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THE CHEMICAL INDUSTRIES OF AMERICA[1]

THE topic which you have done me the honor to invite me to address you upon appears on first consideration quite specific, but investigation shows that this is not quite the case. Thus we find the popular idea of a chemical industry to be one producing acids, alkalies, salts, explosives, fertilizers, dyestuffs and extracts, pigments, distillation products and elementary substances like bromine, phosphorus, sodium and others, and the officials of the U. S. Census Bureau in 1880, in fixing a classification, styled in the various censuses "chemical production" or "chemicals and allied products," adopted this popular view.

In discussing this, I have said:[2]

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

[1] Address delivered before the American Institute of Chemical Engineers at Philadelphia, December 9, 1909.

[2] Bull. 92, Census of 1905, p. 9, by Charles E. Munroe.

undergo no chemical change during the process of compounding the mixtures. It thus became 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: sulphuric, nitric, mixed and other acids; sodas; potashes; alums, coal tar products; cyanides, wood distillation; fertilizers; bleaching materials; chemicals produced by the aid of electricity; dyestuffs; tanning materials; paints and varnishes; explosives; plastics; essential oils; compressed and liquefied gases; fine chemicals; general chemicals.

These were consequently divided into nineteen different classes which were given separate treatment. The combined statistics for these classes for the censuses of 1900 and 1905 are set forth in the following table, the statistics of these two censuses only being compared because they alone dealt with the same materials:

TABLE I. CHEMICALS AND ALLIED PRODUCTS OF THE UNITED STATES, 1900 AND 1905

	Establishments. Number.	Wage Earners. Number.	Total Wages.	Materials Used. Cost.	Products. Value.
1905	1,786	59,198	$29,515,863	$176,400,680	$282,169,216
1900	1,691	46,700	21,783,335	124,018,044	202,506,076
Increase	95	12,498	7,732,528	52,382,636	79,663,140
Per cent. of increase	5.6	26.8	35.5	42.2	39.3

From Table I. it is observed that there was an increase in every item enumerated, but that not only was the actual increase in the number of establishments less than that of any other item, as was to be expected, but that the percentage increase was less. This indicates that the growth of these industries was rather by increased production of existing establishments than by the creation of new ones. In fact, in a more detailed analysis it was found that in some industries the number of establishments had actually decreased, though each of the other items, as enumerated in Table I., showed an increase.

The greater percentage increase in wages over that of the percentage increase in wage earners shows that the lot of the latter was improved and possibly indicates that a better class of labor was employed, and, since the percentage increase in the number of salaried officials for these establishments was 29.6, while the percentage increase in salaries was but 32.4 it is obvious that the wage earners fared, on the whole, better than the salaried officials.

A wholesome feature to be observed is that while the increase in the number of men employed was 12,104, the increase in the number of women employed was but 413, while there was a decrease of over 10 per cent. in the number of children employed. I speak of this condition as a wholesome one because, outside of the clerical and perhaps analytical work, the duties to be performed in these establishments is essentially man's work.

The greater percentage increase in the cost of materials used as compared with the percentage increase in the value of the products shows the growing necessity of intelligent and careful management and skillful workmanship to prevent waste and to increase yields. This is emphasized by examination of the additional item of miscellaneous expenses which, while less in the total than any of the values given in Table I., showed an increase of 77.2 per cent.

As indicated, the census classification of "Chemicals and Allied Products" which gave the data just discussed is a purely empirical one, and it deals with but a very few of the true chemical manufactures of the United States. It is not possible to derive from the returns, of the various

industries as taken, the data for an exact scientific classification such as has been referred to above. Yet, in order to arrive at a better conception of the application of chemistry in manufacturing industries and its magnitude, we may follow such a scheme of classification as that employed in many chemical technologies, though here again we meet with the difficulties common to classification and we are compelled to include in our data some of the products of purely physical processes, either because these processes are operated collaterally with, or related to, the predominating chemical processes, or else because the products are closely associated with the chemical products. In assembling this data it should be said that in order to compare the data of the different epochs one must first eliminate from the data of 1900 the returns for neighborhood industries, for the census of 1905 was a factory census considering only the results of manufacture as carried out in factories, and not solely for consumption at the point where manufactured as is generally the case with neighborhood industries. The results of this treatment are set forth in Table II.

than is set forth in Table I. The increase is easily accounted for by noting that items such as soap, with a product valued at over $68,000,000; glass over $79,000,000; illuminating gas over $125,000,000; dairy products over $168,000,000; refined petroleum over $175,000,000; paper and wood pulp over $188,000,000; bread and other bakery products over $269,000,000; sugar and molasses over $277,000,000; vinous, malt and distilled liquors over $340,000,000; smelting and refining of copper, lead and zinc over $461,000,000; iron and steel over $905,000,000, and many other items have been added to those embraced in Table I.

The simple enumeration of these items indicates how incomplete the statistics usually presented as those of the chemical industries are and how insufficient the popular conception of the chemical industries is. Yet even the data of Table II. does not present the case in full since all agricultural products, amounting in value in 1900 to $4,717,069,973 are really the results of chemical processes and are therefore the products of chemical industries although not factory products.

TABLE II. CHEMICAL INDUSTRIES OF THE UNITED STATES, 1880 AND 1905

	1905	1900	1890	1880
Establishments, number	56,580	53,567	40,451	34,864
Wage earners, average number	1,107,714	943,166	677,123	490,776
Wages, total	$ 575,635,257	$ 438,404,062	$ 305,884,278	$ 176,227,726
Materials used, cost	2,933,660,817	2,215,162,767	1,247,239,582	924,573,773
Products, value	4,716,490,371	3,628,641,475	2,152,490,514	1,357,503,293

Table II., imperfect though it be both in the industries it includes and in those it omits, gives a better conception of the actual magnitude of the industries in which chemical transformations play a part, and which are therefore really chemical industries, than Table I. does, and in so doing it shows the value of the products for 1905 alone to be nearly seventeen-fold greater

As with Table I. so with Table II., the deductions are more readily drawn by observation of the increase and percentages of increase for each item at the various epochs. These have, therefore, been ascertained and are set forth in Table III.

Considering now the data of Table II. and more particularly the increases and percentages of increase set forth for each

TABLE III. INCREASES AND PERCENTAGES OF INCREASES FOR CHEMICAL INDUSTRIES

	1900 to 1905		1890 to 1900		1880 to 1890	
	Increase	Per Cent.	Increase	Per Cent.	Increase	Per Cent.
Establishments, number	3,013	5.6	13,116	32.4	5,537	16.0
Wage earners, average number.	164,548	17.4	266,043	39.3	186,347	38.0
Wages	$ 137,231,195	31.3	$ 132,519,784	43.3	$129,656,552	73.6
Materials used, cost	718,498,053	32.4	967,923,182	77.7	322,665,809	34.9
Products, value	1,087,848,896	30.0	1,476,150,961	68.6	795,987,221	58.6

epoch in Table III., while keeping firmly in mind the fact that we are here dealing with two ten-year periods and one five-year period, it is again to be noted that both the actual and percentage increases in the number of establishments are the smallest of all the various increases set forth and that increase for this item for the 1900–05 period is not only actually less than for 1890–1900 and 1880–90, as should be expected, but is proportionately less, thus emphasizing what has been deduced from Table I. as to the increased production of existing establishments.

Likewise the consideration of the data for this larger number of industries extending over a greater length of time shows that not only is the percentage increase in wages nearly as great at the census of 1905 as those for cost of materials and greater than the value of products, but that, while the proportionate increase in the number of wage earners for the 1900–05 period is less than that of 1890–1900, the proportionate gain in wages is greater. In fact, all statistics point to markedly improved conditions for the wage earner in the chemical industries, and to his increased participation in the income from the enterprise. This fact is one to be reckoned on by the chemical engineer in making up his estimate for the cost of a projected enterprise which it is proposed to install.

The statistics of Tables II. and III., on the other hand, do not so markedly support the deductions drawn from Table I. as to the increase in cost of materials used when compared with the increase in the value of the products in 1900–05. However, when we consider the larger items included in these later statistics, such as iron and steel, smelting and refining of copper, lead and zinc, and others, we may each of us recall a variety of labor-saving devices which have been invented and introduced for cheapening the cost of production and handling of the raw materials of these industries, and that the inventions have increased in number and perfection with the growth in magnitude of these industries.

An increase in cost of materials is in conformity with the long-recognized natural law of supply and demand. A modification of this law through which labor may get its fair share of increase and capital may get its fair share of increase while the actual cost may not proportionately be increased has been brought about in recent times through the increase in the magnitude of the unit of demand, or in other terms, the quantity handled. As stated, this has to an extent been rendered possible by the introduction of labor-saving machinery, much of which has been invented in this country.

But in my opinion, and if I read aright the reports of foreign commentators on our chemical industries, in their opinions, the chief modification in the operation of this law has been made in this country through the development of "team work," though the writers style it organization or systemization.

Entering on my fortieth consecutive year

of college teaching, I might, from what has been so persistently dinned into my ears, have been led to believe that "team work" originated in the minds of the college youths who flock to Franklin Field or to the Harvard Stadium. Sitting on the bleachers with practical politicians and presidents, I might be led to suppose that "team work" was an invention of the professional athlete. As a fact the idea of "team work" is a very old one and military in its essence and original application. It is embodied in our national motto. It is commemorated in the "Charge of the Light Brigade." But this older practise, while greatly promoting efficiency, demanded such unreasoning subordination that the private soldier was properly looked upon as but "food for powder," and when this system was introduced into the factory the operator became but "a cog in the machine."

The modification in this plan of "team work" which has been developed to such advantage in the industrial plants of this country has come through a recognition of the great value of individuality and the necessity for its preservation and development, and it has been demonstrated that the higher the intelligence of the individuals who merge their entities with that of their fellows in a common purpose, and the more complete their comprehension of the means used and the end sought, the more successful is the result whether gauged by the quality, or the quantity, or the cost of the output. I am happy to say that the chemist has destroyed the older military idea, even in the army, for by his invention of high-powered smokeless powder he has compelled armies to fight in open order so that each individual must exercise his own powers in attack and defense, and be trained to take the initiative in case of necessity.

Naturally the application of labor-saving machinery and of "team work" is most readily made and yields most efficient results in the production, transportation and handling of the raw materials of our larger industries, and it is in these that we find the smaller proportionate increase in the cost of materials.

American industries, in which the chemical industries are included, have signalized themselves by the introduction of standards, by the introduction of interchangeable parts into mechanisms, by the wide application of labor-saving machinery and by the use of "team work." Yet notwithstanding the vast resources of this country, their ease of access, and the cheapening, by methods such as described, of many of costs of production, the cost of "living," not only here but throughout the civilized world, has steadily increased, and I attribute this largely to the work of the chemist.

At St. Louis, in 1904, I said:

> Technical chemistry, then, invades the domains of economics, of politics and of diplomacy. A striking example of its effects in economics and politics is found in the settlement of the silver question. Gold is a most widely diffused metal. It has, for instance, been shown by assayers at the U. S. Mint at Philadelphia that if the gold in the clay of the bricks of which the buildings of the Quaker City are built could be brought to the surface, the fronts would all be gilded. In the past our processes for the isolation of this metal have been so costly that only the richer ores would bear treatment. Large bodies of low-grade ores which have been discovered and mountains of tailings carrying values were looked upon as worthless, while enormous quantities of copper, lead and other metals containing gold were sent into the market to be devoted to common uses, because the cost of separation was greater than the value of the separated products. Eight years ago, when the "silver question" was made the national issue, while the orators were declaiming from the stump, the chemists were quietly working at the problem in their laboratories and factories. Manhé's process for bessemerizing copper

ores was combined with the electrolytic refining of the product, so that even traces of gold were economically recovered, while the cyanide processes, such as the MacArthur-Forrest, the Siemens-Halske, the Pelatan-Clerici and others for the extraction and recovery of gold from low-grade ores and tailings, were successfully worked out and put into practical operation to such effect that by the cyanide processes alone gold to the value of $7,917,129 was recovered in the United States in 1902, which is more than was ever won throughout the whole world by all methods in any one year up to 1661, and probably up to 1701. The data for other purposes are not at hand for 1902, but the returns for 1900 show that gold to the value of $88,985,218 was recovered in the treatment of lead and copper ores in the United States, of which $56,566,971 worth was recovered in refining. It has but recently been publicly proclaimed in this city of St. Louis, that the "silver question" is settled, and it is settled, but it was settled largely through the efforts of the technical chemist and metallurgist.

With the improvements in methods and diminution in cost of extraction the Pactolean stream has continued to flow in steadily increasing volume[3] until the flood of gold has become so great that its purchasing power has become markedly reduced, and costs, measured in terms of gold, have become markedly greater. With this condition well determined the chemist has again stepped in to increase the cost of living by requiring the application of costly methods of inspection of food, drugs and other articles of consumption; by demanding the elimination of preservatives which permitted the abundance of the harvest being kept till time of need; or the plethora of one locality being sent to the land smitten with leanness; by insisting on the introduction of expensive sanitary arrangements. Pure food laws are the vogue, and all the other needs of man are becoming the subject of special legislation, some wise, but much otherwise. It would prove an interesting exhibit if a statistician were to assemble the actual costs in the administration and execution of these laws in this country alone during the past five years.

[3] PRODUCTION OF GOLD

Year	World's Production		Production in U. S.	
	Fine Ounces	Value	Fine Ounces	Value
1878	5,761,114	$119,092,800	2,476,800	$51,200,000
1888	5,330,775	110,196,900	1,604,841	43,175,000
1898	13,877,806	286,879,700	3,118,398	64,463,000
1908	21,378,481	441,932,200	4,574,349	94,560,000

I speak with earnestness because I have repeatedly been a participant in these movements, and am even now engaged in an analogous humanitarian enterprise, and I know that a certain result of all such endeavors to improve the lot of man is to put the community to an increased expense.

Having confessed myself, and having found my profession guilty, as charged, I now assert that a chief duty of our profession is to determine methods by which the income may be increased or the costs of living in the land decreased, or preferably both, and I urge as a first measure the advocacy of the policy of preventing any material from leaving the country until it has passed through all processes of manufactures of which it is capable. The meaning of this is evident on inspection of the exports of domestic merchandise prepared by the U. S. Bureau of Statistics, where we find that in 1908 over 885 million dollars worth, or 48.19 per cent., of the total exports consisted of cotton, breadstuffs, meat and dairy products, and coal, much of which had not undergone any degree of manufacture whatever. All this food should have been elaborated in this country into brain and brawn, and the coal made to yield its energy, and these should have been expended here in manufacture. We should further have put into manufactured form the raw materials of other lands.

Inspecting, on the other hand, the table of imports of merchandise prepared by the U. S. Bureau of Statistics, we find in 1908

TABLE IV. VALUES OF EXPORTS OF DOMESTIC MERCHANDISE, BY PRINCIPAL ARTICLES AND CLASSES, IN ORDER OF MAGNITUDE IN 1908, DURING THE YEARS ENDING JUNE 30, 1902–1908

Order of Magnitude, 1908	ARTICLES	1902	1903	1904	1905	1906	1907	1908 Value	1908 Per Cent. of Total
1	Cotton, unmanufactured	$290,651,819	$316,180,429	$370,811,246	$379,965,014	$401,005,921	$481,277,797	$437,788,202	23.86
2	Breadstuffs	213,134,344	221,242,285	149,050,378	107,732,910	186,468,901	184,120,702	215,260,588	11.73
3	Meat and dairy products	199,861,378	179,839,714	176,027,786	169,998,873	210,990,065	202,392,508	192,802,708	10.51
4	Iron and steel, and manufactures of	98,552,562	96,642,467	111,948,586	134,728,363	160,984,985	181,530,871	183,982,182	10.03
5	Copper, and manufactures of	43,820,070	40,594,613	58,119,006	87,564,009	83,178,635	96,600,698	105,872,711	5.77
6	Mineral oils	72,302,822	67,253,533	79,060,469	79,793,222	84,041,327	84,855,715	104,116,440	5.67
7	Wood, and manufactures of	47,779,848	57,743,785	65,428,417	58,002,977	69,080,394	85,349,575	81,521,305	4.44
8	Leather, and manufactures of	29,798,323	31,617,389	33,980,615	37,936,745	40,642,858	45,476,969	40,688,619	2.22
9	Tobacco, and manufactures of	32,772,849	40,444,689	34,683,531	35,491,019	34,218,847	39,115,011	39,463,679	2.15
10	Coal	20,765,461	21,206,498	27,820,323	29,138,322	28,216,376	34,727,762	39,355,779	2.15
11	Animals	44,871,684	34,781,193	47,977,875	46,728,281	49,129,568	41,203,080	34,101,289	1.86
12	Cotton, manufactures of	32,108,362	32,216,[illegible]04	22,403,713	49,666,080	52,944,033	32,305,412	25,177,758	1.37
13	Agricultural implements	16,286,740	21,006,622	22,749,635	20,721,741	24,554,427	26,936,456	24,344,398	1.33
14	Cars, carriages, etc.	9,872,516	10,499,195	10,956,618	10,610,437	17,788,425	20,513,407	22,072,902	1.20
15	Naval stores	11,733,562	12,918,708	16,145,222	16,106,643	20,075,785	21,686,752	21,641,599	1.18
16	Oil cake and oil-cake meal[4]	19,779,142	19,743,711	16,899,257	21,498,085	23,386,218	25,738,471	21,064,974	1.15
17	Chemicals, drugs, dyes and medicines	13,626,837	14,150,493	15,065,682	16,595,523	19,155,989	20,373,036	20,873,155	1.14
18	Vegetable oil	15,308,633	16,234,362	12,618,381	16,652,232	15,906,031	19,550,514	19,653,967	1.07
19	Fruits and nuts	8,719,344	18,057,677	20,678,665	15,606,586	15,274,158	17,588,432	14,338,864	.78
20	Instruments for scientific purposes	5,389,476	7,130,508	8,297,723	8,172,980	10,887,774	13,661,455	11,578,010	.63
21	Fertilizers	6,256,035	6,724,301	7,112,512	7,620,886	8,686,965	8,596,711	10,970,931	.59
22	Paraffin and paraffin wax	8,858,844	9,411,294	8,859,964	7,789,160	8,808,245	9,030,992	8,740,929	.48
23	Seeds	8,027,824	9,455,283	2,583,325	2,557,747	8,912,662	10,094,609	8,683,688	.47
24	Paper, and manufactures of	7,312,030	7,180,014	7,543,728	8,238,088	9,536,065	9,856,733	8,064,706	.44
25	Furs, and fur skins	5,030,204	6,181,115	5,422,945	6,599,222	8,002,282	7,139,221	7,712,890	.42
26	India rubber, manufactures of	4,032,100	4,675,177	5,148,959	5,508,664	6,543,735	7,428,714	7,573,570	.41
27	Fibers, vegetable, etc., manufactures of	4,575,219	5,290,948	6,414,656	6,766,809	8,157,211	8,308,112	7,225,798	.39
28	Books, maps, engravings, etc.	3,997,977	4,442,653	4,347,304	4,844,160	5,839,452	5,813,107	6,107,053	.33
29	Grease, grease scraps, etc.	2,610,925	2,926,565	3,311,771	3,710,907	4,138,333	5,473,623	5,762,709	.31
30	Fish	6,563,199	6,717,274	7,857,047	6,527,863	7,579,178	5,536,856	5,685,916	.31
31	Household and personal effects	2,570,369	2,672,787	2,615,076	3,146,969	3,595,128	3,928,946	4,782,456	.26
32	Coffee, green	3,209,946	3,265,968	3,056,943	1,966,107	3,488,238	4,692,157	4,314,020	.24
33	Sugar, molasses and confectionery	3,257,329	3,104,653	3,522,805	4,131,707	4,526,334	3,973,360	4,068,357	.22
34	Paints, pigments and colors	2,096,379	2,350,937	2,756,581	3,126,317	3,773,064	3,931,899	4,001,824	.22
35	Vegetables	2,546,287	2,543,488	2,603,374	3,200,860	3,567,127	4,007,883	3,895,294	.21
36	Explosives	2,062,381	2,474,710	2,441,596	2,559,837	3,568,038	4,082,402	3,705,517	.20
37	Brass, and manufactures of	1,930,810	2,000,432	2,557,484	3,025,764	3,474,981	4,580,455	3,701,871	.20
38	Soap	1,630,938	2,452,777	2,499,953	2,670,251	2,781,179	3,806,097	3,407,220	.19
39	Musical instruments	3,694,143	3,381,509	3,230,982	3,144,787	3,168,052	3,256,063	3,371,521	.18
40	Hops	1,550,657	1,909,951	2,116,180	4,480,666	3,125,843	3,531,772	2,963,167	.16
41	Nickel, nickel oxide and matte	1,190,606	864,221	940,558	3,196,622	3,240,544	3,218,862	2,948,058	.16
42	Clocks and watches, and parts of	2,144,490	2,133,729	2,281,195	2,316,414	2,598,441	3,169,272	2,848,725	.16
43	Coke	1,720,457	1,912,459	2,223,233	2,228,442	2,435,604	3,013,088	2,718,385	.15
44	Glucose and grape sugar	2,319,286	2,460,022	2,949,545	3,206,794	3,489,192	3,017,527	2,540,640	.14
45	Glass and glassware	1,960,106	2,150,699	1,978,481	2,252,799	2,433,904	2,604,717	2,505,417	.14
46	Wool, manufactures of	1,512,457	1,722,128	1,987,908	2,035,054	2,119,518	2,239,106	2,219,815	.12
47	Lamps, chandeliers, etc.	963,658	1,133,290	1,502,888	1,579,125	1,9[illegible]5,091	1,875,869	1,827,216	.10
48	Spirits, distilled	2,673,273	1,990,091	1,691,467	1,968,767	1,525,225	1,827,757	1,816,287	.10
49	Zinc, and manufactures of	2,017,191	2,346,629	1,710,211	3,085,245	2,780,199	2,143,574	1,606,032	.09
50	Hay	2,580,622	828,483	1,052,705	1,089,505	1,116,307	976,287	1,463,010	.08
51	Marble, stone, and manufactures of	1,761,696	1,465,244	1,589,790	1,283,219	1,466,561	1,433,123	1,248,996	.07
52	Starch	656,705	832,943	1,340,282	1,430,572	1,490,797	1,126,465	1,142,054	.06
53	Malt liquors	1,290,062	1,178,740	854,119	1,012,808	1,116,776	1,215,340	1,020,172	.06
	All other articles	23,761,904	22,557,283	25,770,532	30,732,482	30,298,594	35,784,782	38,463,024	2.10
	Total	$1,355,481,861	$1,392,231,302	$1,435,179,017	$1,491,744,641	$1,717,953,382	$1,853,718,034	$1,834,786,357	100.00

[4] Corn oil cake not included.

TABLE V. IMPORTS OF MERCHANDISE, BY PRINCIPAL ARTICLES AND CLASSES, YEARS ENDING JUNE 30, 1902–1908

Order of Magnitude, 1908	ARTICLES	1902	1903	1904	1905	1906	1907	1908	
								Value	Per Cent. of Total
1	Sugar	$55,061,097	$72,088,973	$71,915,753	$97,645,449	$85,460,088	$92,806,253	$80,258,147	6.72
2	Chemicals, drugs and dyes	57,723,622	64,351,199	65,294,558	64,779,559	74,477,187	82,997,914	73,237,033	6.13
3	Cotton, manufactures of	44,460,126	52,462,755	49,524,246	48,919,936	63,043,322	73,704,636	68,379,781	5.72
4	Coffee	70,982,155	59,200,749	69,551,799	84,654,062	73,256,134	78,231,902	67,688,106	5.67
5	Silk, unmanufactured	42,635,851	50,011,050	46,100,500	61,040,053	54,080,504	71,411,899	64,546,903	5.40
6	Hides and skins	58,011,168	58,031,613	52,006,070	64,764,146	83,882,167	83,200,545	54,770,136	4.59
7	Fibers, vegetable, etc., manufactures of	39,036,364	39,334,521	40,308,837	40,125,406	51,437,581	67,422,557	54,467,572	4.56
8	Wood, and manufactures of	24,445,599	28,746,271	26,984,353	29,564,323	36,532,706	42,909,941	43,527,982	3.64
9	India rubber and gutta-percha, crude	25,652,977	31,004,541	41,049,434	50,729,873	46,035,685	60,206,418	37,753,266	3.16
10	Fruits and nuts	21,480,525	23,726,636	24,435,854	25,937,456	28,915,747	35,867,160	37,354,742	3.13
11	Fibers, vegetable, etc., unmanufactured	31,545,962	34,402,513	37,814,285	38,118,071	39,360,290	42,239,458	35,493,083	2.97
12	Silk, manufactures of	32,640,242	35,963,552	31,973,680	32,614,540	32,910,590	38,653,251	32,717,668	2.74
13	Iron and steel, manufactures of	27,180,247	51,617,312	27,028,312	23,510,164	29,053,987	40,587,865	27,607,909	2.31
14	Tobacco, and manufactures of	17,706,493	20,579,120	20,073,346	22,145,846	26,590,706	30,124,375	27,267,913	2.28
15	Tin, in bars, blocks and pigs	19,461,850	23,618,802	21,486,311	23,378,471	30,932,998	38,117,459	25,295,061	2.12
16	Copper, manufactures of	10,968,948	17,505,247	18,215,442	19,942,511	25,835,502	39,428,687	24,462,663	2.05
17	Wool, unmanufactured	17,711,788	22,152,961	24,813,591	46,225,558	39,068,372	41,534,028	23,664,958	1.98
18	Spirits, wines and malt liquors	15,246,640	17,171,617	16,662,702	17,652,323	19,257,590	22,104,255	20,771,804	1 74
19	Wool, manufactures of	17,384,463	19,546,385	17,733,788	17,893,663	23,080,683	22,321,460	19,387,978	1.62
20	Oils	9,300,198	12,283,957	11,179,442	11,593,520	13,723,948	17,068,777	18,292,393	1.53
21	Furs, and manufactures of	15,625,601	15,301,912	14,763,002	18,306,302	21,855,682	21,884,064	15,918,149	1.33
22	Diamonds and other precious stones	23,348,225	31,479,223	22,964,119	33,313,931	40,247,010	42,278,901	16,642,634	1.39
23	Articles, the growth, etc., of the United States, returned	5,815,628	7,170,573	9,899,470	9,079,124	11,134,912	11,853,983	16,599,766	1.39
24	Tea	9,390,128	15,659,229	18,229,310	16,230,858	14,580,878	13,915,544	16,309,870	1.37
25	Cocoa, crude, and leaves and shells of	6,656,504	7,720,087	8,873,709	8,577,649	8,697,515	15,376,562	14,257,250	1.19
26	Cotton, unmanufactured	11,712,170	10,892,591	8,541,510	9,414,750	10,879,592	19,930,988	14,172,241	1.19
27	Leather, and manufactures of	11,317,785	11,294,167	11,100,215	11,666,233	15,140,926	20,393,533	14,127,347	1.18
28	Earthen, stone and china ware	9,680,156	10,512,052	12,005,014	11,659,723	12,877,528	13,706,790	13,427,969	1.12
29	Fish	8,527,097	8,635,583	9,889,697	10,498,076	11,607,602	12,355,988	12,292,770	1.03
30	Paper, and manufactures of	4,223,125	4,733,036	5,319,086	5,623,638	6,998,761	10,727,885	12,223,058	1.02
31	Meat and dairy products	3,510,696	4,703,536	4,197,466	4,253,414	5,117,054	6,768,442	8,877,183	.74
32	Vegetables	7,039,835	4,581,355	7,008,602	3,983,272	5,092,932	5,728,472	8,289,068	.69
33	Toys	4,023,670	4,232,074	4,977,389	4,964,457	5,887,863	6,993,561	7,206,423	.60
34	Breadstuffs	2,580,295	3,023,160	3,247,503	6,557,347	4,513,667	4,892,968	7,138,214	.60
35	Copper ore	14,003,840	3,385,524	3,466,381	4,892,961	6,727,861	8,296,528	7,057,080	.59
36	Metal, and manufactures of, not elsewhere specified	6,223,383	7,057,202	7,092,125	7,050,118	7,888,565	10,325,446	6,768,637	.57
37	Glass and glassware	6,205,052	7,255,879	6,583,168	5,948,839	7,507,823	7,596,651	6,570,123	.55
38	Seeds	3,252,152	2,831,279	3,587,469	3,457,619	5,388,043	6,404,776	6,371,470	.53
39	Books, maps, engravings and other printed matter	4,133,215	4,324,938	4,529,187	4,589,858	5,599,948	6,451,309	6,036,693	.51
40	Coal, bituminous	5,310,450	10,562,185	5,043,824	3,713,748	4,367,750	4,184,541	5,123,862	.43
41	Fertilizers	2,426,558	3,100,276	3,503,726	4,524,700	4,446,360	5,541,450	4,970,461	.42
42	Hats, bonnets and hoods, and materials for	3,050,478	3,871,278	3,963,043	4,379,473	4,571,184	6,520,259	4,852,548	.41
43	Rice	2,926,921	3,061,473	3,073,430	2,010,966	3,082,203	4,392,146	4,798,553	.40
44	Animals	4,624,531	4,553,845	3,129,609	3,337,454	3,914,382	4,344,282	4,777,459	.40
45	Household and personal effects	2,934,244	2,856,007	3,040,523	3,263,384	3,941,875	4,535,554	4,446,187	.37
46	Feathers and down, crude, not dressed, etc	2,032,566	2,476,659	2,742,018	2,036,791	2,970,260	4,401,131	4,360,721	.37
47	Matting for floors, etc	3,817,866	3,780,050	3,609,795	3,600,088	3,831,436	3,769,202	4,333,044	.36
48	Art works	3,516,536	4,310,315	3,286,262	4,381,324	4,908,782	5,867,265	4,310,767	.36
49	Cork wood, or cork bark, and manufactures of	2,464,934	2,567,580	2,295,138	2,738,319	3,313,306	4,063,982	4,249,006	.36
50	Lead in ore	4,497,360	4,073,099	3,374,661	3,616,476	3,534,876	3,352,534	4,147,720	.35
51	Paper stock, crude	2,770,255	3,015,084	2,900,713	3,796,595	4,374,464	5,580,528	3,675,926	.31
52	Spices	3,685,242	4,815,125	4,366,008	4,583,356	5,188,116	5,113,000	3,591,537	.30
53	Hair, and manufactures of	2,055,536	2,775,084	2,727,062	3,428,404	3,854,349	3,604,599	3,561,012	.30
54	Iron ore	2,362,544	2,351,278	1,593,279	1,670,683	2,728,854	3,360,449	2,949,462	.25
55	Clocks and watches, and parts of	2,460,324	2,672,310	2,990,474	2,966,495	3,105,136	3,593,173	2,922,142	.25
56	Cement	1,478,452	3,607,666	2,052,952	1,355,696	1,394,447	3,778,114	2,100,598	.18
57	Bristles	2,047,331	2,654,604	2,367,301	2,370,498	2,695,746	3,261,877	2,097,777	.18
58	Jewelry and manufacures of gold and silver	2,642,345	2,007,433	2,048,821	1,303,652	1,739,953	1,779,527	1,672,275	.14
	All other articles	50,313,903	57,875,712	52,552,097	57,131,870	73,919,068	88,063,181	74,169,712	6.21
	Total	$903,320,948	$1,025,719,237	$991,087,371	$1,117,513,071	$1,226,562,446	$1,434,421,425	$1,194,341,792	100.00

but a little over 210 million dollars' worth, or 17.87 per cent., of our imports consisted specifically of unmanufactured materials, such as silk, hides and skins, india rubber and gutta percha, wool, cotton, copper, lead and iron ores, and bristles, which would properly go into manufactures here.

We sit back glorying in our country. Its wide extent. Its rich resources. Its teeming millions of independent and self-respecting people. And yet after our fleet has circumnavigated the globe we continue to sacrifice the fertility of our soils to the support of older civilizations and remain content, while ranging ourselves with those nations that live solely on their primary resources, since the "balance of trade" is in our favor. But we as chemists know that this condition can not last. We know that the average fertility of our soil has been growing steadily less and that only by following sound scientific practise can the fertility of the impoverished soil be restored.

The utilization of the soil as a chemical factory is but one of the problems with which the chemist has to deal. That which appeals most nearly to us as chemical engineers is the item that appears as second in magnitude in the table of imports of merchandise and which has held this second place for years, namely, "chemicals, drugs and dyes," for this category embraces those substances commonly known as chemicals, or the products of the "black art." In 1908, we imported 73,237,033 dollars worth of this class of materials or 6.13 per cent. of our total imports. While we exported but 20,873,155 dollars worth, or 1.14 per cent. of our total exports. There was, therefore, a balance of $52,363,878 against us in this item in which the chemical engineers of this country are most nearly concerned. It is true that among these imports are upwards of $15,000,000 worth of crude drugs and dyewoods, and quantities of other crude material, but there are many million dollars worth of substances included here that should have been manufactured in this country. Attention need only to be called to the acids imported to a value of over $1,300,000 to emphasize this fact, for while we are seeking an outlet for our sawdust, we find in this list nearly 9,000,000 pounds of oxalic acid. Or attention might be called to the more than $7,000,000 worth of coal tar products and preparations, not medicinal. Had this been accomplished there is little doubt that our exports of such substances would also have been large. And what is true of the industries commonly called chemical would equally apply to those larger chemical industries not included in the common category.

Another policy we should follow is the promotion of chemical manufactures throughout a larger portion of our great territory. For this purpose I have prepared Table VI., showing by states the locations of each of the 1,786 establishments

TABLE VI. NUMBER OF ACTIVE ESTABLISHMENTS FOR CHEMICALS AND ALLIED PRODUCTS, BY STATES, 1905

	1905		1905
Alabama	27	Mississippi	7
Alaska	1	Missouri	47
Arizona	—	Nebraska	4
California	63	Nevada	3
Colorado	6	New Hampshire	1
Connecticut	40	New Jersey	144
Delaware	13	New York	264
District of Columbia	3	North Carolina	42
Florida	15	Ohio	128
Georgia	75	Oregon	4
Illinois	89	Pennsylvania	315
Indiana	52	Rhode Island	17
Indian Territory	1	South Carolina	26
Iowa	6	Tennessee	22
Kansas	10	Texas	3
Kentucky	21	Vermont	3
Louisiana	12	Virginia	62
Maine	9	Washington	9
Maryland	50	West Virginia	25
Massachusetts	77	Wisconsin	19
Michigan	52	Wyoming	1
Minnesota	10		

reported for chemicals and allied products at the census of 1905, and I find that seven states or territories, viz., Arkansas, Idaho, Montana, New Mexico, North Dakota, South Dakota and Utah did not at that time possess a single establishment devoted to any of the large number of industries embraced in chemicals and allied products. Oklahoma, New Hampshire and Wyoming each possessed but one, and the District of Columbia, Nebraska, Nevada, Oregon, Texas and Vermont each less than five.

In order to bring this matter of the distribution of the industries manufacturing chemicals and allied products more clearly to your attention I have, through the courtesy of the director of the bureau of the census, had prepared a map of the United States showing the location of the establishments, both principal and subsidiary, manufacturing sulphuric acid, those making explosives, and those engaged in wood distillation, each being a typical industry, and the sulphuric acid industry being generally accepted as of fundamental importance.

From this chart it appears that 13 states and territories, being the seven already named (Arkansas, Idaho, Montana, New Mexico, North Dakota, South Dakota, Utah) with Iowa, Nebraska, New Hampshire, Nevada, Oregon and Wyoming, containing 7,648,000 out of the 76,303,387 inhabitants of the continental United States in 1905, or over 10 per cent. of the whole, did not possess a single establishment devoted to any one of these industries.

Considering sulphuric acid only, which is so important an industry that it has frequently been referred to as an index of the state of civilization of a people, we find that 23 states and territories, namely, the 13 just enumerated, together with Delaware, District of Columbia, Kentucky, Maine, Minnesota, Missouri, Oklahoma, Washington and West Virginia containing 19,562,200 population, or 25.6 per cent. of the total did not possess a single sulphuric acid plant within their borders.

Turning now to the east, we find that 11 out of the 13 original colonies, viz., Connecticut, Georgia, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina and Virginia, contained 30,695,000 population, or 40.2 per cent. of the total, and 100 sulphuric acid factories, or 67.1 per cent. of the total number existing in the country. Analysis of the statistics of the separate states shows that the number of these establishments does not follow the population, Georgia, for instance, with about one fourth the population of New York, having twice the number of sulphuric acid factories that New York had.

I am aware that the number of establishments in an industry is an unsafe criterion as to the magnitude or importance of that industry, but this feature has been chosen as lending itself most easily to graphic demonstration. I have therefore assembled, by geographic divisions, in Table VII., data for the quantity of sulphuric acid produced, and we find that inspection of this leads to much the same result as to that which was drawn from the consideration of the distribution of the establishments.

TABLE VII. QUANTITY OF SULPHURIC ACID PRODUCED IN THE UNITED STATES BY GEOGRAPHIC DIVISIONS, 1905 AND 1900

Division	1905	1900
	Tons	Tons
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
Total for United States	1,869,437	1,548,123

All investigations show that there is an enormous extent of fairly well populated area in this country yet awaiting development by the chemical engineer, and I commend this field of service to your attention.

As a field in which costs may be diminished, attention may be called to the saving of waste. So much has been said on this subject that I hesitate to dwell upon it lest I weary you. But I venture to suggest that one remedy for waste, which has not been so markedly dwelt upon as it deserves, is by a change in location, and I take as an example of this the gas industry.

I have long looked upon our present custom of transporting coal long distances to be converted into gas as uneconomic, for a not inconsiderable quantity of coal is burned to provide the energy with which to haul this coal. Not only that but, since the gas constitutes but a very small percentage by weight of the coal, there is a considerable waste in hauling the coke, with its ash, and the by-products. Further, to provide for emergencies, large stocks of coal must be accumulated in advance at the gas works, and as coal, particularly gas coal, begins to deteriorate as soon as it is removed from the mine, there is a very considerable loss going on all the time from this cause. Further, as the by-products or residuals are now purchased in the crude state in relatively small quantities at the different gas works, a large part of their value is consumed in collecting and transporting them to central refineries.

By producing the gas at the mine and shipping it by pipe line the cost of haulage on the coke, with its ash, and crude by-products, is saved. The wastage of coal by weathering is saved. The cost of collection and transportation of the crude residuals is saved. Such coke as is not needed for industrial purposes can be converted in producers into gas which, by means of internal combustion engines, can be used in generating electricity for distribution, and the ash from this coal can be put into the mine for use as a filler in place of coal.

It is evident that gas can, under these circumstances, be made and delivered at a much less cost than is the case at present, though it may be necessary after long travel to enrich it near the point of consumption. Furthermore, the valuable areas now occupied by gas plants in our cities can be given up to more concentrated industries and cheap country lands be substituted for them.

I venture further to suggest that frequently an urgent reason for saving waste is to suppress a nuisance, for I do not hesitate to assert that the existence of a public nuisance is evidence of the existence of an economic waste.

Almost at the outset of my professional life, in 1872, I became involved in the famous Miller's River Nuisance case and it fell to my lot to examine, on behalf of the citizens of Cambridge, Mass., the large slaughtering houses which were believed to be the cause of the nuisance, and to study the operations going on within them. The conditions were very complex and there were a variety of causes which led to the creation and maintenance of this most horrible and most extensive nuisance, but among other causes I found that the slaughtering houses had permitted much valuable blood and offal to escape into the stream and that at that time one establishment alone was pouring into the river, in the water in which it had steamed its hogs, over five tons of gelatinous matter per week, and this was done in ignorance of the existence of this matter in the tank waters.

What I have found to be true regarding matter, I have also found to be true as regards energy, and I cite as an example

the nuisance of "cannonading" in blasting, which is proof in itself of the use of unnecessarily excessive charges of explosives.

But in urging the abating of a nuisance or advising the saving of waste or the conserving of resources, we should not fail to point out that it can usually be accomplished only with added expense, and that a profit can rarely be realized unless the operations are carried out on a quite considerable scale. In fact, it seems to be an economic law that only the rich can really save; that "to him that hath shall be given"; for the poor must pay the price of much subdivision and the consequent cost of much handling and a multiplicity of containers.

In fact, we should make it plain that the advocacy of the saving of waste in manufacture and of conserving our resources necessarily implies the use of great aggregations of capital and the carrying on of large scale operations under a single management. It means the application of methods such as have been applied with great success in the manufacture of hog products or in the refining of petroleum. In dealing with coke at the census of 1905, I found that of the 37,376,251 tons of coal coked in the United States in that census year, only 3,317,585 tons, or 8.9 per cent., were coked in by-product ovens, and I estimated from the yields and values of the by-products which were recovered that had all the coal been coked in by-product ovens there was a possible saving of $37,492,136.[5] This is an enormous amount to save in a single industry in a single year, and if the saving could be made an accomplished fact it would go far toward wiping out that humiliating account against us in our imports of "chemicals, drugs and dyes." But I have never failed to recognize the fact that this could only be accomplished by those controlling large capital, and that it meant the "killing off" of a large number of minor establishments, and I have further recognized the fact that the apparent savings set forth could not be realized until the charges against the more costly plant had been satisfied, nor until the market had been so readjusted that it could absorb this greatly increased output of by-products.

As an example of the commercial advantage resulting from the abating of a nuisance, I cite the instance of Ducktown, Tenn., whose smelters have for decades been notorious offenders. I will not repeat to you the details by which their devastating sulphurous fumes have been converted into valuable merchandise, since they have been so well set forth in current literature, but will simply note that, by report, this saving has resulted in the suspension of a number of the sulphuric-acid works in the contiguous region, and I am ready to believe this report to be true, for I look upon this result as a natural consequence of the operation of a wholesome law in economies.

However, all of the endeavors avail but little so long as we remain a dependent nation, which the quantity of manufactured "chemicals, drugs and dyes" imported by us indicates that we are, and especially while we import over seven million dollars' worth of coal-tar products and nearly two million dollars' worth of ammonium sulphate as we did in 1908, and yet allow 37,000,000 dollars' worth of the by-products produced in the coking of our coal to be wasted. It is evident that there is still a wide opportunity for the employment of the chemical engineer in developing our chemical industries.

I find that I have been led to devote my attention to the chemical industries of the

[5] Bull. 65, U. S. Census of Manufactures, 1905, p. 18.

United States when you have asked me to treat of those of America. I have, however, limited myself not because I consider our country America, but because of the limited amount of information that I have been able to secure relative to the other countries in North and South America. Such as is available for Canada is found in a paper by Dr. W. R. Lang, published in the *Transactions of the Canadian Institute* for 1904, from which it appears that, in 1903, salt was produced in the Dominion to the value of $334,000, and arsenic, in 1901, to the extent of 1,347,000 pounds. Sulphuric acid was produced in Quebec, Ontario and British Columbia, but neither the number of factories, nor the extent of the output is given. However, in treating of the plant at Ontario, which produced about 15 tons of acid per day, it is stated that imported brimstone was used as the raw material, and this in the face of the fact that Canada abounds in pyrites. The wood-distillation industry flourishes in that country, the plant of the Lake Superior Power Company being, it is said, the largest retort plant in the world, but no statistics of production are supplied. Ammonia liquor was produced to the extent of 235,000 pounds of 28° B. strength, a larger part of it being exported. Soap was produced by some 15 concerns employing about 2,000 hands, the value of the product in 1902 being approximately $3,000,000. Glycerine was obtained from the soap lyes, one works being capable of treating 10,000,000 pounds of lye annually. Petroleum refining was carried on at Sarnia, the factory being able to treat 60,000 barrels of crude oil per month. Calcium carbide was made in two works, carborundum and graphite in one. There was a limited manufacture of fine and heavy chemicals. This about completes the tale for Canada.

My efforts to obtain information relative to the Central American and South American states have been less successful, though I have searched the literature and consulted officials from and to these countries. "The Statistical Abstract of Foreign Countries" recently published by Mr. O. P. Austin, chief of the U. S. Bureau of Statistics, covers the exports and imports of these countries for a decade, and it appears to be the only authoritative and detailed report concerning them, yet a painstaking search of the tables of exports for each of these Central American and South American countries shows no other chemical items than borate of lime, iodine and nitrate of soda from Chile; charcoal from British Guiana and Argentina; fermented and distilled liquors from several of the countries, especially from the West Indian Islands; and dyestuffs and extracts from a number of states. Literature relating to the commercial resources and industrial activities of the Pan-American republics, other than the United States, is apparently quite meager, and information regarding their industrial activities appears not to have been collected either by the countries themselves or by students of commerce and industry. It does appear, however, from what information can be obtained, that the resources of these countries are in an undeveloped condition and that these countries present an almost virgin field for development by the chemical engineer.

I have myself attempted to inspire one such development, for at the outset of the undertaking of the construction of the Panama Canal by the United States, I advised that dynamite, which has been consumed in enormous quantities in the excavation work, and the manufactured "raw" materials of its manufacture, be made upon the Isthmus. The easy access

to the nitrate-of-soda deposits of Chile, making but a brief water transportation necessary for delivery, and the existence of pyrites in great abundance in the vicinity of the Isthmus making the production of sulphuric, and hence mixed, acids easy and simple, were a few of the many advantages which would follow the adoption of this plan. But not the least would be the civilizing influence which chemical manufacture always exerts. It is unnecessary to say that up to the present, I have been unsuccessful in my endeavors to introduce chemical manufactures into the Central American states, but I trust that you, who have done me the honor to listen to me, may succeed where I have failed.

Charles E. Munroe
George Washington University

Scientific Notes and News

The funeral of Mr. Alexander Agassiz was held in Appleton Chapel, Harvard University, on Sunday, April 3.

A testimonial dinner to Dr. Charles Frederick Chandler was given at the Waldorf-Astoria on April 2, to permit his former students and associates to express, before his retirement, their appreciation of his forty-six years of service to Columbia University, and his lifetime of devotion to the cause of education and science. It was announced that a lectureship in honor of Dr. Chandler would be endowed by his former students and that the chemical museum of the university would be named in his honor.

Dr. T. Muir, F.R.S., has been elected president of the South African Association for the Advancement of Science for the meeting in Cape Town, the date of which is not yet set.

Dr. Richard Dedekind, professor of mathematics at Brunswick, has been elected a foreign member of the Paris Academy of Sciences.

Sir James Dewar, F.R.S., has been elected an honorary member of the American Chemical Society.

Mr. Frederic A. Lucas, curator-in-chief of the Brooklyn Museum, has been elected a life member of the American Museum of Natural History on account of the practical assistance which he has rendered it and because of his contributions to science.

A dinner was given in honor of Sir John Murray in London on April 5, in connection with the Michael Sars expedition for the exploration of the North Atlantic.

Professor L. A. Wait, head of the department of mathematics at Cornell University, will retire from active service at the close of the present academic year.

Dr. A. R. Ward, director of the State Hygienic Laboratory at Berkeley, Cal., has been appointed chief of the veterinary corps of the Philippine Islands.

At the American Museum of Natural History Dr. E. O. Hovey has been promoted to the curatorship in geology to succeed Dr. R. P. Whitfield, who shortly before his death became curator emeritus. In the department of anthropology, Dr. Pliny E. Goddard has been appointed associate curator, Mr. Harlan I. Smith has been advanced to associate curatorship, Dr. Herbert J. Spinden has been appointed assistant curator and Mr. Alanson Skinner has been added to the list as assistant. A new department of public health has been established with Professor C. E. A. Winslow as curator. A new department of woods and forestry has been established, with Miss Mary C. Dickerson in charge.

Dr. Hermon C. Bumpus, director of the American Museum of Natural History, is making an expedition to Mexico to plan the reproduction of certain prehistoric ruins for structural use in the new hall of Mexican archeology. Mr. Frank M. Chapman, curator of ornithology, accompanied Dr. Bumpus to make studies and collect specimens for a group of Mexican birds.

Chauncey Juday, lecturer in zoology at the University of Wisconsin and expert on the staff of the Wisconsin Natural History Survey, has just returned from a five-weeks trip through Central America, where he studied