

MATERIALS USED IN MANUFACTURES: 1929

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I. PLACE OF MATERIALS IN MANUFACTURES

Introduction.—The gross value of products manufactured in the United States in 1929 was \$70,434,863,000, according to returns made by manufacturers to the Bureau of the Census. This sum was the reported aggregate production (or sales) of the 210,959 individual manufacturing establishments of the country.

Because the products of certain plants were used as the materials for further manufacture in others, duplications appear both in the aggregate cost of materials and in the aggregate value of products. Although the Bureau of the Census calls attention in its reports to the existence of this duplication, users of census statistics not infrequently treat gross value as being the value of the finished output of domestic industry.

To arrive at a figure for the unpyramided factory value of products—equivalent to the value of manufactured commodities ready for ultimate use—the estimated value of semimanufactured materials of domestic origin consumed by all plants may be deducted from the gross value of their products. Another way to arrive at the same result is to compute the cost of the raw materials consumed and to add to it the cost of imported semimanufactures consumed and the value added by the manufacturing processes (this represents salaries, wages, other expenses, and manufacturing profits, and is calculated by subtracting cost of materials, containers for products, and fuel from value of products). Some of the manufacturers who use raw materials are called upon to report the amount, cost, or both, of the chief items consumed. In a large number of industries no raw materials whatsoever are used.

The result of such a computation from the returns for 1929 is a sum, \$47,243,000,000, which represents the estimated net value of manufactures.¹ The figure is approximately two-thirds of the reported gross value of products. In the process of arriving at this figure for the net value of manufactured output it was necessary to study the consumption of materials in each of the 326 industries. The pyramided relationship between materials and products inevitably comes out into the light in the course of such an analysis. The problems, methods, and results of the work are explained in some detail in the following pages.

A decided improvement in the economical utilization of materials has been brought about in recent years in the more efficient manufacturing plants, reflected to some extent in the data to be presented. In fact, the improvement in the preparation, selection, and use of materials is perhaps almost equal to the remarkable advance made in machine construction and operation. This is the result of the increased emphasis on the function of industrial purchasing, the procurement of materials by precise specification, and the development of improved systems of testing, recording, storing, conveying, and inspecting materials.

¹ An estimate of the net value of manufactured products for 1923 was made by Dr. E. Dana Durand, who used substantially the same method of calculation as was used for this study. Doctor Durand's plan, as a matter of fact, served as a guide for the computations for 1929. The results for 1923, published in the *Commerce Yearbook, 1926*, p. 92, were not given in terms of a single figure but rather as a sum lying somewhere between estimated upper and lower limits. The gross value of output for 1923, as reported by the Census of Manufactures, was \$60,555,998,000; the net value was estimated to have been between \$37,350,000,000 and \$39,050,000,000.

Mass production implies the uninterrupted flow of uniform materials from one process to another, the output conforming within established limits to acceptable standards of interchangeability, appearance, or performance.

Since the material elements in manufacture are easier to standardize and manage than are the human ones, modern manufacture has tended to transfer craft skill to machines. Likewise materials, which can be analyzed, changed, and controlled, offer a fertile field for reduction in costs and for improvement in quality of products. This increased attention to the use of materials is unfortunately not fully reflected in the general data furnished by the manufacturers to the Bureau of the Census, although the gradually decreasing percentage of the value of products represented by the cost of materials probably indicates the more economical utilization of the latter.

Classification.—Although raw materials consumed in manufacturing industries may be received at the plants in the same crude state in which they are harvested, mined, etc., most of these materials are, in fact, subjected to a certain amount of processing prior to their delivery to manufacturing establishments. The shelling of corn, the ginning of cotton, and the calcining of gypsum—rudimentary processes applied to materials at the grain elevator, the gin, and the mine—represent the first of a series of operations which may be continued in industrial establishments.² The line between raw and semimanufactured materials is often almost indistinguishable if thus drawn on the basis of processing operations. However, if a line is arbitrarily established as separating, on the one hand, those raw materials which have not been processed at all, or those upon which certain initial operations have been performed before the materials reach a manufacturing establishment, from those materials which have been subjected to either elementary or advanced fabrication in an establishment of some manufacturing industry, the separation of raw and semimanufactured materials ordinarily offers no great practical difficulty.

Semimanufactured materials are, therefore, those materials which either have been processed in a manufacturing establishment or at least have been subjected to certain processing operations generally carried on in factories. Materials in such a condition—as, for example, pig iron from the blast furnace—are still unfit for ultimate use without further manufacture. Other materials, such as sugar, dyes, wire, nails, and paint, although they are in a sense completed products, are used in large quantities as materials or component parts in the manufacture of other products. Such products thus used for further manufacture are classed in this report with the unfinished materials and parts upon which further processing is required.

Containers, often completely manufactured and assembled when obtained by the manufacturers for use as receptacles for their products, belong in much the same category as do dyes, nails, paint, etc., except that the containers do not become component parts of the final product.

² Before much of the output of mines and quarries is suitable for manufacture, smelting, or marketing, the materials are subjected to beneficiating processes, to improvement in grade, or to other treatment. Crushing, grinding, drying, air separation, flotation, amalgamation, sintering, etc.—milling operations of a manufacturing nature—are the processes employed. They are commonly considered, however, as a part of the mining industries, particularly when conducted at or near mines by mining enterprises. On the other hand, such processes as the smelting and refining of metals, the production of cement, lime, clay, etc., and the shaping and dressing of stone, by which mined products are materially changed in nature by enterprises in which these processes generally represent major activities, are classified as manufacturing in the censuses of manufactures.

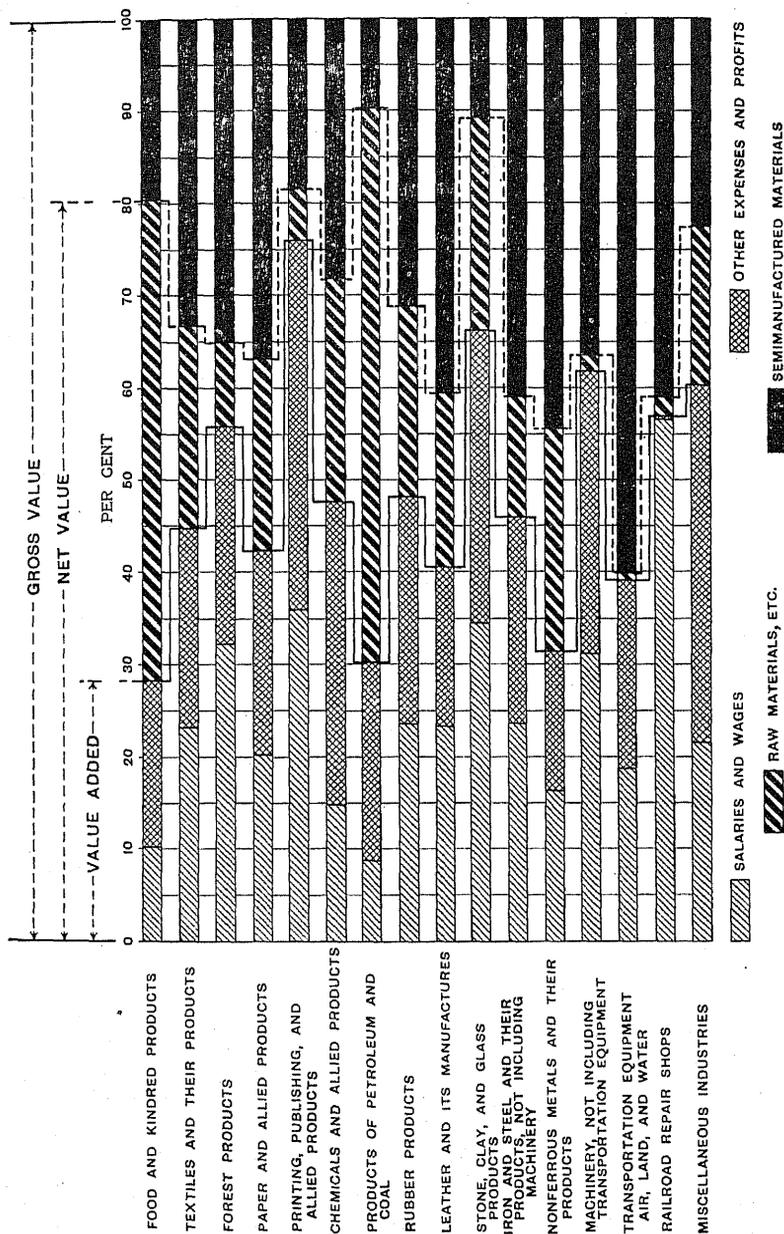


FIGURE 1.—RELATIONSHIP OF THREE KINDS OF PRODUCT VALUE (VALUE ADDED, NET VALUE, AND GROSS VALUE), BY INDUSTRY GROUPS: 1929

Fuels bear a close relationship to materials proper. In fact, they are used in some industries as materials rather than as fuels, as, for example, coal in the manufacture of coke, and natural gas in the production of carbon black; and when they are so utilized the manufacturers are directed to report them as materials and not as fuels. In the great majority of cases, however, fuels are consumed to satisfy power, heat, and process requirements, and as such they do not enter into the finished products, as do other materials. Bituminous coal, anthracite, and natural gas are generally consumed at factory power plants in substantially the condition in which they emerge from the mine and well, while coke, fuel oils, gasoline, kerosene, and manufactured gas are first the products of certain manufacturing industries. Purchased electric energy, generated from fuel or from water power, is ordinarily produced by central power stations not classified by the Census as manufacturing establishments.

There remains the group of numerous expense materials, such as lubricating oils, abrasives, paint for buildings and equipment, minor repair parts, etc. While they do not as a rule enter directly into the product, they resemble in a sense the materials of manufacture more closely than they do the major capital equipment of the plant. The latter represents a comparatively permanent investment which sets it apart from the circulating materials in question.

The raw materials of manufacture—comparatively few in number—branch out by numerous combinations into thousands of distinct products as a result of the manufacturing processes.³ The primary sources of such materials are, of course, farms, mines, quarries, bodies of water, forests, and the atmosphere (e. g., nitrogen). The origin of materials is given more detailed treatment in the following section.

Sources of materials.—It is estimated that the cost of raw materials of domestic and of foreign origin consumed in manufacturing establishments in 1929 amounted to \$12,676,000,000. These materials, for which sources and costs are shown in Table 1, are the products of five major extractive industries. Turned over in an entirely or comparative by crude state to manufacturing industries, they acquired approximately \$32,000,000,000 of added value by being put in condition in factories for ultimate use.

TABLE 1.—ESTIMATED COST TO MANUFACTURERS¹ OF RAW MATERIALS CONSUMED, DISTRIBUTED ACCORDING TO THE EXTRACTIVE INDUSTRIES WHERE PRODUCED: 1929

INDUSTRY	TOTAL		Domestic	Foreign
	Amount	Percent of total		
Five extractive industries, total.....	\$12,676,000,000	100.0	\$10,472,000,000	\$2,204,000,000
Agriculture and animal husbandry.....	8,541,000,000	67.4	6,763,000,000	1,778,000,000
Mining and quarrying.....	3,494,000,000	27.6	3,279,000,000	215,000,000
Logging, etc.....	477,000,000	3.8	390,000,000	87,000,000
Fishing.....	39,000,000	0.3	19,000,000	20,000,000
Hunting and trapping.....	125,000,000	1.0	21,000,000	104,000,000

¹ For detailed lists of raw materials consumed, classified by industry groups, see Table 23, p. 45.

These figures do not, of course, represent the total production of the five extractive industries, some of which was consumed without the necessity of

³ A census report, in pamphlet form, entitled *Products of Manufacturing Industries: 1929*, shows in detail the production in quantity and in value of 3,978 commodities as classified by the Census of Manufactures, together with the numbers of establishments engaged in their production.

manufacture. They are the reported or estimated costs of the materials at the factories, figures which in general combine the values at the farm, mine, etc., with those for such distribution charges as transportation, sales, insurance, and, in some cases, middlemen's profits. No effort has been made in this report to determine what share of the total volume of production of the extractive industries found its way into manufacturing establishments.

The farm value of domestic agricultural products sold, traded, or used by the farm operators' families in 1929 was reported by the Census of Agriculture to have been \$11,011,000,000, distributed as shown in the following table.

TABLE 2.—VALUE OF FARM PRODUCTS SOLD, TRADED, OR USED BY FARM OPERATORS' FAMILIES: 1929

[Farms to the number of 288,766 (4.6 per cent of the total number), unclassified as to type of product, are excluded]

CLASS OF PRODUCTS	Number of farms reporting	VALUE OF PRODUCTS	
		Amount	Per cent of total
Total.....	5,999,882	\$11,011,329,335	100.0
Crops (including plants, flowers, etc.).....	4,923,419	4,424,480,691	40.2
Livestock, sold or traded.....	3,388,016	2,612,770,611	23.7
Livestock products, sold or traded.....	4,490,276	2,472,813,301	22.5
Forest products sold.....	602,992	99,859,580	0.9
Farm products used by family.....	5,609,680	1,401,405,152	12.7

The value of products of the 11,602 mines and quarries of the United States, reported by the Census of Mines and Quarries for 1929, was \$2,392,831,000 (Table 3.) This figure represents in general the selling value at point of production or at point of shipment, and with respect to the industries producing metaliferous ores, the values reported stand in no readily discernible relation to the quantities and market values of products recoverable from the materials mined. The figures, for instance, do not include data for noncommercial clay (clay mined by clay-product manufacturers and used in their own production).⁴

TABLE 3.—NUMBER OF MINES AND QUARRIES AND VALUE OF PRODUCTS, BY INDUSTRIES: 1929

INDUSTRY	Number of mines and quarries	VALUE OF PRODUCTS	
		Amount	Per cent of total
All industries, total.....	11,602	\$2,392,831,178	100.0
Coal, total.....	5,923	1,351,548,071	56.5
Anthracite.....	303	384,854,300	16.1
Bituminous.....	5,620	966,693,771	40.4
Copper.....	180	283,517,373	11.8
Iron ore.....	208	197,334,548	8.2
Limestone.....	1,256	117,257,784	4.9
Sand and gravel.....	1,165	102,311,914	4.3
Lead.....	171	67,561,778	2.8
Zinc.....	204	44,866,026	1.9
Sulphur and pyrites.....	10	37,126,148	1.6
Granite.....	434	30,381,373	1.3
Gold, lode.....	184	17,650,174	0.7
Gold, placer.....	37	3,779,241	0.2
Basalt.....	144	15,543,687	0.6
Phosphate rock.....	33	13,043,769	0.5
Clay.....	236	10,753,445	0.4
Slate.....	130	10,486,390	0.4

⁴ For other exceptions, see report of *Census of Mines and Quarries, 1929, Introduction and General Explanations*, p. 1.

TABLE 3.—NUMBER OF MINES AND QUARRIES AND VALUE OF PRODUCTS, BY INDUSTRIES: 1929—Continued

INDUSTRY	Number of mines and quarries	VALUE OF PRODUCTS	
		Amount	Per cent of total
Stone, miscellaneous.....	234	\$8,475,008	0.4
Silver.....	74	8,457,263	0.4
Marble.....	88	7,538,005	0.3
Minor metals ¹	30	6,649,976	0.3
Sandstone.....	172	6,311,977	0.3
Gypsum.....	63	5,740,188	0.2
Sand, glass.....	32	5,359,216	0.2
Asphalt and bituminous rock.....	25	5,123,836	0.2
Fuller's and filtering earth.....	24	4,811,629	0.2
Sand, molding.....	128	4,775,057	0.2
Silica ²	73	4,645,142	0.2
Other industries ³	344	21,780,360	0.9

¹ Bauxite, 11 mines; molybdenum, titanium, and vanadium, 6; tungsten, 13.

² Diatomaceous earth, 10 mines; ganister, 19; quartz, 9; quartzite, 2; silica rock, 7; silica sand, 14; siliceous mica schist, 3; tripoli, 9.

³ Abrasive materials, 36 mines; asbestos, 11; barite, 44; feldspar, 58; fluor spar, 36; magnesite, 5; manganese, 21; mercury, 40; mica, 32; millstones and pulpstones, 14; talc and soapstone, 28; miscellaneous minerals, 19.

Lumbering, unlike farming, mining, fishing, and trapping, is classified as a manufacturing enterprise by the Bureau of the Census, and the statistics for the "Lumber and timber products" industry include the labor cost and other expense of cutting the timber. The proper raw-material cost is, therefore, the stumpage value of the timber cut. While to some extent independent logging concerns sell the logs to sawmills, in most cases the logging and sawing are done by the same "manufacturing" establishments. Since the manufacturers specify on their returns the particular kinds and quantities of timber consumed, but not its stumpage value separately from the cost of the other materials used, an estimate has been made from the quantity data furnished by the manufacturers and from average stumpage prices for the year. This estimate gives \$307,000,000 as a fair value of stumpage at 1929 prices for timber cut and sawed in commercial sawmills. To this should be added approximately \$9,000,000, the estimated value of crude domestic turpentine, giving a combined cost of \$316,000,000 for forest products, exclusive of paper stock, in the condition in which their manufacturing, in the strict sense, commenced.

The catch of commercial fishery products in the United States and Alaska in 1929 amounted to 3,567,000,000 pounds, valued at \$123,054,000 to the fishermen, according to the Bureau of Fisheries. Of this total, \$117,751,000 represented the value of food fishery products and \$5,303,000 that of such products as nonedible fish and fresh-water mussel shells.

The domestic fur catch for 1929 is estimated to have amounted to about \$21,000,000, a figure based upon the calculated cost of domestic furs purchased by manufacturing establishments in that year.

The values assigned to the products of the five extractive industries (except those shown in Table 1) are, in general, the values received by the persons or organizations engaged in the extractive operations. They represent production for the year 1929 and take no account either of stocks carried over from an earlier period or of current production held for later sale and use. To get the materials to the manufacturing establishments entails costs for transportation, distribution, etc. However, some of the materials of these industries are consumed without being manufactured, while similar materials are brought in from abroad to be consumed by manufacturers along with the domestic supply. For one or more of these reasons the amount and cost of a particular material reported by the manufacturers as having been consumed in 1929 may not agree closely with the values shown above as representing domestic production.

TABLE 4.—SUMMARY STATISTICS FOR MANUFACTURING INDUSTRIES, BY INDUSTRY GROUPS: 1929

INDUSTRY GROUP	Number of establishments	Wage earners (average for the year)	Wages	Materials and containers for products	Fuel and purchased electric energy	Value of products	Value added by manufacture
All groups, total.....	210,959	8,838,743	\$11,620,973,254	\$36,683,414,013	\$1,866,165,719	\$70,434,863,443	\$31,885,283,711
1. Food and kindred products.....	56,320	753,247	992,142,970	8,470,839,064	161,443,793	12,023,589,289	3,391,306,432
2. Textiles and their products.....	27,404	1,707,798	1,735,031,423	4,982,740,911	121,104,813	9,243,302,523	4,139,456,799
3. Forest products.....	26,912	876,383	939,382,973	1,550,372,304	35,810,649	3,591,765,090	2,005,882,137
4. Paper and allied products.....	3,126	233,393	287,330,792	1,011,026,312	81,695,791	1,892,251,148	799,529,045
5. Printing, publishing, and allied industries.....	27,522	357,988	636,371,372	740,748,389	25,735,159	3,170,139,651	2,403,656,103
6. Chemicals and allied products.....	8,278	280,868	354,393,308	1,871,275,949	99,437,820	3,759,404,640	1,788,991,371
7. Products of petroleum and coal.....	1,497	147,216	229,050,010	2,143,614,665	403,225,628	3,647,747,957	1,100,907,764
8. Rubber products.....	1,525	149,148	207,305,857	559,000,306	19,677,375	1,117,460,252	588,782,571
9. Leather and its manufactures.....	4,277	318,415	359,412,972	1,118,164,062	13,777,901	1,905,976,775	774,034,812
10. Stone, clay, and glass products.....	8,514	328,417	432,317,393	368,809,309	157,530,670	1,561,414,590	1,035,074,611
11. Iron and steel and their products, not including machinery.....	6,640	880,882	1,380,986,821	3,399,745,039	463,127,847	7,137,928,058	3,275,054,572
12. Nonferrous metals and their products.....	7,522	314,741	443,466,623	2,400,659,213	64,784,985	3,597,057,717	1,131,613,519
13. Machinery, not including transportation equipment.....	12,955	1,091,269	1,634,165,729	2,584,082,769	110,296,860	7,043,380,390	4,349,000,761
14. Transportation equipment, air, land, and water.....	2,550	583,355	943,221,905	3,629,190,960	53,957,118	6,047,209,890	2,364,061,312
15. Railroad repair shops.....	2,297	398,156	637,311,434	517,159,534	31,183,731	1,269,916,839	721,573,274
16. Miscellaneous industries.....	14,620	417,467	500,581,672	1,335,984,327	23,376,179	3,426,319,134	2,066,958,628

Varying importance in industries.—Materials play rôles of varying importance in the creation of the products of the 326 industries. An attempt was made to classify broadly the industries on this basis at the census of 1880, when the following four classes were set up: ⁵

1. A few industries in which the cost of materials (and fuel) greatly exceeds all the other costs of production combined, as in "Smelting and refining, copper" (Table 5).

2. Industries in which the cost of materials (and fuel) used is small as compared with the values added by the manufacturing processes (represented by combined salaries, wages, overhead and miscellaneous expenses, interest, and manufacturing profits). This group, in which the cost of materials plays only a small part in giving value to the finished products, includes such industries as "Cash registers, adding machines, and calculating machines" (Table 5).

3. Industries in which both the cost of materials (and fuel) and the values added by the manufacturing processes are important elements in the final value of products. The majority of the industries are of this nature. Among the 326 industries there are 190 in which the cost of materials, etc., is from 40 per cent to 70 per cent of the gross value of products (Table 6).

4. A few industries in which the materials are not owned by the plant performing the process and in which the value of products shown represents merely the amount received for work done, such as "Cloth sponging and refinishing."

The five industries in Group A of the following table are those in which the combined cost of materials, containers for products, fuel, and purchased electric energy comes nearest to equaling the factory value of the products. Only 12 per cent of that value is added by the manufacturing processes. The five industries in Group B are at the other end of the scale, their factory processes adding more than 88 per cent to the final value of the products.⁶ Intricate hand or machine workmanship on relatively inexpensive materials accounts for the wide margin between cost of materials and value of products in this group.

TABLE 5.—COST OF MATERIALS, VALUE OF PRODUCTS, AND PERCENTAGE RELATIONSHIP, FOR SELECTED INDUSTRIES: 1929

GROUP AND INDUSTRY	Number of establishments	Cost of materials, containers, fuel, and purchased electric energy	Value of products	Per cent cost of materials, etc., is of value of products
All industries, aggregate.....	210, 959	\$38, 549, 579, 732	\$70, 434, 863, 443	54. 7
Group A, total.....	1, 431	4, 298, 993, 985	4, 384, 065, 306	88. 0
Smelting and refining, copper.....	26	920, 351, 441	994, 783, 862	92. 5
Gold, silver, and platinum, reducing and refining, not from the ore.....	69	61, 570, 093	67, 959, 140	90. 6
Shortenings (not including lard), and vegetable cooking oils.....	40	139, 030, 964	154, 553, 197	90. 0
Smelting and refining, lead.....	19	203, 913, 730	232, 115, 009	87. 9
Meat packing, wholesale.....	1, 277	2, 974, 127, 757	3, 434, 654, 098	86. 6
Group B, total.....	877	30, 642, 027	265, 220, 079	11. 6
Photo-engraving, not done in printing establishments.....	654	11, 003, 121	77, 382, 259	14. 2
Typewriters and parts.....	26	7, 248, 601	61, 857, 615	11. 7
Engraving, wood.....	27	82, 250	738, 951	11. 1
Printing and publishing, music.....	124	1, 542, 042	15, 240, 268	10. 1
Cash registers and adding, calculating, and card tabulating machines.....	46	10, 706, 013	110, 000, 986	9. 8

⁵ *Tenth Census, 1880; Manufactures, Volume II*, pp. 2 and 3.

⁶ Two industries in which the costs of materials were 26 per cent and 10.6 per cent, respectively, are excluded from this group because the plants in these industries work primarily on a contract basis with materials owned by others.

In Table 6 all the industries are classified according to the per cent which the cost of materials forms of the value of products. For all classes combined the material cost is 54.7 per cent of the value of the entire factory output. Of the total, 26.9 per cent comes from a group of 66 industries with 42,384 plants in which the material cost ranges from 50 to 59.99 per cent of the product value. The share of the value of products for this class which goes for the purchase of materials (55.5 per cent) is nearly the same as for the total of all classes of industries (54.7).

TABLE 6.—COST OF MATERIALS, VALUE OF PRODUCTS, AND PER CENT DISTRIBUTION, FOR INDUSTRIES GROUPED ACCORDING TO PER CENT WHICH COST OF MATERIALS FORMS OF VALUE OF PRODUCTS: 1929

CLASS	Number of industries	Number of establishments	Cost of materials, containers, fuel, and purchased electric energy	Value of products	PER CENT DISTRIBUTION				Percent cost of materials, etc., is of value of products (average for the class)
					Industries	Estab-lish-ments	Cost of materials, etc.	Value of products	
All industries, total.....	326	210, 959	\$38, 540, 579, 732	\$70, 434, 863, 443	100. 0	100. 0	100. 0	100. 0	54. 7
90 per cent or more.....	3	135	1, 120, 952, 498	1, 217, 296, 199	0. 9	0. 1	2. 9	1. 7	92. 1
80 per cent to 89. 99.....	15	13, 974	6, 317, 830, 349	7, 428, 741, 443	4. 6	6. 6	16. 4	10. 5	85. 0
70 per cent to 79. 99.....	11	3, 780	3, 891, 295, 344	5, 065, 375, 171	3. 4	1. 8	10. 1	7. 2	76. 8
60 per cent to 69. 99.....	40	13, 100	6, 057, 792, 356	9, 393, 976, 977	12. 3	6. 2	15. 7	13. 3	64. 5
50 per cent to 59. 99.....	66	42, 384	10, 524, 015, 776	18, 957, 392, 153	20. 2	20. 1	27. 3	26. 9	55. 5
40 per cent to 49. 99.....	84	51, 810	5, 821, 099, 559	12, 899, 362, 814	25. 8	24. 6	15. 1	18. 3	45. 1
30 per cent to 39. 99.....	63	44, 127	3, 484, 448, 757	9, 891, 693, 799	19. 3	20. 9	9. 0	14. 0	35. 2
20 per cent to 29. 99.....	31	34, 568	1, 203, 176, 465	4, 789, 636, 914	9. 5	16. 4	3. 1	6. 8	25. 1
10 per cent to 19. 99.....	11	6, 989	117, 505, 275	678, 025, 766	3. 4	3. 3	0. 3	1. 0	17. 3
Less than 10 per cent.....	2	92	10, 854, 353	113, 362, 207	0. 6	(¹)	(¹)	0. 2	9. 6

¹ Less than one-half of 1 per cent.

The class in Table 6 into which a given industry falls depends only in part upon the cost of the raw materials used. We might expect that the material cost in the manufacture of pottery, for example, would be sufficiently small to place the industry well down the list of classes. As a matter of fact, the material cost as related to value of product is low—24.4 per cent—placing it in the group which is third from the last. On the other hand, the five industries in Group A of Table 5 use materials of considerable value. Since the class into which a given industry falls depends upon the ratio of one value to another, it would be quite possible for an industry using precious materials to have a material cost equal to only a very small percentage of the value of the products—if the factory processes were sufficiently intricate and expensive.

Another very important determinant of the class into which an industry falls is the condition in which the materials enter the plants. Even inexpensive raw materials, if purchased in a semimanufactured state from the plants of another industry, may have enough added value to make their cost equal to a very large part of the factory value of the finished products. Therefore, not only the nature of the materials themselves but also the amount of workmanship put upon them before they enter a given industry must be known in order to explain the classification.

The nature of the materials and the kinds of products to be made determine the kinds of manufacturing processes, which may be broadly classified as (a) analytical, (b) synthetical, and (c) conditioning. Processes which break down a compound into its constituent parts, as in the refining of a metal, constitute analytical manufacture; those which build up a compound from the union of simpler compounds or from its elements, as in the manufacture of phenolic resins or in automotive assembly, are synthetical in their nature; while those processes which make some change in a material, as in its form or appearance, without altering its fundamental properties, as in bleaching, may be broadly classed as conditioning processes. There are numerous variants and combinations of these fundamental types.

Secondary materials.—The cost of scrap and waste substances which are used as materials in manufacturing industries is a considerable sum in the total materials expenditure.⁷ Such items offer a problem in classification. Secondary materials which at some time in the past have been products of manufacturing plants are not in a strict sense raw materials. However, "old" scrap which has served its original purpose and has been purchased from scrap dealers to be used again as a material in a manufacturing plant probably comes as near to being a raw material as to being a semimanufacture. At any rate, since it competes directly with other raw materials for a place in the manufacturing processes, it is classed as a raw material for the purposes of this report.

A large amount of scrap consumed is "new" rather than "old" material, particularly in the metal industries; that is, it represents such materials as trimmings, defective parts, dross, sweepings, and skimmings, obtained directly from mills, furnaces, etc. As such, it is in a sense a by-product of manufacture, and to add its cost to that of other raw items, when the material from which it came had already been classified as raw, would be to exaggerate the true cost of raw materials consumed. New scrap, therefore, is considered in this report as a partly manufactured material.

The data collected from manufacturers do not indicate, except in a very few cases, whether scrap consumed is old or new material. Published reports from other than census sources covering secondary-material consumption do not disclose specifically into which industries given materials go. It has been necessary, therefore, to be somewhat arbitrary in classifying secondary materials as raw and semimanufactured and in assigning them to specific industries. For example, the data in Table 7, furnished by metal manufacturers at the census for 1929, do not differentiate between old and new scrap. It is estimated that of the total approximately \$284,000,000 represented the cost of old material, and this amount is, therefore, assigned as the cost of raw materials in the industries in which the scrap was used.

⁷ Secondary metal was defined at a meeting of the American Institute of Mining and Metallurgical Engineers in 1928 as "that metal which has lost its original identity as to source," as quoted in *Mineral Resources of the United States, 1929*, Part I, p. 179. In this volume appears a comprehensive discussion of secondary metals by J. P. Dunlop, pp. 179-201.

TABLE 7.—CONSUMPTION OF SCRAP IRON AND SCRAP STEEL, BY QUANTITY AND COST, FOR PRINCIPAL CONSUMING INDUSTRIES: 1929

[An unsuccessful attempt was made to collect data in regard to consumption of scrap iron and scrap steel from manufacturers of motor vehicles. No attempt was made to collect such data from railroad repair shops]

INDUSTRY	SCRAP IRON AND SCRAP STEEL	
	Quantity (tons 2,240 pounds)	Cost
Total.....	39, 126, 638	\$540, 662, 524
Agricultural implements.....	92, 791	1, 308, 405
Blast furnaces.....	1 5, 673, 176	1 32, 744, 377
Cars, electric and steam railroad.....	265, 949	3, 666, 332
Cast-iron pipe and fittings.....	224, 121	3, 119, 940
Engines, turbines, tractors, and water wheels.....	179, 538	2, 733, 989
Foundry and machine-shop products, not elsewhere classified.....	2, 834, 505	40, 240, 358
Locomotives.....	6, 025	95, 318
Machine tools.....	39, 302	654, 263
Plumbers' porcelain-enameled ware (enameled iron).....	36, 260	513, 516
Ship and boat building, steel and wooden.....	1, 568	19, 405
Pumps and pumping equipment.....	29, 270	464, 975
Steam fittings and steam and hot-water heating apparatus.....	280, 687	4, 228, 370
Steel works and rolling mills ²	³ 29, 356, 522	449, 354, 754
Stoves and ranges.....	86, 185	1, 230, 857
Textile machinery and parts.....	20, 739	287, 665

¹ Some establishments included data for cinder, scale, sinter, and open-hearth and Bessemer slag scrap. The average cost per ton is, therefore, much smaller for the blast-furnace industry than for others.

² Includes data for a steel plant operated by an important manufacturer of motor vehicles.

³ Includes 13,988,399 tons produced and reworked in the same plants, and 958,170 tons transferred to other plants in the same industry under the same ownership.

The kinds and approximate costs of old scrap considered in this report as raw materials are:

Iron and steel.....	\$284, 000, 000
Paper stock.....	74, 000, 000
Rags.....	33, 000, 000
Nonferrous metals.....	80, 000, 000
Precious metal sweepings ⁸	300, 000

The attention given by growing numbers of manufacturers in recent years to the matter of reduction in cost of materials has been one of the reasons for the increase in the proportion of waste materials used, resulting in the formation of numerous commercial companies and trade associations in the field of secondary materials. It has been estimated that the sale of all recovered materials (both new and old) amounts to more than \$1,000,000,000 a year.

New combinations.—The remarkable technical advances of recent years have brought about many new combinations of materials, as well as a demand for some which hitherto had little or no place in industry. Such changes come about either because of the relatively high cost of the natural materials used for a given product or because the new materials have properties lacking in those originally used.

No better illustration of recent changes in the use of materials is available than that which is taking place in the manufacture of plastic products in the "Pulp goods" (and molded composition products) industry. The establishments embraced in this industry are engaged wholly or principally in the manufacture of (a) vulcanized fiber and (b) products pressed or molded from vulcanized fiber, from plastic compositions (phenolic resins and similar plastics), from asphalt compositions, and from pulp. The largest group of products—molded plastics—accounts for about 60 per cent of the total production of the industry.

⁸ This refers to sweepings purchased from jewelers and other users of precious metals, not from refineries.

While no detailed production data for this type of plastic product were collected from the manufacturers, it is common knowledge that the items produced are legion, including machine parts, furniture, toys, knife handles, electric-lamp switches, billiard balls, and radio parts. (Certain other products, such as cement, rayon, wall board, and clay products, all of which are in a broad sense plastics, are not embraced within the "Pulp goods" industry.)

Molded plastic products are derived from the action of acids, formaldehyde, and other chemicals on such materials as vegetable fibers, soybeans, dried blood, and camphor. Some of the natural materials used as a base were formerly regarded as waste. The products consist of these chemically treated, moldable, substances, together with coloring materials and fillers of clay, talc, asbestos, mica, or vegetable fibers. The basic processes are performed largely in the "Chemicals, not elsewhere classified" industry, the semimanufactured materials passing on from there to be finished principally by the establishments classified in the "Pulp goods" (and molded composition products) and in the "Fancy and miscellaneous articles, not elsewhere classified" industries. The chemical industry, in addition to furnishing semiprocessed plastic materials to these other industries, manufactured finished pyroxylin products valued at \$10,522,000 in 1929. Some plastic products are in all likelihood made as by-products in other industries but are not reported separately.

Cellulose or pyroxylin plastics, notably celluloid, photographic films, and the central layer in safety glass, are ordinarily made from cotton linters acted upon by sulphuric, nitric, or acetic acid. Casein plastics, derived from the action of formaldehyde upon sour milk or upon soybeans, are noninflammable and are more brittle than products made from cellulose. They reach the market as novelties, buttons, automobile fittings, inexpensive jewelry, etc. A third group of products are made from synthetic resins, produced by the combination of phenol (carbolic acid) with formaldehyde. This type of product has a high tensile and compressive strength, and serves satisfactorily as an insulator. Automobile, radio, electrical, and telephone parts, furniture, household utensils, and novelties are a few of the scores of products made from phenol plastics. Mixed with natural rosin, this synthetic resinous material competes with natural gums in the manufacture of paints and varnishes. The combination of formaldehyde with urea—a substance produced chemically by high-pressure treatment of carbon dioxide and ammonia gas—yields a white plastic which, because of its ready adaptability to color effects, is used for making colored composition tableware and white electrical fixtures.

The production of plastics is but a section of the large field of synthetic organic chemicals and dye intermediates in which a few of the approximately 200,000 known carbon compounds serve as the starting materials for scores of such products as medicines, tannins, perfumes, dynamite, drugs, solvents, sweetening agents, rayon, antiseptics, and lacquers. By using certain well-known types of chemical reactions on a few basic materials, principally coal, natural gas, petroleum, plants, molasses, and wood, a host of products are made synthetically in competition with similar products made from natural materials.⁹

⁹ According to *Time*, Feb. 13, 1933, p. 13, "Henry Ford took occasion to announce the next major step in his industrial career. He envisages thousands of small rural factories making Ford parts, largely from farm products. Workers would spend part time in the fields, part in the factory. Only motors and other vital parts would be made in a large central plant. Objects of such decentralization would be operating economy and resuscitation of the farm. Holding up a steering wheel, a distributor box and other Ford parts made from soybeans, Mr. Ford declared that much else of an automobile can be 'grown on a farm.' Said he: 'Bodies * * * can be made from cellulose of cornstalks, with a woven-wire reinforcement inside and steel reinforcement at the doors, and will be lighter, stronger and quieter than metal bodies.'"

In some other industries the revolutions brought about by synthetic production have been as marked as in the field of plastics manufacture. For example: The production of rayon, generally from a solution of chemicals and either spruce-wood pulp or cotton linters, has vitally affected the whole textile industry. The cotton linter—a short-staple fiber delinted from the seed in cotton-oil mills—is a material which rose to prominence during the World War. Prior to that period steadily increasing amounts of it were used largely for upholstering and for the manufacture of mattresses and bedding. The extraordinary demand in 1915 and 1916 for the fiber in the production of explosives for European combatants led to a trebling of its price and to a pronounced increase in the amount of cotton linters production. Over the period of a few years the production of linters per ton of seed rose from about 50 pounds to more than 150 pounds in many of the mills. With the cessation of hostilities other uses were sought for linters, notably as a material for paper manufacture. It was not, however, until the production of numerous synthetic products from cellulose got under way that a broad market for the material was established. Production increased from 595,093 running bales in 1919–20 to 1,085,766 in 1928–29.¹⁰

Census data.—Detailed data covering the consumption of materials have not been collected by the census of manufactures in as comprehensive a way as have data for products. Since there are limits, on the sides both of cost and of expediency, to the number of inquiries that can be carried on the manufactures schedules, the emphasis has been placed on product statistics, for which there has been a greater public demand than for materials figures. However, there have been urgent requests for statistics covering the principal materials consumed in numerous industries, and these requests have been met in so far as they were considered practicable.

The schedules used at all censuses have called for data on the combined cost of materials (including those transferred from other plants under the same ownership) which entered into the products, together with the cost of containers for products and that of fuel and purchased electric energy; and at some censuses the cost of materials and containers has been reported separately from that of fuel and purchased energy. It has been the regular practice also to require each manufacturer to specify the principal kinds of materials used, in order of importance, but not in all cases to give cost data for individual items. The census for 1929, however, provided for a more comprehensive and detailed reporting of materials than had ever before been attempted. The special schedules used for more than half the industries called for detailed data on quantities and costs of all the important kinds of materials consumed; and fuel consumption was reported by kind, quantity, and cost for all industries.

Although the principal materials for which data were specially requested comprised both raw and semimanufactured items, the raw materials listed on the schedules predominated both in number and in value. The returns were generally quite helpful in ascertaining the kinds, quantities, and costs of the chief materials consumed in many of the industries, and for some industries they were entirely satisfactory. However, the returns were limited in usefulness in the following respects: (1) Manufacturers in 141 of the 326 industries were not required to specify either quantities or costs of individual kinds of materials used; (2) on some schedules quantity and cost data for only one or, at most, a very few principal materials were called for; and (3) the materials inquiries, placed on some of the schedules for the first time, were answered so incompletely for certain industries that the data were not tabulated.

¹⁰ For further statistics of the industry, see Census Bulletin 106 *Cotton Production and Distribution, Season of 1928–29.*

The incompleteness of the returns was not serious, however, for the ultimate purposes of this study, for, as will be explained, the method used in estimating the net value of production requires detailed cost data only for raw materials and imported semimanufactures consumed in the various industries. Many of the 326 industries consume no raw materials whatsoever except fuel. For example: The motor-vehicle industry, in which large quantities of steel, rubber, textiles, etc., are consumed, uses practically no materials which have not been processed previously in some other industry or industries. Steel sheets, the products of rolling mills in the steel industry, are reported as materials consumed on the returns made by the motor-vehicle industry, and the material (pig iron) from which the sheets are made appears as a product on the returns submitted by plants in the blast-furnace industry. Raw materials, for the purposes of this report, are materials, domestic or imported, in the crude form in which they enter the first plant on their route through the processes of manufactures. For some industries the itemized cost of imported materials and that of materials of domestic origin are given separately.

Every manufacturer, as has been explained, reported the total cost of materials and containers used, whether he gave the cost of specified kinds of materials or not. Since he was not asked specifically to indicate in one sum the amount that was expended for raw materials, as distinguished from partly manufactured materials, it is only by singling out the raw materials specified, if any, or by obtaining information concerning the habits of the industry that the kinds and values of raw materials can be determined. Estimates are required in many cases, always, however, within the limits set by the reported total expenditure for materials and containers.

At the censuses for 1899 and for 1904 the cost-of-materials inquiry on all the schedules was subdivided into (a) raw materials, and (b) semimanufactures, but since so many of the manufacturers reported that their books of account did not permit them to so separate their materials without a great amount of work, and also since it was felt that complete reliance could not be placed upon some of the returns on which the separation had been attempted, that form of inquiry was not repeated.

At censuses prior to that for 1929 the cost of mill and shop supplies was included in the cost of materials as reported, but in order to spare the manufacturers the inconvenience of separating data for this item from those for other expense items with which it is often entered in books of account, the instructions for 1929 directed manufacturers to omit figures for the cost of such supplies. As a result of this change, the increases in the cost-of-materials item over prior years understate the true increases and the indicated decreases overstate the true decreases, but for most industries these understatements and overstatements are slight and unimportant.¹¹

¹¹ In the cases of a comparatively few industries, of which the most important is "Steel works and rolling mills," the cost of supplies is of some importance in comparison with the cost of materials proper. For this industry the cost of materials as reported at previous censuses included the cost of relining and other repairing of furnaces and ladles, the replacement of stools, molds, and rolls, and general repairs to equipment, the total of which amounted to a very considerable sum.

The cost of materials, fuel, and purchased energy for the steel industry in 1927 amounted to 60.8 per cent of the gross value of products, as compared with 56.6 per cent in 1929. The decrease is possibly due in some measure to causes other than the omission of data for mill and shop supplies. The industry was considerably more active in 1929 than in 1927 and less time was left for repairing (although, of course, the relining had to be done at regular intervals in any event). Therefore, even if the cost of supplies had been included for both years, it is likely that the ratio would nevertheless have been somewhat smaller for 1929 than for 1927.

A few other industries in which the cost of supplies is of some importance are: Motor vehicles, motor-vehicle bodies and motor-vehicle parts, foundry and machine-shop products, hardware, and cast-iron pipe. In the cost of the last-named industry, however, special instructions to include data for the cost of supplies were given.

To account for the origin of the raw and semimanufactures materials used in domestic industry in 1929, data for imports, as well as for domestic production, are required. It has already been explained that in some of the industries the figures for imported materials consumed were reported separately from those for materials of domestic origin. In many industries, however, the manufacturers, if they specified their materials at all, made no such separation. Generous use was made, therefore, of the statistics of imports for consumption in 1929, published by the Bureau of Foreign and Domestic Commerce. The values at the foreign point of shipment were adjusted, however, in order to arrive at values thought to represent more closely the factory costs to industrial users of the materials in this country. The import duty, if any, was added to each item, as was also the estimated ocean-freight cost, based upon statistics prepared by the Maritime Records Division, Bureau of Research, United States Shipping Board.¹² No attempt was made to adjust further the values of the various items by the addition of probable costs of sales commissions and freight from the port of entry to the manufacturing plants. Certain items listed as crude materials and crude foodstuffs were without question consumed without being subjected to any manufacture in this country, while certain other articles classified in the import lists among finished products in all probability became component materials and parts for use in our industrial plants. Census returns from some of the industries indicated consumption of some of these finished items of foreign origin; other items were arbitrarily assigned to industries which in all probability obtained them from abroad for further manufacture.

TABLE 8.—VALUE OF CLASSIFIED GENERAL IMPORTS (NOT INCLUDING DUTY¹): 1929, 1919, 1909, AND 1899

[As compiled by Bureau of Foreign and Domestic Commerce]

CLASS	1929	1919	1909	1899
All imports, total value ²	\$4,399,361,000	\$3,904,365,000	\$1,311,920,000	\$697,148,000
Crude materials.....	1,558,620,000	1,701,058,000	460,901,000	213,296,000
Crude foodstuffs and food animals.....	538,560,000	545,300,000	164,111,000	98,933,000
Manufactured foodstuffs.....	423,622,000	555,808,000	165,701,000	123,448,000
Semimanufactures.....	885,051,000	608,997,000	222,102,000	91,954,000
Finished manufactures.....	993,508,000	493,203,000	299,107,000	169,517,000

¹ Duties calculated on imports for consumption were as follows: 1929, \$584,772,000; 1919, \$237,456,000; 1909, \$294,667,000; 1899, \$202,072,000.

² Represents "foreign value or the export value, whichever is higher; that is, the market value or the price at which the merchandise, at the time of exportation to the United States, is offered for sale in the principal markets of the country from which exported, including the cost of containers or coverings and all expenses incident to placing the merchandise in condition ready for shipment to the United States."

While information concerning materials produced and consumed was sought from a number of specialized agencies other than the Bureau of the Census,¹³ the figures for value of manufactured products are all taken from the reports of the Census of Manufactures. Instructions to manufacturers in 251 industries

¹² Published in *The Balance of International Payments of the United States in 1929*, p. 9, by the Bureau of Foreign and Domestic Commerce.

¹³ Considerable use was made of Parts I and II of *Mineral Resources of the United States, 1929*, a 2-volume work published by the Bureau of Mines. The sales-by-producers figures from this publication proved useful both in checking consumption reported by manufacturers and in estimating consumption in those industries in which materials were inadequately specified.

Recent statistics dealing with industrial materials, published by the Interstate Commerce Commission, the United States Traffic Commission and the Bureau of Foreign and Domestic Commerce, were also used.

(reporting approximately half the total production of the country) for making returns covering their operations of 1929 were to report the net selling values, at the plant, of all products of their own manufacture shipped or delivered to customers (or to warehouses on customers' accounts) during the year; or if transferred to other plants under the same ownership, the value at which the transfers were made. All products, including by-products, were covered, and the principal products were reported separately. Values, which include those of containers sold with products, are based on prices at the factory (not at some other point of delivery). Manufacturers in the remaining 75 industries were directed to report their actual production during the year, whether sold or not, as at preceding censuses.¹⁴ This difference of method in reporting production apparently had no material effect on the comparableness of the figures for different industries. Those values which were reported on the sales basis may, it is believed, be accepted as substantially identical with the actual values of products manufactured during the year.

¹⁴ The substitution of the sales basis for the production basis was made in compliance with the recommendation of an advisory committee of 25 members appointed by the Secretary of Commerce. This recommendation was a general one, intended to be applied to all industries. The numerous exceptions were made in some cases at the request of associations or important manufacturers representing the industries concerned, and in others because of the impracticability of employing the sales basis for certain industries.