder is colored to suit the taste of consumers.

The invention and introduction of safety powders has gone on rapidly abroad, and to a more moderate extent in this country, since the census of 1900 was taken. Since, through the researches in France, it was shown that ammonium nitrate diminished the temperature of the products of explosion and tended to render explosives containing it safe for use in fiery mines the ammonia powders have had a marked increase in popularity. In the last edition of his book Guttmann[1] gives two tabular lists of modern explosives for use in mines, one of "nitroglycerin safety explosives," and one of "ammonium nitrate and other explosives." In the first list there are enumerated 23 different explosives containing ammonium nitrate, of which grisoutine A contains as much as 90.45 per cent of this substance, while in the second list there are 38 different powders containing ammonium nitrate, one of these, ammonal, being composed of 95 per cent of ammonium nitrate and 5 per cent of powdered aluminum.

Ammonium nitrate has long been used in dynamites in this country, especially since the invention of protected nitrate of ammonia for use in explosives by Russell S. Penniman in 1885, but foreign experts commented unfavorably upon the use of ammonium compounds in conjunction with organic nitrates such as nitroglycerin and gun cotton. It is gratifying to note the indorsement of American practice, shown in the foregoing statement.

A matter of grave importance in connection with the explosives industry is the transportation of the product, for all of it must be carried from the works to the place where it is to be used, and most of it is transported by railroads. When it is considered that the output for the census year 1905, as given in Table 111, was 363,748,097 pounds, and that a carload of explosives contains 20,000 pounds, it is apparent that there was produced each working day in 1904, on the average, 60 carloads of explosives. It is estimated that on the average 10 days are required in which to transport and deliver these consignments, therefore, there would have been each day on the railroads throughout the United States not less than 600 cars full of explosives. As a matter of fact explosives are more often transported in less than carload lots than in full carload lots especially from central depositories or magazines. From observation and experience railroad officials estimate that the cars carrying small lots are five times as numerous as those carrying full loads. It is therefore apparent that the number 600 is but a minimum and that the actual number of cars carrying explosives must be above this number. Some accidents have occurred in this transportation, but the surprise is that they have occurred so infrequently. It must be inferred that the numerous employees who handle these cars and their contents are especially intelligent, faithful, and vigilant.

But as shown by the statistics presented in this report this industry is a rapidly growing one. It is inevitable that it will continue to increase and that the transportation of explosives will become much larger in the future than it has been in the past. With this condition confronting it, the American Railway Association undertook, in 1905, the drafting of regulations governing this transportation, and prior to doing so called upon a committee of experts, consisting of Charles E. Munroe, Henry S. Drinker, and Charles F. McKenna, for advice. This committee reported as follows:[2]

(1) Your committee finds the explosives industry in the United States to be of importance and continually growing in the quantity and value of its output, as shown by Bulletin 210 of the census for 1900.

(2) It finds that the important and extensive industries of mining and quarrying, the many industries which employ the products

[1] Oscar Guttmann, Handbuch der Sprengarbeit, Braunschweig, 1906.

[2] The American Railway Association, Circular No. 616, 1905, page 14.

of mines and quarries, and engineering operations, can not be economically or safely carried on without explosives.

(3) It finds that the well being, comfort, and advancement of our modern civilization is to a large extent dependent upon the utilization of explosive substances, and that the raw materials from which explosives are manufactured, the products of the mines and quarries made available through the use of explosives, and the great variety of articles manufactured from these products, constitute a considerable part of the freight carried by railroads, while the various industries that are fundamentally dependent on the use of explosives give employment to an immense number of persons.

(4) It is of the opinion that the explosives industry is now so well an established feature of our industrial operations that its products must be transported, and that the best interests of all will be conserved by their being publicly transported by the ordinary routes of travel under such restrictions and conditions as will protect the traveler and the carrier without unduly hampering the producer, dealer, or consumer.

(5) It is of the opinion that a carrier has the right to know the character and properties of the goods he carries, for without such knowledge he may be unable either to protect such goods from injury or so to handle and transport them as to prevent their injuring persons and property. He should therefore be definitely informed regarding the composition and properties of all inflammables or explosives or of substances which may, by contact with other substances, form inflammables or explosives which he is called upon to transport. He also has a right to demand a guarantee that any consignment of an inflammable or explosive character offered possesses the same or a higher standard of stability, both as regards its composition and its method of packing, than the previously accepted or standard substance of this class or variety possessed.

(6) It is of the opinion that explosives and inflammables should be started on their way as soon as possible, forwarded as speedily as practicable, and promptly delivered, since the shorter the time they are in the possession of the carrier the less the risk.

(7) To indicate somewhat the magnitude of the risk following the quantity of explosives shipped in a single lot your committee submits the following table, compiled from a table prepared by Her Majesty's inspectors of explosives, and adopted by the United States authorities. In the original table, among other data, is given the distance which a magazine or factory containing the given weight of explosive should be separated from a public railway in order to protect the latter. The conditions we are considering here are the reverse of those named by Her Majesty's inspectors of explosives, for the explosives are on the railroad and the distance is the danger radius about the car for dwellings, churches, and other buildings.

AMOUNT OF EXPLOSIVES.	Danger radius.
3,000 pounds	240 yards.
4,000 pounds	280 yards.
5,000 pounds	320 yards.
10,000 pounds	525 yards.
20,000 pounds	850 yards.
30,000 pounds	1,200 yards.
40,000 pounds	1,525 yards.
50,000 pounds	1,850 yards.
100,000 pounds	3,500 yards.

This danger radius is not the limit of final effect, for glass may be broken, walls cracked, and weak structures shaken down at greater distances, depending on the topography and geology of the locus of explosion. On the other hand, these very features last mentioned may operate to materially diminish the danger radius. It should be said also that these data are derived from a discussion of those obtained in accidental explosions in the past, and represent extreme conditions.

(8) Your committee is of the opinion that the greatest danger which carriers have to contend with in transporting explosives is fire, and that every effort should be made to protect such shipments from fire.

(9) It recognizes a second and more remote cause of danger in friction, percussion, and concussion, and packages containing explosives should be handled and stored in cars with due precaution against these conditions arising. Freight handlers should know that the striking of a corner of a wooden box smeared with nitroglycerin against the wooden floor of a platform or car might give rise to an explosion.

(10) It recognizes a third cause of danger in high temperatures, which may start or promote decomposition and facilitate leakage. The practical application of this is that it is more hazardous to transport certain explosives in very warm weather, and that they should never be placed near a source of heat.

(11) Holding the above expressed views, your committee calls attention to General Notice No. 174B of the Pennsylvania Railroad Company, dated August 21, 1905, entitled "Information and Regulations for Shippers and Employees," relative to the "Transportation of Explosives." In our opinion, these regulations are practicable, reasonable, and fair, and, if observed, offer a high degree of protection and insurance of safety.

(12) Your committee is of the opinion that the interests of all will be best advanced; that the danger to life and property will be reduced to the minimum; that trade will be promoted and industries fostered by the adoption by all railroads of uniform regulations governing the transportation of explosives and inflammables, and we advise that such regulations be in general conformity with and on the lines of those now in force on the Pennsylvania Railroad as cited above.

(13) Taking up in greater detail the regulations, your committee recommends:

(*a*) That, to guard against "so-called spontaneous combustion or explosion," no nitroglycerin explosive, or an explosive of this class which gives an acid reaction, or which fails in the stability test, or which contains an insufficient amount of ant-acid, be accepted for transportation.

(*b*) That, as a precaution against leakage, cartridges or sticks of explosives be so packed in boxes that when loaded in cars the cartridges shall always lie upon their sides and never stand upon end.

(*c*) That containers be marked "Explosives—Dangerous" on all sides, and, to admit of the method of stowing recommended in (*b*), they be so marked that the position in which the cartridges lie is indicated.

(*d*) That, as a further precaution against leakage from the boxes and to reduce the chance of explosion by shock, cartridges or sticks be packed in dry sawdust or dry infusorial earth.

(*e*) That, as a precaution against explosion from friction, or shock, care be taken in loading explosives in the car that the packages are so stayed or chocked that they can not shift or fall.

(*f*) That no inflammables, no detonators, or blasting caps, and no acids be shipped in the same car with explosives.

(*g*) That cars carrying explosives be strong box cars in good order and be fitted with air brakes and, in trains, be placed between cars fitted with air brakes.

(*h*) That cars carrying explosives be located so far from the engine as to reduce to a minimum the danger from sparks from the engine.

(*i*) That cars carrying explosives be followed in the train by several cars so as to reduce to a minimum the chances of explosion in case of a rear-end collision.

(*j*) That cars carrying explosives be widely separated in a train from cars carrying petroleum or naphtha. So far as possible cars carrying explosives and cars carrying petroleum or naphtha should go by different trains.

(*k*) That in making up trains no cars carrying pig iron, steel billets, heavy structural metal parts, machinery, or other heavy material, which in a collision might crush adjacent cars, be placed adjacent to a car carrying explosives.

(*l*) That in view of the fact that explosives, containing nitroglycerin or other nitric esters, are more liable to decomposition the higher the temperature, the transportation of these explosives should be limited as much as possible during the hottest months of the summer, and when transported in warm weather every available precaution should be taken to keep the temperature of the car as low as possible, such, for example, as wetting the car down at water stations.

(*m*) That it is essential that the containers should be so made and of such strength that they will not be broken in transit.

(*n*) That in the transportation of explosives containing a liquid component it is desirable that the containers be lined with a liquid proof lining.

The regulations which have been framed now govern most of the railroads in this country, and a corps of inspectors of explosives has been organized with Maj. B. W. Dunn of the United States Army as chief inspector.

A second significant advance toward protection in the use of explosives is found in the formation during 1907, under the Technological Branch of the United States Geological Survey, of a corps of experts for the inspection of explosives for use in coal mines, and the study of accidents in such mines resulting from explosions.

Table 115 sets forth the imports and exports of explosives during the years ending June 30, 1891 to 1905, as taken from Statistical Abstract of the United States, published by the Bureau of Statistics.

TABLE 115.—EXPLOSIVES—IMPORTS AND DOMESTIC EXPORTS: 1891 TO 1905.

YEAR ENDING JUNE 30—	IMPORTS.				DOMESTIC EXPORTS.			
	Gunpowder.		All other explosives, fulminates, etc.[1] (value).	Total value.	Gunpowder.		All other explosives (value).	Total value.
	Pounds.	Value.			Pounds.	Value.		
1891	34,312	$19,148	$124,528	$143,676	733,834	$88,676	$906,870	$995,546
1892	31,111	29,533	100,977	130,510	903,077	108,276	752,079	860,355
1893	78,306	68,974	124,661	193,635	885,263	105,547	755,966	861,513
1894	85,481	71,285	67,342	138,627	495,566	66,839	935,287	1,002,126
1895	104,990	84,882	96,940	181,822	972,271	102,885	1,174,396	1,277,281
1896	68,993	49,857	77,192	127,049	1,159,935	124,823	1,256,279	1,381,102
1897	87,921	63,722	98,727	162,449	1,086,465	118,001	1,437,317	1,555,318
1898	98,708	79,992	65,123	145,115	1,202,971	139,644	1,255,762	1,395,406
1899	44,405	29,824	160,620	190,444	1,504,624	181,642	1,350,247	1,531,889
1900	31,212	15,835	169,073	184,908	1,612,822	197,438	1,694,166	1,891,604
1901	79,556	38,644	212,895	251,539	1,463,499	193,345	1,518,757	1,712,102
1902	70,776	55,998	268,788	324,786	1,609,910	224,779	1,837,602	2,062,381
1903	76,766	59,778	375,404	435,182	1,112,490	151,658	2,302,852	2,454,510
1904	64,569	53,370	318,599	371,969	965,740	136,383	2,305,213	2,441,596
1905	73,245	55,979	311,527	367,506	1,062,807	149,466	2,410,371	2,559,837

[1] Does not include firecrackers.

CLASS XV.—PLASTICS.

This class embraces pyroxylin plastics (including celluloid, xylonite, fiberloid, viscoloid, pegamoid, pyralin, and the goods wrought from them), pyroxylin or soluble cotton, and the collodion or photographic films, artificial leather, and other products made from it, viscose and its products, rubber substitutes, and all other plastics formed from caoutchouc, gutta-percha, casein, fibrin, gluten, gums, and glue or other cementing material by which sawdust, wood pulp, bone dust, zinc oxide, antimony sulphide, kaolin, and other fillers are held in solid aggregations which may be molded or shaped with lathes and other tools as desired.

TABLE 116.—*Plastics—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	10	8	2	25.0
Capital	$8,689,547	$7,558,720	$1,130,827	15.0
Salaried officials, clerks, etc., number	198	196	2	1.0
Salaries	$334,151	$308,395	$25,756	8.4
Wage-earners, average number	1,847	1,219	628	51.5
Total wages	$863,702	$590,557	$273,145	46.3
Miscellaneous expenses	$528,504	$214,166	$314,338	146.8
Cost of materials used	$1,952,053	$1,255,841	$696,212	55.4
Value of products	$4,877,380	$3,035,656	$1,841,724	60.7

The statistics of Table 116 show an increase in every item, that in value of products being nearly $2,000,000 and that in capital being over $1,000,000. The proportional increase in value of products was, however, much larger than that in capital, amounting to 60.7 per cent against a gain of 14.1 per cent in the latter item. The largest proportional increase, 146.8 per cent, was in miscellaneous expenses.

TABLE 117.—*Plastics—quantity and value of products: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Value.	Quantity.	Value.
Pyroxylin plastics, pounds	[1] 2,966,820	$2,671,380	[2] 2,074,708	$2,259,338
Pyroxylin, pounds	[3] 2,986,497	2,777,556	[4] 1,561,604	1,359,490
Rubber substitutes, pounds	254,892	63,724		
Leather substitutes				479,842
All other plastics, pounds	90,820	21,743		
All other products		1,659,274		1,101,845

[1] Includes 593,866 pounds, with an assigned value of $534,404, consumed in establishments where manufactured.

[2] Includes 814,184 pounds, with an assigned value of $732,766, consumed in establishments where manufactured.

[3] Includes 2,914,246 pounds, with an assigned value of $2,710,149, consumed in establishments where manufactured.

[4] Includes 1,467,147 pounds, with an assigned value of $1,276,419, consumed in establishments where manufactured.

The statistics of Table 117 show a considerable fluctuation in the character of this industry, as leather substitutes, which appeared at the census of 1900, do not appear at that of 1905, while rubber substitutes and the classification "all other plastics" appear at the present census for the first time. While it is believed that certain of the establishments producing leather substitutes in 1900 have ceased such manufacture, it is believed also that the products of other establishments were included in other categories at the census of 1905, owing to the form or manner in which they were reported. The three items of Table 117 for which returns appear at both censuses all show an increase for 1905 as compared with 1900, the largest increase in quantity, 1,424,893 pounds, and the largest increase in value, $1,418,066, being shown for pyroxylin, the larger part of which (97.6 per cent in 1905) is, however, consumed in further manufacture in the establishments in which it is produced.

TABLE 118.—*Plastics—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1] 14	[2] 13
Connecticut	1	....
Massachusetts	3	1
New Jersey	8	11
New York	2	1

[1] Includes 4 establishments engaged primarily in the manufacture of other products.
[2] Includes 5 establishments engaged primarily in the manufacture of other products.

It will be seen that at both censuses the manufacture of plastics was largely confined to New Jersey, this state reporting, at the census of 1900, 11 out of a total of 13 establishments for the industry, or 84.6 per cent. At the census of 1905 New Jersey showed a loss of 3 establishments but still reported 8 out of a total of 14, or 57.1 per cent. The industry as a whole showed a gain of 1 establishment at the census of 1905.

TABLE 119.—*Plastics—quantity and cost of materials used: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Cost.	Quantity.	Cost.
Acetone, pounds	695,667	$83,481	191,864	$23,024
Alcohol, grain, gallons	8,557	20,858	7,015	16,837
Alcohol, wood, gallons	275,278	204,925	187,381	121,737
Camphor, pounds	1,282,063	457,744	635,111	162,270
Cotton and paper, pounds	1,990,846	288,455	1,006,194	146,430
Dyestuffs and colors, pounds	14,378	8,348	10,278	5,487
Ether, pounds	12,473	7,391	....	....
Mixed acids, pounds	2,680,923	137,384	....	....
Nitric acid, pounds	3,918,794	200,542	2,971,469	151,266
Oils, gallons	49,509	29,914	87,647	17,321
Sulphuric acid, tons	4,177	73,890	4,157	73,196
Zinc oxide, pounds	393,900	28,417	116,400	8,155

The statistics of Table 119 show an increase for 1905 over 1900 for every item presented for both censuses except in the quantity of oils. The term "oils" includes, among others, rape, mustard, linseed, cottonseed, corn, and petroleum oils and the loss in quantity in 1905 appears to be due to the closing of a factory which in 1900 used a very considerable volume of low-priced oil. An item in which there appears but a slight increase is sulphuric acid, but this fact is at least partly accounted for by the fact that mixed acids were returned separately in 1905, since sulphuric acid, as shown in the discussion of Class I, constitutes an important part of this mixed acid. The largest increase in quantity, 984,652 pounds, is found in the item of cotton and paper, these two being joi because they are used interchangeably as sources pyroxylin, but, if the nitric acid of the mixed acids added to the nitric acid reported in 1905, the larg increase in quantity would be found for nitric ac The largest increase in cost, $295,474, is found in t item of camphor, the expenditure for this materi almost trebling since 1900.

TABLE 120.—*Pyroxylin plastics—comparative summary: 1880 1905.*

CENSUS.	Number of establishments.	Capital.	Number of employees.	Value of products
1905	5	$8,639,516	[1] 1,838	$4,795,15
1900	7	7,210,548	[1] 1,176	2,916,02
1890	12	3,158,487	1,023	2,575,73
1880	6	1,214,000	736	1,261,54

[1] Wage-earners only.

It will be seen that at each census there was an increase in every item presented in this table, except in the number of establishments, which shows a falling off at each census since 1890, due probably to the same tendency to concentration that is to be observed in other industries. The greatest increase in value of products, $1,879,130, and in the number of employees, 662, was reported for the five-year period from 1900 to 1905. The greatest increase in capital, $4,052,061, however, was reported for the period from 1890 to 1900, but in spite of this fact the industry appears to have been almost at a standstill during this period, as the census of 1900 shows the extremely low increase of $340,291 in value of products over the census of 1890. Since 1900, however, the industry apparently has been growing rapidly in importance.

The applications of cellulose are already manifold. Although many have been long known, a very considerable number are of quite recent origin, and new methods of application are constantly being invented or discovered. Probably nothing has done more to facilitate such applications than the discovery of cellulose nitrate, as made by Schoenbein in 1846, and the subsequent discovery of the Hyatt Brothers, in 1869, that by the aid of camphor, the cellulose nitrate, which is known as the heptanitrate, could be converted into the plastic mass known as celluloid, for from these discoveries and the inventions following there has grown up the extensive pyroxylin plastics industry shown statistically above.

Another development based on the use of cellulose nitrates is the artificial silk industry, which has grown from the discovery by De Chardonnet, in 1885, that a solution of pyroxylin could be forced through fine apertures into water so as to form fine threads having the luster of silk and showing a marked capacity for dyes. This industry has attained a large degree of importance in Europe, but, although considerable quantities of its products are imported into the United

States, their manufacture is not yet carried on here. The reason for this lies in the fact that large quantities of grain alcohol and ether are employed in this industry, and it is not found that the cost of these materials in this country has as yet reached a point sufficiently low to permit this artificial silk manufacture to be conducted economically.

Attention was called in the report on chemicals and allied products in 1900 to the invention of viscose by Cross and Bevan and others and the production of plastic masses from cellulose by this means. This invention, resulting from a most elaborate scientific research, has been expected to yield most valuable economic results, but as yet there are no statistics to record here.

A recent development of importance in the plastic industry is in the application of casein as the binder for various materials, as these products are expected to replace the pyroxylin plastics. Scherer devotes a chapter in his book[1] to the "Preparation of Plastic Masses from Casein" and mentions particularly galalith, which is prepared from a specially purified casein.

Constantly extending use is being made of the solutions of cellulose nitrate in the manufacture of oilcloth, linoleum, artificial leather, waterproofed cloth and paper, and especially patent leather.

Table 121 sets forth the imports and exports of pyroxylin plastics, for the years ending June 30, from 1891 to 1905, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

TABLE 121.—*Pyroxylin plastics—imports and exports: 1891 to 1905.*

YEAR ENDING JUNE 30—	Imports (value).	Exports (value).
1891	$10,595	....
1892	43,353	$39,004
1893	57,062	36,597
1894	96,977	85,234
1895	371,873	72,926
1896	337,862	146,354
1897	262,675	149,631
1898	160,836	155,444
1899	249,619	173,771
1900	378,583	174,310
1901	277,461	211,781
1902	213,663	189,974
1903	178,144	249,488
1904	240,501	246,601
1905	166,479	294,979

CLASS XVI.—ESSENTIAL OILS.

The class of essential oils embraces the natural essential oils, both crude and refined (except turpentine and petroleum distillates), artificia essential oils, and witch hazel. The number of different substances included is very large. The Standard Dictionary enumerates 159 different essential oils, all of which except petroleum and naphtha are of vegetable origin, but this does not exhaust the list.

[1] Robert Scherer, Casein—Its Preparation and Technical Utilization, translated by Charles Salter, New York, 1906.

TABLE 122.—*Essential oils—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	52	47	5	10.6
Capital	$723,004	$576,286	$146,718	25.5
Salaried officials, clerks, etc., number	37	39	[1] 2	[1] 5.1
Salaries	$40,002	$24,733	$15,269	61.7
Wage-earners, average number	132	168	[1] 36	[1] 21.4
Total wages	$69,711	$61,415	$8,296	13.5
Miscellaneous expenses	$78,886	$48,763	$30,123	61.8
Cost of materials used	$1,110,470	$588,594	$521,876	88.7
Value of products	$1,464,662	$813,495	$651,167	80.0

[1] Decrease.

The statistics of Table 122 show an increase in every item for 1905 as compared with 1900 except in the number of salaried officials, clerks, etc., and the average number of wage-earners. The value of products shows an increase of $651,167, or 80 per cent, but the largest proportional increase, 88.7 per cent, was reported for the cost of materials.

TABLE 123.—*Essential oils—quantity and value of products: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Value.	Quantity.	Value.
Peppermint oil:				
Crude, pounds	41,250	$107,472	147,100	$126,340
Refined, pounds	88,772	362,565	102,068	127,585
Sassafras oil, pounds	30,235	17,673	117,729	37,772
Wintergreen oil, pounds	4,737	15,579	1,300	1,231
Other natural oils, pounds	299,373	522,648	467,319	404,785
Witch hazel extract, gallons	824,874	380,373	110,260	54,649
Artificial oils	....	65,250	....	54,460
All other products	....	7,602	....	9,547

The statistics of Table 123 show an increase in the value of refined peppermint oil, in the quantity and value of wintergreen oil and of witch hazel extract, and in the value of "other natural oils" and of artificial oils, but a decrease in all other items. The decrease in the quantity of peppermint oil, both crude and refined, finds an explanation in the overproduction of this commodity in 1899, which carried the price below that point which made the cultivation of the mint and production of the oil profitable. As a consequence the cultivation has since been much restricted. The reduction in the quantity and value of sassafras oil appears to be due to the fact that this is chiefly a neighborhood industry which is subject to considerable fluctuation. The quantities of other natural oils are subject to similar fluctuations, and it would appear that in 1905 a larger quantity of the more expensive oils was produced than in 1900.

As pointed out elsewhere, in 1900 the census included the neighborhood industries, while in 1905 these were eliminated from the canvass. This difference in methods has had a marked influence on the industries embraced in Class III, Potashes, and Class XVI, Essential Oils, as these industries are largely pursued by farmers at odd moments between the cultivation of their regular crops. As a result of this canvass in 1900, in addition to the quantities presented in Table 123, there were returned 38,925 pounds of oil of peppermint, valued at $32,074; 1,410 pounds of oil of sassafras, valued at $393; 775 pounds of oil of wintergreen, valued at $1,043; and 11,158 pounds of other natural oils, valued at $7,734. These establishments each, as a rule, produced less than $500 worth of product, and would not therefore be considered in any of the regular Census tabulations.

TABLE 124.—*Essential oils—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1]54	[2]50
California	2	2
Connecticut	9	5
Florida	....	1
Illinois	....	1
Indiana	13	....
Massachusetts	1	1
Michigan	7	6
New Hampshire	1	....
New Jersey	1	....
New York	5	15
North Carolina	....	1
Pennsylvania	9	3
Virginia	4	13
Wisconsin	2	2

[1] Includes 2 establishments engaged primarily in the manufacture of other products.
[2] Includes 3 establishments engaged primarily in the manufacture of other products.

The statistics of Table 124 show a most irregular fluctuation, due probably to the fact that the sources of supply are quite irregular and that, as a rule, these establishments spring into existence in the midst of an abundant native supply and are abandoned when this is exhausted.

TABLE 125.—*Essential oils—value of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
United States	$1,479,162	$816,369
North Atlantic	1,160,617	585,972
South Atlantic	9,856	38,772
North Central and Western	308,689	191,625

Table 125 shows that the North Atlantic division held the first rank in the essential oil industry at each census, and at the census of 1905 reported 78.5 per cent, or more than three-fourths, of the total value of products for the industry. The combined North Central and Western divisions ranked second at each census. In both of these divisions the industry shows a marked increase in the value of products for 1905 as compared with 1900, that in the North Atlantic division amounting to 98.1 per cent. There was, on the other hand, a marked decrease in the value of products of the South Atlantic division.

TABLE 126.—*Essential oils—quantity and cost of materials used: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Cost.	Quantity.	Cost.
Alcohol, grain, gallons	84,602	$206,255	13,258	$44,888
Essential oils, crude, pounds	107,713	385,773	443,400	331,050
Herbs, leaves, and seeds, tons	2,410	230,666	7,473	148,050
Wood, bark, and roots, tons	59,981	244,823	6,363	25,684

The statistics of Table 126 show for 1905 as compared with 1900 an increase in the value of every article enumerated, and an increase in the quantity of alcohol and of wood, bark, and roots used. The decreases in the quantity of crude essential oils and of herbs, leaves, and seeds used in 1905 as compared with 1900 are quite in harmony with the variations in products shown elsewhere, and point to a smaller use of the cheaper materials.

Table 127 presents the imports and exports of oils, both volatile, or essential, and distilled, for the years ending June 30, 1891 to 1905, inclusive, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

TABLE 127.—*Oils, volatile, or essential, and distilled—imports and exports: 1891 to 1905.*

YEAR ENDING JUNE 30—	IMPORTS.		EXPORTS.		
			Peppermint oil.		All other (value).
	Pounds.	Value.	Pounds.	Value.	
1891	3,459,533	$1,523,491	45,321	$120,831	$65,104
1892	3,451,519	1,676,064	54,987	156,418	68,501
1893	4,022,117	1,654,036	99,629	267,422	79,920
1894	2,861,875	1,102,108	80,225	209,722	64,907
1895	....	1,398,956	87,633	194,616	190,798
1896	....	1,554,289	85,290	174,810	102,487
1897	....	1,885,523	162,492	257,484	146,569
1898	....	1,511,078	145,375	180,811	201,497
1899	....	1,691,257	117,462	118,227	162,358
1900	....	1,859,184	89,558	90,298	166,424
1901	....	1,959,395	60,166	63,672	169,004
1902	....	2,092,371	36,301	54,898	202,983
1903	....	2,156,331	13,033	34,943	252,770
1904	....	2,396,748	42,939	124,728	440,588
1905	....	2,534,723	36,953	135,060	215,860

CLASS XVII.—COMPRESSED AND LIQUEFIED GASES.

This class embraces acetylene, anhydrous ammonia, carbon dioxide (carbonic acid gas, carbonic anhydride, CO_2), chlorine, coal gas, hydrogen, liquid air, nitrogen monoxide (hyponitrous oxide, nitrous oxide, laughing gas, N_2O), oxygen, compound oxygen, sulphur dioxide (sulphurous oxide, sulphurous acid gas, sulphurous anhydride, SO_2), and all gases that are compressed or liquefied for sale.

The statistics in Table 128 show an increase in every item for 1905 as compared with 1900, the largest increase in amount being found in capital and the second largest in value of products. The largest percentage of increase is also found in the item of capital, and the second largest, in the item of miscellaneous expenses. It is to be noted as indicating the rapid growth of this industry that the smallest percentage of increase, that for the number of establishments, is above 50 per cent.

TABLE 128.—*Compressed and liquefied gases—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	CENSUS.		Increase.	Per cent of increase.
	1905	1900		
Number of establishments	46	30	16	53.3
Capital	$6,943,805	$2,117,355	$4,826,450	227.9
Salaried officials, clerks, etc., number	243	101	142	140.6
Salaries	$258,555	$121,912	$136,643	112.1
Wage-earners, average number	426	211	215	101.9
Total wages	$271,392	$149,986	$121,406	80.9
Miscellaneous expenses	$451,712	$160,561	$291,151	181.3
Cost of materials used	$1,117,930	$636,519	$481,411	75.6
Value of products	$2,673,846	$1,320,042	$1,353,804	102.6

The statistics of Table 129 show an increase for 1905 over 1900 for every item enumerated at both censuses except for the quantity and value of aqua ammonia, the quantity of calcined magnesia, and the value of all other gases. The largest increase in value, $738,697, is in the item of anhydrous ammonia, and the second largest increase, $624,603, in that of carbon dioxide, while the largest percentages of increase in value, 232.2 per cent and 168.6 per cent, respectively, appear for illuminating gas and anhydrous ammonia. The largest increase in quantity, 23,907,346 pounds, is in carbon dioxide, and the second largest increase, 3,308,504 pounds, in anhydrous ammonia. The decrease in the quantity and value of the aqua ammonia produced arises from the fact that the ammonia can now be more profitably manufactured into anhydrous ammonia. The decrease in the quantity and the increase in the value of calcined magnesia appear to arise from the difference in the conditions of the market for this product in different localities, for in some places it is easier to dispose of calcined magnesia at an acceptable price, and in others to dispose of epsom salts, and this determines what final state of combination the magnesium contents of the magnesite shall be made to assume.

TABLE 129.—*Compressed and liquefied gases—quantity and value of products: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Value.	Quantity.	Value.
Anhydrous ammonia, pounds	5,752,233	$1,176,854	2,443,729	$438,157
Aqua ammonia, pounds	[1]1,832,038	[1]86,909	[2]3,216,973	[2]122,619
Calcined magnesia, pounds	2,538,000	35,003	6,556,000	32,000
Carbon dioxide, pounds	35,991,627	1,343,967	12,084,281	719,364
Epsom salts, pounds	10,111,395	102,794	(3)	(3)
Illuminating gas, 1,000 cubic feet	197,072	983,852	60,432	296,174
Laughing gas, pounds	41,020	28,311	(4)	(4)
Lime, bushels	15,785	1,278	8,000	900
Oxygen, gallons	1,898,410	69,246	395,350	38,170
All other gases	....	2,957	....	35,106

[1] Includes 291,589 pounds, with an assigned value of $11,664, consumed in establishments where manufactured.
[2] Includes 201,503 pounds, with an estimated value of $7,254, consumed in establishments where manufactured.
[3] Not shown separately in 1900.
[4] Included in "all other gases" in 1900.

The item of illuminating gas in Table 129 illustrates the manner in which the summations of individual industries are arrived at, for this product primarily, and properly, appears in the industry classified as "gas, manufactured," but as it is compressed, the figures are again shown here in order to present as complete a view as possible of the industry of compressing and liquefying gases for sale. No data for illuminating gas are included in the statistics of Table 128, and therefore there is no duplication in the total values given for chemicals and allied products.

TABLE 130.—*Compressed and liquefied gases—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1]72	[1]56
Alabama	1	1
Arkansas	1	1
California	5	2
Colorado	1	....
Connecticut	1	....
Delaware	....	1
District of Columbia	1	1
Florida	1	1
Georgia	3	1
Illinois	4	4
Indiana	1	1
Iowa	1	....
Kansas	....	1
Louisiana	2	....
Maryland	1	1
Massachusetts	3	2
Michigan	....	1
Minnesota	5	1
Missouri	5	2
New Jersey	8	9
New York	14	10
North Carolina	....	1
Ohio	3	4
Oregon	....	1
Pennsylvania	7	6
Tennessee	....	2
Texas	1	....
Virginia	1	....
Vermont	....	1
Wisconsin	2	1

[1] Includes 26 establishments engaged primarily in the manufacture of other products.

The statistics of Table 130 show that New York has held the first place in rank in this industry at each census, New Jersey the second place, and Pennsylvania the third. No other state shows more than 5 establishments at either census.

TABLE 131.—*Compressed and liquefied gases—value of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
United States	[1]$3,858,628	[1]$1,732,509
North Atlantic	1,442,180	797,802
South Atlantic	322,567	201,272
North Central	1,815,106	618,378
South Central	95,159	41,934
Western	183,616	73,123

[1] Includes "all other products."

The statistics of Table 131 show a marked increase in every division enumerated, the largest increase, $1,196,728, being in the North Central division, and the second largest, $644,378, in the North Atlantic. The largest percentage of increase, 193.5 per cent, is also found for the North Central division. Measured by the value of products, the North Central division, which stood second in this industry at the census of

1900, stands first at the census of 1905, and the North Atlantic division, which stood first in 1900, now stands second.

TABLE 132.—*Compressed and liquefied gases—quantity and cost of materials used: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Cost.	Quantity.	Cost.
Ammonia liquor, gallons [1]	10,258,764	$204,467	916,851	$16,504
Ammonium nitrate, pounds	75,894	10,890	(2)	(2)
Ammonium sulphate, pounds	6,340,661	253,543	4,186,186	106,632
Aqua ammonia, pounds	3,752,267	146,388	4,555,734	225,026
Carbonate of potash, pounds	370,124	15,780	(2)	(2)
Chlorate of potash, pounds	28,573	3,325	(2)	(2)
Lime, bushels	173,824	28,478	113,218	14,263
Limestone, tons	499	4,989	631	4,418
Magnesite, tons	111,106	71,296	134,808	55,899
Oil, gallons	3,506,614	172,146	1,385,021	57,741
Sulphuric acid, tons	8,295	91,976	4,014	46,229

[1] 16-ounce liquor. [2] Not shown separately in 1900.

The statistics presented in Table 132 show an increase in every item shown at each census except in the quantity and cost of aqua ammonia and the quantities of limestone and magnesite. The decrease in the quantity of aqua ammonia used may well be accounted for by such an increase in the quantity of ammonium sulphate and ammonia liquor used as has been reported, while the increased use of carbon dioxide from natural sources and from breweries may account for the decrease in the use of limestone and magnesite. The largest increase in cost, $187,963, is for the ammonia liquor reported, and the second largest, $146,911, for ammonium sulphate. The largest percentage of increase in cost, 1,138.9 per cent, is found for ammonia liquor, and the second largest, 198.1 per cent, for oil. The units of measure employed for the different materials reported are so many and unlike that no comparison by quantity of any value can be made.

The direct liquefaction of acetylene has failed to reach a commercial development, because of the fact that, being an endothermous compound, it is easily decomposed with explosive violence if, when under a pressure of more than 2 atmospheres, it is subjected to a shock. In common with other endothermous compounds this sensitiveness of acetylene is diminished by admixture with other substances, and it has been the custom in Germany to employ, for lighting the coaches on railroads, a mixture of 25 per cent of acetylene and 75 per cent of a gas of low candlepower made from shale, compressed in cylinders under a pressure of 150 pounds to the square inch. Advantage has also been taken of the fact that acetone is a solvent for acetylene, the volume of acetylene gas that may be so dissolved increasing once with each pound of pressure to which the gas is subjected. Containers filled with porous substances to facilitate absorption and localize dissociation, in the event of its occurrence, have met with favor in the lighting of coaches, yachts, buoys, and so on, but the statistics of acetylene compression are as yet too few to permit of separate presentation.

The increase in the quantity of anhydrous ammonia manufactured depends principally upon the extension of the compressor system of artificial refrigeration, though this substance is also employed to some extent in the absorption system. Thus, from the report on manufactured ice,[1] it appears that at the census of 1900, 946,666 pounds of anhydrous ammonia, costing $249,838, were used in the compressor system, and 109,869 pounds, costing $29,842, in the absorption system; while at the census of 1905, 1,795,893 pounds, valued at $484,769, were used in the compressor system and 136,604 pounds, costing $37,506, in the absorption system. There were therefore used in the manufacture of ice, at the census of 1900, a total of 1,056,535 pounds of anhydrous ammonia, costing $279,680, and at the census of 1905 a total of 1,932,497 pounds, costing $522,275. The manufacture of ice, however, represents but a part, and probably the lesser part, of the application of the process of artificial refrigeration, for, as is well known, it is applied very extensively in cold storage for the preservation of food products, and in many manufacturing operations. Mention has already been made of the use of ice or refrigerating machines in the manufacture of nitroglycerin. Another recent application of these machines, due to James Gayley, first vice-president of the United States Steel Corporation,[2] is in the drying of the air for use in blast furnaces used in the production of cast iron, by freezing the moisture out of the air. Many of the large establishments in which such refrigerating appliances are in use manufacture the anhydrous ammonia which they consume in their apparatus, and such manufacture, as a rule, escapes census enumeration. There is no doubt that the anhydrous ammonia produced for sale is considerably less than the entire product of a given year.

In 1905, as in 1900, carbon dioxide was obtained chiefly from the earth about mineral springs, from the fermentation tubs in breweries, from the combustion of coke, from the calcination of limestone or magnesite, and from the treatment of magnesite or other carbonates with sulphuric acid; but the proportions of the total drawn from these various sources in 1905 have changed materially from what they were in 1900. According to Minor,[3] at Saratoga Springs, N. Y., where the gas is recovered from the natural carbonated saline waters found there, over forty springs (or wells) have been drilled for gas producing purposes, and these yield about 20,000 pounds of carbon dioxide per day.

The wells are generally 6 inches in diameter, varying in depth from 150 feet to 600 feet as they extend south. The rock is an argillaceous slate lying above limestone, and it is at the juncture of the two that the carbonated water is generally found, if at all, for many nonyielding wells have been drilled. The water as it issues from the well carrying its gas under pressure, is piped directly into

[1] Census of Manufactures, 1905, Bulletin 83, pages 54 and 55.
[2] James Gayley, "The Application of Dry Air Blast to the Manufacture of Iron," Iron and Steel Institute, 1904.
[3] John C. Minor, jr., "The Production and Modern Uses of Carbonic Acid," The Chemical Engineer, vol. 1, 1904, page 212.

a separator—a large barrel with a 2-foot trap or seal at the bottom from which the water escapes to waste, and with a pipe at the top leading to the gasometer into which the gas, following the path of least resistance, naturally discharges. The process of securing the gas is therefore purely automatic, and but little goes to waste with the water except that in actual solution.

Once stored in the gasometer the methods of treatment are quite similar for all plants. The gas is drawn through calcium chloride dryers to remove any moisture and passes on to the compressor, working generally in three stages, 60,300, and 1,000 pounds, varying a little with the temperature. After each stage the gas is thoroughly cooled, finally passing into the cylinders for shipment, the weight of gas admitted being carefully controlled.

Upon the ability to secure a steel container for shipping, of not excessive weight and capable of withstanding shocks in transit and an internal test pressure of 3,700 pounds per square inch, the future of this industry has rested. The cylinders or tubes now used are either of lap-welded or of seamless steel, the smaller size being $5\frac{9}{16}$ inches O. D., and 48 inches long with a water capacity of 30 pounds, into which 20 pounds of gas are filled, and the larger size of $8\frac{9}{16}$ inches O. D., and 51 inches long with a water capacity of 90 pounds, and filled ordinarily with 60 pounds of gas. This gives a ratio of gas to water capacity of about 67 per cent and the pressures reached under ordinary conditions are as follows:

At 60° F., 745 pounds per square inch.
80° F., 966 pounds per square inch.
110° F., 1,715 pounds per square inch.
130° F., 2,240 pounds per square inch.

The bursting pressure for the seamless tubes varies between 5,100 and 5,900 pounds, and for the lap-welded between 4,900 and 5,500 pounds, and every tube before using is tested to 3,700 pounds per square inch.

According to Fuller[1] the carbon dioxide obtained at Saratoga appears to come mainly from the Trenton limestone and to result from the action upon it of chlorinated water.

A development of the process for producing carbon dioxide from coke consists in burning the coke in a furnace with cold blast, cooling the resultant mixed gases in water-cooled tubes, scrubbing them with water in coke towers in order to remove SO_2, soot and dirt, and then passing them into a solution of a cold normal alkali carbonate, such as potassium or sodium carbonate, thereby causing the formation of an acid carbonate, commonly known as a bicarbonate. The resulting solution of the bicarbonate is then heated by the waste heat from the coke-burning furnace, whereby the carbon dioxide that has been absorbed is set free and the normal carbonate solution is regenerated for use again in the absorbing tower. A characteristic feature in the recovery of the gas from closed fermentation vats in breweries consists in passing the gas, after it has been washed, through a solution of potassium permanganate in order to oxidize and destroy the organic matters that accompany it, and impart to it an odor indicative of its origin.

The several processes in use, when properly carried out, yield a product which is from 98 to 99.5 per cent pure. A considerable number of uses to which compressed carbon dioxide is applied were enumerated in the report on chemicals and allied products at the census of 1900. Additional applications mentioned by Minor are (1) in the operation of block signals by the electro-pneumatic process, which is as follows:

When a train approaches the signal it short circuits a track battery, thereby opening a relay and closing an electrical contact point, which in turn causes an electro-pneumatic valve to open, provided there is no train on the block ahead. Carbonic acid at 54 pounds pressure is thus permitted to pass from a secondary tank, fed by a gas cylinder through a pressure regulator, to the semaphore casting which when forced up by the pressure causes the blade to go from a horizontal or stop position to one of 60°, thus giving a proceed signal to the train.

And (2) in the treatment of logwood:

In the ordinary methods of extraction there is a partial decomposition of the coloring matter into products which can not afterwards be separated from it. These have a most detrimental effect on the efficiency of the product as a dye. By extraction in the presence of CO_2, not only is there a definite compound—hematoxylin carbonate—formed, but the decomposition is prevented which occurs when the color is extracted by any other process. When dyed upon cotton, with an alkaline bath, the glucose contained in the extract made by other methods reduces the copper salt to red oxide, which is precipitated with the color as an insoluble lake, having no affinity for cotton fiber and producing the so-called "dusty" condition. The new product does not reduce copper salts and does produce even and perfect shades of color on the fiber.

The compression of illuminating gas has long been practised, and it was in the examination of the liquid deposited from this compressed gas that Faraday, in 1825, discovered the very important hydrocarbon known as benzene. This very deposition of the heavier hydrocarbon in the gas, however, impoverished the gas and rendered it less fit for use as an illuminant. The great convenience that often results from being able to store gas in portable cylinders and to use it at will is obvious, and this fact has served to stimulate inventors to continued efforts, until success was reached in processes such as that of Pintsch or of Peebles, in which the gas is made by "cracking" certain petroleum, tar, or shale oils in retorts, and then compressing them in cylinders under low pressures. Since this oil gas is rich in benzene and olefiant hydrocarbons, it must be burned in specially designed burners. By admixture with a certain amount of oxygen its combustibility and illuminating powers are improved. In its formation tar and liquid hydrocarbons are obtained as by-products. Compressed illuminating gas is principally used in lighting railway coaches and buoys, although some, obtained by compressing ordinary city gas, is used in the oxyhydrogen lamp with magic lanterns, and is sold under the name of hydrogen, or black gas, the latter name referring to the color of the cylinders in which it is stored.

Liquid hydrogen has not yet appeared in commerce, although the process of liquefying it was exemplified on a large scale in the British Government Exhibit at the Louisiana Purchase Exposition at St. Louis. Compressed hydrogen is utilized in the Clowes lamp employed in detecting the presence of dangerous gases in mines, the holds of ships, and other inclosed places. A recent important industrial use for it, or for com-

[1] Myron L. Fuller, "Carbon Dioxide," Mineral Resources of the United States, 1905, page 1259.

pressed acetylene, is found in the compound blowpipes used in cutting or perforating metals, which enable one to cut into pieces with ease and celerity large masses of iron, steel, or other metals. A competitor to compressed hydrogen is found in the generators making use of metallic hydrides, such as lithium or calcium hydrides, for these substances on contact with water react with it in a manner similar to that of calcium carbide; hydrogen gas is thus set free, and may, if desired, be evolved under pressure. The calcium hydride proposed for this use has been commercially styled hydrolith.

Not much progress seems to have been made in the commercial development of liquid air, though the processes for its production have been greatly improved. This seems to be due to the fact that the demand for it has been limited to the use of a portion of the oxygen obtained from it for medical purposes, and to the use of a still smaller quantity of the liquid air itself for popular demonstrations or scientific researches. As about four-fifths of the atmospheric air is nitrogen, and as there has been in the past no commercial use for nitrogen, the entire cost of production has had to be borne by the oxygen which was sold as such. Mention has been previously made in these pages of the recent utilization of nitrogen in the manufacture of calcium cyanamid, and this application will probably give a marked impetus in the near future to the manufacture of liquid air.

Class XVIII.—Fine Chemicals.

This class embraces those chemicals sold in the trade as chemically pure or absolutely pure; the chemicals which are more especially made use of in analytical perations, in scientific research, and in pharmacy; nd those chemicals for which, like the salts of gold nd of silver, the price per unit is relatively very high. mong the chemicals which are embraced here may e named all chemically pure or "analyzed" acids, ases, and salts; acetone and other ketones; absolute lcohols and all alcohols other than commercial grain nd wood alcohols; aldehydes; alkaloids; elementary ıbstances, other than common and low-priced ones; nzymes, ferments, or diastases, such as pancreatin, epsin, rennet, trypsin, lactose, sucrose, and zymose; ters (ethereal salts or compound ethers); ethers, mple and mixed; rare earth compounds, such as the lts of cerium, lanthanum, thorium, radium, and uraum; terpenes; toxins and antitoxins; and urea d the ureides. In his recent catalogue, Schuardt[1] enumerates upward of 6,700 different subances that he offers for sale, most of which belong in is class, and yet this list does not include all of this ss of substances that are now known.

[1] Dr. Theodor Schuchardt, Chemische Fabrike, Goerlitz, No. 68, tober, 1907.

Table 133.—*Fine chemicals—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	Census. 1905	Census. 1900	Increase.	Per cent of increase.
Number of establishments	43	29	14	48.3
Capital	$13,347,431	$8,029,764	$5,317,667	66.2
Salaried officials, clerks, etc., number	339	147	192	130.6
Salaries	$578,696	$220,724	$357,972	162.2
Wage-earners, average number	1,996	1,091	905	83.0
Total wages	$1,092,473	$542,865	$549,608	101.2
Miscellaneous expenses	$1,186,230	$182,815	$1,003,415	548.9
Cost of materials used	$9,629,567	$3,271,388	$6,358,179	194.4
Value of products	$13,566,955	$5,461,513	$8,105,442	148.4

The census of 1905 shows an increase in every item presented as compared with 1900, the value of products showing the substantial gain of $8,105,442, or 148.4 per cent, while the cost of materials reported increased $6,358,179, nearly trebling. The largest proportional increase, 548.9 per cent, was reported for miscellaneous expenses, and the next largest, 194.4 per cent, for cost of materials.

Table 134.—*Fine chemicals—quantity and value of products: 1905 and 1900.*

Kind.	1905		1900	
	Quantity.	Value.	Quantity.	Value.
Acetone, pounds	[1] 1,589,215	$195,978	1,638,715	$178,666
Acids, C. P., pounds	[2] 6,540,689	218,518	2,480,575	136,105
Alkaloids, ounces	5,797,925	3,229,527	4,054,478	1,750,503
Ammonia, C. P., pounds	(3)	(3)	254,952	18,131
Bromides, pounds	403,997	157,848	314,399	89,319
Camphor, refined and artificial, pounds	1,166,372	722,907	598,708	254,190
Chloroform, pounds	616,670	165,604	(4)	(4)
Esters, pounds	403,260	187,680	785,300	118,725
Ether, pounds	[5] 4,239,174	2,243,965	[6] 1,485,942	741,228
Fusel oil, refined, pounds	[7] 2,077,600	355,417	(4)	(4)
Gold salts, ounces	47,641	453,202	12,347	120,696
Iodides, pounds	84,702	211,619	20,714	32,831
Pepsin, pounds	(3)	(3)	19,030	76,120
Platinum salts, ounces	(3)	(3)	8,112	61,400
Rare earth salts, pounds	[8] 90,558	406,326	5,373	25,550
Silver salts, ounces	1,899,081	778,439	1,606,108	627,252
Vanillin, ounces	579,877	165,044	124,874	113,050

[1] Includes 288,820 pounds, with an assigned value of $34,658, consumed in establishments where manufactured.

[2] Includes 14,661 pounds, with an assigned value of $1,026, consumed in establishments where manufactured.

[3] Not shown for 1905.

[4] Not shown for 1900.

[5] Includes 3,384,763 pounds, with an assigned value of $1,816,564, consumed in establishments where manufactured.

[6] Includes 1,222,704 pounds, with an assigned value of $611,352, consumed in establishments where manufactured.

[7] Includes 925,935 pounds, with an assigned value of $143,417, consumed in establishments where manufactured.

[8] Includes 45,939 pounds, with an assigned value of $183,756, consumed in establishments where manufactured.

The statistics of Table 134 show an increase in every item presented at both censuses except in the quantities of acetone and of esters. As the change in the specifications for the smokeless powder used by the United States Army, from a nitroglycerin-nitrocellulose base to a nitrocellulose base only, necessitated the abandonment of acetone and the adoption of ether-alcohol as the colloidizing agent, there has been as a consequence a reduction in the amount of acetone used notwithstanding the fact that an increase in its use for the manufacture of chloroform has occurred at the same time. The decrease in the quantity of esters produced together with the increase in value of the product shows that the falling off is only in the lowest priced of these products.

The largest total increase in quantity, 4,060,114 pounds, is found in the item of chemically pure acids. The second largest increase, 2,753,232 pounds, is found in the item of ether, but this includes also the ether that is consumed in further manufacture in the establishment where it was produced, the major portion of this last-mentioned ether having been both produced and consumed in explosives works in the manufacture of smokeless powder. The largest increase in value, $1,502,737, appears in the item of ether, but this includes the estimated value of that which was consumed in the establishment where it was produced. Ether shows also a marked increase in the value of the unit. The second largest increase in value, $1,479,024, is found in the item of alkaloids. It will be observed that the number of different products shown in Table 134 is relatively small. This is due partly to the fact that under Census rules statistics can not be presented separately unless there are at least 3 establishments, operating independently, for which such statistics have been obtained; partly to the fact that the fine chemicals made by pharmaceutical manufacturers and the enzymes and ferments produced for sale in zymotechnic laboratories are included, on account of the principal products of the establishments manufacturing them or the uses to which these products are put, in the products of other industries; and partly to the fact that manufacturers frequently fail to make reports in detail. Nevertheless, Schuchardt's catalogue indicates that the manufacture of fine chemicals, and especially of the modern synthetic preparations, is controlled by the German chemical manufacturers. But a small proportion of the fine chemicals that Schuchardt enumerates appear to be manufactured in this country at all, and, judging by the census returns, fewer still are manufactured for sale. The fine chemicals presented in Table 134 named on the schedules which were received at the censuses and which, under the rules, could not be set forth separately, are the elements gold, iodine (resublimed), nickel (purified), phosphorus, and silver; compounds of antimony, magnesium, manganese, mercury, nickel, and titanium; and the organic compounds acetic anhydride, acetanilide, benzaldehyde, formaldehyde, glycosine, paraformaldehyde, phenalgin, resorcin, saccharin, salol, and synthetic perfumery bases.

TABLE 135.—*Fine chemicals—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1] 67	[2] 49
California	1	1
Colorado	1	1
Indiana	......	1
Illinois	1	2
Maryland	1	1
Massachusetts	2	1
Michigan	3	1
Missouri	4	2
Nebraska	......	1
New Jersey	23	15
New York	14	7
Ohio	3	2
Pennsylvania	11	13
Rhode Island	1	1
Virginia	1	....
Wisconsin	1	....

[1] Includes 24 establishments engaged primarily in the manufacture of other products.
[2] Includes 20 establishments engaged primarily in the manufacture of other products.

The statistics of Table 135 show that there has been a gain of 18 in the number of establishments engaged in the manufacture of fine chemicals at the census of 1905 as compared with 1900, the largest increase in number, 8, being for New Jersey, and the second largest increase, 7, being for New York. At each census New Jersey has ranked first in the number of establishments, reporting in 1905, 34.3 per cent, or over one-third of the total. At the census of 1905 New York, which ranked third at the census of 1900, stood second, exchanging places with Pennsylvania. No other state reported as many as 5 establishments at either census.

TABLE 136.—*Fine chemicals—value of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
United States	[1] $14,235,937	[1] $6,272,289
North Atlantic and South Atlantic	11,892,640	5,594,756
North Central and Western	2,343,297	677,533

[1] Includes "all other products."

It will be observed that the industry was practically confined to the North Atlantic and South Atlantic divisions, these two divisions together reporting 89.2 per cent of the total value of products in 1900 and 83.5 per cent of the total in 1905. As a matter of fact the industry is concentrated chiefly in the North Atlantic division, there being but 2 establishments in the South Atlantic division, and may properly be regarded as reaching its highest development in the older communities. The largest proportional increase, 245.9 per cent, was reported for the North Central and Western divisions combined, against a gain of 112.6

per cent in the North and South Atlantic divisions combined, although the absolute increase in the latter divisions exceeded that in the former by $4,632,120.

TABLE 137.—*Fine chemicals—quantity and cost of materials used: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Cost.	Quantity.	Cost.
Acetate of lime, tons	3,553	$108,779	4,232	$130,596
Alcohol, gallons	1,239,708	678,326	219,603	265,477
Caustic soda, tons	86	3,793	(1)	(1)
Crude drugs, pounds	14,444,950	2,388,429	4,330,254	849,894
Fusel oil, gallons	466,632	408,612	192,153	92,269
Gold, troy ounces	18,963	391,248	6,780	136,554
Monazite, pounds	491,132	45,244	(1)	(1)
Muriatic acid, pounds	1,181,078	11,877	1,146,697	14,089
Nitric acid, pounds	1,505,870	74,516	183,667	11,081
Platinum, ounces	(1)	(1)	3,488	61,215
Silver, ounces	996,582	559,556	954,196	562,095
Sulphuric acid, tons	2,249	36,299	1,640	10,432

[1] Not shown separately.

The statistics of Table 137 show an increase in every item presented at each census, except in the quantity and cost of acetate of lime and the cost of muriatic acid and silver. Acetate of lime is used for the manufacture of acetone, and the decrease reported for the former is quite in harmony with the decrease shown in Table 134 for the latter. The decrease shown for muriatic acid apparently arises from the more extended use of the cheaper quality of acid. The largest increase in quantity, 10,114,696 pounds, is for crude drugs, and the second largest increase in quantity, 1,322,203 pounds, is for nitric acid. The largest increase in cost, $1,538,535, is shown for crude drugs, and the second largest increase in cost, $412,849, for alcohol.

Although acetone is no longer employed, in this country at least, in the manufacture of smokeless powder, new uses are being found for this as for other chemical substances. At the last census attention was called to the fact that this substance is used largely as a substitute for grain alcohol in the manufacture of chloroform. It is now found to be of value also in the developing of negatives in photography.

An important group of bodies in this class is that of C. P. chemicals. This designation has long been used in the art, and among consumers has been presumed to signify that the material so designated was chemically pure. But the results of the examinations of many samples of materials so labeled on the market have led to the conclusion that in many instances the abbreviations represent comparatively pure, or commercially pure. The importance of having for use, especially in analytical chemistry, and very frequently in other chemical operations, chemicals of assured purity led the Association of Official Agricultural Chemists and the American Chemical Society to advocate the establishment by the United States Government of a Bureau of Standards, by which the materials offered on the market could be tested and the instruments employed in the profession could be standardized, and such a bureau has been formed. Not content with this, however, the American Chemical Society has maintained for several years past a committee on quality of reagents, with the result that manufacturers are now offering what are known as "analyzed chemicals," because the label bears a record of the analysis, showing the kind and quantity of foreign bodies which are present in the material sold. In fact, the interval since the last census has been marked by a steady progress in the direction of making the label set forth the true character of the goods to which it is applied.

An interesting development is found in the production of camphor by a synthetic process from turpentine. A terpene hydrochloride has been known for some time and used under the name of artificial camphor, but by the process in which anhydrous turpentine is heated with an anhydrous oxalic acid, and the mixture treated with caustic alkali and steam, true synthetic camphor appears to be formed. Unfortunately the operation does not appear thus far to have been commercially successful, but it is believed that it may become so if carried on in the turpentine producing region instead of remote from it, as has thus far been the case.

Another interesting development of recent years is found in the manufacture of chloroform. At the last census it was pointed out that acetone had come to be used on a considerable scale in this manufacture. In the discussion of Class X of the present report attention has been called to the fact that carbon tetrachloride has come to be made in large quantities in connection with this industry. It now appears that a use has been found for this carbon tetrachloride in the manufacture of chloroform by reverse substitution, that is, by replacing one of the chlorine atoms in the carbon tetrachloride molecule by an atom of hydrogen, and that this promises to be successful commercially.

Another is found in the successful commercial development in this country of the invention of P. Fritzsche, for which United States letters patent 475640, of January 19, 1897, were granted, and by which ether is produced from the ethylene occurring in illuminating and other hydrocarbon gases.

Table 138 shows the quantity and value of the imports for consumption, for the years ending June 30, from 1891 to 1905, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

TABLE 138.—FINE CHEMICALS—IMPORTS FOR CONSUMPTION: 1891 TO 1905.

YEAR ENDING JUNE 30—	ACONITE BARK, LEAF, AND ROOT.		NUX VOMICA.		ALL SALTS OF MORPHIA OR MORPHINE.		MORPHIA OR MORPHINE, SULPHATE OF, AND ALL ALKALOIDS OR SALTS OF OPIUM.		STRYCHNIA, STRYCHNINE, AND SALTS OF.		ETHERS. Sulphuric.		ETHERS. Other, not specially provided for.		ETHERS. All on which specific duty does not amount to 25 per cent (value).	ETHERS. Nitrous, spirits of.	
	Pounds.	Value.	Pounds.	Value.	Ounces.	Value.	Pounds.	Value.	Ounces.	Value.	Pounds.	Value.	Pounds.	Value.		Pounds.	Value.
1891	2,761	$266	1,394,013	$32,930	29,564	$42,269	...	...	230	$175	8	$1	981	$1,702	...	...	...
1892	...	...	1,392,437	34,038	38,758	43,301	...	...	305	153	101	28	689	2,093	...	...	...
1893	4,351	236	1,720,315	41,567	23,580	25,035	...	...	16,538	7,053	20	2	730	2,033	...	...	...
1894	1,329	108	1,720,056	39,821	29,076	36,452	...	...	566	259	145	32	584	1,781	...	...	...
1895	...	...	595,497	9,620	16,029	18,507	...	...	1,158	502	55	5	744	2,281	...	17	$7
1896	3,034	197	1,275,500	15,668	896	1,083	...	...	8,766	3,405	191	24	1,463	7,125	...	...	...
1897	4,020	620	1,298,637	15,200	14,949	30,301	...	...	1,377	578	466	44	2,376	9,158	...	...	...
1898	...	...	2,026,465	29,529	2,382	2,832	13,409	$32,836	13,049	6,381	476	103	3,276	5,781	$4,323	...	...
1899	1,392	120	1,636,152	28,995	...	...	13,081	35,357	15,394	6,570	187	35	2,291	3,669	1,457	...	...
1900	3,808	274	3,070,536	65,460	...	...	26,208	75,274	7,753	3,362	817	110	2,573	4,507	1,461	...	...
1901	1,130	113	1,581,757	30,560	...	...	50,819	147,517	4,732	1,921	109	30	2,464	4,769	1,364	...	...
1902	2,066	138	2,876,318	47,856	...	...	38,002	96,559	687	297	940	135	2,117	4,090	1,610	22	10
1903	8,598	600	2,463,340	36,800	...	...	12,371	25,717	372	249	2;003	325	2,286	4,739	1,615	105	27
1904	2,800	295	3,139,211	47,449	...	...	20,763	43,766	5,138	2,033	1,530	259	2,313	4,686	2,360	10	1
1905	2,418	153	2,798,814	47,049	...	...	21,391	41,734	738	433	897	165	3,479	6,600	3,485	...	...

YEAR ENDING JUNE 30—	ALKALOIDS OR SALTS OF CINCHONA BARK. Bark or other materials from which quinine may be extracted.		ALKALOIDS OR SALTS OF CINCHONA BARK. Cinchonidia.		ALKALOIDS OR SALTS OF CINCHONA BARK. Sulphate of quinia.		ALKALOIDS OR SALTS OF CINCHONA BARK. All other.		PHOSPHORUS.		BROMINE.	
	Pounds.	Value.	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.	Pounds.	Value.	Pounds.	Value.
1891	2,672,364	$301,085	156,229	$3,856	3,079,000	$805,821	112,013	$23,977	151,166	$53,590	...	...
1892	3,423,941	299,998	11,483	1,586	2,686,677	542,440	156,442	29,366	85,622	31,643	53,563	$7,094
1893	2,374,041	196,867	364,192	11,714	3,027,819	556,782	48,030	11,695	89,874	44,068	780	234
1894	2,502,224	143,194	313,640	7,177	2,141,130	470,816	40,850	10,991	20,757	11,927	20	11
1895	2,012,399	117,998	72,425	3,534	1,308,959	327,541	37,027	10,857	28,747	14,131	...	...
1896	2,699,789	165,699	282,321	9,980	2,950,078	754,050	76,507	23,147	50,027	26,646	...	...
1897	...	...	...	...	2,714,147	489,821	367,373	57,237	60,731	29,870	...	...
1898	...	...	303,278	38,802	3,643,298	752,211	424,665	106,961	43,351	21,849	...	...
1899	...	...	233,885	34,932	2,788,663	665,819	985,480	252,141	12,399	7,366	...	...
1900	...	...	101,335	15,924	2,628,060	763,986	515,168	155,817	25,228	9,789	...	...
1901	4,196,419	781,895	28,000	9,465	3,495,996	1,078,472	817,315	289,630	38,315	15,125	...	...
1902	3,660,718	617,716	18,000	6,695	2,358,159	641,459	629,735	200,162	32,965	12,869	...	...
1903	3,980,072	547,332	44,000	9,524	2,534,106	576,404	796,338	168,370	23,986	10,229	...	...
1904	3,605,131	501,375	89,110	25,395	3,059,514	659,868	736,625	166,923	21,009	9,671	...	...
1905	4,353,439	596,614	44,580	6,651	2,264,454	504,351	639,823	134,404	19,397	8,554	...	...

YEAR ENDING JUNE 30—	IODINE. Crude.		IODINE. Crude and resublimed.		IODINE. Resublimed.		CHLORAL HYDRATE.		CHLOROFORM.		IODOFORM.		HYDRIODATE, IODIDE, AND IODATE OF POTASH.		CALOMEL, AND OTHER MERCURIAL MEDICINAL PREPARATIONS.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	241,186	$382,009	...	...	35	$106	...	...	...	...	1,242	$19,459	1,024	$935	7,801	$5,244
1892	164,185	167,893	...	...	4	14	...	...	35	$15	244	890	186	505	12,630	8,114
1893	327,248	589,186	...	...	6	25	...	...	11	14	175	649	187	475	13,495	7,941
1894	401,501	587,127	...	...	7	31	...	...	43	18	103	382	181	464	8,435	4,715
1895	...	...	31,374	$48,350	...	...	20,097	$10,976	239	164	158	583	235	561	8,280	4,209
1896	...	...	291,895	566,908	...	...	30,275	17,367	137	46	243	926	5,489	9,289	13,900	7,154
1897	...	...	391,551	872,526	...	...	63,360	35,138	91	18	115	437	2,774	5,032	12,349	6,053
1898	401,214	805,783	...	...	22	53	40,263	23,063	542	123	30	96	280	649	12,316	6,386
1899	315,476	573,469	...	...	43	146	12,370	7,562	227	72	52	163	2,168	3,607	21,963	11,848
1900	573,128	1,452,434	...	...	501	1,410	795	1,534	75	36	202	602	1,288	2,155	16,647	10,163
1901	262,052	658,492	...	...	22	21	4,485	2,993	259	79	21	93	663	1,328	26,933	15,931
1902	316,786	819,272	...	...	116	219	26,977	8,793	1,885	611	154	313	1,654	3,346	22,449	13,606
1903	284,895	785,220	...	...	75	176	18,144	6,252	742	357	72	192	920	1,624	23,570	14,063
1904	418,163	955,702	...	...	63	138	8,733	2,416	2,203	616	65	187	1,093	2,129	28,623	16,566
1905	350,830	699,659	...	...	31	91	...	...	826	293	68	246	891	2,093	26,076	14,137

CLASS XIX.—GENERAL CHEMICALS.

This class embraces all chemicals not enumerated in any of the classes previously considered. In commerce the term "general chemicals" includes also acids, sodas, potashes, alums, acetate of lime, and many other chemicals for which the statistics have been given in the previous sections of this report. These chemicals have a low unit value and are usually sold in ton lots, for which reason they are also designated as heavy chemicals.

The statistics of Table 139 show an increase in every item except the number of establishments. The large increases were reported of $5,751,140 in value of products and of $3,356,028 in cost of materials. The greatest proportional increase is shown in miscellaneous expenses and the next greatest in the item of salaries.

Table 139.—*General chemicals—comparative summary, with amount and per cent of increase: 1905 and 1900.*

	Census. 1905	Census. 1900	Increase.	Per cent of increase.
Number of establishments	74	97	[1] 23	[1] 23.7
Capital	$14,986,703	$12,433,065	$2,553,638	20.5
Salaried officials, clerks, etc., number	660	365	295	80.8
Salaries	$1,001,955	$550,748	$451,207	81.9
Wage-earners, average number	3,720	2,402	1,318	54.9
Total wages	$2,072,341	$1,245,426	$826,915	66.4
Miscellaneous expenses	$1,512,842	$829,205	$683,637	82.4
Cost of materials used	$12,646,513	$9,290,485	$3,356,028	36.1
Value of products	$18,874,897	$13,123,757	$5,751,140	43.8

[1] Decrease.

Table 140 shows an increase for 1905 as compared with 1900 for each item given at both censuses, except in the quantity of acetate of lead, the quantity and value of aqua ammonia, the quantity and value of copperas, the quantity and value of Glauber's salt, the quantity of salt cake, and the value of zinc salts. The largest increase in quantity, 95,113 tons, or 2,686.8 per cent, is found in the item of calcium chloride, and the second largest increase in quantity, 19,740 tons, is found in the item of niter cake, but the second largest proportional increase in quantity, 368.4 per cent, is found in the item of ammonium nitrate. The largest increase in value, $774,859, is shown in the item for cream of tartar, and the second largest, $757,362, is for the item tin compounds. The largest proportional increase in value, however, 807.4 per cent, appears for the item of calcium chloride, and the second largest increase, 580.9 per cent, for ammonium nitrate.

Table 140.—*General chemicals—quantity and value of products: 1905 and 1900.*

Kind.	1905 Quantity.	1905 Value.	1900 Quantity.	1900 Value.
Acetate of lead, pounds	[1] 1,202,383	$78,619	1,296,991	$73,220
Aqua ammonia, pounds	[2] 22,485,732	1,010,723	[3] 25,089,116	1,023,528
Ammonium nitrate, pounds	[4] 3,253,061	521,373	[5] 694,438	76,571
Calcium chloride, tons	98,653	257,311	3,540	28,357
Copperas, pounds	9,700,104	28,096	27,595,909	199,869
Cream of tartar, pounds	15,650,000	2,892,563	10,981,680	2,117,704
Epsom salts, pounds	20,566,443	215,088	9,239,809	75,066
Glauber's salt, pounds	14,665,456	103,392	32,659,907	163,059
Glycerin, pounds	19,311,997	2,397,205	15,383,778	1,893,886
Niter cake, tons	[6] 35,221	87,792	[7] 15,481	46,358
Phosphates of soda, pounds	9,659,519	244,373	4,679,160	155,989
Salt cake, tons	[8] 38,244	417,173	[9] 48,296	399,347
Saltpeter, tons	7,234	596,689	[10] 6,136	487,987
Tin compounds, pounds	11,621,378	1,361,299	6,259,794	603,937
Zinc salts, pounds	11,579,546	201,771	9,511,909	353,900

[1] Includes 91,500 pounds, with an assigned value of $8,235, consumed in establishments where manufactured.
[2] Includes 3,419,978 pounds, with an assigned value of $170,999, consumed in establishments where manufactured.
[3] Includes 275,080 pounds, with an assigned value of $9,902, consumed in establishments where manufactured.
[4] Includes 2,671,564 pounds, with an assigned value of $427,450, consumed in establishments where manufactured.
[5] Includes 657,758 pounds, with an assigned value of $72,353, consumed in establishments where manufactured.
[6] Includes 6,240 tons, with an assigned value of $15,600, consumed in establishments where manufactured.
[7] Includes 3,746 tons, with an assigned value of $11,238, consumed in establishments where manufactured.
[8] Includes 2,088 tons, with an assigned value of $25,056, consumed in establishments where manufactured.
[9] Includes 6,185 tons, with an assigned value of $51,026, consumed in establishments where manufactured.
[10] Includes 849 tons, with an assigned value of $67,071, consumed in establishments where manufactured.

Attention was called, in the report on this class at the census of 1900,[1] to the incompleteness of the statistics for general chemicals. The returns for 1905 were, if possible, even less detailed, so that fewer items can be presented. Two substances which are of especial economic interest in this connection, but which could not well be included in the tabular presentation, are ammonium sulphate and ammonia liquor. A small quantity of ammonium sulphate is reported as being produced in establishments included in the classification of chemicals and allied products, but the larger part of the ammonium sulphate manufactured and all of the ammonia liquor are reported from by-product coke and gas manufacturing plants. In 1900 there were reported from these sources 23,295,485 pounds of ammonium sulphate, having a value of $623,537, and, in addition, 1,681,700 pounds which were produced in the establishments where they were consumed. In 1905 there were reported produced 34,568,000 pounds of ammonium sulphate, having a value of $907,667. Ammonia liquor is produced and reported in so many different grades, or, as they are called in commerce, "strengths," that a proper comparison of the data at different periods can be made only after all such data have been reduced to a common basis, and, as in the reports from coal gas establishments, the largest number reported liquor of 16-ounce strength, this grade has been taken as a basis and all other grades reduced to it. From various data it is estimated for the census of 1900 that there were produced 28,542,800 gallons of ammonia liquor of 16-ounce strength, to which no value was assigned. For 1905 there were produced in the coke industry 40,173,210 gallons, reduced to 16-ounce strength, valued at $763,291, and in the gas industry 37,854,199 gallons, valued at $537,903. The total production of 16-ounce ammonia liquor at the census of 1905 was therefore 78,027,409 gallons, valued at $1,301,194. Another item of importance is glycerin, 27,660,661 pounds, with a value of $2,958,115, having been reported at the census of 1905 as being produced in the soap industry.[2] Combined with the glycerin reported in chemicals and allied products, the total production for 1905 is 46,972,658 pounds, having a value of $5,355,320. At the census of 1900 there were reported from other sources 11,128,676 pounds of glycerin, having a value of $1,202,715, which, combined with that shown for 1900 in Table 140, gives a total for that census of 26,512,454 pounds, valued at $3,096,601.

The statistics of Table 141 show a gain of 13 establishments in the United States total for 1905 as compared with 1900, and indicate that the decrease of 23 establishments, shown in the United States in Table 139, is wholly or partly due to such a change in the proportion of the different products of establishments at the two censuses, that establishments which were

[1] Twelfth Census, Bulletin No. 210, page 93.
[2] Census of Manufactures, 1905, Bulletin 57, page 44.

classified in Class XIX at the census of 1900 have been transferred to other classes at the census of 1905. Considering the individual states, it will be observed that New York has advanced from second to first place in rank and Pennsylvania from third to second place, while New Jersey dropped from first place in 1900 to third in 1905. California has advanced from fifth to fourth place in rank, sharing that place with Ohio.

TABLE 141.—*General chemicals—number of establishments, by states: 1905 and 1900.*

STATE.	1905	1900
United States	[1]165	[2]152
Alabama	2	......
California	11	11
Colorado	2	1
Connecticut	......	2
District of Columbia	1	1
Delaware	1	2
Georgia	2	......
Illinois	9	9
Indiana	3	5
Kentucky	1	1
Louisiana	2	1
Maryland	5	8
Massachusetts	8	8
Michigan	8	5
Missouri	6	3
Nebraska	......	1
New Jersey	26	28
New York	34	26
Ohio	11	12
Pennsylvania	27	24
Rhode Island	4	2
Tennessee	......	1
Vermont	1	......
Virginia	1	......
West Virginia	......	1

[1] Includes 91 establishments engaged primarily in the manufacture of other products.
[2] Includes 55 establishments engaged primarily in the manufacture of other products.

The statistics of Table 142 show an increase in the value of the products for 1905 as compared with 1900 for each division except the Western, in which there has been a decrease, the greatest increase, $3,672,463, being found in the North Atlantic division, and the second greatest increase, $1,496,588, in the North Central. At each census, measured by the value of its products, the North Atlantic division has stood first, reporting 67.8 per cent of the total in 1900 and 68.4 per cent in 1905, almost exactly two-thirds in each case. The North Central division stood second at both censuses, the South Atlantic third, the Western fourth, and the South Central fifth.

TABLE 142.—*General chemicals—value of products, by geographic divisions: 1905 and 1900.*

DIVISION.	1905	1900
United States	[1]$22,431,792	[1]$17,234,087
North Atlantic	15,351,853	11,679,390
South Atlantic	1,246,775	1,052,082
North Central	5,330,269	3,833,681
South Central	29,903	22,200
Western	472,992	646,734

[1] Includes "all other products."

The statistics of Table 143 show many irregularities, growing largely out of the fact that many of the chemicals belonging to this class are produced in establishments in which a large variety of substances is manufactured, and where in consequence the labor of making out a complete detailed return is regarded as burdensome, while others are subordinate products, so that they, as well as the materials from which they are produced, may be overlooked in the preparation of the returns. The degree in which these factors affect the returns will, of course, vary at different censuses. An effort is made in the inspection of the individual returns to remedy these defects, but this meets with only partial success. Moreover, it is not possible to reduce all grades of materials to a common standard of strength, and hence it may occur, as for instance in the case of the ammonia, or gas, liquor in Table 143, that a much larger volume at a less cost may be reported as used at one census than at another, because that reported at the former census was of lower grade.

TABLE 143.—*General chemicals—quantity and cost of principal materials used: 1905 and 1900.*

KIND.	1905		1900	
	Quantity.	Cost.	Quantity.	Cost.
Ammonia, aqua, pounds	7,246,642	$333,210	6,242,934	$270,373
Ammonia liquor, gallons	23,466,749	468,647	32,512,758	590,423
Argols, tartar and lees, tons	15,797	2,478,562	24,057	2,256,271
Bones and boneblack, tons	30,379	489,419	18,591	397,131
Brine, gallons	256,478	703,137	(1)	(1)
Glycerin, crude, pounds	21,482,084	1,933,254	15,473,126	1,302,642
Lime, bushels	569,040	80,333	164,977	25,736
Magnesite, tons	6,196	47,468	(1)	(1)
Muriatic acid, pounds	13,096,827	108,360	3,488,000	24,563
Nitrate of soda, tons	38,048	1,505,881	35,990	1,189,515
Nitric acid, pounds	4,256,111	210,163	353,014	10,629
Phosphate rock, tons	5,663	33,465	4,584	31,671
Pig lead, tons	634	60,460	257	22,668
Potassium salts, tons	11,470	512,099	9,361	278,413
Salt, tons	28,062	151,418	31,803	219,656
Soda ash, tons	14,946	283,458	7,923	122,356
Sulphur, tons	14,438	297,943	14,292	303,535
Sulphuric acid, tons	63,147	624,604	39,316	170,100
Tin, pounds	7,032,993	876,208	10,791,177	413,157
Zinc and zinc dross, pounds	5,768,186	121,412	6,048,000	163,003

[1] Not shown separately.

The marked increase in the quantity of calcium chloride reported as produced deserves attention. This increase is partly fictitious, for, as stated in the report for that census,[1] the quantity returned in 1900 was probably less than that actually produced. On the other hand, there has been, no doubt, a real increase during the interval, for this substance has come to be used extensively in automobiles, while its use in making nonfreezable solutions for fire buckets and automatic sprinkler systems, for brine and ice machines and refrigerating plants, for drying the gases in the manufacture of liquefied carbon dioxide and anhydrous ammonia, and in drying the air in compressed air power plants and of cold storage warehouses, for the manufacture of dry colors or lakes, in tempering steel, and in forming high boiling point solutions for use in such industries as the canning of foods, has been more marked. Calcium chloride is met with in the market as a solid containing 75 per cent of anhydrous calcium chloride, 24 per cent of water, and 1 per cent of foreign bodies; as a solution

[1] Twelfth Census, Bulletin No. 210, page 95.

containing from 40 to 50 per cent of anhydrous calcium chloride; and as a solution of calcium chloride and sodium bicarbonate for use in the extinction of fires. The solid material is offered in 635-pound iron drums and in 10-pound tins. The solution is offered in 4,500-gallon tank cars, in 110-gallon drums, and in 2-gallon cans.

Equally of interest is the decrease in the quantity and value of the copperas, green vitriol, or crystallized ferrous sulphate reported, since, as pointed out in the report for 1900,[1] this substance is a by-product in the pickling of iron and steel, and is used in the manufacture of venetian red and other iron pigments; in making dye liquors, prussian blue, and writing inks; for disinfecting purposes; and for the precipitation of gold from its solutions. In addition it has in recent years come to be used as a substitute for alum in the purification of service waters. The Quincy process, so called from its development at Quincy, Ill.,[2] "involves the use of ferrous sulphate and lime water, applied separately in small quantities in solution to the raw water to coagulate it, with subsequent sedimentation of the coagulated water and final rapid filtration." It is probable, in view of this new use, added to the fact that the industries in which it was previously used have shown a marked increase, that the decrease in the returns for copperas for 1905 was due to the product not being completely reported, and not to an actual decrease in its production.

Table 144 sets forth the imports of general chemicals from 1891 to 1905, inclusive, for the years ending June 30, as taken from Commerce and Navigation of the United States, published by the Bureau of Statistics.

[1] Twelfth Census, Bulletin No. 210, page 95.

[2] Water Purification for Cities by Sulphate of Iron, American Steel and Wire Company, 1903, page 48.

TABLE 144.—GENERAL CHEMICALS—IMPORTS FOR CONSUMPTION: 1891 TO 1905.

YEAR ENDING JUNE 30—	AQUA, OR WATER, AMMONIA.		AMMONIA, CARBONATE OF, MURIATIC OR SAL-AMMONIAC, AND SULPHATE OF.		POTASH, CHROMATE AND BICHROMATE.		SODA, BICHROMATE AND CHROMATE.		ARGAL, OR ARGOL, OR CRUDE TARTAR.		ARGOLS, OR WINE LEES.		NITRATE OF POTASH, OR SALTPETER, CRUDE.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	276,756	$12,858	24,331,113	$740,567	1,234,085	$95,951	545,458	$31,565	21,579,102	$2,197,507			15,040,757	$459,084
1892		3,136	14,275,362	472,276	1,058,521	81,287	703,246	44,091	24,813,171	2,216,525			14,254,514	435,839
1893		718	18,794,599	560,222	969,067	79,174	671,503	44,183	28,770,810	2,341,575			16,560,599	465,666
1894			7,638,848	309,701	1,009,499	83,420	267,397	17,657	22,373,180	1,504,200			9,671,217	251,418
1895			19,836,379	653,146	2,024,776	173,139	600,600	40,321	27,911,122	1,893,730			8,735,290	245,552
1896			30,523,313	804,671	1,444,716	129,339	556,631	38,103	28,481,665	2,724,709			14,758,974	389,524
1897			24,891,603	576,152	1,366,074	112,783	319,641	22,070	23,457,576	1,967,042			19,719,876	408,761
1898			20,595,623	456,273	1,016,029	79,495	295,549	19,027	741,150	65,154	18,461,479	$1,525,873	12,920,986	270,291
1899			19,228,311	520,752	1,099,093	75,254	598,262	29,861			23,300,762	1,914,450	19,985,505	409,818
1900			22,185,935	684,904	645,183	41,449	474,654	21,982			27,339,489	2,388,693	10,332,836	269,739
1901			33,925,826	951,823	200,519	14,401	54,105	2,781			28,598,781	2,476,482	11,361,113	288,897
1902			43,263,326	1,188,579	489,011	31,971	36,567	1,643			29,276,148	2,263,588	9,387,979	264,430
1903			40,193,046	1,191,124	32,376	2,411	33,004	1,509			29,966,557	2,734,027	11,790,415	318,515
1904			40,962,643	1,290,727	38,423	2,554	95,999	4,381			24,571,730	2,550,223	13,518,301	366,526
1905			38,174,070	1,205,361	55,864	3,433	113,562	5,449			26,250,353	2,289,417	14,512,306	386,098

YEAR ENDING JUNE 30—	NITRATE OF SODA.		GLYCERIN.		CAMPHOR, REFINED.		IRON, SULPHATE OF, OR COPPERAS.		LEAD — Brown acetate of.		LEAD — White acetate of.		MAGNESIA, SULPHATE OF, OR EPSOM SALTS.		MILK, SUGAR OF.	
	Tons.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	100,428	$2,923,374	13,975,577	$996,686	63	$21	896,937	$4,103			13,279	$707	16,370	$206	251,408	$42,330
1892	109,863	2,976,816	14,197,549	831,810	56,820	17,361	495,596	2,597	2,902	$123	1,220	101	31,742	360	236,869	34,304
1893	94,661	3,062,715	16,540,213	893,636	156,291	51,229	1,010,039	4,099			2,185	154	61,337	480	98,785	12,089
1894	88,079	2,785,048	8,321,853	519,296	137,882	44,233	927,162	3,619			3,217	220	59,294	402	31,346	3,499
1895	124,803	4,124,712	13,488,825	784,613	271,164	83,382	542,316	1,344	3,510	154	59,399	2,822	650	16	14,117	1,828
1896	127,557	3,870,724	21,158,829	1,472,302	153,912	68,785	1,123,443	4,161	30,154	934	48,060	1,873	100,859	691	16,365	2,162
1897	83,331	2,640,389	12,717,098	1,182,099	249,994	84,539	9[illegible]1,000	6,925	26,020	850	3,122	190	240,573	1,122	17,117	2,824
1898	125,081	2,729,750	12,274,987	774,709	170,406	54,602	250,270	1,087	6,008	257	3,594	231	91,137	614	1,844	270
1899	122,314	2,054,805	15,665,252	1,024,131	90,743	28,806	127,041	606	3,437	138	5,145	337	74,186	526	4,064	461
1900	184,247	4,736,807	27,943,106	2,155,414	109,971	42,901	2,700	111	18,192	711	4,093	269	377,274	2,163	2,378	399
1901	203,609	5,776,566	20,369,712	1,722,882	77,313	39,507	24,786	243	11	4	1,500	99	266,290	1,682	3,638	619
1902	192,321	5,565,361	28,576,400	2,358,325	186,882	61,592	38,745	501	79	26	497	48	164,285	1,283	189	23
1903	252,084	7,737,405	35,295,575	2,937,802	43,696	19,399	751	20	21,829	771	214	35	2,438,604	11,427	2,576	480
1904	293,574	9,259,656	31,078,455	2,583,270	152,558	64,234	600	8			64	5	1,591,959	7,729	1,832	296
1905	282,692	9,557,522	27,100,640	2,050,393	214,050	117,277	13	1			372	58	7,100,296	31,283	1,301	239

TABLE 144.—GENERAL CHEMICALS—IMPORTS FOR CONSUMPTION: 1891 TO 1905—Continued.

YEAR ENDING JUNE 30—	REFINED SULPHUR.		SULPHATE OF COPPER, OR BLUE VITRIOL.		HYPOSULPHITE OF SODA.		NITRITE OF SODA.		PHOSPHATE OF SODA.		SILICATE OF SODA OR OTHER ALKALINE SILICATES.		SULPHATE OF SODA, OR GLAUBER'S SALTS.		SULPHATE OF SODA, SALT OR NITER CAKE.	
	Tons.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	307	$6,579	3,432	$310	....	....	....	....	....	....	535,030	$6,429	274,784	$2,167	16,927,804	$85,368
1892	....	....	2,189	156	....	....	....	....	....	....	571,153	7,090	187,398	2,088	22,465,878	121,900
1893	5	118	8,941	363	....	....	....	....	....	....	608,228	6,991	489,798	4,012	44,180,349	221,846
1894	48	1,255	2,470	140	....	....	....	....	....	....	485,435	5,054	924,874	4,916	11,794,586	43,938
1895	122	2,392	245,787	5,481	....	....	....	....	....	....	492,207	4,562	49,414	4,497	37,248,332	107,459
1896	305	5,338	876,401	28,792	....	....	....	....	....	....	580,310	5,277	1,916,486	9,769	25,692,755	71,801
1897	430	9,111	192,114	6,797	6,965,581	$74,501	....	....	505,373	$9,045	600,132	5,468	612,026	3,366	7,748,600	36,590
1898	55	1,542	12,302	518	11,007,111	98,733	155	$37	1,436,171	24,599	417,476	3,971	732,094	7,120	5,228,060	20,652
1899	227	5,802	15,981	342	10,686,997	94,534	5,455	298	3,723,907	59,175	527,531	4,256	519,080	5,828	4,984,940	20,569
1900	186	4,470	2,134	113	8,676,351	78,591	308,386	15,838	2,226,835	43,817	1,306,782	9,536	1,028,240	8,892	6,382,260	29,086
1901	154	4,115	1,788	95	5,222,369	50,639	90,125	4,642	377,834	7,178	1,229,857	10,461	609,040	6,826	6,825,280	34,645
1902	240	5,703	2,703	210	4,808,697	40,942	87,860	4,512	547,688	10,164	1,640,960	14,802	917,500	8,593	3,178,320	16,706
1903	20	482	1,603,524	63,684	3,743,580	34,833	259,372	13,244	1,397,118	22,795	1,113,502	9,526	2,698,700	24,385	4,936,480	27,483
1904	239	5,902	527,329	22,743	2,110,960	23,235	494,235	23,788	497,227	8,583	756,655	9,188	764,600	8,937	2,062,100	12,089
1905	225	5,937	651,660	27,258	1,005,997	10,436	627,446	29,590	79,907	1,462	1,104,215	13,434	709,120	7,202	2,765,109	15,738

TABLE 145.—CHEMICALS—DETAILED

		United States.	California.	Georgia.	Illinois.	Indiana.	Louisiana.
1	Number of establishments	275	15	3	14	3	3
2	Capital, total	$96,621,294	$1,968,880	$292,482	$4,280,108	$143,313	$41,258
3	Land	$8,320,566	$270,569	$25,000	$665,943	$10,889	$4,700
4	Buildings	$18,228,577	$312,983	$56,000	$803,586	$37,700	$8,177
5	Machinery, tools, and implements	$31,911,537	$916,277	$149,870	$1,925,760	$58,156	$22,596
6	Cash and sundries	$38,160,614	$469,051	$61,612	$884,819	$36,568	$5,785
7	Proprietors and firm members	123	3	3	2	2	1
	Salaried officials, clerks, etc.:						
8	Total number	2,778	41	17	123	6	2
9	Total salaries	$4,047,889	$44,376	$21,100	$185,579	$7,344	$1,440
	Officers of corporations—						
10	Number	267	11	3	10		1
11	Salaries	$903,257	$12,600	$8,000	$19,760		$1,040
	General superintendents, managers, clerks, etc.—						
12	Total number	2,511	30	14	113	6	1
13	Total salaries	$3,144,632	$31,776	$13,100	$165,819	$7,344	$400
	Men—						
14	Number	2,240	20	13	105	6	
15	Salaries	$2,992,091	$26,799	$12,860	$162,125	$7,344	
	Women—						
16	Number	271	10	1	8		1
17	Salaries	$152,541	$4,977	$240	$3,694		$400
	Wage-earners and total wages:						
18	Greatest number employed at any one time during the year [1]	22,426	403	31	778	83	16
19	Least number employed at any one time during the year	17,708	195	31	666	63	9
20	Average number	19,806	259	30	721	70	10
21	Total wages	$10,789,780	$189,284	$12,450	$392,140	$35,434	$6,491
	Men 16 years and over—						
22	Average number	18,651	258	29	711	70	7
23	Wages	$10,482,559	$188,764	$12,180	$388,260	$35,434	$5,881
	Women 16 years and over—						
24	Average number	1,081	1	1	10		1
25	Wages	$291,019	$520	$270	$3,880		$100
	Children under 16 years—						
26	Average number	74					2
27	Wages	$16,202					$510
	Average number of wage-earners employed during each month:						
	Men 16 years and over—						
28	January	18,468	302	28	691	71	8
29	February	18,781	267	28	691	68	8
30	March	18,882	256	28	696	67	7
31	April	18,831	244	28	744	68	7
32	May	18,819	272	28	722	66	6
33	June	19,024	229	30	686	70	6
34	July	18,404	184	30	683	71	6
35	August	18,283	192	30	691	73	6
36	September	18,523	248	30	713	69	6
37	October	18,412	273	30	731	70	8
38	November	18,661	328	30	738	74	8
39	December	18,722	301	28	746	73	8
	Women 16 years and over—						
40	January	1,051	1	1	9		3
41	February	1,088	1	1	9		3
42	March	1,104	1	1	9		3
43	April	1,126	1	1	9		3
44	May	1,138	1	1	9		
45	June	1,135	1	1	9		
46	July	1,078	1	1	11		
47	August	1,047	1	1	11		
48	September	1,042	1	1	11		
49	October	1,072	1	1	11		
50	November	1,074	1	1	11		
51	December	1,017	1	1	11		
	Children under 16 years—						
52	January	78					2
53	February	78					3
54	March	77					3
55	April	77					3
56	May	77					3
57	June	77					1
58	July	72					1
59	August	72					1
60	September	74					1
61	October	68					2
62	November	68					2
63	December	70					2
64	Miscellaneous expenses, total	$7,592,852	$109,909	$27,388	$306,119	$18,674	$2,857
65	Rent of works	$155,196	$450	$750	$3,919		$100
66	Taxes	$382,240	$7,960	$844	$12,888	$1,589	$64
67	Rent of offices, interest, insurance, and all other sundry expenses not hitherto included.	$6,899,858	$100,453	$25,794	$289,312	$17,085	$2,693
68	Contract work	$155,558	$1,046				
69	Materials used, total cost	$42,062,611	$700,311	$41,322	$1,354,969	$188,623	$11,146
70	Products, total value	$75,222,249	$1,123,871	$132,740	$2,282,629	$273,087	$29,467

[1] Includes establishments distributed as follows: Alabama, 2; Colorado, 4; Connecticut, 4; District of Columbia, 1; Florida, 1; Louisiana, 2; Maine, 1; Mississippi, 1; Nevada, 1; North Carolina, 2; Texas, 2; West Virginia, 1.

SUMMARY, BY STATES: 1905.

Maryland.	Massachusetts.	Michigan.	Minnesota.	Missouri.	New Jersey.	New York.	Ohio.	Pennsylvania.	Wisconsin.	All other states.[1]	
3	14	14	3	11	47	63	18	41	5	18	1
$1,627,976	$2,651,786	$14,796,767	$98,146	$4,366,417	$16,293,650	$23,149,126	$3,654,791	$20,657,278	$194,072	$2,405,244	2
$179,004	$124,756	$1,144,943	....	$334,423	$1,227,500	$2,305,797	$190,128	$1,518,130	$1,500	$317,284	3
$118,582	$627,471	$2,561,634	$9,883	$527,224	$2,427,132	$5,200,961	$564,778	$4,530,406	$6,400	$435,660	4
$356,165	$710,047	$7,901,143	$70,434	$567,075	$3,572,940	$7,172,835	$1,782,971	$5,631,938	$101,209	$972,121	5
$974,225	$1,189,512	$3,189,047	$17,829	$2,937,695	$9,066,078	$8,469,533	$1,116,914	$8,976,804	$84,963	$680,179	6
2	3	2	1	1	26	30	10	29	2	6	7
41	106	322	9	186	425	848	269	290	29	64	8
$51,564	$187,768	$388,114	$8,136	$232,684	$678,142	$1,274,141	$400,033	$455,644	$23,195	$88,629	9
5	16	18	....	18	41	70	24	32	....	18	10
$17,000	$65,520	$50,983	....	$55,733	$157,780	$307,188	$89,670	$85,790	....	$32,193	11
36	90	304	9	168	384	778	245	258	29	46	12
$34,564	$122,248	$337,131	$8,136	$176,951	$520,362	$966,953	$310,363	$369,854	$23,195	$56,436	13
29	74	276	5	137	355	704	220	222	29	45	14
$32,155	$112,937	$323,728	$5,652	$159,069	$502,742	$922,936	$292,334	$351,951	$23,195	$56,264	15
7	16	28	4	31	29	74	25	36	....	1	16
$2,409	$9,311	$13,403	$2,484	$17,882	$17,620	$44,017	$18,029	$17,903	....	$172	17
377	977	3,974	8	759	4,028	5,457	1,162	3,521	70	782	18
291	758	2,907	8	572	3,238	4,504	881	3,074	58	453	19
323	860	3,333	8	640	3,597	4,967	1,025	3,373	65	525	20
$141,197	$504,217	$1,848,114	$5,504	$309,673	$1,852,945	$2,677,956	$651,708	$1,891,720	$29,232	$241,715	21
323	777	3,246	8	505	3,141	4,765	1,023	3,213	50	525	22
$141,197	$479,551	$1,835,678	$5,504	$275,657	$1,727,338	$2,624,701	$651,032	$1,843,631	$26,036	$241,715	23
....	77	76	....	102	445	197	2	154	15	....	24
....	$23,306	$9,966	....	$27,022	$123,125	$52,448	$676	$46,510	$3,196	....	25
....	6	11	....	33	11	5	....	6	....	....	26
....	$1,360	$2,470	....	$6,994	$2,482	$807	....	$1,579	....	....	27
296	758	3,316	8	481	3,081	4,681	1,065	3,130	50	502	28
295	752	3,452	8	477	3,133	4,711	1,090	3,244	50	507	29
307	746	3,505	8	489	3,169	4,729	1,081	3,249	50	495	30
324	764	3,348	8	496	3,200	4,759	1,063	3,239	53	486	31
327	748	3,303	8	506	3,141	4,835	1,033	3,245	53	526	32
326	766	3,605	8	509	3,156	4,656	1,007	3,206	48	716	33
335	779	3,152	8	529	3,136	4,688	983	3,224	48	548	34
316	800	3,000	8	526	3,101	4,788	983	3,217	48	504	35
336	788	3,060	8	517	3,132	4,868	980	3,224	51	493	36
317	798	3,023	8	511	3,116	4,764	1,005	3,208	50	500	37
344	813	3,049	8	509	3,149	4,842	992	3,223	50	504	38
353	812	3,139	8	510	3,178	4,859	994	3,147	49	517	39
....	72	98	....	88	440	175	1	147	16	....	40
....	75	107	....	88	457	181	1	148	17	....	41
....	66	111	....	88	444	208	1	155	17	....	42
....	70	106	....	88	461	212	2	156	17	....	43
....	68	100	....	97	473	212	3	157	17	....	44
....	81	28	....	147	482	212	3	157	14	....	45
....	82	29	....	127	462	191	3	157	14	....	46
....	90	29	....	127	431	187	3	154	13	....	47
....	86	27	....	107	435	200	2	156	16	....	48
....	84	85	....	89	427	203	2	156	13	....	49
....	86	88	....	89	430	200	2	153	13	....	50
....	64	104	....	89	398	183	1	152	13	....	51
....	6	17	....	33	11	3	....	6	....	....	52
....	6	16	....	33	11	3	....	6	....	....	53
....	6	14	....	33	11	3	....	7	....	....	54
....	6	15	....	33	11	3	....	6	....	....	55
....	6	15	....	33	10	4	....	6	....	....	56
....	6	15	....	33	12	4	....	6	....	....	57
....	6	7	....	33	11	9	....	5	....	....	58
....	6	6	....	33	11	9	....	6	....	....	59
....	6	7	....	33	11	10	....	6	....	....	60
....	6	6	....	33	11	4	....	6	....	....	61
....	6	6	....	33	11	4	....	6	....	....	62
....	6	8	....	33	11	4	....	6	....	....	63
$164,988	$469,446	$1,126,320	$13,590	$250,041	$1,240,764	$2,312,912	$243,096	$1,065,428	$58,126	$183,194	64
$3,497	$4,863	$10,000	$692	$9,946	$26,558	$68,152	$5,244	$8,697	$5,500	$6,828	65
$8,225	$22,242	$57,806	$292	$24,870	$54,112	$117,460	$28,586	$38,472	$644	$6,186	66
$153,266	$440,841	$908,234	$12,606	$214,593	$1,160,094	$2,125,800	$208,666	$1,018,259	$51,982	$170,180	67
....	$1,500	$150,280	....	$632	....	$1,500	$600	....	....	....	68
$588,897	$1,513,524	$4,402,624	$9,480	$2,172,144	$6,630,468	$12,958,436	$3,002,610	$7,265,245	$137,414	$1,085,398	69
$1,081,778	$3,508,759	$9,037,450	$53,644	$3,278,993	$13,023,629	$23,021,705	$4,589,749	$11,773,719	$265,457	$1,745,572	70

TABLE 145.—CHEMICALS—DETAILED

		United States.	California.	Georgia.	Illinois.	Indiana.	Louisiana.
	Power:						
71	Number of establishments reporting	237	14	2	13	3	2
72	Total horsepower	140,372	1,060	109	3,854	340	85
	Owned—						
	Engines—						
	Steam—						
73	Number	1,081	23	2	31	4	4
74	Horsepower	70,194	741	54	2,816	245	85
	Gas and gasoline—						
75	Number	25	8				
76	Horsepower	438	119				
	Water wheels—						
77	Number	25					
78	Horsepower	6,455					
	Water motors—						
79	Number	3					
80	Horsepower	14					
	Electric motors—						
81	Number	409			40	9	
82	Horsepower	8,110			980	95	
83	Other power, horsepower	1,097	200		25		
	Rented—						
	Electric motors—						
84	Number	263		2	2		
85	Horsepower	10,078		55	8		
86	Other kind, horsepower	43,986			25		
87	Furnished to other establishments, horsepower	319	30				

TABLE 146.—PAINTS—DETAILED

		United States.	California.	Delaware.	Georgia.	Illinois.	Indiana.	Iowa.	Kansas.	Kentucky.	Maryland.	Massachusetts.
1	Number of establishments	449	18	4	5	39	9	5	3	10	11	23
2	Capital, total	$55,783,259	$1,439,985	$118,478	$156,894	$7,828,577	$174,869	$60,798	$28,350	$328,904	$443,500	$1,625,359
3	Land	$6,410,389	$44,000	$14,000	$5,000	$510,300	$5,000	$3,000		$22,900	$26,000	$142,053
4	Buildings	$7,081,890	$160,247	$12,800	$7,000	$910,926	$13,457	$5,200		$56,000	$22,500	$187,631
5	Machinery, tools, and implements	$8,533,218	$241,571	$23,815	$16,802	$976,031	$36,383	$3,760	$10,000	$58,861	$79,900	$157,066
6	Cash and sundries	$33,757,762	$994,167	$67,863	$128,092	$5,431,320	$120,029	$48,838	$18,350	$191,143	$315,100	$1,138,609
7	Proprietors and firm members	328	10	2	7	10	7	4	2	4	16	21
	Salaried officials, clerks, etc.:											
8	Total number	3,044	88	7	22	422	13	13	2	29	55	76
9	Total salaries	$3,654,289	$84,912	$8,500	$19,052	$616,167	$13,828	$12,438	$2,050	$27,286	$50,708	$103,872
	Officers of corporations—											
10	Number	357	6	3	2	51	2	1		10	2	13
11	Salaries	$935,701	$9,300	$5,400	$3,400	$161,269	$3,700	$60		$13,120	$1,600	$36,900
	General superintendents, managers, clerks, etc.—											
12	Total number	2,687	82	4	20	371	11	12	2	19	53	63
13	Total salaries	$2,718,588	$75,612	$3,100	$15,652	$454,898	$10,128	$12,378	$2,050	$14,166	$49,108	$66,972
	Men—											
14	Number	2,201	72	4	18	288	11	10	2	15	43	52
15	Salaries	$2,463,840	$70,200	$3,100	$14,987	$408,966	$10,128	$11,650	$2,050	$12,120	$44,720	$60,922
	Women—											
16	Number	486	10		2	83		2		4	10	11
17	Salaries	$254,748	$5,412		$665	$45,932		$728		$2,046	$4,388	$6,050
	Wage-earners, including pieceworkers, and total wages:											
18	Greatest number employed at any one time during the year.	11,570	311	34	31	1,282	48	16	13	97	196	485
19	Least number employed at any one time during the year.	7,830	246	25	27	755	38	13	10	70	162	309
20	Average number	9,781	275	28	28	1,029	38	12	11	88	182	398
21	Total wages	$5,063,177	$184,942	$21,229	$12,140	$595,077	$17,629	$7,949	$5,265	$31,461	$73,697	$211,141
	Men 16 years and over—											
22	Average number	8,775	264	24	27	923	31	12	10	59	172	365
23	Wages	$4,777,392	$180,665	$19,079	$11,932	$561,767	$15,761	$7,949	$4,940	$26,032	$71,617	$201,249
	Women 16 years and over—											
24	Average number	965	8	2	1	106	7		1	29	10	33
25	Wages	$276,551	$3,497	$1,400	$208	$33,310	$1,868		$325	$5,429	$2,080	$9,892
	Children under 16 years—											
26	Average number	41	3	2								
27	Wages	$9,234	$780	$750								
	Average number of wage-earners, including pieceworkers, employed during each month:											
	Men 16 years and over—											
28	January	8,226	243	27	26	857	30	12	10	55	169	324
29	February	8,688	245	26	26	925	30	12	10	55	172	334
30	March	9,025	249	29	26	1,050	29	12	9	59	172	337
31	April	9,331	260	27	26	1,056	30	12	11	61	177	379
32	May	9,039	273	24	26	1,034	30	12	10	61	181	385
33	June	9,036	282	22	29	944	33	12	10	63	178	364
34	July	8,587	271	21	29	862	36	12	11	63	164	359
35	August	8,599	271	21	29	841	33	12	11	61	162	384
36	September	8,768	261	23	29	870	30	12	11	60	173	406
37	October	8,880	276	23	26	894	30	12	9	60	180	387
38	November	8,725	271	23	26	884	32	12	9	55	168	376
39	December	8,396	266	22	26	859	29	12	9	55	168	345

[1] Includes establishments distributed as follows: Alabama, 2; Colorado, 4; Connecticut, 4; District of Columbia, 1; Florida, 1; Louisiana, 2; Maine, 1; Mississippi, 1; Nevada, 1; North Carolina, 2; Texas, 2; West Virginia, 1.

SUMMARY, BY STATES: 1905—Continued.

Maryland.	Massachusetts.	Michigan.	Minnesota.	Missouri.	New Jersey.	New York.	Ohio.	Pennsylvania.	Wisconsin.	All other states.	
3	11	14	3	9	41	56	12	37	4	13	71
625	3,431	24,048	62	1,593	10,168	70,178	6,419	11,161	243	6,996	72
15	24	•233	1	24	164	292	73	162	5	24	73
625	2,495	20,850	15	1,330	8,571	15,259	5,734	10,342	243	789	74
...	...	...	...	...	2	9	2	3	...	1	75
...	...	...	...	...	9	241	30	37	...	2	76
...	2	...	...	...	...	5	...	1	...	17	77
...	75	...	...	...	...	529	...	1	...	5,850	78
...	...	...	...	...	1	2	...	...	...	...	79
...	...	...	...	...	2	12	...	...	...	...	80
...	27	85	...	48	51	112	10	21	...	6	81
...	150	1,188	...	263	1,086	3,529	250	499	...	70	82
...	...	...	...	...	...	10	405	176	...	281	83
...	13	53	1	...	28	155	...	9	...	...	84
...	707	2,010	2	...	165	7,043	...	88	...	...	85
...	4	...	45	...	335	43,555	...	18	...	4	86
10	...	40	...	90	110	9	...	...	...	30	87

SUMMARY, BY STATES: 1905.

Michigan.	Minnesota.	Missouri.	Nebraska.	New Jersey.	New York.	Ohio.	Oregon.	Pennsylvania.	Rhode Island.	Tennessee.	Virginia.	Washington.	Wisconsin.	All other states.[1]	
11	5	20	3	20	89	49	3	74	4	4	3	6	9	22	1
$2,459,256	$672,324	$3,906,906	$226,597	$2,421,247	$14,852,314	$6,096,266	$159,600	$10,355,786	$112,017	$224,299	$213,034	$121,475	$935,863	$820,561	2
$144,837	$30,000	$313,926	$10,500	$197,940	$2,704,007	$659,700	$8,000	$1,329,235	$4,000	$15,625	$25,690	$8,950	$87,950	$97,776	3
$489,083	$85,000	$362,164	$34,699	$519,693	$1,434,597	$942,044	$9,000	$1,418,755	$14,840	$27,533	$46,456	$16,250	$187,028	$118,987	4
$321,174	$83,676	$501,322	$22,134	$466,635	$2,118,555	$831,892	$40,000	$2,071,906	$22,700	$23,399	$80,112	$24,450	$153,179	$167,895	5
$1,504,162	$473,648	$2,729,494	$159,264	$1,236,979	$8,595,155	$3,662,630	$102,600	$5,535,890	$70,477	$157,742	$60,776	$71,825	$507,706	$435,903	6
8	2	7	1	15	76	24	5	73	5	1	5	1	6	16	7
198	45	385	20	102	651	349	3	416	13	14	17	27	34	43	8
$229,741	$56,052	$420,283	$34,160	$139,895	$834,548	$389,216	$3,300	$441,655	$15,332	$24,880	$27,590	$14,322	$30,120	$54,382	9
19	8	31	2	19	48	49	...	61	2	5	3	2	5	13	10
$56,925	$15,680	$68,870	$9,600	$43,434	$174,710	$114,805	...	$146,568	$7,500	$11,700	$12,000	$900	$11,150	$27,110	11
179	37	354	18	83	603	300	3	355	11	9	14	25	29	30	12
$172,816	$40,372	$351,413	$24,560	$96,461	$659,838	$274,411	$3,300	$295,087	$7,832	$13,180	$15,590	$13,422	$18,970	$27,272	13
146	31	301	16	61	499	239	2	295	7	7	13	22	19	28	14
$155,652	$35,692	$321,853	$23,180	$85,109	$602,954	$242,440	$2,700	$266,886	$5,960	$11,800	$15,090	$12,450	$16,375	$26,856	15
33	6	53	2	22	104	61	1	60	4	2	1	3	10	2	16
$17,164	$4,680	$29,560	$1,380	$11,352	$56,884	$31,971	$600	$28,201	$1,872	$1,380	$500	$972	$2,595	$416	17
594	94	677	45	747	3,183	1,121	19	1,945	22	90	98	41	190	191	18
394	65	399	37	587	2,099	725	13	1,385	22	56	83	34	142	134	19
497	78	567	40	667	2,711	941	15	1,645	22	76	93	34	152	154	20
$222,966	$37,390	$290,009	$18,502	$339,023	$1,464,270	$475,045	$13,230	$798,313	$13,065	$30,356	$23,148	$23,440	$70,182	$83,708	21
410	63	534	33	589	2,381	834	15	1,532	22	62	93	32	145	143	22
$203,325	$32,266	$279,609	$16,260	$317,791	$1,373,164	$446,605	$13,230	$760,841	$13,065	$26,927	$23,148	$22,972	$67,374	$79,824	23
82	15	30	7	74	316	106	...	106	...	13	...	2	7	10	24
$18,641	$5,124	$9,854	$2,242	$20,528	$88,195	$28,240	...	$35,525	...	$3,189	...	$468	$2,808	$3,728	25
5	...	3	...	4	14	1	...	7	...	1	...	...	...	1	26
$1,000	...	$546	...	$704	$2,911	$200	...	$1,947	...	$240	...	...	...	$156	27
351	64	439	33	549	2,306	788	18	1,476	22	49	93	31	130	124	28
380	67	522	34	568	2,425	869	17	1,507	22	61	93	31	131	126	29
386	70	548	34	597	2,456	912	17	1,539	22	65	93	33	144	137	30
402	75	582	34	604	2,575	912	12	1,580	22	63	93	37	154	147	31
412	68	555	34	615	2,391	831	13	1,564	22	63	93	37	159	146	32
434	72	576	34	603	2,431	827	12	1,583	22	64	93	31	162	155	33
415	61	551	31	578	2,315	765	13	1,511	22	63	93	27	156	158	34
419	60	542	32	567	2,352	747	13	1,536	22	63	93	26	148	154	35
446	56	530	33	595	2,353	826	14	1,535	22	65	93	25	147	153	36
442	54	543	32	601	2,421	846	13	1,521	22	65	93	34	146	150	37
444	54	526	32	612	2,320	846	19	1,537	22	60	93	34	133	137	38
389	55	494	33	579	2,227	839	19	1,495	22	63	93	38	130	129	39

TABLE 146.—PAINTS—DETAILED

		United States.	California.	Delaware.	Georgia.	Illinois.	Indiana.	Iowa.	Kansas.	Kentucky.	Maryland.	Massachusetts.
	Average number of wage-earners, including pieceworkers, employed during each month—Continued.											
	Women 16 years and over—											
40	January	929	7	2	1	112	6		1	26	10	23
41	February	969	7	3	1	117	6		1	26	10	36
42	March	1,037	8	3	1	125	7		1	31	10	37
43	April	1,038	8	3	1	123	7		1	31	10	36
44	May	1,053	9	3	1	124	7		1	31	10	30
45	June	1,037	11	2	1	108	8		1	31	10	29
46	July	938	8	1	1	94	8		1	31	10	36
47	August	918	8	1	1	90	7		1	31	10	34
48	September	935	9	1	1	92	7		1	30	10	33
49	October	907	8	1	1	89	7		1	30	10	31
50	November	910	7	2	1	91	7		1	25	10	32
51	December	909	6	2	1	107	7		1	25	10	39
	Children under 16 years—											
52	January	39	3	2								
53	February	44	3	2								
54	March	46	3	2								
55	April	47	3	3								
56	May	43	4	3								
57	June	43	3	3								
58	July	38	3	1								
59	August	38	3	1								
60	September	38	2	1								
61	October	42	3	2								
62	November	37	3	2								
63	December	37	3	2								
64	Miscellaneous expenses, total	$6,055,367	$102,521	$5,851	$25,940	$1,086,502	$24,602	$9,015	$4,460	$33,483	$42,422	$172,483
65	Rent of works	$300,541	$9,829	$1,600	$3,245	$35,462	$6,131	$395	$1,890	$2,050	$8,250	$15,363
66	Taxes	$221,715	$3,205	$464	$1,457	$30,306	$1,068	$445	$395	$807	$1,812	$10,545
67	Rent of offices, interest, insurance, and all other sundry expenses not hitherto included.	$5,441,870	$89,487	$3,787	$21,238	$1,020,734	$17,403	$7,660	$2,175	$30,626	$32,360	$146,575
68	Contract work	$91,241						$515				
69	Materials used, total cost	$46,306,183	$1,568,269	$41,252	$155,396	$6,523,137	$135,276	$50,449	$36,110	$264,321	$410,884	$1,414,110
70	Products, total value	$67,277,910	$2,221,846	$81,552	$257,903	$9,484,280	$225,809	$86,074	$59,800	$522,017	$680,990	$2,159,680
	Power:											
71	Number of establishments reporting	402	17	4	5	35	8	3	3	7	10	22
72	Total horsepower	42,148	927	195	102	5,210	290	76	51	523	519	1,414
	Owned—											
	Engines—											
	Steam—											
73	Number	369	2	3	1	25	3	2	1	2	8	21
74	Horsepower	31,628	229	185	30	3,620	200	66	25	275	425	1,189
	Gas and gasoline—											
75	Number	72	5	1	1	9	2	2		1	5	1
76	Horsepower	1,471	105	10	15	257	48	7		12	79	12
	Water wheels—											
77	Number	22				1						2
78	Horsepower	969				15						65
	Water motors—											
79	Number	6										
80	Horsepower	18										
	Electric motors—											
81	Number	267	18			29				6	2	
82	Horsepower	4,693	318			759				125	10	
	Rented—											
	Electric motors—											
83	Number	168	21		3	38	7	1	2	5	1	3
84	Horsepower	2,394	275		57	507	42	3	26	111	5	23
85	Other kind, horsepower	975				52						125
86	Furnished to other establishments, horsepower.	234				5				25		

TABLE 147.—FERTILIZERS—DETAILED

		United States.	Alabama.	California.	Connecticut.	Delaware.	Florida.	Georgia.	Illinois.	Indiana.	Kentucky.
1	Number of establishments	400	19	14	10	7	8	57	4	14	4
2	Capital, total	$69,023,264	$3,050,922	$903,849	$987,378	$205,554	$899,049	$11,158,070	$546,171	$235,195	$872,487
3	Land	$4,813,130	$91,033	$60,450	$104,050	$5,700	$9,000	$368,345	$115,200	$8,100	$70,000
4	Buildings	$11,366,004	$588,533	$125,466	$174,489	$17,300	$99,444	$1,765,685	$146,261	$54,700	$476,280
5	Machinery, tools, and implements	$9,023,201	$362,661	$107,876	$171,419	$34,500	$119,991	$1,354,012	$105,218	$74,723	$77,820
6	Cash and sundries	$43,820,929	$2,008,695	$610,057	$537,420	$148,054	$670,704	$7,670,028	$179,492	$97,672	$248,387
7	Proprietors and firm members	294	6	10	6	8	1	40		20	2
	Salaried officials, clerks, etc.:										
8	Total number	1,618	79	35	32	5	61	210	13	13	15
9	Total salaries	$1,940,712	$67,539	$39,231	$36,712	$4,440	$63,179	$260,344	$16,318	$14,050	$13,762
	Officers of corporations—										
	Number	266	16	5	11		10	44	1	3	3
	Salaries	$554,542	$24,725	$6,000	$19,000		$22,590	$86,986	$720	$5,000	$4,842
	General superintendents, managers, clerks, etc.—										
	Total number	1,352	63	30	21	5	51	166	12	10	12
	Total salaries	$1,386,170	$42,814	$33,231	$17,712	$4,440	$40,589	$173,358	$15,598	$9,050	$8,920
	Men—										
	Number	1,250	63	29	18	5	44	162	9	9	9
	Salaries	$1,332,426	$42,814	$32,511	$16,680	$4,440	$36,213	$170,774	$14,358	$8,750	$7,620
	Women—										
	Number	102		1	3		7	4	3	1	3
	Salaries	$53,744		$720	$1,032		$4,376	$2,584	$1,240	$300	$1,300

[1] Includes establishments distributed as follows: Alaska, 1; District of Columbia, 1; Kansas, 1; Michigan, 1; Missouri, 2; Nebraska, 1; Oregon, 1; Rhode and, 1; Washington, 2.

SUMMARY, BY STATES: 1905—Continued.

Michigan.	Minnesota.	Missouri.	Nebraska.	New Jersey.	New York.	Ohio.	Oregon.	Pennsylvania.	Rhode Island.	Tennessee.	Virginia.	Washington.	Wisconsin.	All other states.	
76	16	27	7	68	308	103	...	103	...	12	...	2	10	9	40
76	17	30	7	72	308	109	...	107	...	14	...	2	10	10	41
76	17	32	7	77	341	115	...	111	...	14	...	2	10	12	42
76	15	32	7	80	337	121	...	116	...	13	...	2	7	12	43
77	16	31	8	81	333	122	...	136	...	14	...	2	7	10	44
78	14	31	7	82	354	112	...	125	...	14	...	2	7	10	45
91	14	28	6	75	299	106	...	103	...	9	...	2	6	9	46
92	14	28	7	74	289	100	...	103	...	10	...	2	6	10	47
92	14	28	7	71	307	99	...	101	...	14	...	2	6	10	48
91	15	32	7	69	303	95	...	87	...	13	...	2	5	10	49
92	14	29	7	70	305	96	...	90	...	14	...	2	5	10	50
67	14	32	7	69	308	94	...	90	...	15	...	2	5	8	51
5	...	3	...	3	13	1	...	7	...	1	...	...	...	1	52
5	...	3	...	3	17	1	...	8	...	1	...	...	...	1	53
5	...	3	...	3	19	1	...	8	...	1	...	...	...	1	54
5	...	3	...	3	18	1	...	9	...	1	...	...	...	1	55
5	...	3	...	3	15	1	...	7	...	1	...	...	...	1	56
5	...	3	...	4	16	1	...	6	...	1	...	...	...	1	57
5	...	3	...	5	12	1	...	6	...	1	...	...	...	1	58
5	...	3	...	6	11	1	...	6	...	1	...	...	...	1	59
5	...	3	...	6	12	1	...	6	...	1	...	...	...	1	60
5	...	3	...	3	13	1	...	7	...	1	...	...	...	1	61
5	...	3	...	3	11	1	...	7	...	1	...	...	...	1	62
5	...	3	...	3	11	1	...	7	...	1	...	...	...	1	63
$459,284	$104,930	$351,963	$36,989	$286,535	$1,451,586	$573,114	$15,967	$947,468	$27,595	$52,689	$16,578	$11,713	$67,018	$144,659	64
$1,825	$9,170	$14,170	$600	$8,333	$92,749	$23,707	$1,350	$47,770	$3,450	...	$3,197	$1,480	$2,700	$5,845	65
$12,244	$2,335	$17,350	$1,482	$13,693	$53,347	$34,210	$567	$26,995	$343	$941	$648	$543	$3,494	$3,019	66
$445,215	$93,425	$319,883	$34,907	$258,489	$1,305,168	$447,697	$14,050	$856,379	$23,822	$51,748	$12,733	$9,690	$60,824	$135,795	67
...	...	$560	...	$6,020	$322	$67,500	...	$16,324	...	...	...	...	...	...	68
$1,524,294	$454,222	$4,588,108	$237,137	$2,250,984	$13,220,075	$4,700,988	$189,886	$6,659,353	$176,622	$287,990	$113,696	$92,414	$764,005	$447,205	69
$2,823,933	$708,924	$6,144,521	$346,645	$3,511,375	$18,721,872	$6,601,428	$267,200	$9,428,890	$247,842	$480,991	$194,594	$165,924	$1,048,037	$805,783	70
11	4	17	3	20	76	47	3	69	3	4	3	4	8	16	71
1,581	222	1,989	170	2,969	10,545	5,190	102	7,370	137	295	645	80	731	815	72
10	2	18	4	26	80	48	...	88	2	4	1	1	6	11	73
1,144	150	1,684	160	2,024	8,262	3,595	...	6,339	125	295	450	35	655	466	74
1	...	...	1	1	11	11	...	14	1	...	...	...	2	3	75
14	...	...	10	8	169	265	...	395	12	...	...	...	31	22	76
...	...	...	...	2	6	...	...	6	...	...	3	...	...	2	77
...	...	...	...	40	293	...	...	131	...	...	175	...	...	250	78
...	...	5	...	...	...	...	...	1	...	...	...	...	...	...	79
...	...	13	...	...	...	...	...	5	...	...	...	...	...	...	80
29	...	2	...	57	54	44	...	26	...	...	...	...	...	...	81
398	...	16	...	735	790	1,128	...	414	...	...	...	...	...	...	82
3	5	15	...	4	27	14	4	7	...	...	1	3	2	2	83
25	72	276	...	71	485	136	102	41	...	...	20	45	45	27	84
...	...	...	...	91	546	66	...	45	...	...	...	...	...	50	85
...	...	...	...	...	183	1	...	...	20	...	...	...	...	...	86

SUMMARY, BY STATES: 1905.

Louisiana.	Maine.	Maryland.	Massachusetts.	Mississippi.	New Jersey.	New York.	North Carolina.	Ohio.	Pennsylvania.	South Carolina.	Tennessee.	Virginia.	All other states.[1]	
4	3	39	9	5	25	13	27	17	43	20	10	37	11	1
$2,143,846	$53,683	$6,058,246	$3,600,183	$1,048,733	$6,290,706	$2,598,356	$3,697,799	$3,551,267	$5,386,058	$7,086,878	$3,381,073	$4,871,810	$395,951	2
$119,206	$4,500	$827,565	$163,772	$26,432	$776,619	$167,700	$90,245	$237,552	$621,528	$232,958	$350,871	$336,304	$26,000	3
$190,737	$11,000	$894,595	$354,991	$153,508	$846,855	$499,379	$596,182	$604,435	$796,788	$1,559,265	$680,244	$629,607	$100,260	4
$388,386	$7,500	$815,518	$490,240	$106,050	$1,060,845	$195,975	$312,356	$509,090	$693,256	$728,330	$434,146	$765,356	$108,023	5
$1,445,517	$30,683	$3,520,568	$2,591,180	$762,743	$3,606,387	$1,735,302	$2,699,016	$2,200,190	$3,274,486	$4,566,325	$1,915,812	$3,140,543	$161,668	6
...	4	38	6	...	23	9	33	8	48	1	6	16	9	7
36	1	206	66	23	91	68	78	106	129	149	67	118	17	8
$65,997	$1,354	$229,734	$85,202	$28,273	$150,985	$99,664	$75,070	$135,847	$169,796	$153,045	$98,219	$111,287	$20,664	9
11	...	24	...	5	14	11	13	13	23	17	12	23	7	10
$39,654	...	$51,600	...	$9,350	$46,500	$22,200	$23,469	$28,900	$45,825	$40,300	$35,152	$32,009	$9,720	11
25	1	182	66	18	77	57	65	93	106	132	55	95	10	12
$26,343	$1,354	$178,134	$85,202	$18,923	$104,485	$77,464	$51,601	$106,947	$123,971	$112,745	$63,067	$79,278	$10,944	13
25	1	172	49	18	69	55	64	77	91	128	53	91	9	14
$26,343	$1,354	$173,506	$74,860	$18,923	$99,680	$76,132	$51,121	$97,776	$117,041	$111,005	$62,387	$77,578	$10,560	15
...	...	10	17	...	8	2	1	16	15	4	2	4	1	16
...	...	$4,628	$10,342	...	$4,805	$1,332	$480	$9,171	$6,930	$1,740	$680	$1,700	$384	17

TABLE 147.—FERTILIZERS—DETAILED

		United States.	Alabama.	California.	Connecticut.	Delaware.	Florida.	Georgia.	Illinois.	Indiana.	Kentucky.
	Wage-earners, including pieceworkers, and total wages:										
18	Greatest number employed at any one time during the year.	28,432	1,241	194	433	283	494	5,285	113	303	87
19	Least number employed at any one time during the year.	8,666	271	87	204	96	145	1,724	20	71	42
20	Average number	14,201	551	123	310	149	242	2,192	48	97	57
21	Total wages	$5,142,147	$152,713	$69,389	$124,198	$33,371	$70,259	$581,184	$24,472	$45,526	$19,329
	Men 16 years and over—										
22	Average number	14,065	550	123	252	149	236	2,188	48	97	57
23	Wages	$5,113,232	$152,665	$69,389	$109,837	$33,371	$69,451	$580,757	$24,472	$45,526	$19,329
	Women 16 years and over—										
24	Average number	110			58		6				
25	Wages	$25,446			$14,361		$808				
	Children under 16 years—										
26	Average number	26	1					4			
27	Wages	$3,469	$48					$427			
	Average number of wage-earners, including pieceworkers, employed during each month:										
	Men 16 years and over—										
28	January	15,069	799	139	181	83	279	3,642	40	66	46
29	February	18,614	882	130	187	124	350	4,467	55	69	43
30	March	20,666	835	123	211	142	375	4,594	54	81	66
31	April	16,908	514	112	261	130	255	2,787	49	77	71
32	May	13,111	350	116	314	128	181	1,479	47	70	47
33	June	11,014	325	113	302	99	198	983	44	77	47
34	July	11,084	395	107	287	179	182	1,031	44	94	47
35	August	12,230	422	118	290	178	160	1,114	57	129	51
36	September	14,060	419	136	274	190	192	1,258	91	297	85
37	October	12,494	427	127	285	204	198	1,318	37	82	85
38	November	11,566	530	117	244	231	197	1,548	39	61	51
39	December	11,964	702	138	188	100	265	2,035	19	61	45
	Women 16 years and over—										
40	January	122			60		6				
41	February	130			60		6				
42	March	125			63		6				
43	April	130			69		5				
44	May	106			52		6				
45	June	97			55		6				
46	July	96			53		6				
47	August	109			56		6				
48	September	96			52		6				
49	October	103			56		6				
50	November	99			58		6				
51	December	107			62		7				
	Children under 16 years—										
52	January	61	6					10			
53	February	59	3					13			
54	March	43						15			
55	April	29						7			
56	May	14						3			
57	June	11									
58	July	14									
59	August	14									
60	September	14									
61	October	16									
62	November	17									
63	December	20	3								
64	Miscellaneous expenses, total	$4,919,824	$147,806	$66,851	$81,088	$58,293	$81,983	$718,325	$49,252	$31,342	$74,622
65	Rent of works	$76,895	$700	$3,452		$250	$6,342	$1,425	$220	$1,560	$825
66	Taxes	$249,282	$9,542	$2,725	$3,570	$583	$2,307	$30,932	$3,306	$1,340	$4,262
67	Rent of offices, interest, insurance, and all other sundry expenses not hitherto included.	$4,550,015	$137,564	$60,674	$77,518	$57,460	$73,334	$681,968	$45,726	$28,442	$69,535
68	Contract work	$43,632						$4,000			
69	Materials used, total cost	$39,343,914	$1,606,330	$519,169	$524,891	$287,414	$1,325,070	$6,527,065	$90,702	$156,017	$279,151
70	Products, total value	$56,632,853	$2,341,132	$893,711	$943,221	$370,889	$1,590,371	$9,461,415	$131,298	$298,677	$439,111
	Power:										
71	Number of establishments reporting	350	16	11	9	5	8	47	4	13	4
72	Total horsepower	50,986	1,485	852	657	665	555	7,283	445	652	455
	Owned—										
	Engines—										
	Steam—										
73	Number	721	30	7	11	19	6	82	5	12	8
74	Horsepower	44,752	1,465	505	453	665	350	6,277	440	600	440
	Gas and gasoline—										
75	Number	17	1		1			6		1	
76	Horsepower	246	15		25			38		2	
	Water wheels—										
77	Number	15			2						
78	Horsepower	353			79						
	Electric motors—										
79	Number	126			2			18			2
80	Horsepower	2,917			50			752			15
81	Other power, horsepower	185						10			
	Rented—										
	Electric motors—										
82	Number	78	1	11	2		7	4	1		
83	Horsepower	2,358	5	272	50		205	206	5		
84	Other kind, horsepower	175		75						50	
85	Furnished to other establishments, horsepower	190									

SUMMARY, BY STATES: 1905—Continued.

Louisiana.	Maine.	Maryland.	Massachusetts.	Mississippi.	New Jersey.	New York.	North Carolina.	Ohio.	Pennsylvania.	South Carolina.	Tennessee.	Virginia.	All other states.	
754	61	2,236	550	527	1,679	851	2,094	1,128	1,331	3,217	1,747	3,271	553	18
193	22	760	241	151	770	400	525	300	762	371	351	932	228	19
344	26	1,256	358	348	1,139	596	908	490	958	1,071	781	1,801	356	20
$122,969	$11,910	$524,353	$183,163	$78,847	$637,320	$254,049	$281,775	$235,269	$446,564	$303,885	$209,593	$571,177	$160,832	21
309	26	1,247	355	348	1,124	596	907	490	955	1,071	781	1,800	356	22
$118,364	$11,910	$521,867	$182,359	$78,847	$632,445	$254,049	$281,666	$235,269	$446,266	$303,885	$209,593	$571,083	$160,832	23
23		8	3		12									24
$2,940		$2,186	$804		$4,347									25
12		1			3		1		3			1		26
$1,665		$300			$528		$109		$298			$94		27
461	20	793	345	538	950	480	787	345	817	1,454	1,009	1,484	311	28
572	20	906	409	643	1,150	506	1,137	366	906	2,313	1,435	1,641	303	29
472	21	1,389	493	853	1,340	598	1,411	453	983	2,408	1,492	1,872	400	30
319	23	1,555	518	487	1,384	654	1,310	582	1,226	1,216	946	2,072	360	31
320	25	1,315	478	199	1,202	647	897	395	965	829	500	2,246	361	32
174	24	1,332	297	171	1,069	584	554	379	898	659	432	1,779	474	33
194	21	1,277	294	104	1,054	630	563	407	892	675	460	1,670	477	34
200	31	1,497	271	104	1,022	651	714	725	1,043	624	596	1,833	400	35
230	36	1,938	279	118	1,120	636	890	1,084	1,180	588	756	1,976	287	36
248	35	1,190	287	251	1,172	578	1,061	415	897	656	719	1,946	276	37
238	35	870	290	313	986	635	851	371	810	712	524	1,602	311	38
280	21	902	299	395	1,039	553	709	358	843	718	503	1,479	312	39
31		6	4		15									40
35		10	4		15									41
24		10	4		18									42
25		10	4		17									43
23		9	4		12									44
18		3	4		11									45
20		7	4		6									46
22		14	4		7									47
19		12			7									48
21		9			11									49
19		2	2		12									50
19		4	2		13									51
34					3		1		4			3		52
32					3		1		4			3		53
17					3		1		4			3		54
10					3		1		5			3		55
4					3		1		3					56
4					3		1		3					57
5		2			3		1		3					58
5		2			3		1		3					59
5		2			3		1		3					60
8		2			3		1		2					61
10		2			3		1		1					62
10		2			3		1		1					63
$230,450	$9,748	$472,559	$244,951	$61,499	$484,020	$205,057	$285,213	$258,914	$415,286	$231,137	$297,433	$336,767	$77,228	64
$200		$26,758	$9,138		$1,282	$240	$54		$19,519	$2,400	$560	$1,625	$345	65
$3,942	$1,690	$31,643	$8,562	$4,521	$20,497	$13,254	$27,033	$10,642	$11,744	$19,948	$16,208	$18,405	$2,626	66
$226,308	$8,058	$414,158	$227,251	$56,978	$461,028	$188,874	$254,585	$248,272	$367,726	$206,478	$280,665	$303,156	$74,257	67
					$1,213	$2,680	$3,541		$16,297	$2,311		$13,581		68
$1,013,640	$38,765	$4,991,789	$1,276,299	$857,412	$3,928,047	$1,333,868	$2,217,756	$1,386,446	$2,890,780	$2,692,031	$1,711,800	$3,240,675	$448,797	69
$1,556,227	$66,054	$6,631,763	$1,978,356	$1,082,387	$5,651,914	$2,082,404	$3,098,561	$2,289,176	$4,094,978	$3,637,576	$2,700,561	$4,659,281	$633,790	70
4	3	31	9	5	20	13	22	17	39	19	9	33	9	71
910	228	4,293	2,575	645	4,370	1,537	2,653	3,218	4,580	4,286	2,030	5,653	950	72
10	6	45	21	7	46	21	53	34	80	58	20	119	12	73[1]
860	165	3,533	1,920	645	3,437	1,014	2,428	2,630	4,426	4,011	1,970	5,568	950	74
		2			2		1		1			2		75
		35			88		10		25			8		76
	2	2			1				6			2		77
	63	45			30				100			36		78
		25	9		44			19	3		3	1		79
		309	280		815			588	38		60	10		80
			175											81
2		10	4			21	6			6		3		82
50		371	200			523	215			225		31		83
										50				84
		90	100											85

TABLE 148.—EXPLOSIVES—DETAILED SUMMARY, BY STATES: 1905.

	United States.	Illinois.	Indiana.	Michigan.	Missouri.	New York.	Ohio.	Pennsylvania.	All other states.[1]
Number of establishments	124	5	7	4	4	5	16	40	43
Capital, total	$42,307,163	$774,776	$2,096,288	$315,473	$2,364,490	$507,948	$2,868,417	$5,320,285	$28,059,486
Land	$2,484,354	$50,246	$56,545	$9,400	$146,624	$38,237	$208,667	$310,723	$1,663,912
Buildings	$6,605,693	$161,135	$282,245	$51,129	$363,193	$79,502	$582,511	$789,731	$4,296,247
Machinery, tools, and implements	$8,358,003	$262,141	$452,557	$22,945	$476,431	$156,400	$684,273	$1,185,402	$5,117,854
Cash and sundries	$24,859,113	$301,254	$1,304,941	$231,999	$1,378,242	$233,809	$1,392,966	$3,034,429	$16,981,473
Proprietors and firm members	24			1			2	19	2
Salaried officials, clerks, etc.:									
Total number	1,289	32	28	11	29	24	83	163	919
Total salaries	$1,797,050	$56,457	$52,262	$15,174	$33,560	$27,817	$125,709	$233,049	$1,253,022
Officers of corporations—									
Number	288	9	4	3	5	7	22	50	188
Salaries	$741,742	$24,900	$15,533	$5,092	$7,900	$12,240	$57,250	$117,799	$501,028
General superintendents, managers, clerks, etc.—									
Total number	1,001	23	24	8	24	17	61	113	731
Total salaries	$1,055,308	$31,557	$36,729	$10,082	$25,660	$15,577	$68,459	$115,250	$751,994
Men—									
Number	895	22	20	8	19	14	47	99	666
Salaries	$1,001,444	$31,256	$33,945	$10,082	$22,540	$14,146	$61,341	$107,761	$720,373
Women—									
Number	106	1	4		5	3	14	14	65
Salaries	$53,864	$301	$2,784		$3,120	$1,431	$7,118	$7,489	$31,621
Wage-earners, including pieceworkers, and total wages:									
Greatest number employed at any one time during the year	6,598	270	371	155	385	126	503	977	3,811
Least number employed at any one time during the year	5,709	96	294	100	232	92	401	877	3,617
Average number	5,800	142	299	123	306	93	428	897	3,512
Total wages	$3,308,774	$82,611	$174,563	$87,964	$125,247	$49,095	$236,205	$526,609	$2,026,480
Men 16 years and over—									
Average number	5,708	142	299	119	273	92	416	874	3,493
Wages	$3,283,729	$82,611	$174,563	$86,116	$116,565	$48,735	$233,115	$520,181	$2,021,843
Women 16 years and over—									
Average number	91			4	33	1	12	22	19
Wages	$24,945			$1,848	$8,682	$360	$3,090	$6,328	$4,637
Children under 16 years—									
Average number	1							1	
Wages	$100							$100	
Average number of wage-earners, including pieceworkers, employed during each month:									
Men 16 years and over—									
January	5,761	109	316	117	284	110	414	846	3,565
February	5,743	120	316	120	284	112	420	839	3,532
March	5,810	159	323	123	284	113	420	856	3,532
April	5,835	164	316	117	258	116	422	870	3,572
May	5,798	164	297	121	273	83	416	878	3,566
June	5,743	145	305	118	231	83	412	865	3,584
July	5,743	104	319	147	232	83	432	861	3,565
August	5,577	99	337	133	274	87	394	880	3,373
September	5,658	156	299	130	290	84	405	887	3,407
October	5,633	172	264	132	288	80	408	903	3,386
November	5,646	158	255	121	300	77	421	908	3,406
December	5,549	154	241	49	278	76	428	895	3,428
Women 16 years and over—									
January	78			2	30	1	12	20	13
February	87			3	41	1	9	26	13
March	74			3	29	1	10	20	11
April	76			3	29	1	10	21	12
May	84			4	30	1	11	23	15
June	85			4	31	1	11	20	18
July	91			6	31	1	12	21	20
August	101			5	40	1	11	22	22
September	102			5	32	1	15	23	26
October	104			5	37	1	13	23	25
November	104			5	33	1	13	26	26
December	106			3	32	1	17	25	27
Children under 16 years—									
January	1							1	
February	1							1	
March	1							1	
April	1							1	
May	1							1	
June	1							1	
July	1							1	
August	1							1	
September	1							1	
October	1							1	
November	1							1	
December	1							1	
Miscellaneous expenses, total	$1,657,665	$43,062	$118,146	$19,096	$52,595	$49,975	$134,016	$234,664	$1,006,111
Rent of works	$9,812		$2,385			$150	$2,761	$3,146	$1,370
Taxes	$71,263	$495	$3,126	$2,443	$1,020	$1,841	$12,209	$11,740	$38,389
Rent of offices, interest, insurance, and all other sundry expenses not hitherto included	$1,574,140	$42,567	$110,635	$16,653	$51,575	$47,784	$119,046	$219,528	$966,352
Contract work	$2,450		$2,000			$200		$250	
Materials used, total cost	$17,203,667	$412,129	$1,188,014	$519,399	$1,270,931	$152,046	$1,274,786	$2,516,461	$9,869,901

[1] Includes establishments distributed as follows: Alabama, 3; California, 5; Connecticut, 1; Delaware, 1; Indian Territory, 1; Iowa, 1; Kansas, 5; Kentucky, 1; Maine, 1; Maryland, 1; Massachusetts, 1; New Jersey, 10; Tennessee, 3; West Virginia, 8; Wisconsin, 1.

TABLE 148.—EXPLOSIVES—DETAILED SUMMARY, BY STATES: 1905—Continued.

	United States.	Illinois.	Indiana.	Michigan.	Missouri.	New York.	Ohio.	Pennsylvania.	All other states.
Products, total value	[1]$29,602,884	$711,626	$1,679,306	$791,278	$1,645,705	$348,118	$1,843,211	$4,012,857	$18,570,783
Power:									
Number of establishments reporting	123	5	7	4	4	5	16	39	43
Total horsepower	37,554	2,158	1,410	431	734	1,028	6,326	6,356	19,111
Owned—									
Engines—									
Steam—									
Number	375	7	13	16	11	14	38	105	171
Horsepower	21,636	1,383	1,025	181	388	285	3,027	4,596	10,751
Gas and gasoline—									
Number	15				1	2	3		9
Horsepower	427				5	59	68		295
Water wheels—									
Number	186			8		23	7	47	101
Horsepower	6,962			250		594	980	1,021	4,117
Water motors—									
Number	29								29
Horsepower	215								215
Electric motors—									
Number	428	25	18		20	6	73	15	271
Horsepower	7,889	775	355		116	90	2,251	657	3,645
Other power, horsepower	425		30		225			82	88
Rented—									
Electric motors—									
Number									
Horsepower									
Other kind, horsepower									
Furnished to other establishments, horsepower									

[1] Exclusive of 2 governmental establishments reporting products valued at $574,032.

TABLE 149.—VARNISHES—DETAILED

		United States.	California.	Connecticut.	Illinois.
1	Number of establishments	190	4	10	24
2	Capital, total	$19,702,955	$177,150	$368,955	$3,511,836
3	Land	$1,403,641	$15,000	$20,200	$348,676
4	Buildings	$2,651,344	$10,500	$47,709	$578,101
5	Machinery, tools, and implements	$1,649,785	$7,100	$39,718	$295,283
6	Cash and sundries	$13,998,185	$144,550	$261,328	$2,289,776
7	Proprietors and firm members	111	3	6	9
	Salaried officials, clerks, etc.:				
8	Total number	1,364	1	24	262
9	Total salaries	$2,023,162	$1,500	$44,200	$371,174
	Officers of corporations—				
10	Number	201		6	27
11	Salaries	$649,858		$10,700	$82,780
	General superintendents, managers, clerks, etc.—				
12	Total number	1,163	1	18	235
13	Total salaries	$1,373,304	$1,500	$33,500	$288,394
	Men—				
14	Number	905	1	17	195
15	Salaries	$1,252,909	$1,500	$32,800	$266,085
	Women—				
16	Number	258		1	40
17	Salaries	$120,395		$700	$22,309
	Wage-earners, including pieceworkers, and total wages:				
18	Greatest number employed at any one time during the year	2,009	20	58	271
19	Least number employed at any one time during the year	1,724	16	39	233
20	Average number	1,852	18	53	247
21	Total wages	$1,200,431	$15,997	$28,460	$176,088
	Men 16 years and over—				
22	Average number	1,767	18	51	238
23	Wages	$1,177,331	$15,997	$28,160	$173,525
	Women 16 years and over—				
24	Average number	77		1	6
25	Wages	$21,418		$50	$1,939
	Children under 16 years—				
26	Average number	8		1	3
27	Wages	$1,682		$250	$624
	Average number of wage-earners, including pieceworkers, employed during each month:				
	Men 16 years and over—				
28	January	1,782	18	50	234
29	February	1,784	18	50	234
30	March	1,792	18	50	236
31	April	1,799	18	50	237
32	May	1,799	17	53	234
33	June	1,773	18	53	235
34	July	1,751	18	51	235
35	August	1,725	18	53	235
36	September	1,737	18	51	242
37	October	1,755	17	51	244
38	November	1,760	19	50	245
39	December	1,747	19	50	245
	Women 16 years and over—				
40	January	77		1	6
41	February	78		1	6
42	March	80		1	6
43	April	83		1	6
44	May	79		1	6
45	June	87		1	6
46	July	79		1	6
47	August	70		1	6
48	September	68		1	6
49	October	73		1	6
50	November	76		1	6
51	December	74		1	6
	Children under 16 years—				
52	January	9		1	3
53	February	9		1	3
54	March	9		1	3
55	April	9		1	3
56	May	9		1	3
57	June	8		1	3
58	July	8		1	3
59	August	7		1	3
60	September	7		1	3
61	October	7		1	3
62	November	7		1	3
63	December	7		1	3
64	Miscellaneous expenses, total	$3,595,970	$1,814	$55,383	$657,495
65	Rent of works	$64,191	$600	$1,870	$5,560
66	Taxes	$79,121	$629	$2,202	$15,222
67	Rent of offices, interest, insurance, and all other sundry expenses not hitherto included	$3,397,165	$585	$51,311	$635,213
68	Contract work	$55,493			$1,500
69	Materials used, total cost	$13,520,491	$109,424	$301,829	$2,132,672
70	Products, total value	$23,561,699	$148,406	$514,670	$3,840,753
	Power:				
71	Number of establishments reporting	107	1	6	20
72	Total horsepower	4,030	5	170	704
	Owned—				
	Engines—				
	Steam—				
73	Number	87	1	4	10
74	Horsepower	3,324	5	163	441
	Gas and gasoline—				
75	Number	15			5
76	Horsepower	202			73
	Water wheels—				
77	Number				
78	Horsepower				
	Water motors—				
79	Number	1			
80	Horsepower	10			
	Electric motors—				
81	Number	39			10
82	Horsepower	197			87
	Rented—				
	Electric motors—				
83	Number	41		2	12
84	Horsepower	256		7	103
85	Other kind, horsepower	41			
86	Furnished to other establishments, horsepower	88		15	25

[1] Includes establishments distributed as follows: Louisiana, 1; Maryland, 2; Minnesota, 1; Rhode Island, 1; Virginia, 1; Wisconsin, 1.

SUMMARY, BY STATES: 1905.

Indiana.	Kentucky.	Massachusetts.	Michigan.	Missouri.	New Jersey.	New York.	Ohio.	Pennsylvania.	All other states.[1]	
5	3	10	6	10	22	39	26	24	7	1
$405,591	$261,887	$232,320	$2,061,445	$209,502	$3,415,805	$5,154,246	$1,809,547	$1,962,714	$131,957	2
$30,157	$6,504	$3,800	$38,380	$17,000	$247,672	$369,442	$97,368	$200,942	$8,500	3
$104,325	$39,908	$27,997	$297,835	$11,000	$535,597	$591,381	$221,556	$164,085	$21,350	4
$36,003	$15,762	$19,486	$112,185	$23,041	$337,428	$390,133	$148,146	$212,638	$12,862	5
$235,106	$199,713	$181,037	$1,613,045	$158,461	$2,295,108	$3,803,290	$1,342,477	$1,385,049	$89,245	6
...	...	4	2	8	4	31	16	23	5	7
39	23	33	102	10	323	298	135	101	13	8
$53,213	$16,774	$48,536	$78,203	$19,192	$490,258	$504,453	$210,699	$171,696	$13,264	9
14	1	12	11	5	26	42	37	15	5	10
$19,800	$2,400	$30,000	$26,160	$14,000	$99,600	$177,146	$124,940	$54,332	$8,000	11
25	22	21	91	5	297	256	98	86	8	12
$33,413	$14,374	$18,536	$52,043	$5,192	$390,658	$327,307	$85,759	$117,364	$5,264	13
24	16	18	50	4	242	198	65	69	6	14
$33,049	$11,774	$17,172	$37,951	$4,812	$365,309	$297,058	$73,821	$107,094	$4,484	15
1	6	3	41	1	55	58	33	17	2	16
$364	$2,600	$1,364	$14,092	$380	$25,349	$30,249	$11,938	$10,270	$780	17
52	59	52	162	44	308	581	189	181	32	18
35	52	41	139	32	286	495	160	175	21	19
43	55	48	151	37	293	539	170	174	24	20
$24,198	$28,032	$25,703	$80,967	$22,919	$187,721	$358,407	$106,336	$129,739	$15,864	21
43	55	47	136	32	288	507	156	174	22	22
$24,198	$28,032	$25,403	$77,379	$21,839	$186,135	$349,024	$102,626	$129,739	$15,274	23
...	...	1	15	5	5	28	14	...	2	24
...	...	$300	$3,588	$1,080	$1,586	$8,575	$3,710	...	$590	25
...	...	...	...	...	...	4	...	...	...	26
...	...	...	...	...	...	$808	...	...	...	27
47	55	47	148	31	288	509	155	176	24	28
46	55	47	148	31	288	512	158	176	21	29
50	55	47	148	30	289	516	156	176	21	30
48	56	47	147	34	289	517	156	176	24	31
52	55	47	135	31	290	527	157	176	25	32
42	55	47	136	31	288	511	159	176	22	33
37	55	47	136	32	287	499	161	175	18	34
38	55	47	134	32	286	483	154	171	19	35
36	55	47	124	33	283	501	154	171	22	36
36	55	47	125	34	288	509	155	171	23	37
35	55	47	125	35	291	508	156	171	23	38
49	54	47	126	30	289	492	151	173	22	39
...	...	1	15	5	5	29	11	...	4	40
...	...	1	15	5	5	28	13	...	4	41
...	...	1	15	5	5	30	14	...	3	42
...	...	1	15	5	5	32	16	...	2	43
...	...	1	15	5	5	27	18	...	1	44
...	...	1	15	5	5	34	19	...	1	45
...	...	1	15	4	5	29	17	...	1	46
...	...	1	15	4	5	25	13	...	...	47
...	...	1	15	6	5	24	10	...	...	48
...	...	1	15	6	5	24	12	...	3	49
...	...	1	15	6	5	25	14	...	3	50
...	...	1	15	4	5	29	11	...	2	51
...	...	...	...	...	...	5	...	...	...	52
...	...	...	...	...	...	5	...	...	...	53
...	...	...	...	...	...	5	...	...	...	54
...	...	...	...	...	...	5	...	...	...	55
...	...	...	...	...	...	5	...	...	...	56
...	...	...	...	...	...	4	...	...	...	57
...	...	...	...	...	...	4	...	...	...	58
...	...	...	...	...	...	3	...	...	...	59
...	...	...	...	...	...	3	...	...	...	60
...	...	...	...	...	...	3	...	...	...	61
...	...	...	...	...	...	3	...	...	...	62
...	...	...	...	...	...	3	...	...	...	63
$91,010	$90,369	$88,291	$428,380	$23,948	$663,675	$978,813	$212,082	$274,044	$30,666	64
$372	$390	$6,925	$350	$3,447	$9,800	$24,183	$4,165	$5,441	$1,088	65
$2,700	$2,194	$1,147	$5,424	$1,028	$14,041	$15,729	$12,328	$5,922	$555	66
$87,938	$87,785	$80,219	$422,606	$19,473	$639,834	$937,901	$194,789	$210,488	$29,023	67
...	...	...	...	...	...	$1,000	$800	$52,193	...	68
$301,631	$300,793	$215,554	$1,880,724	$148,864	$1,762,267	$3,649,561	$1,154,106	$1,405,859	$148,207	69
$522,475	$500,645	$413,884	$3,134,258	$255,412	$3,455,494	$6,399,574	$1,928,714	$2,208,148	$239,266	70
4	2	5	2	2	12	23	13	14	3	71
135	100	122	230	55	625	839	213	768	64	72
3	6	3	2	4	11	17	6	18	2	73
125	100	110	230	35	542	672	140	716	45	74
...	...	...	...	1	1	3	1	4	...	75
...	...	...	...	20	6	31	30	42	...	76
...	...	...	...	...	...	...	...	...	...	77
...	...	...	...	...	...	...	...	...	...	78
...	...	...	...	...	...	...	1	...	...	79
...	...	...	...	...	...	...	10	...	...	80
1	...	...	...	...	9	18	...	1	...	81
5	...	...	...	...	60	35	...	10	...	82
...	...	3	...	...	3	11	7	...	3	83
...	...	12	...	...	17	65	33	...	19	84
5	...	...	...	...	...	36	...	...	...	85
...	...	30	...	...	...	18	...	...	...	86

TABLE 150.—DYESTUFFS AND EXTRACTS—

		United States.	Maine.	Massachusetts.
1	Number of establishments	98	3	16
2	Capital, total	$14,904,150	$20,922	$978,121
3	Land	$1,364,545	$500	$169,300
4	Buildings	$1,853,818	$4,000	$140,200
5	Machinery, tools, and implements	$3,565,327	$1,600	$108,643
6	Cash and sundries	$8,120,460	$14,822	$559,978
7	Proprietors and firm members	82	5	17
	Salaried officials, clerks, etc.:			
8	Total number	361	1	24
9	Total salaries	$608,790	$300	$29,052
	Officers of corporations—			
10	Number	63	....	3
11	Salaries	$191,887	....	$8,000
	General superintendents, managers, clerks, etc.—			
12	Total number	298	1	21
13	Total salaries	$416,903	$300	$21,052
	Men—			
14	Number	274	....	18
15	Salaries	$404,641	....	$19,760
	Women—			
16	Number	24	1	3
17	Salaries	$12,262	$300	$1,292
	Wage-earners, including pieceworkers, and total wages:			
18	Greatest number employed at any one time during the year	3,613	16	286
19	Least number employed at any one time during the year	2,178	7	130
20	Average number	2,707	9	150
21	Total wages	$1,264,492	$3,615	$84,311
	Men 16 years and over—			
22	Average number	2,678	6	149
23	Wages	$1,256,946	$3,021	$84,103
	Women 16 years and over—			
24	Average number	25	3	....
25	Wages	$6,966	$594	....
	Children under 16 years—			
26	Average number	4	....	1
27	Wages	$580	....	$208
	Average number of wage-earners, including pieceworkers, employed during each month:			
	Men 16 years and over—			
28	January	2,596	5	121
29	February	2,709	7	166
30	March	2,714	10	167
31	April	2,778	10	153
32	May	2,879	5	122
33	June	2,765	4	143
34	July	2,805	4	146
35	August	2,898	4	150
36	September	2,804	6	159
37	October	2,469	6	156
38	November	2,406	6	147
39	December	2,313	5	158
	Women 16 years and over—			
40	January	25	3	....
41	February	25	3	....
42	March	27	5	....
43	April	28	6	....
44	May	27	5	....
45	June	24	2	....
46	July	22	....	....
47	August	22	....	....
48	September	23	1	....
49	October	27	5	....
50	November	26	4	....
51	December	24	2	....
	Children under 16 years—			
52	January	4	....	2
53	February	3	....	1
54	March	3	....	1
55	April	3	....	1
56	May	4	....	1
57	June	5	....	1
58	July	5	....	1
59	August	5	....	1
60	September	5	....	1
61	October	4	....	1
62	November	4	....	1
63	December	3	....	....
64	Miscellaneous expenses, total	$944,360	$9,254	$72,556
65	Rent of works	$22,253	$84	$8,225
66	Taxes	$55,386	$60	$6,808
67	Rent of offices, interest, insurance, and all other sundry expenses not hitherto included	$864,046	$9,110	$57,323
68	Contract work	$2,675	....	$200
69	Materials used, total cost	$6,829,340	$7,219	$616,581
70	Products, total value	$10,893,113	$30,051	$999,262
	Power:			
71	Number of establishments reporting	79	....	13
72	Total horsepower	18,310	....	1,205
	Owned—			
	Engines—			
	Steam—			
73	Number	192	....	21
74	Horsepower	17,348	....	1,170
	Gas and gasoline—			
75	Number	1	....	....
76	Horsepower	4	....	....
	Water wheels—			
77	Number	6	....	1
78	Horsepower	196	....	35
	Electric motors—			
79	Number	33	....	....
80	Horsepower	639	....	....
81	Other power, horsepower	76	....	....
	Rented—			
	Electric motors—			
82	Number	2	....	....
83	Horsepower	20	....	....
84	Other kind, horsepower	27	....	....

1 Includes establishments distributed as follows: California, 2; Connecticut, 2; Florida, 2; Illinois, 2; Kentucky, 1; Michigan, 1; South Carolina, 1; Wisconsin, 1.

DETAILED SUMMARY, BY STATES: 1905.

New Jersey.	New York.	North Carolina.	Pennsylvania.	Rhode Island.	Tennessee.	Virginia.	West Virginia.	All other states.[1]	
14	9	6	8	8	5	12	5	12	1
$1,599,846	$3,547,048	$1,308,317	$3,031,823	$182,677	$1,113,241	$1,407,790	$295,668	$1,418,697	2
$179,344	$453,008	$215,565	$182,250	$1,100	$47,505	$74,509	$9,870	$31,594	3
$183,418	$357,837	$202,810	$183,918	$19,878	$266,602	$282,396	$15,050	$197,709	4
$285,801	$778,576	$385,021	$374,268	$43,360	$429,466	$417,603	$158,027	$582,962	5
$951,283	$1,957,627	$504,921	$2,291,387	$118,339	$369,668	$633,282	$112,721	$606,432	6
9	4	3	16	5	8	6	5	4	7
95	93	17	26	12	19	27	9	38	8
$192,030	$147,688	$31,833	$40,826	$21,183	$21,360	$45,055	$8,266	$71,197	9
9	12	7	3	3	4	9	5	8	10
$39,150	$44,537	$22,749	$10,000	$2,000	$8,100	$20,849	$6,152	$30,350	11
86	81	10	23	9	15	18	4	30	12
$152,880	$103,151	$9,084	$30,826	$19,183	$13,260	$24,206	$2,114	$40,847	13
78	76	10	21	8	14	17	4	28	14
$147,680	$101,065	$9,084	$30,410	$18,455	$12,900	$23,706	$2,114	$39,467	15
8	5	...	2	1	1	1	...	2	16
$5,200	$2,086	...	$416	$728	$360	$500	...	$1,380	17
280	603	569	254	78	334	601	98	494	18
212	376	329	151	54	243	302	47	327	19
250	519	435	203	70	259	424	82	306	20
$138,332	$316,678	$132,853	$105,264	$41,167	$102,652	$136,535	$28,294	$174,791	21
235	513	435	201	70	259	423	82	305	22
$133,832	$315,170	$132,853	$105,004	$41,167	$102 652	$136,423	$28,294	$174,427	23
15	6	...	...	...	...	...	...	1	24
$4,500	$1,508	...	...	...	...	...	...	$364	25
...	...	...	2	...	...	1	...	...	26
...	...	...	$260	...	...	$112	...	...	27
227	547	344	207	69	186	407	88	395	28
227	565	413	206	69	175	412	80	389	29
233	571	396	215	72	185	397	92	376	30
246	564	428	207	65	268	389	93	355	31
236	566	527	184	65	271	451	94	358	32
239	480	487	194	71	261	447	75	364	33
235	508	444	184	71	286	512	74	341	34
244	517	497	187	70	299	514	74	342	35
243	469	464	203	69	302	440	81	368	36
230	463	431	193	69	299	415	88	119	37
231	468	402	216	74	284	370	80	128	38
229	438	387	216	76	292	322	65	125	39
15	6	...	...	...	...	...	...	1	40
15	6	...	...	...	...	...	...	1	41
15	6	...	...	...	...	...	...	1	42
15	6	...	...	...	...	...	...	1	43
15	6	...	...	...	...	...	...	1	44
15	6	...	...	...	...	...	...	1	45
15	6	...	...	...	...	...	...	1	46
15	6	...	...	...	...	...	...	1	47
15	6	...	...	...	...	...	...	1	48
15	6	...	...	...	...	...	...	1	49
15	6	...	...	...	...	...	...	1	50
15	6	...	...	...	...	...	...	1	51
...	...	...	2	...	...	...	...	...	52
...	...	...	2	...	...	...	...	...	53
...	...	...	2	...	...	...	...	...	54
...	...	...	2	...	...	...	...	...	55
...	...	...	2	...	...	1	...	...	56
...	...	...	2	...	...	2	...	...	57
...	...	...	2	...	...	2	...	...	58
...	...	...	2	...	...	2	...	...	59
...	...	...	2	...	...	2	...	...	60
...	...	...	2	...	...	1	...	...	61
...	...	...	2	...	...	1	...	...	62
...	...	...	2	...	...	1	...	...	63
$167,443	$233,786	$83,478	$65,675	$45,037	$82,458	$70,138	$33,843	$80,692	64
$5,180	$860	$200	$720	$3,624	...	$920	...	$2,440	65
$7,886	$15,052	$3,049	$3,034	$306	$6,041	$5,664	$596	$6,890	66
$154,377	$217,874	$79,029	$61,921	$41,107	$76,417	$63,554	$31,972	$71,362	67
...	...	$1,200	...	...	...	...	$1,275	...	68
$1,499,867	$1,651,653	$418,243	$629,499	$327,218	$362,252	$392,755	$119,280	$804,773	69
$2,176,253	$2,705,580	$636,628	$966,364	$513,006	$720,255	$736,622	$249,465	$1,159,627	70
13	7	5	5	6	5	11	5	9	71
1,023	2,431	2,160	2,731	294	2,541	4,400	435	1,090	72
17	27	15	14	8	15	49	8	18	73
987	2,257	2,060	2,420	280	2,396	4,365	435	978	74
1	...	...	...	...	...	...	...	...	75
4	...	...	...	...	...	...	...	...	76
...	...	...	...	1	...	2	...	2	77
...	...	...	...	14	...	35	...	112	78
1	6	1	22	...	3	...	...	...	79
5	78	100	311	...	145	...	...	...	80
...	76	...	...	...	...	...	...	...	81
...	2	...	...	...	...	...	...	...	82
...	20	...	...	...	...	...	...	...	83
27	...	...	...	...	...	...	...	...	84

TABLE 151.—SULPHURIC, NITRIC, AND MIXED ACIDS—DETAILED SUMMARY, BY STATES: 1905.

	United States.	California.	New York.	Pennsylvania.	All other states.[1]
Number of establishments	32	4	7	5	16
Capital, total	$12,761,920	$1,524,764	$3,666,375	$899,589	$6,671,192
Land	$1,431,440	$105,045	$321,153	$124,562	$880,680
Buildings	$2,808,457	$131,200	$513,327	$165,508	$1,998,422
Machinery, tools, and implements	$4,960,647	$601,956	$1,800,552	$406,431	$2,151,708
Cash and sundries	$3,561,376	$686,563	$1,031,343	$203,088	$1,640,382
Proprietors and firm members	2				2
Salaried officials, clerks, etc.:					
Total number	308	21	69	38	180
Total salaries	$556,106	$43,670	$159,437	$57,431	$295,568
Officers of corporations—					
Number	37	3	6	13	15
Salaries	$71,775	$12,000	$16,080	$14,760	$28,935
General superintendents, managers, clerks, etc.—					
Total number	271	18	63	25	165
Total salaries	$484,331	$31,670	$143,357	$42,671	$266,633
Men—					
Number	261	14	62	24	161
Salaries	$479,232	$29,220	$142,421	$42,191	$265,400
Women—					
Number	10	4	1	1	4
Salaries	$5,099	$2,450	$936	$480	$1,233
Wage-earners, including pieceworkers, and total wages:					
Greatest number employed at any one time during the year	3,023	303	834	219	1,667
Least number employed at any one time during the year	1,888	172	670	130	916
Average number	2,447	237	726	155	1,329
Total wages	$1,505,406	$158,092	$436,819	$84,670	$825,825
Men 16 years and over—					
Average number	2,443	237	723	154	1,329
Wages	$1,504,359	$158,092	$435,944	$84,498	$825,825
Women 16 years and over—					
Average number	1		1		
Wages	$250		$250		
Children under 16 years—					
Average number	3		2	1	
Wages	$797		$625	$172	
Average number of wage-earners employed during each month:					
Men 16 years and over—					
January	2,296	265	573	146	1,312
February	2,390	261	580	145	1,404
March	2,636	255	794	154	1,433
April	2,510	253	775	157	1,325
May	2,429	214	730	176	1,309
June	2,425	195	754	158	1,318
July	2,236	218	743	143	1,132
August	2,399	241	726	159	1,273
September	2,451	253	741	163	1,294
October	2,499	246	746	155	1,352
November	2,516	240	759	147	1,370
December	2,505	203	755	145	1,402
Women 16 years and over—					
January					
February					
March	2		2		
April	2		2		
May	1		1		
June	1		1		
July	1		1		
August	1		1		
September	1		1		
October	1		1		
November	1		1		
December	1		1		
Children under 16 years—					
January					
February					
March	2		2		
April	2		2		
May	2		2		
June	2		2		
July	8		2	6	
August	8		2	6	
September	3		3		
October	3		3		
November	3		3		
December	3		3		
Miscellaneous expenses, total	$712,953	$44,401	$201,566	$35,045	$431,941
Rent of works	$41,512		$10,000		$31,512
Taxes	$60,511	$2,785	$15,697	$6,619	$35,410
Rent of offices, interest, insurance, and all other sundry expenses not hitherto included	$603,091	$41,616	$175,869	$28,426	$357,180
Contract work	$7,839				$7,839
Materials used, total cost	$4,972,838	$596,469	$1,302,079	$265,702	$2,808,588
Products, total value	$9,052,646	$915,473	$2,711,692	$560,594	$4,864,887
Power:					
Number of establishments reporting	31	4	7	4	16
Total horsepower	5,241	616	1,240	1,031	2,354
Owned—					
Engines—					
Steam—					
Number	143	6	34	16	87
Horsepower	3,645	276	835	180	2,354
Gas and gasoline—					
Number	7	3		4	
Horsepower	161	125		36	
Water wheels—					
Number					
Horsepower					
Water motors—					
Number					
Horsepower					
Electric motors—					
Number	13			13	
Horsepower	125			125	
Other power, horsepower	895	15	190	690	
Rented—					
Electric motors—					
Number	32	18	14		
Horsepower	415	200	215		

[1] Includes establishments distributed as follows: Alabama, 2; Colorado, 1; Connecticut, 2; Indiana, 1; Kansas, 1; Maryland, 2; New Jersey, 4; Ohio, 1; Rhode Island, 1; Virginia, 1.

TABLE 152.—WOOD DISTILLATION—DETAILED SUMMARY, BY STATES: 1905.

	United States.	Florida.	Georgia.	Michigan.	New York.	North Carolina.	Pennsylvania.	South Carolina.	All other states.[1]
Number of establishments	141	4	9	9	32	7	63	5	12
Capital, total	$10,506,979	$114,080	$269,902	$1,333,999	$3,199,359	$139,845	$5,009,357	$44,310	$396,127
Land	$761,402	$9,250	$12,000	$16,345	$217,406	$12,855	$476,425	$750	$16,371
Buildings	$1,311,702	$11,500	$23,100	$173,000	$414,657	$18,900	$607,866	$5,700	$56,979
Machinery, tools, and implements	$4,394,964	$85,000	$188,847	$838,714	$889,035	$93,475	$2,073,366	$26,950	$199,577
Cash and sundries	$4,038,911	$8,330	$45,955	$305,940	$1,678,261	$14,615	$1,851,700	$10,910	$123,200
Proprietors and firm members	82	2	2	4	19	6	42	4	3
Salaried officials, clerks, etc.:									
Total number	301	8	15	32	66	8	135	5	32
Total salaries	$297,528	$9,800	$12,472	$32,360	$93,046	$5,840	$110,661	$2,912	$30,437
Officers of corporations—									
Number	77	3	6	7	9	1	43	2	6
Salaries	$114,494	$6,500	$6,000	$7,980	$40,998	$2,000	$43,261	$1,200	$6,555
General superintendents, managers, clerks, etc.—									
Total number	224	5	9	25	57	7	92	3	26
Total salaries	$183,034	$3,300	$6,472	$24,380	$52,048	$3,840	$67,400	$1,712	$23,882
Men—									
Number	212	5	9	24	52	6	90	3	23
Salaries	$177,758	$3,300	$6,472	$24,200	$49,323	$3,340	$66,925	$1,712	$22,486
Women—									
Number	12	...	...	1	5	1	2	...	3
Salaries	$5,276	...	...	$180	$2,725	$500	$475	...	$1,396
Wage-earners, including pieceworkers, and total wages:									
Greatest number employed at any one time during the year	2,835	48	88	339	542	67	1,551	40	160
Least number employed at any one time during the year	2,134	38	63	274	494	47	1,117	20	81
Average number	2,272	34	54	291	489	51	1,249	21	83
Total wages	$1,066,786	$13,797	$16,653	$156,125	$218,031	$16,469	$597,743	$4,222	$43,746
Men 16 years and over—									
Average number	2,272	34	54	291	489	51	1,249	21	83
Wages	$1,066,786	$13,797	$16,653	$156,125	$218,031	$16,469	$597,743	$4,222	$43,746
Average number of wage-earners, including pieceworkers, employed during each month:									
Men 16 years and over—									
January	2,399	20	58	277	512	53	1,387	18	74
February	2,374	20	50	281	525	54	1,350	20	74
March	2,381	20	46	330	517	50	1,323	20	75
April	2,342	36	51	307	493	48	1,305	21	81
May	2,256	36	40	303	478	48	1,243	26	82
June	2,164	34	42	294	454	48	1,175	35	82
July	2,052	34	37	294	440	50	1,100	14	83
August	2,088	34	44	314	449	50	1,109	14	74
September	2,182	44	75	274	476	51	1,170	17	75
October	2,286	44	73	254	500	53	1,233	27	102
November	2,392	43	65	273	521	55	1,298	26	111
December	2,348	43	67	291	503	52	1,295	14	83
Miscellaneous expenses, total	$631,437	$7,554	$10,960	$85,547	$233,347	$6,630	$229,079	$2,176	$56,144
Rent of works	$3,859	$120	$60	...	$300	...	$1,758	$200	$1,421
Taxes	$47,010	$368	$513	$11,219	$14,827	$890	$16,970	$211	$2,012
Rent of offices, interest, insurance, and all other sundry expenses not hitherto included	$558,598	$7,066	$10,387	$52,828	$218,220	$5,740	$209,881	$1,765	$52,711
Contract work	$21,970	...	...	$21,500	...	...	$470	...	...
Materials used, total cost	$4,847,770	$31,127	$35,857	$350,854	$2,479,941	$26,764	$1,708,505	$6,809	$207,913
Products, total value	$7,813,483	$85,240	$80,674	$738,254	$3,357,087	$74,531	$3,092,687	$14,418	$370,592
Power:									
Number of establishments reporting	112	4	9	7	31	3	47	5	6
Total horsepower	4,634	135	460	366	706	125	2,311	162	369
Owned—									
Engines—									
Steam—									
Number	154	4	12	15	36	5	67	8	7
Horsepower	3,744	135	460	354	578	125	1,561	162	369
Gas and gasoline—									
Number	13	...	...	...	...	...	13	...	...
Horsepower	287	...	...	...	...	...	287	...	...
Water wheels—									
Number	35	...	...	...	12	...	23	...	...
Horsepower	370	...	...	...	106	...	264	...	...
Water motors—									
Number	1	...	...	...	1	...	...	...	...
Horsepower	2	...	...	...	2	...	...	...	...
Electric motors—									
Number	2	...	...	...	...	...	2	...	...
Horsepower	14	...	...	...	...	...	14	...	...
Other power, horsepower	185	...	...	...	...	...	185	...	...
Rented—									
Electric motors—									
Number	2	...	...	2	...	...	...	...	...
Horsepower	12	...	...	12	...	...	...	...	...
Other kind, horsepower	20	...	...	...	20	...	...	...	...

[1] Includes establishments distributed as follows: Alabama, 1; Connecticut, 1; Kentucky, 1; Louisiana, 2; Massachusetts, 2; Minnesota, 1; Mississippi, 1; Vermont, 2; Washington, 1.

TABLE 153.—OIL, ESSENTIAL—DETAILED SUMMARY, BY STATES: 1905.

	United States.	Connecticut.	Indiana.	Michigan.	New York.	Pennsylvania.	Virginia.	All other states.[1]
Number of establishments	52	9	13	6	5	9	4	6
Capital, total	$723,004	$244,787	$14,625	$173,725	$41,452	$13,080	$5,336	$229,999
Land	$74,035	$31,050	$625	$2,325	$4,525	$200	$110	$35,200
Buildings	$140,755	$38,300	$1,425	$12,600	$9,900	$2,800	$330	$76,300
Machinery, tools, and implements	$157,014	$59,500	$2,575	$8,400	$21,284	$5,975	$2,100	$57,180
Cash and sundries	$351,200	$115,937	$10,000	$150,400	$6,643	$4,105	$2,796	$61,319
Proprietors and firm members	68	10	16	18	5	8	7	4
Salaried officials, clerks, etc.:								
Total number	37	11		5	4	2		15
Total salaries	$40,002	$9,724		$8,600	$3,832	$900		$16,946
Officers of corporations—								
Number	7				3			4
Salaries	$9,650				$3,000			$6,650
General superintendents, managers, clerks, etc.—								
Total number	30	11		5	1	2		11
Total salaries	$30,352	$9,724		$8,600	$832	$900		$10,296
Men—								
Number	24	9		4	1	2		8
Salaries	$26,756	$8,024		$8,000	$832	$900		$9,000
Women—								
Number	6	2		1				3
Salaries	$3,596	$1,700		$600				$1,296
Wage-earners, including pieceworkers, and total wages:								
Greatest number employed at any one time during the year	272	70	37	39	25	14	13	74
Least number employed at any one time during the year	190	45	24	31	13	12	9	56
Average number	132	33	3	13	16	5	4	58
Total wages	$69,711	$16,396	$1,369	$8,000	$7,415	$2,000	$971	$33,560
Men 16 years and over—								
Average number	127	33	3	13	15	5	4	54
Wages	$68,370	$16,396	$1,369	$8,000	$7,103	$2,000	$971	$32,531
Women 16 years and over—								
Average number	5				1			4
Wages	$1,341				$312			$1,029
Average number of wage-earners, including pieceworkers, employed during each month:								
Men 16 years and over—								
January	158	63		4	18	15		58
February	154	61		6	17	12		58
March	158	60		7	18	12	3	58
April	130	27		11	20	6	8	58
May	105	12		9	19		8	57
June	87	6		9	18		8	46
July	88	4	3	17	13			51
August	136	4	29	39	13			51
September	112	4	4	39	13		4	48
October	120	46		6	12	3	6	47
November	132	51		5	9	3	6	58
December	144	58		4	10	9	5	58
Women 16 years and over—								
January	10				2			8
February	10				2			8
March	10				2			8
April	11				2			9
May	11				2			9
June	8				2			6
July								
August								
September								
October								
November								
December								
Miscellaneous expenses, total	$78,886	$40,494	$1,955	$2,019	$10,088	$1,531	$87	$22,712
Rent of works	$1,442	$135			$750	$64	$12	$481
Taxes	$3,897	$324	$223	$545	$238	$35	$38	$2,494
Rent of offices, interest, insurance, and all other sundry expenses not hitherto included	$73,547	$40,035	$1,732	$1,474	$9,100	$1,432	$37	$19,737
Materials used, total cost	$1,110,470	$195,471	$12,962	$166,188	$453,747	$11,874	$3,923	$266,305
Products, total value	$1,464,662	$289,883	$25,470	$240,215	$502,014	$22,421	$9,856	$374,803
Power:								
Number of establishments reporting	34	9	7	2	2	5	4	5
Total horsepower	849	430	130	11	59	46	53	120
Owned—								
Engines—								
Steam—								
Number	36	14	7	2	1	5	4	3
Horsepower	709	360	130	11	12	46	53	97
Gas and gasoline—								
Number	2				1			1
Horsepower	28				35			3
Water wheels—								
Number	3	3						
Horsepower	70	70						
Rented—								
Electric motors—								
Number	1							1
Horsepower	20							20
Other kind, horsepower	12				12			

[1] Includes establishments distributed as follows: California, 1; Massachusetts, 1; New Hampshire, 1; New Jersey, 1; Wisconsin, 2.

TABLE 154.—BONE, IVORY, AND LAMP BLACK—DETAILED SUMMARY, UNITED STATES: 1905.

	United States.
Number of establishments	25
Capital, total	$1,663,143
Land	$179,589
Buildings	$558,864
Machinery, tools, and implements	$474,154
Cash and sundries	$450,536
Proprietors and firm members	11
Salaried officials, clerks, etc.:	
Total number	47
Total salaries	$48,490
Officers of corporations—	
Number	22
Salaries	$22,102
General superintendents, managers, clerks, etc.—	
Total number	25
Total salaries	$26,388
Men—	
Number	21
Salaries	$24,840
Women—	
Number	4
Salaries	$1,548
Wage-earners, including pieceworkers, and total wages:	
Greatest number employed at any one time during the year	235
Least number employed at any one time during the year	181
Wage-earners, including pieceworkers, and total wages—Cont'd.	
Average number	200
Wages	$105,159
Men 16 years and over—	
Average number	192
Wages	$103,699
Women 16 years and over—	
Average number	7
Wages	$1,360
Children under 16 years—	
Average number	1
Wages	$100
Miscellaneous expenses, total	$69,454
Rent of works	$6,290
Taxes	$5,866
Rent of offices, interest, insurance, and all other sundry expenses not hitherto included	$57,298
Materials used, total cost	$203,396
Components of products	$134,162
Fuel	$13,755
Mill supplies	$2,840
All other materials	$51,215
Freight	$1,424
Products, total value	$647,717

TABLE 155.—CHEMICALS—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905.

	United States.
Materials used, total cost	$42,062,611
Bauxite—	
Tons	46,383
Cost	$370,169
Limestone—	
Tons	755,255
Cost	$936,974
Phosphate rock—	
Tons	9,309
Cost	$61,053
Pyrites—	
Tons	136,360
Cost	$778,209
Sulphur—	
Tons	28,482
Cost	$591,700
Acids—	
Sulphuric—	
Tons	104,489
Cost	$945,486
Nitric—	
Pounds	6,136,867
Cost	$320,818
Mixed—	
Pounds	3,467,726
Cost	$156,605
Acetate of lime—	
Tons	12,310
Cost	$364,847
Argols, cost	$2,013,400
Ammonia—	
Aqua—	
Pounds	25,251,853
Cost	$832,076
Sulphate—	
Pounds	11,351,100
Cost	$356,109
Alcohol—	
Grain—	
Gallons	187,389
Cost	$449,604
Wood—	
Gallons	601,077
Cost	$367,223
Bones, cost	$263,264
Coal tar—	
Gallons	160,000
Cost	$4,226
Common salt—	
Tons	183,241
Cost	$473,913
Cotton—	
Pounds	97,000
Cost	$10,900
Glycerin—	
Pounds	21,482,084
Cost	$1,933,254
Lead—	
Tons	514
Cost	$54,213
Lime—	
Bushels	5,642,303
Cost	$656,316
Nitrate of potash—	
Tons	673
Cost	$53,000
Nitrate of soda—	
Tons	17,615
Cost	$751,968
Materials used—Continued.	
Potash salts, cost	$630,612
Sodium—	
Pounds	34,000
Cost	$430
Tallow and fats, cost	$231,026
Wood ashes—	
Bushels	193,000
Cost	$24,125
All other components of products, cost	$19,763,601
Fuel	$3,909,719
Rent of power and heat	$631,870
Mill supplies	$281,420
All other materials	$3,296,146
Freight	$548,335
Products, total value	$75,222,249
Acids—	
Total value	$7,583,059
Tartaric—	
Pounds	2,684,000
Value	$680,280
Acetic—	
Pounds	27,001,322
Value	$537,542
Other, value	$6,365,237
Sodas, total value	$16,858,929
Soda ash—	
Tons	518,789
Value	$8,202,292
Sal soda—	
Tons	56,870
Value	$792,248
Bicarbonate of soda—	
Tons	68,867
Value	$1,135,610
Caustic soda—	
Tons	80,159
Value	$2,924,182
Borax—	
Tons	20,882
Value	$2,122,808
Other soda products, value	$1,681,789
Potashes—	
Pounds	5,113,706
Value	$563,489
Alums—	
Pounds	169,032,501
Value	$2,126,612
Coal tar products, total value	$844,817
Coal tar distillery products, value	$340,641
Chemicals made from coal tar distillery products, value	$504,176
Cyanides, total value	$1,179,104
Potassium cyanide—	
Pounds	78,584
Value	$17,438
Yellow prussiate of potash—	
Pounds	5,027,264
Value	$683,277
Other cyanides, value	$478,389
Bleaching materials, total value	$777,750
Hypochlorites—	
Tons	6,098
Value	$162,671
Other bleaching agents, value	$615,079
Electro-chemical products, value	$5,896,632
Plastics, total value	$4,755,761
Pyroxylin plastics, value	$2,857,093
All other products in this group, value	$1,898,668

TABLE 155.—CHEMICALS—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905—Continued.

	United States.
Products—Continued.	
Compressed and liquefied gases, total value	$2,787,689
Anhydrous ammonia, value	$1,173,184
Carbon dioxide, value	$1,343,966
All other compressed and liquefied gases, value	$270,539
Fine chemicals, total value	$9,145,853
Alkaloids—	
Ounces	4,949,525
Value	$2,925,789
Gold salts—	
Ounces	59,969
Value	$449,864
Silver salts—	
Ounces	1,743,882
Value	$683,761
Platinum salts—	
Ounces	19,068
Value	$175,682
Chloroform—	
Pounds	616,670
Value	$165,604
Ether—	
Pounds	660,783
Value	$334,935
Acetone—	
Pounds	1,300,395
Value	$161,320
Vanillin—	
Pounds	45,801
Value	$165,044
All other, value	$4,083,854
Products—Continued.	
Chemicals not otherwise specified, total value	$16,959,48[illegible]
Glycerin—	
Pounds	18,791,997
Value	$2,345,205
Cream of tartar—	
Pounds	11,553,660
Value	$2,263,872
Epsom salts—	
Pounds	15,935,837
Value	$145,801
Blue vitriol—	
Pounds	50,100
Value	$2,500
Copperas—	
Pounds	8,815,059
Value	$28,061
Phosphates of soda—	
Pounds	12,018,815
Value	$243,822
Tin salts—	
Pounds	9,573,719
Value	$904,679
All other, value	$11,025,544
Miscellaneous, value	$5,743,070
Products consumed:	
Acids—	
Sulphuric, tons	95,768
Nitric, pounds	4,976,461
Ether, pounds	1,868
Pyroxylin, pounds	2,926,266
All other products consumed, pounds	3,135,902,134

TABLE 156.—PAINTS—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905.

	United States.
Materials used, total cost	$46,306,183
Limestone and cliffstone—	
Tons	13,520
Cost	$24,841
Gums—	
Pounds	4,612,369
Cost	$624,463
Pig lead—	
Tons	128,513
Cost	$11,119,402
White lead, dry—	
Pounds	57,569,584
Cost	$2,835,105
White lead, in oil—	
Pounds	326,155
Cost	$15,131
Zinc white—	
Pounds	63,352,603
Cost	$2,731,765
All other pigments—	
Pounds	288,723,657
Cost	$4,469,836
Lime—	
Bushels	3,538
Cost	$1,072
Coal tar colors—	
Pounds	645,499
Cost	$243,794
Oils—	
Linseed—	
Gallons	16,641,795
Cost	$6,222,169
Cottonseed—	
Gallons	1,000
Cost	$400
All other—	
Gallons	2,146,960
Cost	$478,728
Alcohol (grain)—	
Gallons	6,613
Cost	$15,971
Alcohol (wood)—	
Gallons	48,708
Cost	$46,025
All other solvents—	
Gallons	8,919,937
Cost	$2,631,616
Sulphuric acid—	
Tons	1,337
Cost	$28,062
All other components of products—	
Pounds	232,687,321
Cost	$7,785,634
Fuel	$707,680
Rent of power and heat	$89,026
Mill supplies	$106,527
All other materials	$5,953,739
Freight	$175,197
Products, total value	$67,277,910
Pigments, total value	$11,650,396
White lead, dry—	
Pounds	62,395,868
Value	$2,877,109
Oxides of lead—	
Pounds	49,710,330
Value	$2,590,472
Products—Continued.	
Lamp and other blacks—	
Pounds	757,244
Value	$49,869
Barytes—	
Pounds	22,279,980
Value	$134,674
Fine colors—	
Pounds	7,780,330
Value	$1,076,853
Iron oxides and other earth colors—	
Pounds	47,322,913
Value	$327,994
Dry colors—	
Pounds	84,308,151
Value	$3,678,642
Pulp colors, sold moist—	
Pounds	25,351,515
Value	$915,383
Paints, total value	$39,609,396
White lead, in oil—	
Pounds	216,460,087
Value	$11,226,889
Paints in oil, in paste—	
Pounds	124,948,405
Value	$8,298,483
Paints already mixed for use—	
Gallons	21,822,755
Value	$20,084,024
Varnishes and japans, total value	$2,568,800
Oil and turpentine varnishes—	
Gallons	2,236,024
Value	$1,701,151
Alcohol varnishes—	
Gallons	85,675
Value	$134,221
Pyroxylin varnishes—	
Gallons	3,892
Value	$4,003
Liquid dryers, japans, and lacquers, value	$499,411
All other products in this group, value	$230,014
Fillers, total value	$1,847,311
Liquid—	
Gallons	541,146
Value	$415,915
Paste, dry and putty—	
Pounds	65,982,997
Value	$1,431,396
Water paints and kalsomine, total value	$934,037
Dry or in paste—	
Pounds	27,932,447
Value	$924,807
Mixed for use—	
Gallons	123,400
Value	$9,230
All other products, value	$10,667,970
Products consumed:	
White lead, dry, pounds	122,288,484
Lead oxides, pounds	13,589,147
Linseed oil, gallons	325,145
Varnishes, gallons	1,099,908
Drying japans and dryers, gallons	960,679
Collodion and other cellulose nitrate solutions, gallons	1,570,642
All other products consumed, pounds	1,764,281

TABLE 157.—FERTILIZERS—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905.

	United States.
Materials used, total cost	$39,343,914
Fish—	
Thousands	923,305
Cost	$880,142
Kainit—	
Tons	190,493
Cost	$1,891,073
Limestone—	
Tons	20,281
Cost	$10,731
Phosphate rock—	
Tons	888,571
Cost	$4,244,554
Pyrites—	
Tons	342,962
Cost	$2,020,759
Sulphur—	
Tons	4,210
Cost	$92,234
Lime—	
Bushels	22,131
Cost	$3,475
Potash salts—	
Tons	122,107
Cost	$3,606,701
Nitrate of potash—	
Tons	1,160
Cost	$39,039
Nitrate of soda—	
Tons	42,213
Cost	$1,760,432
Wood ashes—	
Bushels	17,083
Cost	$2,050
Sulphuric acid—	
Tons	197,865
Cost	$1,084,304
Acid phosphate—	
Tons	320,559
Cost	$2,912,010
Ammoniates—	
Tons	125,888
Cost	$2,445,051
Ammonium sulphate—	
Tons	10,540
Cost	$600,856
Common salt—	
Tons	2,406
Cost	$13,245
Materials used—Continued.	
Cottonseed and cottonseed meal, cost	$2,376,448
Bones, tankage, and offal, cost	$5,094,149
All other components of products, cost	$5,591,236
Fuel	$953,490
Rent of power and heat	$33,737
Mill supplies	$124,962
All other materials	$3,193,992
Freight	$369,244
Products, total value	$56,632,853
Fertilizers, total value	$50,506,294
Superphosphates—	
From minerals, bones, etc.—	
Tons	766,338
Value	$7,515,257
Ammoniated—	
Tons	775,987
Value	$12,901,057
Complete—	
Tons	1,329,149
Value	$25,673,511
All other—	
Tons	396,303
Value	$4,416,469
Sulphuric acid, total value	$194,578
66° Baumé—	
Tons	337
Value	$9,251
50° Baumé—	
Tons	23,997
Value	$185,327
Other acids—	
Tons	45,689
Value	$241,506
Epsom salts—	
Pounds	1,712,698
Value	$13,716
Soda products—	
Tons	3,241
Value	$36,935
All other products, value	$5,639,824
Products consumed:	
Sulphuric acid, tons	692,904
Acid phosphate, tons	884,211
All other products, tons	99,785

TABLE 158.—EXPLOSIVES—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905.

	United States.
Materials used, total cost	$17,203,667
Wood—	
Cords	5,628
Cost	$38,780
Pyrites—	
Tons	12,256
Cost	$67,261
Sulphur—	
Tons	[1] 19,574
Cost	[2] $507,469
Charcoal—	
Bushels	1,251,749
Cost	$232,048
Nitrate of soda—	
Tons	133,034
Cost	$5,608,557
Nitrate of potash—	
Tons	2,336
Cost	$175,258
Chloride of potassium—	
Tons	1,329
Cost	$51,831
Cotton—	
Pounds	3,749,293
Cost	$369,228
Sulphuric acid—	
Tons	18,298
Cost	$247,301
Nitric acid—	
Pounds	2,699,500
Cost	$122,047
Mixed acid—	
Pounds	105,552,404
Cost	$3,093,429
Glycerin—	
Pounds	24,561,527
Cost	$3,129,665
Aqua ammonia—	
Pounds	997,830
Cost	$46,916
Alcohol—	
Gallons	850,560
Cost	$231,353
Materials used—Continued.	
All other components of products, cost	$1,516,859
Fuel	$509,860
Rent of power and heat	$175
Mill supplies	$128,291
All other materials	$973,010
Freight	$154,329
Products, total value	[3] $29,602,884
Explosives, total value	$27,695,963
Gunpowder (black)—	
Pounds	10,383,944
Value	$1,541,483
Blasting powder—	
Kegs	8,217,448
Value	$7,377,977
Nitroglycerin—	
Pounds	7,935,936
Value	$1,620,117
Dynamite—	
Pounds	130,920,829
Value	$12,900,193
Guncotton or pyroxylin (sold as such)—	
Pounds	293,970
Value	$167,322
Smokeless powder—	
Pounds	6,009,855
Value	$3,938,073
All other explosives, value	$150,798
All other products, value	$1,906,921
Products consumed:	
Saltpeter, pounds	3,559,376
Nitroglycerin, pounds	44,077,828
Sulphuric acid, tons	30,994
Nitric acid, tons	18,988
Charcoal, bushels	1,156,918
Ether, pounds	2,740,286
Nitrate of ammonia, pounds	2,863,857
All other products consumed, pounds	6,299,317

[1] Includes 1,004 tons of coal and guhr in California.
[2] Includes $5,649 cost of coal and guhr in California.
[3] Exclusive of 2 governmental establishments reporting products valued at $574,832.

TABLE 159.—VARNISHES—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905.

	United States.
Materials used, total cost	$13,520,491
Gums—	
Pounds	33,091,256
Cost	$3,704,161
White lead, dry—	
Pounds	2,608,870
Cost	$131,658
White lead, in oil—	
Pounds	15,859
Cost	$1,204
Zinc white—	
Pounds	1,992,900
Cost	$79,750
All other pigments—	
Pounds	21,640,280
Cost	$521,812
Lime—	
Bushels	12
Cost	$6
Coal tar colors—	
Pounds	7,433
Cost	$3,223
Oils—	
Linseed—	
Gallons	3,765,309
Cost	$1,647,101
Cottonseed—	
Gallons	4,800
Cost	$1,440
All other—	
Gallons	1,106,534
Cost	$531,089
Alcohol (grain)—	
Gallons	51,070
Cost	$118,433
Alcohol (wood)—	
Gallons	1,217,008
Cost	$693,402
All other solvents—	
Gallons	14,276,709
Cost	$3,458,939
Pyroxylin—	
Pounds	52,530
Cost	$40,953
Mixed acid—	
Tons	26
Cost	$1,046
All other components of products, cost	$919,300
Fuel	$125,818
Rent of power and heat	$7,497
Mill supplies	$14,307
All other materials	$1,369,608
Freight	$149,744

	United States.
Products, total value	$23,561,699
Pigments, total value	$315,410
Oxides of lead—	
Pounds	24,000
Value	$1,300
Barytes—	
Pounds	20,000
Value	$100
Iron oxides and other earth colors—	
Pounds	1,023,065
Value	$3,422
Dry colors—	
Pounds	6,105,600
Value	$310,588
Paints, total value	$780,663
White lead, in oil—	
Pounds	36,363
Value	$2,000
Paints in oil, in paste—	
Pounds	6,992,059
Value	$414,700
Paints already mixed for use—	
Gallons	556,265
Value	$363,963
Varnishes and japans, total value	$20,302,686
Oil and turpentine varnishes—	
Gallons	14,926,695
Value	$14,001,846
Alcohol varnishes—	
Gallons	1,467,887
Value	$2,046,492
Pyroxylin varnishes—	
Gallons	144,428
Value	$158,160
Liquid dryers, japans, and lacquers, value	$2,846,944
All other products of this group, value	$1,249,244
Fillers, total value	$497,325
Liquid—	
Gallons	510,002
Value	$369,702
Paste and dry putty—	
Pounds	2,778,177
Value	$127,623
All other products, value	$1,665,615
Products consumed:	
Linseed oil, gallons	30,000
Varnishes, gallons	102,766
Drying japans and dryers, gallons	28,300
Collodion and other cellulose nitrate solutions, gallons	5,800
Pyroxylin and other cellulose nitrates, pounds	12,000

TABLE 160.—DYESTUFFS AND EXTRACTS—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905.

	United States.
Materials used, total cost	$6,829,340
Wood—	
Cords	258,981
Cost	$795,786
Bark—	
Tons	103,119
Cost	$948,997
Logwood—	
Tons	37,733
Cost	$678,590
Sumac leaves—	
Tons	4,456
Cost	$93,519
Palmetto root—	
Tons	4,350
Cost	$11,500
Indigo, natural—	
Pounds	96,500
Cost	$82,000
Coal tar colors—	
Pounds	1,802,826
Cost	$293,573
Sulphuric acid—	
Pounds	3,557,884
Cost	$49,779
Other acids—	
Pounds	5,301,413
Cost	$71,393
All other components of products, cost	$2,822,676
Fuel	$386,249
Rent of power and heat	$976
Mill supplies	$53,799
All other materials	$469,835
Freight	$70,668
Products, total value	$10,893,113
Dyestuffs—	
Natural—	
Pounds	8,172,552
Value	$233,935
Artificial—	
Pounds	4,600,462
Value	$1,764,454
Mordants—	
Pounds	733,245
Value	$64,656
Iron liquor—	
Pounds	1,860,744
Value	$30,757
Turkey red oil—	
Pounds	3,022,470
Value	$159,666
Products—Continued.	
Logwood extract—	
Pounds	29,799,606
Value	$1,472,047
Ground bark—	
Pounds	38,001,017
Value	$249,101
Ground and chipped wood—	
Pounds	9,999,906
Value	$95,237
Ground sumac—	
Pounds	5,061,333
Value	$65,190
Extracts—	
Sumac—	
Pounds	4,093,619
Value	$95,958
Hemlock—	
Pounds	18,833,450
Value	$406,619
Oak and chestnut—	
Pounds	156,520,123
Value	$2,411,184
Palmetto—	
Pounds	1,740,000
Value	$34,800
Chrome tannage solution—	
Pounds	2,847,400
Value	$85,422
Other tanning liquors—	
Pounds	41,571,529
Value	$1,618,821
Tannic acid—	
Pounds	5,165,500
Value	$200,136
Sizes—	
Pounds	7,812,433
Value	$217,859
Gums and dextrin—	
Pounds	6,651,731
Value	$231,708
All other products, value	$1,455,563
Products consumed:	
Ground wood, pounds	524,505,744
Ground bark, pounds	40,390,640
Ground leaves, pounds	3,586,171
Ground roots, pounds	1,141,513
All other products consumed, pounds	1,728,797

TABLE 161.—SULPHURIC, NITRIC, AND MIXED ACIDS—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905.

	United States.
Materials used, total cost	$4,972,838
Pyrites—	
Tons	197,847
Cost	$967,207
Sulphur—	
Tons	23,044
Cost	$479,529
Nitrate of soda—	
Tons	27,406
Cost	$1,143,280
Sulphuric acid—	
Tons	98,252
Cost	$992,549
Nitric acid—	
Pounds	1,960,000
Cost	$98,000
All other components of products, cost	$540,266
Fuel	$366,129
Rent of power and heat	$5,549
Mill supplies	$23,051
All other materials	$356,110
Freight	1,168
Products, total value	$9,052,646
Sulphuric, nitric, and mixed acids, total value	$6,955,078
Oleum—	
Tons	13,268
Value	$361,018
Sulphuric acid, 66° Baumé—	
Tons	199,663
Value	$2,886,179
Products—Continued.	
Sulphuric, nitric, and mixed acids—Continued.	
Sulphuric acid, 60° Baumé—	
Tons	13,634
Value	$121,432
Sulphuric acid, 50° Baumé—	
Tons	128,389
Value	$917,683
Nitric acid—	
Pounds	30,306,555
Value	$1,446,471
Mixed acid—	
Pounds	42,812,894
Value	$1,222,295
Pyrite cinder—	
Tons	93,146
Value	$97,089
Niter cake—	
Tons	24,845
Value	$33,264
All other products, value	$1,967,215
Products consumed:	
Sulphuric acid, 66° Baumé, tons	51,083
Sulphuric acid, 60° Baumé, tons	14,703
Sulphuric acid, 50° Baumé, tons	6,601
Nitric acid, pounds	18,875,989
All other products consumed, tons	984,560

TABLE 162.—WOOD DISTILLATION—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905.

	United States.		United States.
Materials used, total cost	$4,847,770	Products—Continued.	
Wood—		Wood alcohol—Continued.	
Cords	586,144	Refined wood alcohol—	
Cost	$1,783,004	Gallons	4,316,346
Lime—		Value	$2,613,886
Bushels	523,334	Acetate of lime—	
Cost	$101,068	Pounds	105,141,361
Soda—		Value	$1,474,982
Pounds	371,780	Charcoal—	
Cost	$5,484	Bushels	23,872,055
Crude wood alcohol—		Value	$1,197,973
Gallons	5,723,011	Turpentine—	
Cost	$1,976,156	Gallons	442,185
Smoke, cost	$22,988	Value	$176,521
Fuel	$578,251	All other wood distillation products, value	$138,481
Rent of power and heat	$850	All other products, value	$49,827
Mill supplies	$23,480	Products consumed:	
All other materials	$305,205	Crude wood alcohol, gallons	[1] 620,391
Freight	$51,284	Charcoal, bushels	11,026,978
Products, total value	$7,813,483		
Wood alcohol, total value	$4,775,699		
Crude wood alcohol—			
Gallons	6,684,871		
Value	$2,161,813		

[1] Includes 54,800 gallons of pyroligneous acid consumed in Massachusetts.

TABLE 163.—OIL, ESSENTIAL—DETAILED SUMMARY, MATERIALS AND PRODUCTS: 1905.

	United States.		United States.
Materials used, total cost	$1,110,470	Products—Continued.	
Principal materials, total cost	$1,068,176	Natural essential oils—Continued.	
Purchased in raw state—		Sassafras—	
Tons	53,201	Pounds	30,235
Cost	$307,351	Value	$17,673
Purchased in partially manufactured form—		Wintergreen—	
Pounds	1,693,570	Pounds	4,737
Cost	$760,825	Value	$15,579
Fuel	$10,159	Other natural oils—	
Rent of power and heat	$3,592	Pounds	297,673
Mill supplies	$1,965	Value	$520,648
All other materials	$22,245	Witch hazel—	
Freight	$4,333	Gallons	797,700
Products, total value	$1,464,662	Value	$367,873
Natural essential oils, total value	$1,391,810	All other products, value	$72,852
Peppermint—			
Pounds	130,022		
Value	$470,037		

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