

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.

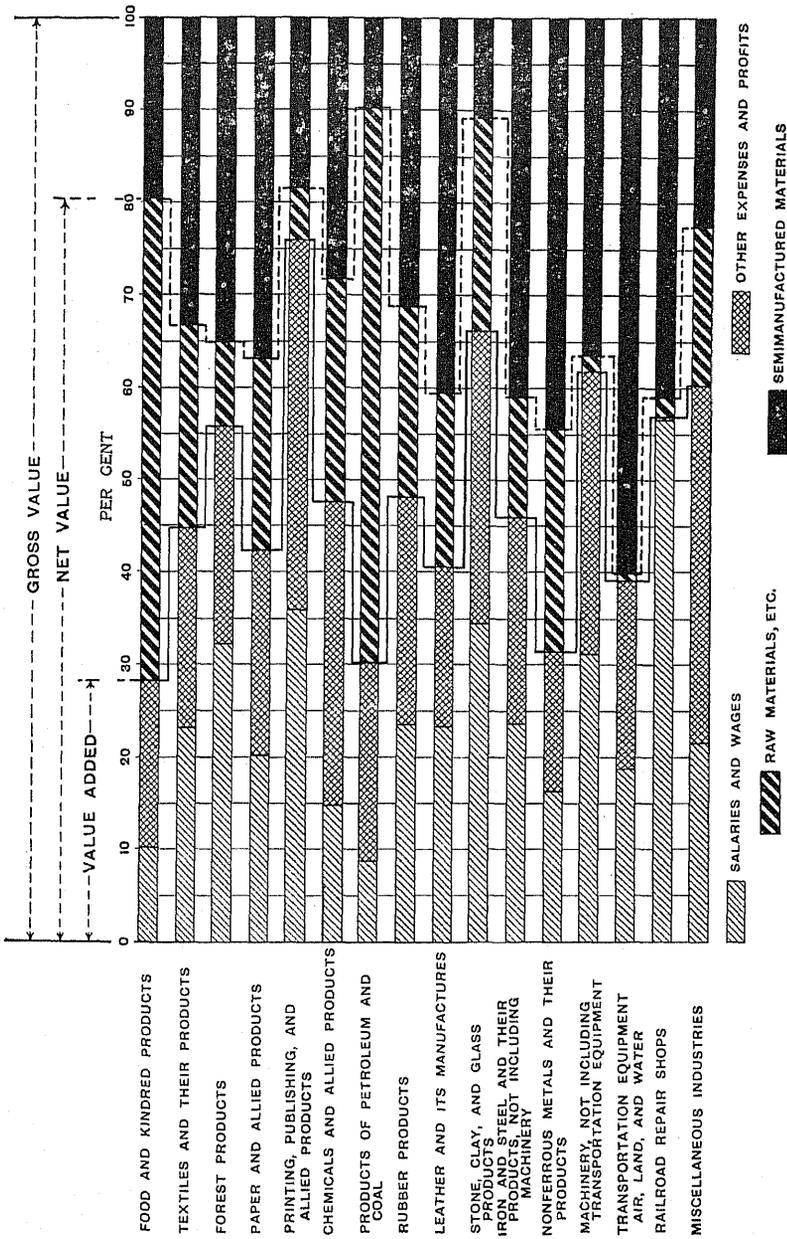


FIGURE 1.—RELATIONSHIP OF THREE KINDS OF PRODUCT VALUE (VALUE ADDED, NET VALUE, AND GROSS VALUE), BY INDUSTRY GROUPS: 1929

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	399,000,000	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. 48.

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: 1920*, 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	99,859,680	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	1,351,543,071	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	7,538,905	0.3
Minor metals ¹	30	6,049,976	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
Puller's and filtering earth.....	24	4,811,629	0.2
Sand, molding.....	128	4,775,957	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; fluorspar, 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	8,888,758	\$11,620,978,284	\$86,082,414,012	\$1,866,165,719	\$70,434,863,443	\$31,885,283,711
1. Food and kindred products.....	56,320	753,247	909,149,970	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	1,733,031,423	4,892,740,011	121,104,612	9,243,302,523	4,139,459,799
3. Forest products.....	26,912	576,363	639,322,073	1,550,372,304	33,810,649	3,691,765,090	2,003,883,137
4. Paper and allied products.....	3,126	283,393	281,930,792	1,011,026,312	81,086,791	1,862,251,148	799,629,045
5. Printing, publishing, and allied industries.....	27,622	357,988	636,371,372	740,748,389	25,735,159	3,170,139,651	2,403,656,108
6. Chemicals and allied products.....	8,478	294,868	354,393,208	1,971,273,040	99,437,820	3,759,404,640	1,788,691,371
7. Products of petroleum and coal.....	1,525	147,243	229,050,010	2,143,614,663	403,224,828	3,647,747,957	1,108,907,764
8. Rubber products.....	1,925	149,148	207,306,857	559,000,300	19,677,378	1,117,460,252	538,782,571
9. Leather and its manufactures.....	4,277	318,419	359,412,072	1,118,164,062	13,777,901	1,905,976,775	774,034,812
10. Stone, clay, and glass products.....	8,514	323,417	432,317,893	368,809,309	157,560,670	1,561,414,500	1,033,074,011
11. Iron and steel and their products, not including machinery.....	6,640	880,832	1,380,086,821	3,399,745,639	463,127,847	7,137,928,058	3,275,054,572
12. Nonferrous metals and their products.....	7,322	314,741	443,406,023	2,400,659,213	64,784,986	3,597,037,717	1,191,613,619
13. Machinery, not including transportation equipment.....	12,055	1,091,269	1,634,165,729	2,834,082,769	110,296,860	7,043,880,390	4,349,000,761
14. Transportation equipment, air, land, and water.....	2,550	389,356	643,271,405	3,629,190,049	53,057,118	6,047,209,390	2,364,061,312
15. Railroad repair shops.....	2,237	393,196	637,311,393	3,177,156,824	31,183,731	1,269,916,839	724,573,274
16. Miscellaneous industries.....	14,620	417,467	500,381,672	1,855,984,827	23,376,179	3,426,319,194	2,066,968,628

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	4,298,093,985	4,884,065,306	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	77,382,269	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	10,766,013	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, 549, 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, 839, 349	7, 428, 741, 443	4.6	6.6	16.4	10.5	85.0
70 per cent to 79.99....	11	3, 730	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	18.7	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, 699, 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 nonflammable 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 166 *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.

II. ELIMINATION OF DUPLICATIONS IN MATERIAL COSTS

Material costs and gross value of products.—The gross value of the manufactured output of the 210,959 industrial establishments in 1929 was in excess of \$70,000,000,000 (Table 10). This sum covered payments by the manufacturers for salaries, wages, materials and containers, and fuel and purchased electric energy, with nearly \$17,000,000,000 left after deducting the sum of the above items from the gross value. Out of this remainder must come numerous expenses, such as those for rent, shop and office supplies, taxes, interest, and in some cases, advertising, as well as reserve funds and manufacturing profits. The returns to the Census are not such as to give any indication of the size of these individual items.¹

No indication of the amount of investment in plant and equipment can be gained from the manufacturers' returns, except such as might be suggested by the volume of production. At recent censuses no inquiry concerning capital investment has been carried on the schedules. Although such interest charges as may be required to meet obligations for plant extensions, new machinery, etc., are included in the miscellaneous group of expenditures, arrived at by deduction, their amounts are not reported separately by the manufacturers.

The large item of approximately \$17,000,000,000 is composed, therefore, of such a multitude of payments to the various contributors to the manufacturing processes that it is not very useful for purposes of cost analysis. In part, the sum is a return on capital invested. On the other hand, that portion which goes for taxes may be translated quite directly into wage and salary budgets for public offices and for other governmental projects. Another increment destined for the purchase of shop and office supplies is closely related to the cost of the larger body of materials which enter directly into the products of industry and which are included in the "materials and containers" item in Table 9.

¹ Annual income returns made by manufacturing corporations to the Bureau of Internal Revenue show profits or losses for the year. All manufacturing and nonmanufacturing operations of the companies are covered by the income statements. Of the manufacturing corporations (incorporated concerns accounted for 92.1 per cent of the gross value of output of manufactures in 1929) which submitted corporate income statements to the Treasury covering the year 1929, 55,488 reported combined "statutory net income" of \$5,216,016,000, while 36,742 corporations having no net income reported a total deficit of \$810,243,000. For further details, see *Statistics of Income for 1929*, Bureau of Internal Revenue.

Figures showing the distribution of the gross value of products among the various component items for 1929 and for 1899 follow:

TABLE 9.—DISTRIBUTION OF GROSS VALUE OF MANUFACTURED PRODUCTS AMONG FIVE COMPONENT ITEMS: 1929 AND 1899

	1929		1899	
	Amount	Per cent of gross value	Amount	Per cent of gross value
Gross value of products, total.....	\$70,434,863,000	100.0	\$11,406,927,000	100.0
Salaries ¹	4,195,501,000	6.0	380,771,000	3.3
Wages.....	11,620,973,000	16.5	2,008,361,000	17.6
Materials and containers.....	36,683,414,000	52.1	6,368,712,000	55.8
Fuel and purchased energy.....	1,866,166,000	2.6	207,140,000	1.8
Other expenses, interest, and profits ²	16,068,809,000	22.8	2,441,943,000	21.4

¹ Data for employees of central-administrative offices are included in the figures both for 1929 and for 1899. The salaries of such employees as reported for 1929 amount to \$600,437,000 and exceed salary figures published in other reports of the Census by that amount. The figures are generally omitted from the published totals because in many cases the salaries paid to central-administrative employees who serve establishments classified in a number of industries can not be accurately apportioned among the several industries.

² The addition of \$600,437,000 to the "salaries" figure, as explained in note 1, reduces "other expenses, interest, and profits" by a like amount.

The above method of distributing the items, while commonly resorted to, may be quite misleading. It does not disclose the real comparative importance of the several factors which make up the value of products, because both the gross value itself and the cost of materials and containers are exaggerated on account of the use of the products of some manufacturing plants as materials in others. The cost item for materials and containers comprises both the cost of certain raw materials and that of semimanufactures, which latter, in turn, includes the cost of the raw materials entering into the semimanufactures, as well as the other costs which went into their production. To compare the size of this group of costs with the other relatively clear-cut, unduplicated items for salaries, wages, and other expenses conveys an inaccurate idea of the respective sizes of the several shares. Differences in the percentages of the five items as between the two years will not be commented upon until later in the report, when the duplications of value will have been eliminated and a more nearly accurate basis of comparison established.

TABLE 10.—DISTRIBUTION OF GROSS VALUE OF MANUFACTURED PRODUCTS AMONG COMPONENT ITEMS, BY INDUSTRY GROUPS: 1929

INDUSTRY GROUP	Gross value of products	Salaries ¹	Wages	MATERIALS AND CONTAINERS		Fuel and purchased electric energy	Other expenses, interest, and profits
				Raw materials and imported semimanufactures	Domestic semimanufactures		
All groups, total ²	\$70,434,863,000	\$3,595,064,000	\$11,620,973,000	\$14,531,000,000	\$22,152,000,000	\$1,866,166,000	\$16,669,246,000
Food and kindred products.....	12,023,589,000	316,144,000	902,143,000	6,156,000,000	2,315,000,000	161,444,000	2,173,020,000
Textiles and their products.....	9,243,303,000	410,623,000	1,733,031,000	1,907,000,000	3,073,000,000	121,106,000	1,995,802,000
Forest products.....	3,591,795,000	216,713,000	930,383,000	236,000,000	1,235,000,000	38,811,000	849,486,000
Paper and paper products.....	1,892,291,000	94,283,000	287,331,000	319,000,000	692,000,000	81,696,000	417,913,000
Printing, publishing, and allied industries.....	3,170,140,000	501,714,000	636,371,000	157,000,000	584,000,000	25,735,000	1,265,570,000
Chemicals and allied products.....	3,759,405,000	201,556,000	354,303,000	821,000,000	1,050,000,000	99,437,000	1,232,942,000
Products of petroleum and coal.....	3,647,748,000	86,236,000	220,050,000	1,893,000,000	248,000,000	403,228,000	785,622,000
Rubber products.....	1,117,460,000	58,558,000	207,306,000	211,000,000	348,000,000	19,677,000	276,124,000
Leather and its products.....	1,905,977,000	84,359,000	359,413,000	343,000,000	775,000,000	13,778,000	330,263,000
Stone, clay, and glass products.....	1,561,415,000	107,156,000	432,817,000	219,000,000	150,000,000	157,531,000	495,102,000
Iron and steel and their products, not including machinery.....	7,137,928,000	310,072,000	1,350,987,000	760,000,000	2,640,000,000	463,128,000	1,553,995,000
Nonferrous metals and their products.....	3,597,058,000	143,719,000	443,467,000	825,000,000	1,576,000,000	64,785,000	544,428,000
Machinery, not including transportation equipment.....	7,043,380,000	562,518,000	1,634,166,000	54,000,000	2,530,000,000	110,297,000	2,152,317,000
Transportation equipment, air, land, and water.....	6,047,209,000	187,029,000	943,222,000	4,000,000	8,625,000,000	53,957,000	1,253,811,000
Railroad repair shops.....	1,269,917,000	81,595,000	637,311,000	-----	217,000,000	-----	2,067,000
Miscellaneous industries.....	3,428,319,000	236,193,000	500,552,000	564,000,000	772,000,000	23,376,000	1,336,184,000

¹ Salaries for employees of central-administrative offices, amounting to \$600,437,000, are not included. See Table 9, footnote 1.

² Each total is the sum, expressed to the nearest thousand, or to the nearest million, of the individual items expressed in units. For this reason, the totals in some cases may differ slightly from the sums of the items.

TABLE 11.—PER CENT DISTRIBUTION OF GROSS VALUE OF MANUFACTURED PRODUCTS AMONG COMPONENT ITEMS, BY INDUSTRY GROUPS: 1929

[In dividing the gross value of products into the cost of raw materials and the cost of semimanufactures, both divisor and dividend were rounded to the nearest million dollars. The sums of the percentages for some of the groups do not, therefore, equal exactly 100. See Table 10]

INDUSTRY GROUP	Gross value of products	Salaries	Wages	MATERIALS AND CONTAINERS		Fuel and purchased electric energy	Other expenses, interest, and profits
				Raw materials and imported semimanufactures	Domestic semimanufactures		
All groups.....	100.0	16.0	16.5	20.6	31.5	2.6	22.8
Food and kindred products.....	100.0	2.6	7.5	51.2	19.3	1.3	18.1
Textiles and their products.....	100.0	4.4	18.7	20.6	33.3	1.3	21.6
Forest products.....	100.0	6.0	26.2	8.2	34.9	1.0	23.7
Paper and allied products.....	100.0	5.0	15.2	16.9	36.6	4.3	22.1
Printing, publishing, and allied industries.....	100.0	15.8	20.1	4.9	18.4	0.8	39.9
Chemicals and allied products.....	100.0	5.4	9.4	21.8	27.9	2.6	32.8
Products of petroleum and coal.....	100.0	2.4	6.3	52.0	6.8	11.1	21.5
Rubber products.....	100.0	5.0	18.6	18.9	31.2	1.8	24.7
Leather and its manufactures.....	100.0	4.4	18.9	18.0	40.7	0.7	17.3
Stone, clay, and glass products.....	100.0	6.9	27.7	14.1	9.5	10.1	31.7
Iron and steel and their products, not including machinery.....	100.0	4.3	19.3	10.6	37.0	6.5	22.2
Nonferrous metals and their products.....	100.0	4.0	12.3	23.0	43.8	1.8	15.1
Machinery, not including transportation equipment.....	100.0	8.0	23.2	0.8	35.9	1.6	30.6
Transportation equipment, air, land, and water.....	100.0	3.1	15.6	0.1	60.0	0.9	20.4
Railroad repair shops.....	100.0	6.4	50.2	-----	40.7	2.5	0.2
Miscellaneous industries.....	100.0	6.9	14.6	16.5	22.5	0.7	38.8

¹ Basic figure for "All groups" includes salaries paid to central-administrative-office employees; that for each of the 16 groups below does not. See footnotes to Table 9.

The gross value of manufactures exceeds by a considerable margin the amount of wealth created by the manufacturing processes. In the first place, as already pointed out, the gross includes a large amount of duplication due to the use of the products of some establishments as materials by others, and in the second place, it includes the cost of the raw materials derived from farms, mines, and other natural sources of basic materials. To manufacturing industries should be credited only the share of the gross value which is represented by the sum of salaries, wages, and other expenses and profits, an amount referred to in Census reports as "value added by manufacture." This value is calculated by subtracting the cost of materials, containers for products, fuel, and purchased electric energy from the gross value of products. It amounted in 1929 to \$31,885,284,000, or 45.3 per cent of the gross value of products; in 1899 to \$4,831,075,000, or 42.4 per cent of the gross. Value added by manufacture is a figure which contains very little, if any, duplication of value. It measures approximately the contribution of the factory processes to the value of manufactured commodities. This figure falls short of the final, unduplicated sales value of the finished goods by an amount equal to the cost of the raw materials which enter into the goods.

It is highly desirable to know the value, at f. o. b. factory prices, of those manufactured products, and those only, which are made for sale to ultimate consumers. This figure for industry as a whole should equal the value of the raw materials and imported semimanufactures consumed, plus the value added

by the processes of manufacture. Neither of the two values just considered, namely, gross value and value added by manufacture, represents the desired amount, the first being too large and the second too small.

Indirectness of manufacture.—If each manufacturing plant in the country consumed only raw materials and turned out only products ready for ultimate consumption, the figures for the combined output of all plants would give the amount desired (net value). Manufacture, under this hypothetical condition, would consist simply in adding value to given raw materials within a single establishment, and the report made for such an establishment would cover only the value of products made for sale to ultimate consumers. Data for such a hypothetical organization of industry are shown in Figure 2, using figures for the year 1929.

In few industries, however, is the route from the raw-material to the final-product state so direct. Manufacturers tend to specialize, many considering it more profitable to produce one or at most a few kinds of materials or parts on a mass-production basis to be sold to other producers as semimanufactures than to carry the items through to their finished form. In the manufacture of an automobile, for example, one plant may produce wheels, another the engine, a third the body, etc., the processes carried on in the final plant consisting largely in the assembly of component parts furnished by a number of specialized establish-

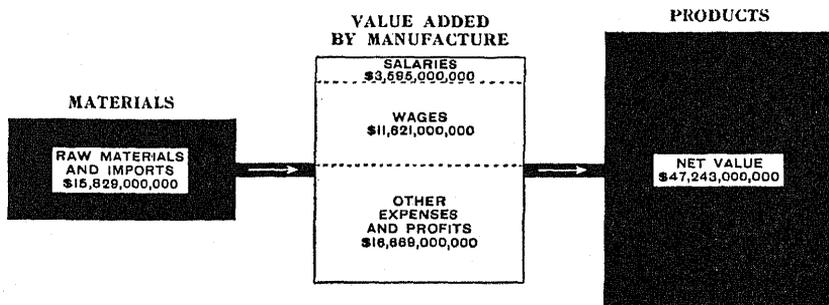


FIGURE 2.—NET VALUE AND COMPONENT ITEMS, BASED ON AN ASSUMED RAW-MATERIAL-TO-FINISHED-PRODUCT ORGANIZATION FOR EACH PLANT: 1929

ments. (In many cases, especially in the motor-vehicle industry, all these plants may be under the same ownership.) Examples of this indirectness of modern manufacture are available in practically all industries.² We speak of this wide distribution of processes among many plants, but we have no conclusive measure of its extent. It would seem that one of the bases for determining its amount would be the change shown from census to census in the volume of semimanufactured materials consumed relative to total production.

The tendency to separate the stages of manufacture, which results in the materials passing from one establishment to another until the production cycle is finally completed, is counteracted to some extent by an opposing trend. The development in some industries of series of semiautomatic machines, thus tele-

² The choice between buying or manufacturing certain required items constitutes a major problem for every industrialist able to finance a vertical organization of his concern or to accomplish the same purpose by a merger. To control all the processes from the raw-material stage to final assembly theoretically insures the manufacturer against many uncertainties and delays resulting from conditions beyond his immediate control. In general, coordination of industrial processes is best attained by complete vertical organization of an enterprise. Some manufacturers who have adopted the plan, however, have decided against it after discovering that it is most profitable in the long run to concentrate their efforts on a few processes, requiring the other manufacturers who furnish materials and parts to share the hazards of the business cycle and other vicissitudes of the market.

scoping processes heretofore separately performed, tends to concentrate the manufacture of a given product in fewer plants.

The passage of a material from the plant where it first enters in a raw state successively through other plants in each of which certain operations are performed upon it and further value added may be illustrated by a simplified hypothetical series of stages in manufacture of wool into clothing.

PLANT NO. 1 (MEAT-PACKING PLANT)

Process: Wool pulling.	
Cost of pelts purchased.....	\$1, 000
Value added by manufacture.....	300
Value of pulled wool produced (sold to plant No. 2).....	1, 300

PLANT NO. 2 (WOOLEN MILL)

Processes: Scouring, sorting, blending, picking, carding, combing, spinning, and weaving.	
Cost of pulled wool purchased.....	\$1, 300
Value added by manufacture.....	1, 200
Value of cloth produced (sold to plant No. 3).....	2, 500

PLANT NO. 3 (MEN'S-CLOTHING FACTORY)

Processes: Cutting and stitching.	
Cost of cloth purchased.....	\$2, 500
Value added by manufacture.....	2, 200
Value of garments produced.....	4, 700

SUMMARY

Gross value of products of plants No. 1, 2, and 3.....	\$8, 500
Cost of materials:	
1. Raw (pelts).....	\$1, 000
2. Semimanufactured (pulled wool and cloth).....	3, 800
Value added by manufacture.....	\$3, 700
Net value of products (gross value less cost of semimanufactured materials).....	\$4, 700
Per cent of duplication in gross value.....	44. 7

These three stages required to convert a sheep pelt into a finished garment, while typical, are not universally followed. Wool pulling is rarely done except in pullery departments of meat-packing plants and none of the processes assigned in the table to woolen mills would be likely to be performed by the packers. On the other hand, the grouping of processes shown for woolen mills may be modified considerably. For example: Scouring, sorting, blending, and picking may be done in a specialized establishment, and the wool may then be sold to the woolen mill, which may complete the manufacture of it into cloth. Or the wool may be carried only through the spinning stage, to be sold thereafter as yarn to woolen mills engaged solely in weaving. Clothing shops would perform none of the processes required to produce finished cloth, their functions being limited to cutting and stitching. Those of the large clothing manufacturers who spin and weave their own cloth conduct those processes in specialized woolen mills for which separate returns covering mill operations are made to the Bureau of the Census.

The number of different industries required for the complete processing of a given manufactured product varies from a single one, as in the fabrication of some of the simpler clay products, to half a dozen or more. The conversion of copper

ingots into automobile parts is a type of production which is broken up into many stages and which consequently results in a great amount of duplication in reported value of output. To illustrate: Copper ingots made in the copper smelting and refining industry are sold to copper-rolling mills, which roll them into rods. The rods are sold to copper-wire mills, which draw them into wire. Wire made by these mills is sold to establishments in the "Electrical machinery, apparatus, and supplies" industry, which use it in the manufacture of ignition apparatus for internal-combustion engines. These establishments sell the ignition apparatus to manufacturers of automobile engines. The engines in turn are sold to automobile manufacturers, who install them in complete automobiles. The value of the automobiles, as reported by the automobile manufacturers, includes, of course, the value of the engines; similarly, the value of the engines includes the value of the ignition apparatus; and so on. Thus in the aggregate of the values of products reported by the copper smelters and refiners, the rod mills, the wire mills, the manufacturers of ignition apparatus, the engine manufacturers, and the automobile manufacturers, the value of the copper ingots is included six times, of the rods five times, of the wire four times, of the ignition apparatus three times, and of the engines twice; and corresponding duplications occur in the aggregate cost of materials.

This duplication in the aggregate value of products of all industries appears also in the value of products reported for a given State, industrial area, county, or city, its amount depending in each instance upon the extent to which the products of certain establishments become the materials for remanufacture in other establishments in the same political division or industrial area. There is probably no city of any industrial importance in which the total value of products reported for its industries represents the actual value of output ready for ultimate consumption.

Determination of net value of products.—The next step is to measure for all industries the amount of this duplication of value and to arrive at the aggregate net value of output. Three general methods of approach are possible:

1. Compute the aggregate value of those products which are completely manufactured and are therefore ready for ultimate consumption.
2. From the gross value of products deduct the cost of semimanufactures used as materials in manufacturing establishments. The remainder is net value.
3. Add to the computed cost of raw materials and fuel consumed the value added by manufacture (equal to the total of salaries, wages, other expenses, except materials and fuel, and profits).

The first method is impracticable. To go over the list of thousands of manufactured items and to select those which will not become materials for further manufacture would be extremely laborious, and the results would be of uncertain value. Consider the many items such as paint, hardware, glass, fabrics, and chemicals, which, though in a sense finished, are nevertheless used in considerable quantities as materials for further manufacture. To compute, with any close approximation of accuracy, the value of those only which are destined for household and other nonmanufacturing uses would be impossible.

The second method calls for the summation of the costs of thousands of semi-manufactured materials consumed by factories, a procedure closely related to the one described in the preceding paragraph. Many of these materials are specified on the manufacturers' returns; many more are not. When it is realized how many are the component parts, often purchased from numerous vendors, required for the assembly, for example, of any complex piece of machinery, the magnitude of such a task is evident. To illustrate: According to the classification of units which appears on the engineering releases of one of the large automotive manufacturers, the number of parts required for the assembly of a current model of a standard

MATERIALS USED IN MANUFACTURES, 1929

sedan automobile is 10,118. The total number of *different kinds* of parts on this same car, exclusive of parts purchased from vendors, is 1,993. A second type of standard sedan made by the same company is composed of 9,363 parts, a third of 8,926, and a fourth of 7,582. These figures cover parts made by the company which assembles the finished car, but not those purchased from outside manufacturers, such as generators, carburetors, distributors, gages, instruments, locks, etc. The purchased items, if separately listed, might equal in number those made by the manufacturer of the car.

TABLE 12.—COST OF MATERIALS AND CONTAINERS, FUEL, AND PURCHASED ELECTRIC ENERGY, BY INDUSTRY GROUPS: 1929

INDUSTRY GROUP	Total	MATERIALS AND CONTAINERS		FUEL AND ENERGY	
		Raw	Semimanufactured	Coal, natural gas, and purchased energy	Manufactured fuels
All groups, total.....	\$38,549,579,732	\$12,676,402,000	\$24,007,012,000	\$1,298,319,367	\$567,846,352
Food and kindred products....	8,632,282,857	5,677,515,000	2,793,324,000	134,218,841	27,224,952
Textiles and their products....	5,103,845,724	1,578,341,000	3,404,400,000	109,173,933	11,930,830
Forest products.....	1,586,182,953	236,593,000	1,313,779,000	31,219,400	4,591,249
Paper and allied products.....	1,092,722,103	223,178,000	787,848,000	75,131,224	6,564,567
Printing, publishing, and allied industries.....	766,483,548	-----	740,748,000	22,147,106	3,588,053
Chemicals and allied products.....	1,970,713,269	564,629,000	1,306,647,000	84,474,662	14,962,658
Products of petroleum and coal.....	2,546,840,193	1,895,299,000	248,316,000	1,294,764,176	108,461,352
Rubber products.....	573,677,681	210,234,000	348,767,000	19,067,788	609,587
Leather and its manufactures.....	1,131,941,963	293,511,000	824,653,000	13,181,407	596,494
Stone, clay, and glass products.....	526,339,979	206,145,000	162,664,000	138,813,844	18,716,825
Iron and steel and their products, not including machinery.....	3,862,873,486	647,917,000	2,751,828,000	166,994,501	296,133,346
Nonferrous metals and their products.....	2,465,444,198	576,971,000	1,823,689,000	43,503,460	21,281,525
Machinery, not including transportation equipment.....	2,694,379,629	49,508,000	2,534,575,000	78,113,499	32,183,361
Transportation equipment, air, land, and water.....	3,683,148,078	3,781,000	3,625,410,000	41,153,215	12,803,903
Railroad repair shops.....	548,343,565	-----	517,160,000	26,678,923	4,504,808
Miscellaneous industries.....	1,359,360,506	512,780,000	823,204,000	19,683,388	3,662,841

¹ Includes \$38,263,293, cost of crude oil used as fuel.

The third method for eliminating duplication in cost of materials and value of products entails the segregation of the cost of all raw materials and of imported semimanufactured materials consumed from that of domestic semimanufactured materials. It requires that the reported or estimated cost of raw materials and of imported semimanufactures be determined, industry by industry, and then deducted from the total cost of materials, in order to arrive at a figure representing the cost of domestic semimanufactured materials used. The cost of materials divided in this manner discloses wide differences in materials usage in the 16 industry groups.

Before arranging the data so as to permit the computation of the net value of output for each of the 16 groups of industries, figures have been brought together in Table 13 to bring out merely the nature of the materials consumed by the several groups, regardless of whether they are of domestic or of foreign origin. The basic statistics for this classification appear in Table 23.

TABLE 13.—PER CENT DISTRIBUTION OF COST OF RAW MATERIALS, SEMI-MANUFACTURED MATERIALS, UNMANUFACTURED FUEL, AND MANUFACTURED FUEL, BY INDUSTRY GROUPS: 1929

INDUSTRY GROUP	Total	MATERIALS AND CONTAINERS		FUEL AND PURCHASED ELECTRIC ENERGY	
		Raw	Semi-manufactured	Coal, natural gas, and purchased energy	Manufactured fuels
All groups, total.....	Per cent 100.0	Per cent 32.9	Per cent 62.3	Per cent 3.4	Per cent 1.5
Food and kindred products.....	100.0	65.8	32.4	1.6	0.3
Textiles and their products.....	100.0	30.9	65.7	2.1	0.2
Forest products.....	100.0	14.9	82.8	2.0	0.3
Paper and paper products.....	100.0	20.4	72.1	6.9	0.6
Printing, publishing, and allied industries.....	100.0	-----	95.6	2.9	0.5
Chemicals and allied products.....	100.0	28.7	66.3	4.3	0.8
Products of petroleum and coal.....	100.0	74.4	9.7	11.6	4.3
Rubber products.....	100.0	36.3	60.3	3.3	0.1
Leather and its manufactures.....	100.0	25.9	72.9	1.2	0.1
Stone, clay, and glass products.....	100.0	39.2	30.9	26.4	3.6
Iron and steel and their products, not including machinery.....	100.0	16.8	71.2	4.3	7.7
Nonferrous metals and their products.....	100.0	23.4	74.0	1.8	0.9
Machinery, not including transportation equipment.....	100.0	1.8	94.1	2.9	1.2
Transportation equipment, air, land, and water.....	100.0	0.1	98.4	1.1	0.3
Railroad repair shops.....	100.0	-----	94.3	4.9	0.8
Miscellaneous industries.....	100.0	37.7	60.6	1.4	0.3

¹ The figures from which this percentage was computed include \$38,263,000, representing cost of crude oil used as fuel.

Two groups, "Food and kindred products" and "Products of petroleum and coal" lead all others by wide margins in the percentages which the cost of raw materials forms of the cost of all materials (65.3 per cent and 74.4 per cent, respectively). The question at once arises why these groups of industries consume greater proportions of raw materials than do other groups of basic industries, such as "Forest products" and "Stone, clay, and glass products." The answer in brief is that comparatively little semimanufactured material, obtained either from the same or from other industry groups, is required for production in either the food group or the petroleum group.

For example: In five industries in the food group—those engaged in the manufacture of butter, livestock feed, flour and other grain-mill products, and meat products, and in the roasting and grinding of coffee and spice—the raw material costs averaged about 87 per cent of the total material costs. In these industries the amount of fabrication required to prepare raw materials for ultimate consumer use is relatively small. Containers are required, and of course some semimanufactured materials, but in general the raw materials which enter a given plant are themselves processed, but combined to only a slight extent with other materials, and they then leave the plant approximately ready for distribution to ultimate consumers. This is the type of fabrication which was often carried on in small local plants before the advent of modern, centralized, mass production.

The processes employed in manufacture in the "Products of petroleum and coal" group are, in general, more complex. They are, however, like those of the food group, largely analytical; in other words, they consist primarily in breaking down raw materials into component products, not in assembling them with other materials.

The "Forest products" group, with only 14.9 per cent of its material cost expended for raw commodities offers a striking contrast to the other two groups. The reason that the cost of its raw materials is so small a percentage of the total material cost is that the processes required to convert the logs into finished products are divided among two or more industries. The sequence is approximately as follows: Standing timber is the material from which logs are made in the first manufacturing process in the "Lumber and timber products" industry. The logs as materials then enter the sawmills (in the same industry), where they are cut into boards. The boards in turn pass to the "Planing-mill products" industry for planing,³ after which they may be purchased by furniture plants and other establishments in the finishing industries for conversion into furniture, etc. The result is that only in the first stage of manufacture in the "Lumber and timber products" industry is there any raw material consumed; the logs and boards consumed by the sawmill, the planing mill, and the furniture plant, having once been reported as products, have become semimanufactures for consumption in the second and subsequent stages.

It will be noted that the printing and publishing industries, two groups of industries in which machinery and transportation equipment are manufactured, and finally, the group composed of railroad repair shops, consume practically no raw materials whatever, except unmanufactured fuels. The materials and component parts required for their production and assembly operations are first processed in pulp and paper mills, in blast furnaces, in foundries, in textile mills, etc., before they enter the plants of these four industry groups.

It appears, therefore, that the distribution of the cost of materials among raw commodities and semimanufactures in any industry group depends upon the plan of classification, but that that plan generally follows the practice of industry in distributing processes among specialized lines of manufacture. The industries engaged in the basic analytical processes have comparatively high raw-material costs; those which carry manufacture through the intermediate and final stages of production engage in synthesis or assembly, which requires the collection of semimanufactured materials and parts from numerous other specialized industries.

³ In many cases planing mills are operated in conjunction with sawmills, and these combined mills are classified in the "Lumber and timber products" industry.

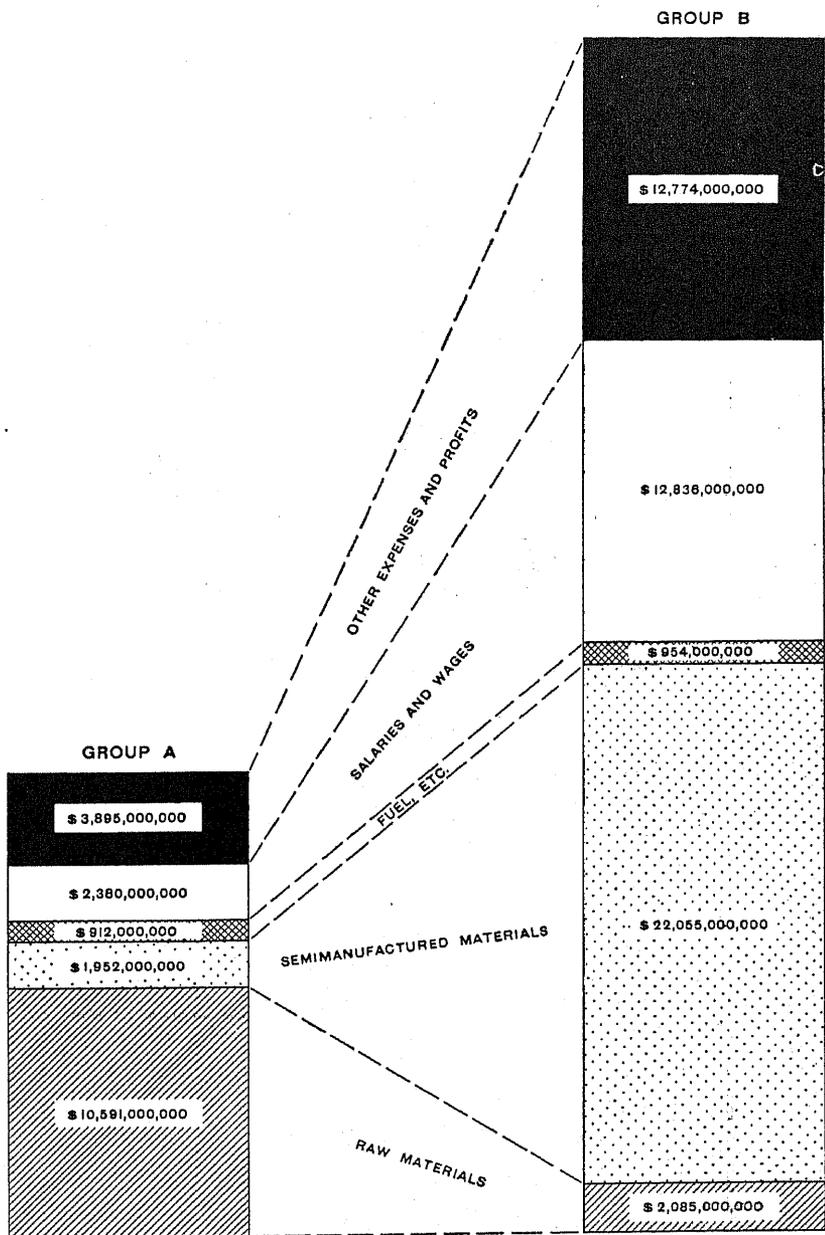


FIGURE 3.—GROSS VALUE OF PRODUCTS AND COMPONENT ITEMS FOR 68 RAW-MATERIAL-CONSUMING INDUSTRIES (GROUP A) AND FOR 258 SEMIMANUFACTURED-MATERIAL-CONSUMING INDUSTRIES (GROUP B): 1929

TABLE 14.—VALUE OF PRODUCTS AND COMPONENT ITEMS FOR 68 RAW-MATERIAL-CONSUMING INDUSTRIES, BY INDUSTRY GROUPS:
1929

[For list of industries included, see p. 57]

INDUSTRY GROUP	Num-ber of indus-tries	Gross value of products	Salaries and wages	Cost of fuels and purchased energy	Cost of raw materials ¹	Cost of semi-manufactured materials ¹	Other expenses, interest, and profits
68 industries, total.....	68	\$19,780,045,335	\$2,379,674,748	\$912,106,900	\$10,591,246,000	\$1,951,935,000	\$3,895,062,733
Food and kindred products.....	19	8,387,580,174	602,617,732	76,939,152	5,522,681,000	1,039,356,000	1,145,996,672
Textiles and their products.....	11	2,756,656,585	647,680,501	65,210,265	1,175,293,000	1,361,186,000	507,317,689
Forest products.....	4	37,164,773	31,699,522	1,174,698	23,307,000	9,474,000	21,691,849
Paper and paper products.....	1	238,928,279	38,523,708	14,330,410	104,829,000	29,594,000	51,651,842
Chemicals and allied products.....	9	621,804,077	56,546,977	15,962,734	383,558,000	70,568,000	93,143,466
Products of petroleum and coal.....	3	3,568,666,054	306,530,858	* 400,133,267	1,894,449,000	206,768,000	762,676,172
Leather and its manufactures.....	1	461,340,269	79,062,956	6,740,633	293,511,000	37,846,000	64,679,472
Stone, clay and glass products.....	8	992,877,571	354,752,169	122,118,477	174,097,000	17,987,000	323,672,830
Iron and steel and their products.....	1	771,425,464	48,804,938	193,671,870	400,449,000	16,172,000	112,926,835
Nonferrous metals and their products.....	3	255,236,091	39,704,584	12,612,369	131,106,000	24,621,000	47,191,793
Miscellaneous industries.....	8	1,508,355,968	173,750,803	3,193,025	487,995,000	138,664,000	764,752,974

¹ The total is the sum, expressed to the nearest thousand, of the individual items expressed in units. For this reason, the totals differ slightly from the sums of the items below.
² Includes \$33,263,293, cost of crude oil used as fuel.

TABLE 15.—VALUE OF PRODUCTS AND COMPONENT ITEMS FOR 258 SEMIMANUFACTURED-MATERIAL-CONSUMING INDUSTRIES, BY INDUSTRY GROUPS: 1929

INDUSTRY GROUP	Number of industries	Gross value of products	Salaries and wages	Cost of fuels and purchased energy	Cost of raw materials ¹	Cost of semimanufactured materials ¹	Other expenses, interest, and profits
258 industries, total	258	\$50,704,818,108	\$12,836,362,567	\$954,059,299	\$2,085,156,000	\$22,055,076,000	\$12,774,163,663
Food and kindred products	13	3,635,989,115	615,668,936	84,504,641	154,634,000	1,753,968,000	1,027,023,092
Textiles and their products	42	6,486,645,988	1,495,973,930	55,894,548	403,078,000	3,043,215,000	1,468,484,779
Forest products	16	3,504,600,317	1,124,396,653	34,035,951	213,286,000	1,304,105,000	828,176,883
Paper and paper products	9	1,653,322,869	343,092,251	67,365,381	118,350,000	758,254,000	366,261,244
Printing, publishing, and allied industries	13	3,170,139,651	1,138,085,787	25,735,159	740,748,000	1,265,570,316	1,265,570,316
Chemicals and allied products	24	3,137,600,563	499,202,303	83,454,586	181,071,000	1,236,079,000	1,137,793,622
Products of petroleum and coal	2	79,081,903	8,754,967	3,092,741	850,000	41,547,000	24,836,754
Rubber products	3	1,117,460,252	262,638,438	19,677,375	210,234,000	348,767,000	276,124,133
Leather and its manufactures	9	1,424,636,476	364,708,673	7,037,268	32,048,000	787,307,000	268,583,708
Stone, clay, and glass products	12	568,537,019	185,220,918	35,412,193	247,468,000	144,677,000	171,178,094
Iron and steel and their products, not including machinery	25	6,366,502,594	1,642,254,255	269,455,977	32,048,000	2,735,656,000	1,471,668,544
Nonferrous metals and their products	20	3,241,821,626	547,481,288	52,172,616	445,864,000	1,799,088,000	497,233,854
Machinery, not including transportation equipment	16	7,043,380,390	2,196,683,792	110,296,860	49,508,000	2,534,578,000	2,152,316,969
Transportation equipment, air, land, and water	10	6,047,309,360	1,130,250,459	58,957,118	3,781,000	3,625,410,000	1,233,810,863
Railroad repair shops	2	1,269,916,839	1,718,906,127	31,183,731	---	517,160,000	2,097,347
Miscellaneous industries	42	1,897,963,166	563,023,790	20,183,154	24,785,000	684,540,000	565,431,061

¹ The total is the sum, expressed to the nearest thousand, of the individual items expressed in units. For this reason, the total cost of raw materials differs slightly from the sum of the items below.

When the 326 industries are divided into two groups according to the percentage which the cost of raw materials forms of the total cost of materials and containers, 68 industries stand out as the principal consumers of crude materials. They are the ones in which more than half the total expenditure for materials goes for raw commodities. In fact, almost 54 per cent of the gross value of output of these industries is represented by outlays for crude materials consumed, in comparison with only about 10 per cent for purchased semimanufactures. (See Tables 14 and 15 and Figure 3.) In the remaining 258 industries the cost of semimanufactures, as a percentage of the value of products, amounts to about 44 per cent, that of raw materials 4 per cent. The relatively large expenditure for fuels in the raw-material-consuming industries is noteworthy.

The next step in determining net value is so to combine the cost of raw and semimanufactured materials consumed as to make possible the calculation of the net figure.

To the cost of raw materials must be added the cost of imported semimanufactures consumed in domestic factories.⁴ The latter may be determined in part from the returns of certain of the industries, on which imported as well as domestic semimanufactures are specified, and in part from estimates based upon import statistics. The cost of *old* scrap materials consumed should also be added to the raw-material expenditures, but new scrap is treated as a semimanufactured material (see page 10). The sum of these three items plus the cost of unmanufactured fuels is next combined with the value added by manufacture (or, now that the cost of domestic semimanufacture has been found by deduction, this item may be subtracted from the gross value of products) (Table 16). The process of arriving at net value is then complete, except for the deduction of receipts for contract work to the amount of \$471,957,935 from the results for two industry groups. This is done because payment for contract work represents clear duplication of value. (Since the concern doing the work reports the receipts from contract work as the value of its products and the manufacturer for whom the work is done adds it to the cost of his materials and is paid for it in receipts from his production, the amount appears twice in value of products.)

⁴ Imported semimanufactures, like raw materials, are in the condition in which they enter for the first time into manufacturing operations in this country.

TABLE 16.—ESTIMATED NET VALUE OF MANUFACTURED PRODUCTS, BY INDUSTRY GROUPS, 1929

[While the net-value figure in the final column for "All groups" represents the value of all the finished products of industry, the 16 items for the individual-industry groups which together make up the total net value of products do not represent exactly the values of completely manufactured products for the respective groups. For example: To arrive at the value of "Food and kindred products," ready for ultimate consumption it would be necessary to add to the \$8,682,000,000 item an estimated cost of containers obtained from other industry groups. On the other hand, for the "Rubber products" group it would be necessary to deduct from the gross-value figure the estimated value of rubber semi-manufactures, such as tires sold for initial installation on motor vehicles]

INDUSTRY GROUP	COST OF MATERIALS, CONTAINERS, FUEL, AND PURCHASED ELECTRIC ENERGY				VALUE OF PRODUCTS		
	Total	Fuel and purchased electric energy		Raw materials and imported semi-manufactures ¹	Domestic semi-manufactures ¹	Gross	Net ¹
		Coal, natural gas, and purchased energy	Manufactured fuels				
All groups, total.....	\$38,549,579,732	\$1,298,319,367	\$597,846,352	\$14,531,000,000	\$22,152,000,000	\$70,434,863,443	\$47,243,000,000
Food and kindred products.....	8,632,292,857	134,218,841	27,224,952	6,156,000,000	2,315,000,000	12,023,530,289	9,682,000,000
Textiles and their products.....	5,103,845,724	109,173,983	11,930,830	1,907,000,000	3,075,000,000	9,243,302,523	5,854,000,000
Forest products.....	1,586,182,953	31,219,400	4,591,249	295,000,000	1,255,000,000	3,591,765,090	2,352,000,000
Paper and paper products.....	1,092,722,103	75,131,224	6,564,567	319,000,000	692,000,000	1,892,251,148	1,194,000,000
Printing, publishing, and allied industries.....	765,483,548	22,147,106	3,588,053	157,000,000	584,000,000	3,170,139,651	2,412,000,000
Chemicals and allied products.....	1,970,713,269	84,474,662	14,962,658	821,000,000	1,050,000,000	3,759,404,640	2,695,000,000
Products of petroleum and coal.....	2,546,840,193	4,294,764,176	108,461,352	1,895,000,000	243,000,000	3,647,747,957	3,291,000,000
Rubber products.....	578,677,681	19,067,788	699,537	211,000,000	343,000,000	1,117,460,252	769,000,000
Leather and its manufactures.....	1,131,941,963	13,181,407	593,494	343,000,000	775,000,000	1,905,976,775	1,130,000,000
Stone, clay, and glass products.....	826,339,979	138,813,844	18,716,826	219,000,000	150,000,000	1,561,414,590	1,302,000,000
Iron and steel and their products, not including machinery.....	3,826,873,486	166,994,501	296,133,346	760,000,000	2,640,000,000	7,137,928,058	4,202,000,000
Nonferrous metals and their products.....	2,465,444,198	43,593,460	21,281,525	825,000,000	1,576,000,000	3,597,057,717	2,000,000,000
Machinery, not including transportation equipment.....	2,694,379,829	78,113,499	32,183,361	54,000,000	2,530,000,000	7,043,380,390	4,481,000,000
Transportation equipment, air, land, and water.....	3,683,145,078	41,153,215	12,803,903	4,000,000	3,625,000,000	6,047,299,390	2,409,000,000
Railroad repair shops.....	548,343,555	26,678,923	3,692,841	564,000,000	517,000,000	1,269,916,839	748,000,000
Miscellaneous industries.....	1,359,360,506	19,683,338	3,692,841	564,000,000	772,000,000	3,426,319,134	2,651,000,000

¹ The total is the sum, expressed to the nearest million, of the individual items expressed in units. For this reason, the total cost of raw materials and imported semi-manufactures differs slightly from the sum of the items below.

² Amount deducted, \$302,059,330, representing receipts for contract work.

³ Amount deducted, \$169,898,605, representing receipts for contract work.

⁴ Contains \$38,263,293, which represents the cost of crude oil used as fuel.

The net value was 67 per cent of gross value in 1929; in other words, one-third of the gross value represented duplication. (See Fig. 4.)

In a strict sense, the term *net value* as here used does not measure precisely the cost of raw materials plus the value created in manufacturing establishments. Fixed capital assets, represented by plant, machinery, and equipment, undergo more or less wear and tear in the process of manufacture. Some share of the factory output is required, therefore, to cover the costs of obsolescence and depreciation of capital equipment before there can be said to be a genuine net product. Since census data afford no exact knowledge of the amount of the output required for replacement of worn-out capital assets, this item was left out of consideration in the net-value calculations.

For those purposes which require an estimate for *net value added to existing wealth*, rather than one for *net value of transactions or sales*, probably the best procedure for revising the estimate made in this study would be to deduct the sum which the Bureau of Internal Revenue permits manufacturing corporations to charge off for depreciation and depletion. The amount thus allowed was \$2,017,754,000 for the year 1929, which, if deducted from the net-value figure

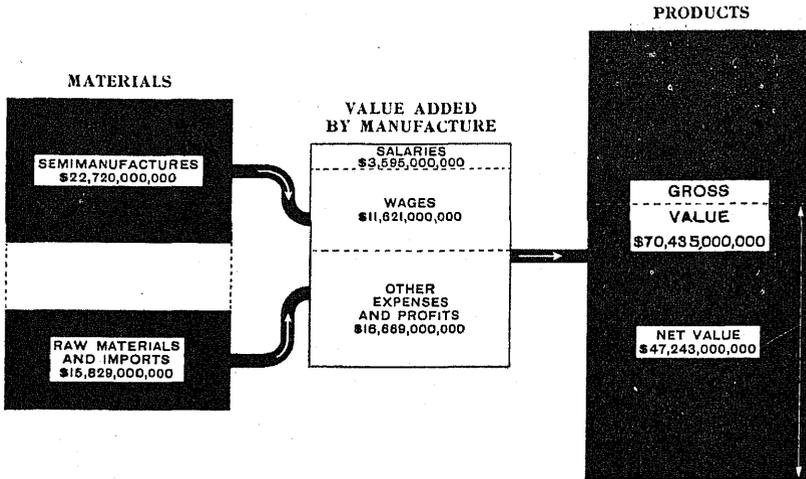


FIGURE 4.—GROSS VALUE OF PRODUCTS, NET VALUE, AND COMPONENT ITEMS: 1929

shown herein, would leave approximately \$45,225,000,000 as the corrected estimate for 1929.⁵

The estimated cost of domestic semimanufactures, \$22,152,000,000—the principal duplicated item—measures the volume of transactions among manufacturers themselves; that is, it represents the amount paid by manufacturers for materials which had been processed previously by other manufacturers. It is not meant to imply that all these transactions were made direct from manufacturer to manufacturer; in fact, a large though indeterminable share of them was made through middlemen. On the other hand, these figures do not cover all transactions between manufacturers, since the cost of machinery and major equipment purchased by manufacturers for use in their plants is not embraced in the total cost of materials, containers, etc. In fact, no canvass of such purchases is made as part of the census of manufactures, although an inventory of certain items of machinery and equipment is called for from a few industries. The other item for semimanu-

⁵ See *Statistics of Income for 1929*, Bureau of Internal Revenue, p. 267.

factures, that for "manufactured fuels" consumed in manufacturing establishments, is first the product of several industries in the "Products of petroleum and coal" group.

The original plan for this study called for an itemization of the major items of semimanufactures consumed in somewhat the way that raw materials are specified in Table 23. However, since that step is not required in order to arrive at an estimate for the net value of products, it was thought best not to attempt it at this time. Such an analysis should throw considerable light on the interdependence of manufacturing industries by further examining the nature of the interchange of materials and products between manufacturers and the flow of semimanufactured goods from plant to plant and from industry to industry in the course of manufacture. For example, the \$22,152,000,000 which represents the cost of domestic semimanufactures, if distributed by industries and by commodities, would give some indication of the extent to which the steel industry is dependent upon a market for semiprocessed steel in the automotive industry and the plants engaged in shoe manufacture sustain those of the tanning industry. It is this industrial interdependence, born of a highly specialized form of organization, which constitutes one of the principal obstacles to the attainment of stability of manufacturing operations.

It should be pointed out also that while the net total for all groups is the estimated net value of all finished products, the net items for the respective groups differ somewhat from the actual values of finished products made therein. To illustrate: The net value of products of the group "Products of petroleum and coal" was \$3,291,000,000 in 1929. Some of this output was sold to manufacturers in other industry groups who purchased it as "manufactured fuels" and for whom it became a semimanufactured material for further use in manufacture. Also, fabrics produced by manufacturers in the textile group are purchased by automotive manufacturers in the transportation-equipment group for use in motor-vehicle assembly. It would have been desirable, but altogether impracticable, to estimate the net values of *all finished products* made in the respective groups.

TABLE 17.—CONSUMPTION OF FUEL, BY KIND, QUANTITY, AND COST, AND OF PURCHASED ELECTRIC ENERGY, BY QUANTITY AND COST, BY INDUSTRY GROUPS: 1929

INDUSTRY GROUPS	Total cost of fuel and purchased electric energy (dollars)	COAL				COKE		FUEL OILS (INCLUDING CRUDE OIL AND GAS OILS USED AS FUEL)	
		Anthracite		Bituminous		Tons (2,000 lbs.)	Cost (dollars)	Gallons	Cost (dollars)
		Tons (2,240 lbs.)	Cost (dollars)	Tons (2,000 lbs.)	Cost (dollars)				
All industries, total.....	1,973,863,329	9,281,416	43,543,316	214,024,754	754,509,376	52,391,830	243,649,015	6,583,198,995	212,639,372
1. Food and kindred products.....	161,443,763	1,387,545	3,680,006	12,144,289	46,702,044	623,348	5,411,507	331,619,932	11,403,673
2. Textiles and their products.....	121,034,813	1,250,725	5,122,407	7,642,549	37,110,515	36,151	84,358	273,438,344	9,460,302
3. Forest products.....	36,510,649	124,577	736,384	2,998,064	12,391,875	20,903	110,607	65,537,717	2,269,256
4. Paper and allied products.....	81,695,791	1,181,764	5,262,763	10,247,091	42,728,436	3,198	15,851	136,871,533	4,371,267
5. Printing, publishing, and allied industries.....	25,725,159	101,395	806,980	402,842	2,223,373	7,173	54,795	17,189,760	954,732
6. Chemicals and allied products.....	99,437,220	728,958	3,409,898	10,440,986	37,410,769	290,267	1,506,989	295,838,621	8,854,457
7. Products of petroleum and coal.....	510,923,138	537,953	2,560,164	95,886,128	324,437,827	3,193,941	14,751,200	3,098,786,710	81,639,557
8. Rubber products.....	19,077,375	84,269	380,987	2,305,542	8,279,167	472	2,656	19,993,678	543,440
9. Leather and its manufactures.....	13,777,901	73,983	455,252	1,434,015	6,284,347	4,092	19,347	10,253,945	353,879
10. Stone, clay and glass products.....	157,650,670	769,745	3,701,227	22,045,960	73,968,001	154,105	807,684	344,495,539	11,965,101
11. Iron and steel and their products, not including machinery.....	463,127,847	685,094	2,553,013	29,151,532	87,158,774	45,270,251	198,158,259	1,181,105,911	47,015,826
12. Nonferrous metals and their products.....	64,784,985	1,074,017	4,268,118	3,517,241	13,767,132	726,552	5,937,936	269,807,072	12,395,034
13. Machinery, not including transportation equipment.....	110,296,860	400,611	2,061,943	5,989,024	24,745,430	1,830,182	14,972,293	190,413,278	9,122,304
14. Transportation equipment, air, land, and water.....	58,957,118	97,711	443,181	3,691,068	14,478,691	184,913	1,272,221	141,150,919	6,281,835
15. Railroad repair shops.....	31,183,731	638,054	1,302,244	7,135,730	14,586,160	26,084	151,126	159,670,176	4,001,376
16. Miscellaneous industries.....	23,376,170	147,505	805,139	1,732,634	7,536,835	50,207	382,186	46,956,860	1,798,733

INDUSTRY GROUPS	GASOLINE AND KEROSENE		GAS				OTHER FUELS		PURCHASED ELECTRIC ENERGY	
	Gallons	Cost (dollars)	Natural		Manufactured		Cost (dollars)	Kilowatt-hours	Cost (dollars)	
			M cubic feet	Cost (dollars)	M cubic feet	Cost (dollars)				
All industries, total.....	48,473,195	7,556,341	2,429,826,799	86,369,465	81,298,450,089	127,571,114	22,391,453	37,393,833,046	475,633,877	
1. Food and kindred products.....	4,140,454	648,198	34,752,333	8,666,105	8,572,983	6,610,633	3,150,941	4,171,254,936	70,170,686	
2. Textiles and their products.....	1,468,447	217,504	1,750,325	364,202	1,703,774	1,536,455	682,121	4,052,919,344	65,776,859	
3. Forest products.....	5,177,410	977,970	2,492,916	522,400	493,761	306,870	926,546	830,277,136	17,568,741	
4. Paper and allied products.....	1,773,735	26,795	12,411,249	1,092,428	164,323	164,323	1,852,359	2,979,398,234	26,047,597	
5. Printing, publishing, and allied industries.....	474,321	75,489	1,705,525	711,855	2,055,372	1,794,528	708,509	686,333,145	18,404,898	
6. Chemicals and allied products.....	1,631,208	225,869	11,973,198	2,318,331	1,472,869	1,090,956	3,284,387	6,965,135,933	41,387,664	
7. Products of petroleum and coal.....	530,504	71,390	129,902,410	17,545,308	298,213,785	54,842,325	3,117,803	1,128,874,465	11,957,564	
8. Rubber products.....	172,719	30,000	1,296,559	167,059	32,152	32,585	882,449,734	882,449,734	10,240,575	
9. Leather and its manufactures.....	99,030	14,140	95,579	38,363	133,044	128,957	80,191	227,718,474	6,373,415	
10. Stone, clay, and glass products.....	2,953,080	461,898	121,038,585	24,452,853	2,900,370	1,913,359	3,568,754	2,845,280,055	36,691,763	
11. Iron and steel and their products, not including machinery.....	3,565,192	554,949	68,298,915	20,013,080	925,688,163	47,708,452	2,695,860	4,986,174,297	57,268,434	
12. Nonferrous metals and their products.....	1,826,395	259,976	24,609,575	4,669,339	3,022,557	2,185,461	503,118	2,147,087,563	21,368,871	
13. Machinery, not including transportation equipment.....	11,464,833	1,450,287	9,004,736	3,797,710	8,103,422	5,275,651	1,362,216	2,822,563,455	47,508,407	
14. Transportation equipment, air, land, and water.....	11,987,431	2,174,035	3,316,274	1,135,248	4,503,938	2,837,818	229,994	1,625,101,989	24,696,065	
15. Railroad repair shops.....	1,665,258	188,047	6,345,839	1,093,058	137,965	118,913	45,296	618,311,793	9,397,461	
16. Miscellaneous industries.....	1,135,469	176,644	532,776	351,517	1,251,626	1,092,856	292,422	454,942,503	10,826,847	

¹ The difference between the total cost of fuel and purchased energy as shown in this table, \$1,973,863,329, and the corresponding total as given in other tables, \$1,866,165,719, is found in the fact that the figure given here represents the total cost of all fuel actually consumed in manufacturing industries, including that produced and consumed in the petroleum-refining, manufactured-gas, and coke industries, whereas the figure in other tables covers only the cost of fuel purchased.

² The figures for natural gas do not include data for 25,536,328 M cubic feet used in mining and quarrying nor for considerable quantities consumed in the so-called "service industries," which are not covered by the census of manufactures. To determine the total consumption of natural gas in manufactures it would be necessary to add to the total shown in this report the quantity used as a material in the "Bureau black, carbon black, and lampblack" industry, but census data therefor are incomplete, some of the manufacturers having failed to report their consumption of gas. The Bureau of Mines reports the consumption of 261,107,000 M cubic feet in this industry in 1929.

³ The amount of manufactured gas as reported for certain States, industry groups, and industries, appears abnormal in comparison both with the published figures for manufactured gas produced and sold by commercial gas companies and with those for gas consumption reported by the census of manufactures for 1919. The reason for the first condition is found in the inclusion of data for blast-furnace, coke-oven, and petroleum gases, the consumption in 1929 of these gases in steel works and rolling mills, coke and gas plants, cast-iron pipe plants, and structural and ornamental iron manufacturing establishments having aggregated 1,215,451,259 M cubic feet, at a cost of \$97,631,850. This cost-in many instances merely a transfer charge between plants or departments—reduced the average unit price of the aggregate amount consumed in manufactures to a point far below the usual market rate for manufactured gas. The reasons for the increase in reported gas consumption for 1929 as compared with 1919 are found largely in improved methods of recovering, purifying, and utilizing what were formerly waste by-product gases, permitting the transfer of greatly increased quantities of gas from coke ovens and blast furnaces to steel works and rolling mills and to other steel-fabricating plants, and by the inclusion in the recent figures of data for gases produced and consumed in the same plants, or in plants under the same ownership.

Material costs and net value.—Now that the amount of duplication in the cost of materials has been determined and an estimated net value of products found, the several components of product value bear a different relation to one another from that shown in Tables 10 and 11, in which they are proportioned on the basis of gross value. In the former table the figure labeled "Materials and containers" is not truly that, for in addition to the cost of the raw materials there is included in the item a considerable amount covering labor and other

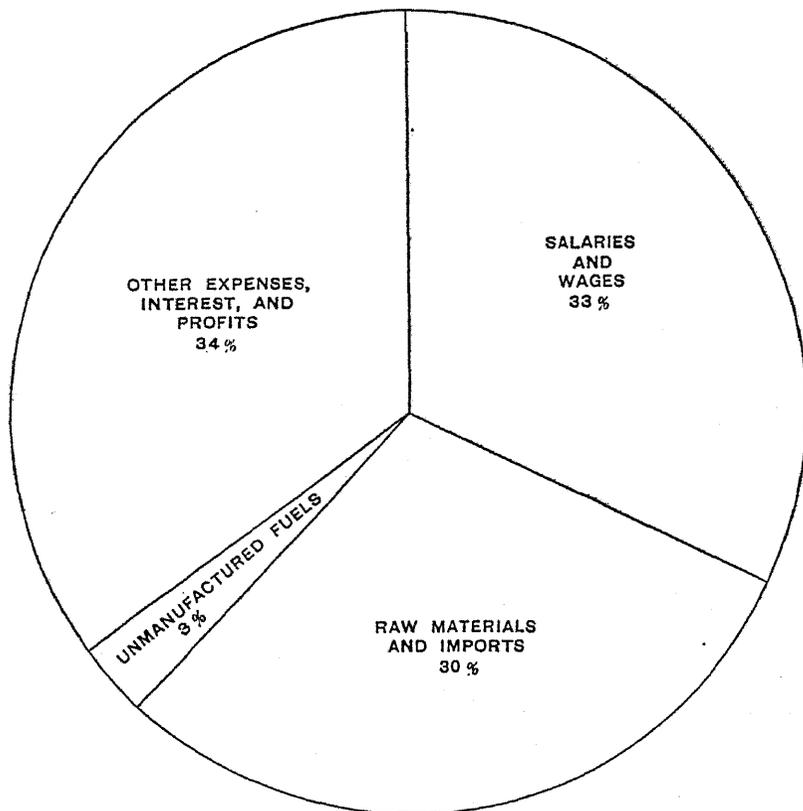


FIGURE 5.—PER CENT DISTRIBUTION OF ELEMENTS IN NET VALUE OF PRODUCTS: 1929

manufacturing costs. The relationship between the several unduplicated items of cost and value may be seen in the percentages in Table 18. It should be pointed out, however, that since the cost of even the raw materials to the manufacturer includes a certain amount of labor cost,⁶ the wage and salary item in

⁶ For example, the salaries and wages paid in the mining and quarrying industries in 1929 amounted to \$137,639,000 and \$1,091,990,000, respectively; the amount expended in cash for farm labor (exclusive of housework) was \$955,420,000. (This figure does not cover compensation to farm owners or operators.)

manufacturing industries falls short of measuring the actual payment to direct and indirect labor for a given manufactured product.⁷

The Bureau of the Census puts forth no claim that its manufactures statistics provide the basis for precise cost analysis. The values and costs, except detailed values for many items of product and costs for specified materials, are too broadly classified to give anything more than general information on manufacturing incomes and expenditures.

TABLE 18.—PER CENT DISTRIBUTION OF NET VALUE OF MANUFACTURED PRODUCTS AMONG COMPONENT ITEMS, BY INDUSTRY GROUPS: 1929

INDUSTRY GROUP	Net value of products	Salaries	Wages	Cost of raw materials and imported semi-manufactures	Cost of un-manufactured fuels	Other expenses, interest, and profit
All groups, total	100.0	28.8	24.4	30.4	2.7	33.7
Food and kindred products.....	100.0	3.3	9.3	63.6	1.4	22.4
Textiles and their products.....	100.0	6.7	28.2	30.9	1.8	32.4
Forest products.....	100.0	9.3	40.3	12.7	1.3	36.4
Paper and allied products.....	100.0	7.9	24.1	26.7	6.3	35.0
Printing, publishing, and allied industries.....	100.0	19.4	24.6	6.1	0.9	49.0
Chemicals and their products.....	100.0	7.5	13.2	30.5	3.1	45.8
Products of petroleum and coal.....	100.0	2.6	7.0	57.6	8.9	23.9
Rubber products.....	100.0	7.2	27.0	27.4	2.5	35.9
Leather and its manufactures.....	100.0	7.5	31.8	30.4	1.2	29.2
Stone, clay, and glass products.....	100.0	7.7	31.1	15.7	10.0	35.5
Iron and steel and their products, not including machinery.....	100.0	7.4	32.9	18.1	4.0	37.7
Nonferrous metals and their products.....	100.0	7.2	22.2	41.2	2.2	27.2
Machinery, not including transportation equipment.....	100.0	12.6	36.5	1.2	1.8	48.0
Transportation equipment, air, land, and water.....	100.0	7.8	39.2	0.2	1.7	51.2
Railroad repair shops.....	100.0	10.9	85.2	-----	3.6	0.3
Miscellaneous industries.....	100.0	8.9	18.9	21.3	0.7	50.2

¹ Basic figure includes amount of receipts for contract work in order that the sum of the percentages for the several items will equal 100.

² Total includes salaries of central-administrative-office employees. See footnotes to Table 10.

The figures in Table 18 indicate that in 1929 the budget for factory salaries and wages, exclusive of incomes of proprietors and firm members, was 33.2 per cent, or one-third of the value of finished manufactured goods. In the 16 groups the corresponding percentage ranged from 9.6 for "Products of petroleum and coal" to 96.1 for "Railroad repair shops." In the first of these two groups the cost of

⁷ In computing the payment for the labor which enters into the value of a given product, both the "direct" labor item, represented in general by wages, and the "indirect" item, as measured by salaries, should be considered. There is no doubt that the work performed in return for wages contributes directly to the creation of the product. The services rendered in return for salaries are more diverse in nature. Proprietors and firm members may obtain their incomes as returns on their capital investment, in which case they are not reported as receiving salaries, even though some of their work may be similar in character to that performed by wage earners. To exclude salaries from the aggregate for labor in its broad sense means that payments to mill clerks, accountants, stenographers, foremen, and research workers, shall not be added into the personnel cost of manufacturing the product.

It is quite probable that in recent years more of the manufacturing functions formerly performed by "productive" workers are given over to salaried employees. For example: The work of the planning department of the large factory, representing a concentration of those duties once performed largely by superintendents, foremen, and factory workers, is likely to be done entirely by salaried workers. Furthermore, much of the technical research originally conducted, at least in part with the help of shop workers, is now done by specialized salaried staffs.

the raw materials was a larger percentage of the value of output than in any other group except that comprising the food industries. In railroad repair shops, in which no raw materials are used and for which the value of products reported for the industries represents, in general, the cost of semimanufactured materials plus the amounts of salaries and wages paid to shop executives and employees, the manufacturing operations are not strictly comparable with those of the other 15 groups of industries.

The estimated net value of manufactures for 1929 was equal to 67.1 per cent of the gross value, as compared with 66.3 per cent for 1904 and 64.7 per cent for 1899 (Table 19). These percentages are not strictly comparable with one another since the composition of the values of the products for the three years differed in some minor respects, and it is impossible to eliminate these differences with the data available. Comparisons of the percentages by groups of industries for the three census years are further impaired by the differences in the composition of the groups in 1899 and 1904 and in 1929. For the two earlier years the industries were classified into 14 groups, for 1929 into 16 groups.

TABLE 19.—GROSS VALUE AND NET VALUE OF MANUFACTURED PRODUCTS BY INDUSTRY GROUPS: 1904 AND 1899

[The classification in effect at the censuses for 1904 and 1899 embraced only 14 groups of industries]

	GROSS VALUE		NET VALUE		PER CENT NET VALUE IS OF GROSS VALUE	
	1904	1899 ¹	1904	1899 ¹	1904	1899 ¹
All groups, total ¹	\$14,802,147,087	\$11,820,784,665	\$9,821,205,387	\$7,649,490,317	66.3	64.7
Food and kindred products.....	2,845,234,900	2,277,702,010	2,176,489,626	1,753,171,220	76.5	77.0
Iron and steel and their products.....	2,176,739,726	1,793,490,908	1,289,490,273	983,821,918	56.9	54.9
Textiles.....	2,147,441,418	1,637,484,484	1,397,009,940	1,081,961,248	65.1	66.1
Lumber and its remanufactures.....	1,223,730,336	1,030,906,579	805,315,333	547,350,520	65.8	53.1
Chemicals and allied products.....	1,031,965,263	552,891,877	714,489,549	372,592,807	69.2	67.4
Miscellaneous industries.....	941,604,873	1,004,092,294	602,990,604	638,191,538	64.0	63.6
Metals and metal products, other than iron and steel.....	922,262,456	748,795,464	442,912,699	371,154,446	48.0	49.6
Paper and printing.....	857,113,256	606,317,768	596,872,350	419,798,101	69.6	69.2
Leather and its finished products.....	705,747,470	583,731,046	401,011,414	329,614,996	56.8	56.5
Vehicles for land transportation.....	643,924,442	508,649,129	324,109,901	250,688,696	50.3	49.3
Liquors and beverages.....	501,266,605	425,504,167	431,735,208	349,157,618	86.1	82.1
Clay, glass, and stone products.....	391,230,422	293,564,235	334,971,057	245,447,118	85.6	83.6
Tobacco.....	331,117,681	283,076,546	307,100,175	264,052,573	92.7	93.3
Shipbuilding.....	82,769,239	74,578,158	46,707,258	42,492,518	56.4	57.0

¹ Values assigned to "hand trades" at the census for 1899 are deducted, but it was impossible to deduct either the values for establishments with products valued at less than \$5,000 or those for custom flour and feed mills (gristmills) and custom sawmills, the combined output of which amounted to \$413,858,000.

The percentages for 1904 for all groups in combination, when adjusted so that they are comparable with those for 1929 should throw some light upon whether manufacture is becoming less direct; that is, upon whether there is a tendency for the processes required for the manufacture of a given product to be distributed among a larger number of specialized establishments and for the cycle of production to be thereby lengthened. The tendency can best be seen by observing changes in the distribution of the gross value of products among the several items which compose the total, as shown in Table 20.

TABLE 20.—PER CENT DISTRIBUTION OF THE GROSS VALUE OF MANUFACTURED PRODUCTS AMONG COMPONENT ITEMS: 1929 AND 1904

ITEM	1929	1904	ITEM	1929	1904
Gross value of products..	100.0	100.0	Cost of semimanufactures, total.....	34.1	133.5
Salaries.....	6.0	3.9	<i>a.</i> Domestic.....	31.5	(?)
Wages.....	16.5	17.6	<i>b.</i> Imported.....	2.6	(?)
Cost of raw materials.....	18.0	21.4	Cost of fuel and purchased energy.....	2.6	2.2
			Other expenses, interest, and profits.....	22.8	21.4

¹ Freight charges, reported separately, were added to the costs of raw and of semimanufactured materials to secure comparableness with data for 1929; cost of mill supplies was deducted from that of semimanufactured for the same reason.

² No data.

The cost of raw materials, as a percentage of gross value of products, was considerably less in 1929 than in 1904; the cost of semimanufactures, on the other hand, increased slightly, the combined share of the two types of materials being 54.9 per cent of the gross value of products in 1904 and 52.1 per cent in 1929. The corresponding percentage amounted to 57.4 for the postwar year 1919, a year of comparative extravagance in the utilization of materials; by 1927 it had fallen to 53. These percentages, together with corresponding figures for the other census years from 1899 to 1929, are given in the following table:

TABLE 21.—PER CENT WHICH COST OF MATERIALS FORMS OF GROSS VALUE OF PRODUCTS: 1899 TO 1929

CENSUS YEAR	PER CENT OF GROSS VALUE FORMED BY—		CENSUS YEAR	PER CENT OF GROSS VALUE FORMED BY—	
	Cost of materials, fuel, and purchased electric energy	Cost of materials and containers only		Cost of materials, fuel, and purchased electric energy	Cost of materials and containers only
1929.....	54.7	52.1	1919.....	60.0	57.4
1927.....	56.0	53.0	1914.....	59.5	56.7
1925.....	57.3	(¹)	1909.....	59.0	56.2
1923.....	57.3	(¹)	1904.....	57.7	² 55.5
1921.....	58.0	(¹)	1899.....	57.6	55.8

¹ No data.

² Unadjusted. See Table 20, footnote 1.

The material cost constituted an increasing proportion of the value of products from 1899 to 1919, after which year the figures took a downward direction.

At least three explanations of the trends are possible: (a) The first has to do with the disparity in the prices of raw materials and of manufactured goods; (b) another concerns the increasing economy in the utilization of industrial materials; (c) while a third has to do with the relative increase in the proportion of semimanufactures consumed, that is, with the increasing indirectness of manufacture.

The comparison of price changes may be made from the following indexes:

TABLE 22.—INDEX NUMBERS¹ OF WHOLESALE PRICES OF RAW MATERIALS AND OF MANUFACTURED GOODS: 1899 TO 1929

YEAR	Raw materials	Manufactured goods	YEAR	Raw materials	Manufactured goods
1929	181.1	187.4	1913	128.7	123.7
1928	185.3	189.4	1912	136.4	121.5
1927	180.3	188.1	1911	127.7	118.7
1926	184.9	194.9	1910	127.0	123.8
1925	196.8	200.9	1909	123.9	118.7
1924	180.8	197.0	1908	116.7	117.1
1923	182.1	201.7	1907	126.8	125.1
1922	171.2	191.5	1906	119.6	119.2
1921	160.9	201.3	1905	115.8	112.7
1920	260.2	296.3	1904	113.5	109.6
1919	252.4	255.0	1903	115.2	110.4
1918	243.1	245.5	1902	114.9	109.6
1917	224.5	209.6	1901	106.2	106.5
1916	164.6	160.1	1900	106.4	108.9
1915	134.1	126.2	1899	100.0	100.0
1914	127.0	121.0			

¹ Computed by National Bureau of Economic Research from data collected by the United States Bureau of Labor Statistics, and published in *Economic Tendencies in the United States*, by F. C. Mills. Adjusted for the purposes of this table on an 1899 base.

As has been said, the cost of materials formed a gradually increasing proportion of the gross value of products from 1899 to the period of the World War, a trend consistent with price movements for the same period. During those years the wholesale prices of raw materials rose almost 125 per cent, while those for manufactured goods increased about 110 per cent. Although two-fifths—scarcely more than one-third in 1929—of the manufacturers' expenditures for materials generally go for the purchase of raw materials as distinguished from semimanufactures, whose price levels are governed both by those of finished goods and of crude materials—nevertheless, the disparity between the prices of raw materials and of fabricated goods modified the ratio between the total cost of materials and the value of the products made from them.

In the postwar period the proportion which the material cost formed of the value of output decreased from 60 per cent in 1919 to 55 in 1929, a change of much greater magnitude than can be accounted for by price movements as measured by the indexes. Raw materials and manufactured goods were at levels in 1919 more than 150 per cent above their respective 1899 positions. The former rose moderately and the latter strikingly in 1920. Then came the drastic drop in the two sets of prices in 1921, and thereafter both sets fluctuated, but the net movement of the raw-material index was upward, while that of the index for manufactured goods was downward. By 1929 raw-material prices had fallen 28 per cent below the 1919 levels but were still 13 per cent higher than in 1921, while those for manufactured goods were 27 per cent lower than in 1919 and 7 per cent lower than in 1921. Although there was considerable disparity between the movements of the two series of prices during the 10-year period, price differences alone can not account for the pronounced change in the ratio of cost of materials to value of products.

It is significant that from 1904 to 1929, the only two census years for which separate and comparable costs of semimanufactures are available, the proportion which those costs formed of the gross value of output underwent only a slight change. This relationship seems to indicate, as would be expected, a close correlation between the price levels of what the manufacturer buys as partially manufactured materials and of what he sells as products. This could hardly be other-

wise, since approximately one-third of the products (as measured in monetary terms) sold by manufacturing establishments are purchased by other plants for further processing or assembly.

The Census Bureau collects no data by which economy and efficiency in the utilization of materials can be measured directly, but there is considerable evidence elsewhere of noteworthy improvement in the selection, handling, and use of materials during recent years.⁸ Pronounced extravagance in the utilization of materials in the factory preceding the postwar decade was not at all uncommon. Since rigid systems for controlling the requisitions of materials from factory store-rooms were not generally in effect, the spaces beneath the workbenches of the foremen and workers were likely to be repositories for much unused and spoiled material. Losses from theft were in some cases considerable. Without the technique of precise specification and of expert purchasing, unsatisfactory materials were often obtained. The reclamation of scrap materials did not then receive the attention given it in recent years.

In the decade after the war marked improvement was made in the use of materials. The prices of manufactured goods were declining, and the necessity for cost reduction was felt by most of the manufacturers. Materials, among the most docile and manageable factors in production, lent themselves well to closer control. Methods were introduced which were intended to prevent waste, such as specialized purchasing, rigid inspection and careful handling, release of materials to workers only upon formal requisitions, maintenance of quality scores for workers and departments dependent in part upon amounts of materials spoiled, and the development of the reclamation of scrap. The greater efficiency in the utilization of materials and the growth of the practice of manufacturing by-products in salable form tended to increase the amount of fabrication applied to materials—in other words, to increase the value created in the manufacturing plant more than in proportion to the added cost of materials.

It is impossible to measure accurately the effect of these changes on material costs, although it seems likely that here might be found at least a part of the explanation for the gradually decreasing proportion which material costs form of value of output.

Finally, it is probable that manufacturing has become more indirect, thereby increasing the cost of semimanufactured materials as a share of the value of products. The fact that the proportion for semimanufactures increased in 1929 over 1904, while that for raw materials decreased, gives credence to this explanation. It would seem that the developments in recent years in manufacture have increased the number of stages and therefore in all probability the number of separate plants through which materials pass before they emerge in the form of finished products. (It is doubtful that the many combinations of industrial establishments have greatly affected the situation, for generally an individual return is made to the Census for each plant, whether it be an independent concern or a subsidiary of a multiplant organization.)

⁸ A graphic description of material organizations and administrative procedures in various types of metal-manufacturing plants is found in *Material Control and Storekeeping in Machine Shops and Foundries*, by Willis Wissler, published by the Bureau of Business Research, The Ohio State University.