U. S. DEPARTMENT OF LABOR
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MISCELLANEOUS SERIES

PRODUCTIVITY OF LABOR IN MERCHANT BLAST FURNACES

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FOREWORD

It has been the purpose of the Bureau of Labor Statistics in this study to measure the increase of productivity in pig-iron manufacture in recent years in terms of output per man-hour and to study the causes of increased productivity with special reference to technical improvements and to reductions in the number of men required in the labor crews. The present bulletin contains the results of the bureau's work in the merchant blast-furnace industry.

To determine output per man-hour it has been necessary to obtain (*a*) annual production of pig iron in gross tons, and (*b*) total annual man-hours of labor chargeable against blast-furnace operation. To explain the changes in tons of pig iron produced per man-hour, information has been obtained relating to materials, operation, and equipment showing some of the principal causes of increasing productivity.

Data for this study were compiled for the most part by agents of the bureau in the field from the records of the companies. The response to the bureau's requests has been exceedingly gratifying. The information relating to *production* and *operation* was quite easily accessible in most cases, but difficulty was frequently encountered in compiling figures for the total man-hours of labor.[1] Pay rolls, force reports, and other records from which man-hours may be derived were sometimes fragmentary, or completely absent for some years, while in other cases the effort required to make compilations from available records was so great that the schedules for certain companies have been confined to recent years only. The period covered, from 1911 to 1927, was selected for two reasons. (1) It was desired to include pre-war, war, and postwar conditions, and (2) the bureau had already collected figures during this period showing the total man-hours worked in many of the blast-furnace plants in the country. The data obtained have made it possible to construct a thoroughly comprehensive picture of the productivity situation for 1926; in addition, the information available for earlier years has been reasonably adequate for the measurement of changing productivity since 1920, while for years prior to 1920 the number of plants studied is sufficiently large to be at least a fair sample of the industry.

The merchant blast-furnace industry.—Pig iron is an unfinished product requiring further refinement before final use in the manufacture of castings, rolled, and forged products, etc. The pig-iron industry is devoted to the production of pig iron from iron ore, the smelting process taking place in a blast furnace.

The term "*merchant blast furnace*," as it is commonly understood in the industry, covers those plants producing pig iron for sale in the open market. As used in this bulletin, the merchant industry covers not only the above plants but it also includes a few steel-company furnaces which, because of their isolation and independence of operation, closely resemble the former group. The definition of a merchant blast furnace for the purposes of this study has been framed so as to

[1] A full description of the methods used in computing man-hours may be found in Appendix 6.

include all blast-furnace plants with management and labor crews independent of steel works and whose metal is cast into pigs to be remelted by consumers instead of being furnished in molten condition to adjacent steel furnaces. For purposes of measuring productivity of labor neither the ownership of the plant nor the marketing of the product is of any special importance, while the method of casting the metal and the organization of the labor crews are decisive factors; therefore, steel-company blast-furnace plants which are independently operated and which cast their metal into pigs are assigned to the merchant blast-furnace industry in this study.

Three merchant furnaces in recent years have been furnishing part of their product in molten condition direct to an adjacent foundry or open-hearth plant; but these plants are merchant in the strict sense, and being fundamentally different from blast-furnace plants connected with a steel works are here included as merchant furnaces.

On the other hand, a blast furnace which furnishes virtually all its product in molten condition to an adjacent steel works, or which is an integral part of the layout of a steel plant, is classed as a *steel-works* stack and is excluded from the merchant group. Two former merchant furnaces became so intimately connected with steel plants during the war that practically all their product is now disposed of in molten condition. These furnaces have been classed as steel-works stacks since that time.

Meaning of productivity.—Productivity is here defined as the rate of output of the workers in a given process, plant, or industry. It represents a ratio between production and labor time, and it may be expressed either as the output of product per man-hour of labor time or as the man-hours of labor time required to produce a unit of product. The unit of production used in the blast-furnace industry is a gross ton of pig iron; the unit of labor time is the man-hour.

The total labor time charged against the product includes the unweighted hours of labor of all men working on the particular process regardless of their skill or training. The hours of the superintendent are counted just the same as the hours of the unskilled laborer in the yard crew, though the former may be worth many times as much as the latter. It is not practicable to make any allowances for the quality of the labor entering into the product. The total man-hours of labor time charged against the blast furnace include all direct labor hours as well as the hours of all overhead producing labor—plant superintendent, foremen, chemists, and all clerks in the plant office directly concerned with production. On the other hand, clerks and bookkeepers working in accounting, all labor in the general office (if any), and all labor connected with sales or delivery of the product have been excluded.

A productivity study in the merchant blast-furnace industry is largely a study of the substitution of machinery and engineering efficiency for labor. When output is increased because of enlargement of the plant or improved operating efficiency it is at least possible to assume that the increased production has come about in response to a better demand, and therefore no reduction need be made in the number of men employed; but an increase in productivity by the introduction of a new labor-saving machine is sure to result in some displacement of labor in the particular plant. As far as the whole industry is concerned, unless the increase in productivity, through the expansion in production, is paralleled by an equal increase in demand for the product, it will cause a reduction in the labor requirements of the industry and throw some men out of work.

When changing productivity can be related to its underlying causes light is thrown on the relative importance of various methods of increasing production per worker or reducing the labor time required in production. A cross section view of an industry such as here presented, showing the variations between plants, brings out the possibilities of improvement which lie in bringing the industry as a whole closer to the best practice, as seen in the records of the most productive plants. Some of the obstacles to such improvement, such as irregular operation which is brought about primarily by unstable market conditions, are also shown incidentally by the data compiled.

Because output per man per hour in pig-iron production has increased, it is not to be assumed that either the workers or the management should claim sole responsibility for the change. An hour of a man's time expended in production is merely a useful unit to be related to production in measuring the combined effectiveness of management, labor efficiency, new processes, and all other factors which affect productivity. Where possible important and readily measurable factors in changing productivity have been isolated and discussed.

The problem in measuring productivity, whether from original records and individual plants or for an entire industry, is that of using and harmonizing the statistics of production and of employment which are already being compiled for other purposes. This is being done in the internal statistics of many large concerns, but it is not easily done from secondary statistics by industries. When the importance and practicability of productivity measurement are clearly understood it may lead to the keeping of records in such a way that changes in output per man-hour can be shown with fair accuracy from month to month or year to year without undue effort.

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U. S. BUREAU OF LABOR STATISTICS

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LABOR PRODUCTIVITY IN THE MERCHANT BLAST-FURNACE INDUSTRY, 1912–1927

CHAPTER 1.—SUMMARY

The productivity of labor in the merchant blast-furnace industry was more than twice as great in 1926 as in the pre-war period 1912–1914. A summary of those plants covered by the bureau survey shows that the average output of pig iron per man-hour of labor in the period 1912 to 1914 was 0.141 gross ton, while for the year 1926 the output was 0.296 gross ton. Or to state it another way, it required slightly more than 7 hours of labor time to produce a gross ton of pig iron in the pre-war period as against 3 hours and 23 minutes in 1926. While 1911 figures are given in this study for a few plants, the sample is not sufficiently representative to stand for the industry as a whole, and figures for that year have not been considered in the summary.

This increase in productivity has taken place almost entirely since the war. The great expansion in pig-iron production, which began in 1915 and continued almost without interruption until the summer of 1920, was accompanied by a comparatively small increase in output per man-hour of labor. The summary averages indicate that the output per man-hour in the merchant-furnace industry remained fairly constant from 1912 until after the war. In 1920 the output was 0.157 gross ton per man-hour, which means that it required 6 hours and 22 minutes of labor time to produce a ton of pig iron, only a slight increase in productivity as compared with the pre-war period. Beginning with 1921 the productivity averages turn sharply upward and continue in that direction in every succeeding year except one—that is, the increase in productivity during the period covered by this study has been due almost entirely to the rapid improvement in the industry during the last six years.

One of the most important causes of the great improvement in output per man-hour has been the abandonment of many of the inefficient low-productivity plants. In 1921 the average output per man-hour in merchant blast furnaces was very much higher than in the previous year because the depression forced out many of the weaker plants, leaving mostly high-productivity plants in operation. During the prosperity of 1923 many low-productivity plants came back into the industry, but the keener competition of the steel works blast furnaces since then has driven a great number of them out of business. Less than three-fourths of the merchant plants operating in 1923 remained active until 1926, and the high-productivity average of the later year is due in no small degree to the closing down of inefficient plants.

Prosperity and depression, however, exert a second influence on productivity which directly counteracts the effect of the one mentioned above. It is usual to find that the productivity of a single plant is highest in years of full and complete operation and lowest in times of depression. For general purposes the labor required to operate a blast furnace can be divided into two parts—the direct producing labor which is essential to the operation of the stack itself and the indirect auxiliary labor required for repairs, transportation, power, etc. The man-hours of the first type of labor will ordinarily vary directly with the number of stacks and the length of time operated; but the indirect labor is not so flexible in amount, being quite out of proportion when only one stack of a two-stack plant is operating or when one stack operates only a short time during the year. Applying this to the industry as a whole, it is evident that the decline in productivity brought about by the influx of low-productivity plants in prosperous years is partly counteracted by the output per man-hour which will be attained by those plants which have been operating at full capacity all along.

Another important factor causing the increase in productivity has been the improvement of blast furnaces and the technical improvements in operation, both of which are reflected in greater daily production per furnace. Prior to the war the average daily output of a merchant blast furnace was about 260 gross tons, while in 1926 the average was 369 tons, about 40 per cent higher. This does not mean, of course, that the general run of stacks had their capacity enlarged to this extent; the increased average for the industry has been due in part to the abandonment of many small stacks and the construction of a few large ones. An increase in the daily output of a blast furnace does not require a proportionate increase in labor per ton; therefore, one method of improving productivity in a plant is to enlarge the furnace or to operate it more efficiently. In fact, a considerable part of the increase in productivity from 1911 to 1927 was due to the high output per stack-day of the average blast furnace.

Productivity has also been influenced by the substitution of machinery for labor. The most important labor-saving devices have been (*a*) mechanical charging and (*b*) machine casting, which have eliminated large numbers of hand laborers engaged in charging materials into the stack and in handling the pig iron after it has been cast. Of the 37 plants furnishing data for pre-war years 1911–1914, 15 were both hand filled and sand cast, while only 8 were mechanically filled and machine cast. But in 1926, out of 49 plants furnishing data, only 3 were both hand filled and sand cast, while 34 were both mechanically filled and machine cast.

Another development in recent years, which has had an important effect on the number of men required to operate a blast furnace, is the substitution of the 8-hour day for the 12-hour day. Although three crews were required where two had been used before, the labor force was so reorganized in a majority of plants that very few more men were employed, while the total man-hours were actually reduced. Shorter hours have lessened the strain on the workers, so that the men can be kept more continuously at work. This has frequently led to the combination or elimination of occupations formerly essential. Thus shorter hours have furnished added incentive to more efficient production, resulting in higher productivity of labor. The effect of the 8-hour day on the productivity averages for the industry has been limited because the 12-hour day still persists in a considerable number of plants, but the influence of the shorter day can be measured in the productivity of individual plants.

The above analysis does not by any means exhaust the list of causes affecting productivity. It is impossible to take account statistically of the increased good will existing between the management and the workers because of shorter hours and higher wages, or of the increased skill and efficiency of the workers, or of improved management of labor. These have contributed to the remarkable advance in the productive efficiency of the industry, but nothing more can be done in this study than to indicate their presence in the total mass of factors which have brought about the change.

ANALYSIS OF THE TREND IN PRODUCTIVITY

The summary for the merchant blast-furnace industry, which is presented in Table 1, shows the productivity averages for the 80 plants covered in this study. Annual averages are shown for all years, 1919 to 1926, but averages for years prior to 1919 are given for one 2-year period, 1917–1918, and one 3-year period, 1912–1914. Figures for the years 1911, 1915, 1916, and 1927 do not cover a sufficient number of plants to be representative of the industry and these years have not been considered in the summary. From 1919 to 1926 the productivity averages represent from about 75 to 90 per cent of the industry in each year, with only a slightly smaller representation in 1917 and 1918. In the pre-war years, 1912, 1913, and 1914, the proportion of the industry covered is about 30 per cent, which would be a sufficiently large sample, if it were thoroughly representative. However, when the figures for 1912, 1913, 1914, 1917, and 1918 are analyzed (see Table 2) it is found that the sample for each year, while large enough as regards number of plants covered, is not sufficiently representative in character to be used in drawing conclusions for the industry as a whole. Certain plants with low productivity are missing from the data for some years, while the reverse is true in others. Therefore, since the purpose of this summary is to give as clear a picture of the trend in labor productivity in the industry as possible, it was considered desirable to combine the data for the years 1917 and 1918 and for the years 1912, 1913, and 1914, thus obtaining figures for larger and more representative samples.

TABLE 1.—*Average labor productivity in all merchant blast-furnace plants covered in this study, by selected periods and years, 1912 to 1926*

Year	Total number of plants	Total number of stacks	Average number of full-time stacks active	Average productivity	
				Output per man-hour (gross ton)	Man-hours per gross ton of pig iron produced
1926	49	78	50.3	0.296	3.379
1925	43	67	43.1	.285	3.511
1924	49	76	42.2	.244	4.095
1923	60	88	[1] 60.3	.213	4.693
1922	40	66	27.1	.232	4.302
1921	36	68	[1] 15.4	.178	5.614
1920	57	90	[2] 63.1	.157	6.367
1919	50	79	[1] 45.7	.144	6.948
1918, 1917	56	86	[2] 70.8	.143	7.013
1914, 1913, 1912	37	60	[3] 44.6	.141	7.087

[1] Not including 1 plant for which days operated were not reported.
[2] Not including 3 plants for which days operated were not reported.
[3] Not including 2 plants for which days operated were not reported.

SUMMARY BY YEARS

Table 2 shows the annual totals and unadjusted averages for the 80 plants covered in this study. The total man-hours of labor and the total production of pig iron include those plants which reported man-hours in each year, the number of plants being shown in column 2. During the period 1921 to 1926 the variations in the number of plants shown represent almost exactly the number of plants operating in the industry each year, and the sample shown for 1919 and 1920 represents a considerable portion of the industry in those years; but for the period 1911 to 1918 it can not be assumed that the variations in number of plants correspond very closely to the number of plants operating. The percentage of the total industry represented in the bureau figures increases rapidly from 1911 to 1920, partly because many blast furnaces now abandoned were then operating and partly because many of the plants for which the bureau has schedules could not furnish the man-hours for these early years. Lack of data is responsible for the annual variations in the number of plants in the averages for 1911 to 1920.[1]

[1] The extent to which the bureau figures cover the blast-furnace industry as a whole and the merchant industry in particular is shown in Appendix 5.

TABLE 2.—*Labor productivity, total hours of labor, total production, and average production per stack-day, in all merchant blast furnaces combined, by years, 1911 to 1927*

Year	Total number of plants	Total number of stacks	Average number of full-time stacks active during year	Average labor productivity: Output per man-hour	Average labor productivity: Man-hours per gross ton of pig iron produced	Total one-man hours of labor	Production of pig iron: Total	Production of pig iron: Average per stack-day	Per cent of total—: Production which was machine cast	Per cent of total—: Stacks which were mechanically charged
	1	2	3	4	5	6	7	8	9	
				Gross ton			*Gross tons*	*Gross tons*		
1927 [1]	21	34	25.5	0.300	3.329	6,108,201	1,834,736	397.5	81	91
1926	49	78	50.3	.296	3.379	22,881,062	6,770,861	369.1	85	87
1925	43	67	43.1	.285	3.511	19,526,548	5,561,138	353.5	82	88
1924	49	76	42.2	.244	4.095	20,675,056	5,049,452	327.2	75	84
1923	60	88	[2] 60.3	.213	4.693	30,649,850	6,531,544	[2] 294.9	72	71
1922	40	66	27.1	.232	4.302	14,014,155	3,257,670	329.8	75	73
1921	36	68	[2] 15.4	.178	5.614	9,130,917	1,626,427	[2] 287.1	71	68
1920	57	90	[3] 63.1	.157	6.367	37,573,753	5,901,039	[3] 247.5	63	56
1919	50	79	[2] 45.7	.144	6.948	29,368,837	4,227,118	[2] 246.6	58	56
1918	48	75	[4] 60.8	.131	7.654	40,231,261	5,256,144	[4] 225.6	56	54
1917	45	61	[4] 49.8	.150	6.688	31,711,303	4,741,447	[4] 249.8	50	49
1916	9	15	10.9	.147	6.787	6,271,090	923,950	231.9	50	73
1915	10	16	11.6	.159	6.278	6,715,495	1,069,715	252.5	31	75
1914	27	47	[3] 29.0	.160	6.457	18,710,140	2,994,879	[3] 262.3	31	64
1913	28	39	[3] 29.0	.151	6.632	18,982,366	2,862,336	[3] 258.3	42	56
1912	27	37	[5] 23.7	.150	6.667	16,759,540	2,513,681	[5] 261.4	50	57
1911	22	30	[3] 16.4	.140	7.119	11,959,131	1,679,982	[3] 260.5	45	57

[1] First six months.
[2] Not including 1 plant for which the days operated were not reported.
[3] Not including 3 plants for which the days operated were not reported.
[4] Not including 4 plants for which the days operated were not reported.
[5] Not including 5 plants for which the days operated were not reported.

EXPLANATIONS

Column 1. Number of plants reporting data in each year.
Column 2. Number of stacks represented by the plants in column 1.
Column 3. Number of full-time, active stacks of the plants in column 1; figure obtained by dividing total stack-days of operation by 365.
Column 4. Gross tons of pig iron produced per man-hour of labor time; obtained by dividing total tonnage produced (col. 7) by total man-hours of labor (col. 6).
Column 5. Number of man-hours of labor required to produce a gross ton of pig iron; total man-hours (col. 6) divided by total production (col. 7).
Column 6. Total hours of labor of all plants shown in column 1.
Column 7. Total production of pig iron of all plants shown in column 1.
Column 8. Average output of pig iron per stack per day; obtained by dividing total production of pig iron by the total stack-days of operation.
Column 9. Total tonnage which was cast by a pig machine divided by the total production of pig iron (col. 7).

The above summary table contains the annual man-hour and production totals for the full years 1911 to 1926 and the first six months of 1927. No attempt was made to cover for 1927 all plants covered for 1926. From these totals the year-by-year productivity averages, also shown, were computed. In addition the table furnishes much data from which to study those averages. The average number of full-time stacks active during the year, when compared with the total number of stacks, shows the extent to which the plants have been operated. This is very important as a plant operated intermittently or one which uses only a part of its equipment can not be expected to be as effective as one which operates to its full capacity all the time. Also the average production of pig iron per stack-day, per cent of total production which was machine cast and the per cent of total stacks which were mechanically charged are very significant. Collectively, they constitute the most important checks on labor productivity contained in this study. Production per stack-day measures, among other things, the changes in the size of the producing unit. The per cent of total stacks mechanically charged furnishes one of the best clews to the reduction of the labor force. The extent to which the pig-casting machine has been introduced into the industry also has a bearing on the reduction of labor crews. However, in the early years the per cent of machine-cast metal is too high, as it happens that nearly all of the plants missing from the productivity data for 1911–1914 were sand-cast plants. However, this is partly offset by the fact that in recent years a few plants have used some metal in molten condition. In 1926, for example, only about 10 per cent of the total product was sand cast instead of 15 per cent as indicated by the table. All of these factors are discussed at considerable length later on.

The averages of output per man-hour indicate that the increase in productivity, while not a gradual one, has been continuous. In only one year, 1923, was there a decrease in output per man-hour, and in that year more plants were in operation than in any other covered by the bureau's figures. This shows that the boom conditions of that year brought many low-productivity plants, which had been compelled to discontinue operation during the depression of 1921, back into the industry. Thus the decrease in productivity in 1923 was not due to any decrease in efficiency on the part of the workers but to a change in the type of plants operating.

In the history of labor productivity from 1912 to 1926 there are two distinct periods of man-hour production. The first beginning with 1912 and continuing through 1921, and the second starting with 1922 and ending with 1926. During the first period there was no concentrated effort on the part of the managements to provide the newest and best tools or equipment for the use of labor in the manufacturing process. In many cases the equipment was antiquated and most of the work was done by hand. As a result, productivity during that period was on a low level, the variations from year to year being mostly due to the variation in plants in operation. However, as competition became keener and profits lower the fact was brought home to a large number of operators that if they remained in the industry their equipment must be modernized. Many operators took advantage of the depression in busines in 1921 to overhaul their plants. Thus, with the beginning of 1922, the modern plants in operation increased rapidly and by 1926 only a few of the plants still used the old hand methods.

ADJUSTED SUMMARY

An analysis of Table 2 shows that the available productivity data year by year do not adequately represent the whole industry throughout the period 1911 to 1927. The averages of output per man-hour indicate a slow, but steady, increase in productivity from 1912 to 1914, then a rather marked drop during the war period, 1916 to 1919, followed by a recovery to pre-war levels in 1920, with a rapid increase since that time except for the year 1923. The number of plants covered in 1911, 1915, 1916, and 1927 is too small and unrepresentative to be accepted as a basis for indicating the trend of the industry as a whole and data for those years are not considered in this summary. As previously stated, the productivity averages from 1919 to 1926 represent about 75 to 90 per cent of the industry, and the averages for years prior to 1919 cover a sufficient number of establishments to be used for the industry, provided the samples are thoroughly representative. However, certain plants, with low productivity are absent in the averages for the 1912–1914 period, but they appear in the averages for one of the years 1917 or 1918. Also the averages for 1917 and 1918 are not thoroughly representative of the industry as certain other types of plants are included in the averages for one year and not in the other. Therefore, the fluctuations in productivity prior to 1919 are due in part to the variations in the number of plants covered.

Since the trend of productivity over the period covered by this study is extremely important, it was considered desirable to make an adjusted summary for years prior to 1919 which would better express the changes in labor output. When the plants covered in the years 1917 and 1918 are taken collectively they form an excellent sample of the industry. A total of 56 plants are included instead of 48, the highest number covered in a single year, and all types of plants are covered. Thus, as both 1917 and 1918 were war years and subject to the same operating conditions, it was decided to combine the data and use an average for the war period rather than one for a single year. All plants with productivity data for either year are included in the adjusted summary. Since the figures for 1917 were more representative than those for 1918, the 1918 data were used for only those plants not furnishing figures for 1917.

A somewhat more complicated adjustment was made in the data for the years 1912–1914. The first step in the adjustment was almost identical with the one outlined above. All plants with productivity data for any year during the period were used. If a plant has data for more than one year the year of best productivity, which is usually the one of full operation, has been selected. This makes possible a pre-war average including 37 plants instead of 28. However, the average for the industry of 0.166 gross ton per man-hour is entirely too high, as the low-productivity plants mentioned above are still missing from the data. As these plants are included in the figures for later years it is obvious that some further refinement of the average must be made if it is to be used. This has been done by computing productivity averages for the 30 identical plants covered in both periods, 1912–1914 and 1917–18. These plants are thoroughly representative of conditions in both periods, and the change in the averages for them, from 0.160 gross ton in 1912–1914 to 0.162 gross ton in 1917–18, has been accepted as typical of the change in all plants during that time. Thus, the figure which has been used in this report as the best representation of the productivity of labor in the industry as a whole during the period 1912–1914 was obtained from the proportion 0.162:0.143::0.160:X. This results in 0.141 gross ton of product per man-hour of labor.

The following is an outline of the method used in adjusting the data:

TABLE 3.—*Outline of method used in adjusting the productivity averages for the years 1912, 1913, 1914, 1917, and 1918*

Year	Total number of plants covered in each year	Average output per man-hour in each year	Total number of plants covered in each period	Average output per man-hour in each period	Total number of identical plants covered in each period	Average output per man-hour for identical plants in each period	Adjusted average output per man-hour based on the averages for identical plants
		Gross ton		*Gross ton*		*Gross ton*	*Gross ton*
1918	48	0.131	56	0.143	30	0.162	----------
1917	45	.150					
1914	27	.160	37	.166	30	.160	[1] 0.141
1913	28	.151					
1912	27	.150					

[1] Obtained from the proportion 0.162 : 0.143 :: 0.160 : X.

CHAPTER 2.—GEOGRAPHICAL COMPARISONS

DESCRIPTION OF THE DISTRICTS

The iron and steel industry as a whole has migrated steadily and persistently westward and lakeward as western markets have expanded and the industry has come to depend on lake ores. To this general trend the merchant blast-furnace industry has been no exception. The relation between these shifting areas of production and changes in productivity will be brought out by geographical comparisons below.

In defining districts within the merchant-blast industry it is necessary to be somewhat arbitrary. The districts used have been created with particular reference to the direct bearing of geographical location on productivity; for example, all plants located on the Great Lakes have been grouped together because all of them use dock facilities and dock labor in handling metals throughout the district from Lake Ontario to Duluth. The districts are as follows:

THE GREAT LAKES DISTRICT

This district includes all plants located directly on the Lakes, excluding plants near the Lakes not having a water front.

Without exception, these plants use dock facilities for unloading materials. Irregular employment of unloading labor during the open shipping season has caused an inflation of unloading crews to some extent as compared with inland plants.

The majority of plants in this district are on Lake Erie with several in or near Chicago. The ores are invariably from Lake Superior mines, Mesabi ores predominating. Limestone is quarried near the Lakes, and coke is usually produced in by-product ovens integrated with furnace plants.

Lakeside plants have an advantage in a ready, inexhaustible water supply for steam and cooling purposes, and the lake shore furnishes an easy method of slag disposal, new land being made by dumping slag along the shores of the lake. The excellent operation characteristic of merchant plants in the Lakes district is better understood when it is kept in mind that great batteries of steel-works furnaces are located in this district. Competition with these steel-works stacks forces merchant furnaces to maintain efficiency of operation if they are to survive. Most lakeside plants, therefore, are of the most modern type equipped with complete labor-saving machinery. It is notable that most of these plants have maintained regular and continuous operation and have been able to take advantage of the growing market for merchant iron in the large foundry and steel-making centers in Buffalo, Cleveland, Detroit, Chicago, and contributory territory.

THE OHIO "INLAND" DISTRICT

Here are included all Ohio furnaces, not having Lake or Ohio River frontage, together with plants in the Shenango Valley of western Pennsylvania—furnaces along the Shenango and Mahoning Rivers near Youngstown. The ores, coke, and limestone used by these plants come from the same sources as those used in the Great Lakes district.

The majority of these plants have been in operation for many years, but have been thoroughly modernized. All of them receive materials by railroad, unloading at the plant being done mechanically by car dumpers or, in smaller plants, on trestles from which the ores or other materials fall through car bottoms to be repiled as necessary until ready for use. Few of these plants are integrated with by-product coke plants. Several are owned and operated by large steel companies. Coking coal is usually brought from the Connellsville district, or from Kentucky or West Virginia, although some Illinois coal is now used in making metallurgical coke.

OHIO RIVER DISTRICT

Like plants in the Great Lakes district these plants may be called "waterside," being located on both sides of the Ohio River in West Virginia, Ohio, and Kentucky. Ores are brought in from Lake Superior ranges, coke and limestone coming from near-by territory in Kentucky and West Virginia. The long rail shipment of ore across Ohio from the Lakes is a disadvantage partially counterbalanced by cheap coal right at hand. There is an increasing use of river barges for delivery of coke and limestone and shipment of pig iron.

Formerly this district was of great importance in the merchant blast-furnace industry but in recent years it has declined. Many old inefficient plants, handicapped by distance from markets and materials, have been abandoned, while in some cases the furnaces have been acquired by expanding steel companies.

PENNSYLVANIA AND NEW YORK

Merchant furnaces in Pennsylvania are located mainly between the eastern slope of the Alleghenies and the seaboard, with a number of scattering plants in the western section of the State. As noted above, the Shenango Valley in extreme western Pennsylvania has been included with Ohio plants, due to its proximity and similarity to the Youngstown district. Only those New York plants located in the eastern section of the State are included in this district. One New England stack is added in 1926.

Production of merchant pig iron in Pennsylvania by merchant furnace plants is distinctly on the down grade due to a variety of factors. Many of the plants are located adjacent to ore banks, but experience has shown that these ores are lean or difficult to smelt in furnaces as large as those using the fine Mesabi ores. Frequently located in isolated rural communities, these plants can not obtain the advantage of intergation with coke plants since there is no local market for coke-oven gas. Western ores are economically inaccessible to eastern Pennsylvania smelters on account of long-distance shipment involving reloading at Lake Erie docks. To offset freight handicaps in the assembly of materials the large eastern pig-iron markets are near by, but competition with steel-works stacks and foreign producers has placed the small blast-furnace operator in a precarious position.

THE SOUTH

Virginia and Tennessee furnaces have been grouped with the Birmingham district plants in this classification. However, Virginia and Tennessee are declining in importance while production around Birmingham is expanding.

A distinguishing characteristic of the entire southern district is the easy economy of operations. Some Alabama ores, although apparently lean in iron content, contain enough limestone to flux completely the ore in the blast furnace, while coal is usually located within a few miles of the ore deposits. Virginia and Tennessee ores are somewhat richer than Alabama deposits, but limestone must be quarried from the surrounding hills for fluxing purposes.

Geographical advantages and a mild climate combine to render the problem of handling raw materials a less difficult one than in northern plants where ores must be shipped in and stored during the summer months when the Great Lakes are navigable. In the South, mines are operated the year round and materials are shipped to the furnaces as needed. Labor requirements in handling materials are therefore more regular in the South than in districts where storage of immense stocks is necessary.

PRODUCTIVITY BY DISTRICTS

The summaries made thus far show data for the whole merchant blast-furnace industry; the next step is the analysis of productivity by districts. This is set forth in Table 4, which shows the productivity for selected periods of all districts combined and of each district separately. The table also shows in each instance the number of plants reporting, the average number of full-time stacks active, the average output per stack-day, and the average consumption of materials per ton of pig iron produced.

Table 4 covers the same plants shown in Table 2, except that in each period or year prior to 1926 one plant is missing. The missing plants are those in the West, which are not numerous enough to constitute a district in any year except 1926; one plant is thus lost from the record in 1923, and another in the three earlier periods 1912–1914, 1917–1918, and 1920. The loss of these plants, however, scarcely affects the averages at all.

Thus the productivity averages for all districts combined (Table 4) correspond very closely to those shown in Table 2. In the discussion on Table 2 it was pointed out that the productivity average for the pre-war period 1912–1914 was not sufficiently representative of the industry, and therefore the average would have to be adjusted in order to bring it into line with the averages for the later years. That adjustment was made in Table 3. The necessity for this adjustment is shown by the data in Table 4, in which the unadjusted productivity average for the industry is broken down into a number of district averages; for example, southern district, with a productivity of 0.119 ton per man-hour, is represented in the 1912–1914 average by only 5 full-time furnaces; but in 1917–18 this same district, with a productivity of 0.106 ton, is represented in the average to the extent of 23.4 full-time operating furnaces. The Pennsylvania-New York district also is not sufficiently weighted in the 1912–1914 average, being represented by 6.6 full-time furnaces as against 13.4 in 1917–18. This does not mean that the plants in these two districts were not operating in 1912–1914, but simply that the bureau was unable to get data for them in this earlier period. This is the situation which necessitated the adjustment of the 1912–1914 productivity average in Table 3 by means of data from a series of identical plants.

However, with the exception of the single period 1912–1914, the variations in the number of operating furnaces as shown in the table correspond quite closely to actual conditions in each district and in each period. The influence on the productivity averages of this shift in production from one district to another is evident. From 1917–18 down to 1926 the South, for example, has steadily declined in importance. During the war the South had approximately one-third of the operating furnaces, while in 1926 this was reduced to one-fifth. It is obvious that the productivity average for all districts combined in 1926 would have been considerably lower had the South maintained its earlier proportion of the total number of operating furnaces.

TABLE 4.—*Labor productivity, output per stack-day, and consumption of materials charged, by districts and all districts combined for selected periods and years, 1912 to 1926*

District	Number of plants	Average number of full-time furnaces active during the year	Average labor productivity		Average output per stack-day	Average consumption of materials charged per gross ton of pig iron produced.		
			Output per man-hour	Man-hours per gross ton of pig iron produced		Metallic charge	Coke	Flux
1926			*Gross ton*		*Gross tons*	*Pounds*	*Pounds*	*Pounds*
All districts	46	48.7	0.299	3.349	379.5	4,325	2,123	841
Western	3	3.5	.431	2.322	424.1	4,383	2,122	897
Great Lakes	10	15.3	.371	2.699	459.2	4,218	1,979	839
Ohio River	4	3.7	.385	2.600	317.9	3,983	2,071	764
Ohio inland	9	8.5	.407	2.459	430.4	4,109	1,983	938
New York and Pennsylvania	11	8.7	.236	4.245	312.2	3,961	2,149	868
Southern	9	9.1	.156	6.417	270.0	5,510	2,823	670
1923								
All districts	58	58.8	.218	4.579	[1] 303.5	4,470	2,347	999
Great Lakes	10	18.0	.283	3.537	381.2	4,311	2,159	945
Ohio River	5	3.7	.321	3.120	281.5	3,963	2,195	1,064
Ohio inland	13	10.0	.272	3.672	[1] 393.3	4,112	2,148	1,092
Pennsylvania and New York	13	11.8	.168	5.965	242.2	4,135	2,350	1,257
Southern	17	15.3	.138	7.242	206.0	5,770	3,092	866
1920								
All districts	53	60.4	.155	6.457	[1] 246.8	4,584	2,519	1,142
Great Lakes	7	14.2	.224	4.469	352.6	4,694	2,450	1,136
Ohio River	4	3.2	.260	3.844	289.5	4,211	2,404	1,280
Ohio inland	9	9.2	.181	5.533	[1] 336.6	4,226	2,223	1,192
Pennsylvania and New York	14	15.9	.118	8.482	181.5	4,023	2,482	1,322
Southern	19	17.9	.101	9.907	163.6	5,509	3,205	946
1917–1918								
All districts	53	68.2	.140	7.128	[2] 234.9	4,601	2,556	1,111
Great Lakes	9	16.8	.161	6.222	297.0	4,607	2,399	1,058
Ohio River	3	2.7	.205	4.874	233.6	4,194	2,298	1,214
Ohio inland	9	11.7	.195	5.120	324.4	4,162	2,223	1,191
Pennsylvania and New York	13	13.4	.116	8.611	[2] 192.2	4,262	2,586	1,379
Southern	19	23.4	.106	9.414	169.8	5,382	3,154	1,006
1912–1914								
All districts	34	40.4	.165	6.045	[3] 272.2	4,587	2,580	1,050
Great Lakes	10	17.3	.184	5.447	304.7	4,486	2,546	1,108
Ohio inland	9	11.6	.187	5.344	280.1	4,314	2,284	1,182
Pennsylvania and New York	11	6.6	.134	7.444	[3] 221.5	4,153	2,460	1,400
Southern	4	5.0	.119	8.434	207.9	5,358	3,079	643

[1] Not including one plant for which the days operated were not reported.
[2] Not including three plants for which the days operated were not reported.
[3] Not including four plants for which the days operated were not reported.

The Pennsylvania and New York district is very similar to the South, even to the extent that it is not adequately represented in the pre-war period. It is undoubtedly true, also, that the apparent increase in furnaces operating between the war period and 1920 is due to a lack of data in 1917–1918 and not due to actual increase in furnace operations in the district. However, since 1920 there is clear evidence of the steady decline of this district.

The Ohio River district is not represented at all in the averages for 1912–1914 because of lack of data, but was a flourishing district at that time. The district has experienced a considerable reduction in the number of operating furnaces since pre-war days. However, the number of plants representing the district is so small in all periods that the "All districts" average for the industry is hardly affected by it.

Even the inland Ohio district has not held its own over the five periods. There has been a considerable decline in the number of operating furnaces, and while this is partly balanced by the increasing size of the stacks the fact still remains that the production of pig iron has steadily declined.

The Great Lakes district alone has increased in importance since the pre-war period. The data in the table show that the number of full-time furnaces in the district has not changed since the pre-war period, but the annual production of pig iron has increased considerably; the average daily output per stack has risen more than 50 per cent in the last 15 years. In 1917–1918 this district produced about 30 per cent of the total pig-iron output of plants shown in the table, while in 1926 the proportion had increased to nearly 40 per cent of the total.

The western district is not geographically compact, being composed of scattered plants which do not logically fall within the other districts. It consists largely of new plants which were not in existence in the earlier periods.

Thus, it is evident that the average output per man-hour for the whole merchant blast-furnace industry in each of these periods is markedly influenced by the shifting volume of production in the different districts. The low-productivity districts (Pennsylvania and New York and the South) are not adequately represented in the data for the pre-war period of 1912–1914, which makes the figures for this period too high, as previously indicated. However, in 1917–1918 these two districts are adequately represented in the productivity average. The rapid decline of these low-productivity areas in the more recent period and the increasing production in high-productivity areas, such as the Great Lakes, tend to increase the average productivity of the industry. The increased productivity in the merchant blast-furnace industry then has been partly due to the changing regional composition of the industry. Even if there had been no increase in productivity from 1912 to 1926 in any district, the average for the industry as a whole would have increased considerably.

However, the data do show conclusively that in every district there was a pronounced increase in productivity between 1912–1914 and 1926. In the Great Lakes district the average output per man-hour in 1912–1914 was 0.184 gross ton; the 1926 productivity of 0.371 gross ton was more than double that amount. The apparent decline in productivity to 0.161 gross ton in 1917–1918 is due to the absence of certain plants from the averages. The 1920 average is also somewhat depressed because three important plants could not furnish data for that year. The increase in productivity which took place between 1923 and 1926 is all the more remarkable because of the fact that the productivity averages in the two periods are for identical plants. Thus the productivity increase was brought about entirely by improvements in operating efficiency and not by the closing down of low-productivity plants. As a matter of fact, in this district all increases in productivity since 1912–1914 have been due almost entirely to actual improvements in operation in individual plants, since practically none have been abandoned, a condition which contrasts sharply with the steady abandonment of low-productivity plants in all other districts. It is significant that all but one small plant in this district had changed from the 12-hour to the 8-hour turn by 1926.

The inland Ohio district slightly exceeds the Great Lakes district in productivity in 1912–1914 and in 1926. However, in the intermediate periods their histories are not at all similar. There was no improvement in productivity in the inland Ohio district until after 1920, when the output per man-hour increased more than 50 per cent over a period of three years. This increase was due to improvements in operation of the existing plants; but the increase in the following period (from 1923 to 1926), however, was due partly to the inactivity of some old plants.

The Ohio River district is not adequately represented by the data for any period except 1926. The figures for all periods represent only the plants surviving in 1926; in all the earlier periods there were a large number of plants in operation for which it was impossible to get data because they had gone out of business in the depressions of 1921 and 1924. Since the plants which survive are usually those of high productivity, it is reasonable to assume that the averages shown for this district in all periods prior to 1926 are somewhat too high to be representative.

The point of special interest in connection with the Pennsylvania-New York district is the decline of the industry in Pennsylvania. This decline is obscured in 1926 by the inclusion in the averages of several newly constructed New York and New England plants. When these new plants are eliminated from the 1926 data the result shows nine plants, 6.8 full-time furnaces in operation, an output per man-hour of 0.220 gross ton, and an output per stack-day of 278.3 gross tons. These figures and those shown in the table for the other four periods are for Pennsylvania plants almost exclusively, only one New York plant being included in the figures for each period. The extent of the decline of the merchant industry in Pennsylvania can be measured by comparing the number of full-time furnaces in operation in 1920 and in 1926, 15.9 as against 6.8.

The trend of productivity in the Pennsylvania-New York district as a whole is shown by the data from 1917 to 1926, the figures for the pre-war period being somewhat uncertain because of inadequate representation of plants. By 1923 a considerable increase in productivity is evident, due for the most part to improved operation of existing plants, although three old plants were abandoned during the period. The period 1923 to 1926 was feautured by the abandonment of old plants in Pennsylvania and the construction of new ones in New York and New England. These two contrasting developments combined to bring about a marked increase in productivity in the whole district during the period.

The inadequate representation of plants in the southern district in 1912–1914 must be taken into consideration in interpreting the productivity figures. Since 1917–18 productivity in the South has increased barely 50 per cent, which is less than the increase in any other district. Labor-saving machinery and new equipment have not been generally introduced in the southern district; naturally the output per man-hour is considerably lower than that in the other districts of the country. In 1920 the man-hour output in the South was 0.101 gross ton, while the average for the rest of the country was 0.178 gross ton. In 1926 the variation is still greater, 0.156 gross ton per man-hour in the South as against 0.349 gross ton for all other districts combined. The plants in the South are operated mostly by negro labor. The plentiful supply of this labor tends to prevent the introduction of improved machinery, thus keeping productivity at a low level.

A fundamental factor affecting the output per man-hour for all districts combined is the change in daily production per furnace. While output per man-hour was increasing from 0.140 gross ton in 1917–18 to 0.299 gross ton in 1926, the output per stack-day was increasing from 234.9 gross tons to 379.5 gross tons. These figures show the influence on the output per man-hour of the increased output of the individual blast furnace.

The data for the various districts reenforce the conclusions drawn from the data for the industry as a whole. In 1926 in the Great Lakes district 15.3 full-time furnaces showed an average output of almost 460 gross tons per day as compared with a daily output of approximately 300 gross tons in the war and pre-war periods. Nearly one-half this increase in daily output occurred in the three years from 1923 to 1926. Correspondingly, the output per man-hour increased from 0.161 gross ton in 1917–18 to 0.371 gross ton in 1926.

In the southern district, the increase in output per man-hour from 1917–18 to 1926 has almost exactly paralleled the increased output per stack-day—that is, a large part of the increased productivity in this district is explained by the increased daily output of the blast furnaces.

The Ohio River district also furnishes an interesting illustration of the relationship between productivity and a stack-day output. The average output per man-hour in 1926 exceeds that of the Great Lakes and is only slightly below that of inland Ohio, but the average daily output of the blast furnaces in this district was only 317.9 gross tons as compared with 459.2 gross tons in the Great Lakes and 430.4 gross tons in inland Ohio. The explanation of this fact, that plants with such a comparatively low output per stack-day should attain such a high level of productivity, is that the district is represented throughout the four periods in which it occurs by the few merchant plants which survived until 1926; naturally, these are the best plants, and it is not surprising that their average productivity should be high. All the other districts have their averages greatly reduced by the inclusion of at least a few inefficient, low-productivity plants.

CONSUMPTION OF RAW MATERIALS, BY DISTRICTS

The daily output of a blast furnace is determined by the size and design of the stack and by the smelting process itself. While the increased size of the stack has been a major factor in making possible large daily output, data on this point are available for 1926 only and will be discussed elsewhere.[1] In a blast furnace of any given size the quality of the raw materials and the efficiency with which they are smelted determine the stack-day output.

Other things remaining the same a higher yield of iron from the ores will increase output per stack-day. As a matter of fact ores are becoming leaner each year as the richer materials are taken from the mines. In spite of lean ores it has nevertheless been possible to increase furnace yields by more efficient smelting practice and by an increasing use of iron and steel scrap and other ore equivalents rich in iron content. The use of scrap, comparatively rare prior to the war, has increased rapidly since 1920. Since scrap is practically pure iron, its use increases furnace yields and therefore output per stack-day.

Limestone or other flux is required in the blast furnace for the purpose of combining with the impurities in the ore. The nonferrous materials in the ore are combined with the flux and are removed from the furnace in the form of slag. The amount of flux required depends largely on the nature of the ore and may vary widely.

Fuel requirements vary with the quality and physical characteristics of the materials charged. More coke is needed in smelting hard, lumpy, eastern ores than for the fine Mesabi or northern ores. However, with a given quality of materials, the consumption of coke per ton of iron varies considerably, according to the skill and judgment of the furnace operators.

Analysis of materials consumption in the various districts brings out in sharp contrast the differing conditions in the South as compared with other districts. The pounds of ore charged per gross ton of pig iron produced in the South exceed that of any other district by about 40 per cent; the coke consumption is also very much greater than the average for the industry, but on the other hand the amount of flux used is appreciably lower.

As stated elsewhere,[2] the southern district in these tables consists of two distinct areas: (*a*) The Birmingham section, which includes the blast furnaces in Alabama, and (*b*) the Virginia-Tennessee section, which includes all furnaces in Tennessee, Virginia, and eastern Kentucky. The ores in the vicinity of Birmingham are of two general types, the so-called "red" and "brown" ores. The red or hematite ores can be further subdivided into "soft red" and "hard red," which differ only in the amount of limestone they contain. The soft red ore is found on or near the surface and is the hard ore with the lime removed by atmospheric action. Underneath the top layer of soft red the ore becomes hard in proportion to the depth at which it lies; the amount of lime increases while the iron content correspondingly diminishes. This hard red ore is therefore largely "self-fluxing"; in fact, it is not unusual to find these ores so rich in limestone that soft red or brown ores must be mixed with them in order to take up the surplus limestone and prevent waste of iron in the blast furnace.

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[1] See p. 32. [2] Ch. 2, p. 10

These hard red ores often run as low as 30 to 35 per cent in iron content. The brown ores, or limonites, are also found near the surface, frequently mixed with clay and gravel. They contain very little lime and are not self-fluxing; they compare with the soft red ores in iron content, sometimes running well over 40 per cent. However, all the southern ores are considerably leaner than the typical ores used in the North.

These qualities of the southern ores explain the high metallic charge and the low flux consumption of the southern district. Some plants in this district use as much as 6,000 pounds of ore to produce a ton of pig iron, while the average for the district is approximately 5,500 pounds. The consumption of flux in the southern district as a whole falls far below that in other districts, being 670 pounds per ton of pig iron as compared with an average of 863 pounds for the rest of the country. However, it is the high flux consumption in the Virginia-Tennessee section of the South that makes the average as high as it is; in 1926 the blast furnaces in the immediate vicinity of Birmingham averaged about 271 pounds of flux per ton of iron.

The Virginia-Tennessee ores resemble those farther south near Birmingham in iron content, but they do not contain the large quantities of limestone. Thus the furnace operators in this section must charge almost as much limestone as would be required in a northern furnace.

Attention must be called to the fact that the number and identity of the plants represented in the averages for consumption of materials do not correspond exactly to those represented in the productivity averages. Some plants which reported productivity data failed to furnish any information on consumption of materials, while on the other hand there are numerous cases of plants which reported on production of pig iron and consumption of materials in years for which it was impossible to compute their productivity. Since the purpose is to obtain as full and complete a record as possible of the average materials consumption in each district, data have been assembled from all plants whether represented in the productivity averages or not. It was only by the use of this method that sufficient data could be obtained for some of the districts in the earlier periods. For example, the southern district in 1912–1914 shows only 4 plants in the productivity average, but the average metallic charge covers 10 plants, the average coke consumption 11 plants, and the average flux consumption 7 plants. On the other hand, the Pennsylvania-New York district with 11 plants in the productivity average, covers 6 plants in the average metallic charge, 7 in average coke, and 4 in average flux. In other districts and in all later periods the correspondence between the plants in the productivity averages and those in the consumption of materials averages is very much closer. In general the data on metallic charge, coke, and productivity averages cover practically the same number of plants, but the data on flux consumption are somewhat weaker, fewer plants being represented in nearly every case. However, this figure is of much less significance than the other two, and the number of plants covered is sufficient to bring out the peculiarities of each district.

Data on the consumption of raw materials by districts are shown in Table 4. The figures show the number of pounds of each raw material consumed in the production of a gross ton of pig iron. The metallic charge per ton is found by adding together the poundage of iron ore, scrap, cinder, scale, and all other iron-bearing materials or ore equivalents, then dividing this total by the number of tons of pig iron produced. The pounds of coke per ton of pig iron are likewise computed by dividing the total pounds of coke consumed by the number of tons of pig iron produced. The flux per ton of pig iron is derived by the same method from the total consumption of limestone and dolomite.

The amount of coke required is much higher in the South than in other districts. Because of the leanness of the southern ores, the charge of metal-bearing materials in this district is 20 to 40 per cent higher, and the smelting of this material requires more coke. In addition, the southern furnaces use a stronger blast for a given furnace volume than do those in the North, which probably increases the consumption of coke.

There has been a remarkable decline in coke consumption in the four northern districts. The situation in the Great Lakes district is most striking. In 1912–1914 the blast furnaces in this district required on the average 2,546 pounds of coke to smelt a ton of pig iron, while in 1926 they required only 1,979 pounds. Part of this decrease is due to a greater use of scrap in the charge, but some of it at least is due to better furnace operation. Each district shows a lower consumption of coke per ton of pig iron than in war and prewar years. The close connection between the relative amounts of ore and coke consumed is brought out in the data for 1926; the Great Lakes, Ohio River, and Ohio inland districts, all of which use Mesabi ores almost exclusively, show very nearly the same amount of coke consumption per ton of product, the variation being less than 100 pounds—from 1,979 pounds in the Great Lakes to 2,071 pounds in Ohio River. The western and Pennsylvania-New York districts show a markedly different coke consumption, thus emphasizing the different quality of the ores used in those districts.

CHAPTER 3.—CROSS SECTION OF PRODUCTIVITY SHOWING VARIATIONS BETWEEN PLANTS, BY YEARS

An array of plants according to productivity for each year is set forth in Table B, page 104, which shows the position in the industry of each plant. The data emphasize the fact that there has been a wide range of productivity in all years covered by this study. In 1926 one plant attained an output per man-hour of 0.573 gross ton, while the plant at the bottom of the list had an output of only 0.115 gross ton. Expressed in the opposite way, the first plant required 1.746 hours of labor to produce a ton of pig iron, while the low-productivity plant required 8.693 hours. In 1925 the plants vary from a high of 0.512 ton to a low of 0.105 ton. The range remains wide all through the years from 0.462 to 0.069 ton in 1923, from 0.446 to 0.063 in 1920, from 0.326 to 0.059 in 1917, and from 0.313 to 0.051 ton in 1911. The significance of these figures can perhaps be better understood when it is pointed out that an output of 0.051 ton per man-hour means that it requires nearly 20 man-hours of labor to produce a ton of pig iron. Thus while many low-productivity plants are abandoned with each depression, nevertheless some plants of this type continue to operate regardless of all productivity advances in the better plants.

The plants which represent the extremes of productivity are by no means unique. A comparison of large groups of plants emphasizes still more the great variations in productivity which can and do exist side by side in the industry. In 1926 there were 4 plants with an output per man-hour of more than 0.500 ton, and 7 additional plants with an output between 0.400 and 0.500 ton. At the other extreme there were 6 plants with an output per man-hour of less than 0.150 ton, and 5 others with an output between 0.150 and 0.200 ton. The average for all plants in that year was 0.296 gross ton per man-hour.

The marked contrast between conditions in the industry in 1923 as compared with 1926 is clearly shown by the array of plants for those years. In 1926 there were 11 plants with a productivity of better than 0.400 ton per man-hour, while there were an equal number with productivity less than 0.200 ton. But in 1923 there were no plants above 0.500 ton, only 4 plants between 0.400 and 0.500 ton, and only 7 others between 0.300 and 0.400 ton, while at the other end of the list the contrast is even more striking—19 plants with a productivity of less than 0.150 ton and 12 others between 0.150 and 0.200 ton. It has been stated previously that 1923 was a year of full activity when many low-productivity plants came back into operation after having been idle for about two years. But it is important to note also what has happened to these plants in later years. Of the 31 plants having a productivity record in 1923 of less than 0.200 ton per man-hour, only 17 were operating in 1926, and 2 of these ran a very small part of the year. Thus almost half the low-productivity plants of 1923 had ceased operations by 1926. Not all these plants have been abandoned, but most of them will not operate again.

The "spread" of the productivity figures for individual plants, about the average for the industry in pre-war years, does not differ markedly from the examples cited above. The variations in 1912 are typical of pre-war conditions. In that year the 6 best plants had productivity records between 0.200 and 0.300 ton per man-hour; at the other extreme there were 5 plants with a productivity of less than 0.100 ton, with 11 others ranging between 0.100 and 0.150 ton. This leaves only 5 plants with a productivity between 0.150 and 0.200 ton. The average for all plants in 1912 was 0.150 ton per man-hour.

The productivity position occupied by each plant with reference to the rest of the industry is determined by a large number of factors which in some way affect the productivity of the plant. For purposes of this analysis these factors may be classified into two main groups—(1) general, and (2) specific. General factors, or causes, are those which may be common to a number of plants throughout the industry and which can therefore be measured to some extent, or at least can be rated. Specific factors, or causes, are those which are peculiar to an individual plant, and which therefore can not be taken into account other than by merely being noted.

From the data presented in Table B it is possible to enumerate four general factors which have had some influence in determining the relative position of the plants in productivity. These are (1) integration, (2) full-time operation, (3) output per stack-day, and (4) use of labor-saving machinery.

An integrated plant is one in which the blast furnace is operated in conjunction with a coke plant, steel works, or any other auxiliary manufacturing process. Integration is usually advantageous for productivity because the indirect labor is shared between the different processes, and a considerable saving of such labor often results. Plant No. 3, which ranks at the top of the industry in 1926, illustrates the advantage of being integrated with a coke plant. There are a number of blast-furnace plants which rank above No. 3 in the productivity of the immediate blast-furnace crew, but the latter ranks far above all others in the output per man-hour of its "all other" labor. This shows very clearly the influence of the coke plant in reducing the indirect labor charged against the blast furnace. Plant No. 25, which is second in productivity in 1926, is situated near a rolling mill which shares the indirect labor. The next plant (No. 12) is not integrated at all, but it is a two-stack plant which operated both stacks nearly all the year. The operation of additional stacks has some of the advantages of integration in that it makes possible some saving in indirect labor.

However, the labor economies made possible by joint operation are not always realized in practice, for even at the bottom of the list there are plants which have the advantages of integration without obtaining any results in productivity, for example, plants No. 30 and No. 40 are both integrated, but their productivity averages do not show any evidence of it. The situation may be summarized by stating that integration may lead to a considerable saving of labor, but it does not necessarily do so. In 1926 the following blast furnaces were operated in conjunction with coke plants or other manufacturing processes: Nos. 1, 3, 5, 9, 13, 25, 26, 28, 30, 31, 33, 37, 39, and 40.

The second factor influencing productivity is the extent of full-time operation. To obtain best performance a plant must be operated full time at full capacity. Both the blowing-in and the blowing-out of a stack require several days, during which time there is very little output of pig iron to balance the additional man-hours of labor. Even after the stack has been blown-in it often takes several weeks to bring its daily output up to full capacity. And lastly, when a plant operates only a few months during the year the indirect yard and repair labor is usually much heavier in proportion than normally. All these circumstances combine to cause a comparatively low output and a comparatively high total of labor time. This is clearly shown in Table B. The plant which ranks eighth in productivity in 1926 is the first one on the list which did not operate full time. On the other hand, of the six plants at the bottom of the list, only one operated full time.

A third factor of very considerable importance in determining the relative position of a plant in the productivity averages is the output per stack-day. Of the 9 leading plants in 1926 only 3 had an average daily output of less than 400 tons, and of these 3 the lowest averaged 368 tons. Dividing the entire list into two groups, all 28 plants having a productivity average higher than 0.250 ton per man-hour have an average output per stack-day of more than 300 tons, with only two exceptions, one of which is just under 300 tons. On the other hand, of the 21 plants having a productivity of less than 0.250 ton per man-hour there are only 4 which have a stack-day output of more than 300 tons, and one of these averages 300.8 tons. These comparisons indicate that in the main the plants of high daily output have the best productivity averages.

Before leaving this point, however, it is necessary to call attention to the important exceptions to this general statement. Plant No. 50, with a daily output of 262.1 tons, ranks as No. 13 in productivity, far above any other furnace of this size, and even above many furnaces averaging 400 and 500 tons per day. One stack with a daily output of 500 tons and another with 400 tons rank quite far down the list in productivity—below what would be normally expected. However, one of these had just begun operations and had not reached its best operating efficiency. Three plants with a fairly large output per stack-day have positions almost at the bottom of the list. One of these is a northern plant whose average represents only partial operation; the other two are southern plants in which modern labor-saving devices have not yet been installed.

The fourth point in connection with variations in productivity concerns the use of labor-saving machinery, especially machines for charging and casting. Table B shows the method of charging and casting of each plant individually.[1] These data are summarized in the following table, only one minor change being made to facilitate classification. Plants which are listed in Table B as using both methods of charging or casting in any one year are, for the purposes of Table 5, classed according to the proportion of the total production handled by each method. Thus, plant No. 2 is shown in Table B as being both hand cast and machine cast in 1926, but in Table 5 the plant is classed as machine cast because 86 per cent of the total product was cast by that method.

[1] See Appendix 1, p. 104.

TABLE 5.—*All merchant blast-furnace plants covered in this study, classified by methods of charging and casting, by years, 1911–1927*

Year	Total number of plants	Hand filled and sand cast	Mechanically filled and sand cast	Hand filled and machine cast	Mechanically filled and machine cast	Insufficient data
1927	21	2	3		16	
1926	49	3	8	4	34	
1925	43	3	8	3	29	
1924	49	6	10	3	30	
1923	60	12	15	8	23	2
1922	40	7	12	4	17	
1921	36	8	11	5	12	
1920	57	21	11	7	17	1
1919	50	21	9	5	15	
1918	48	20	10	5	12	1
1917	45	18	9	6	10	2
1916	9			3	6	
1915	10	3	5		2	
1914	27	12	8	1	5	1
1913	28	12	6	2	6	2
1912	27	12	6	2	7	
1911	22	11	5		6	

The introduction of machinery into the industry is best illustrated by the decline in the number of hand-filled, sand-cast plants since 1920. Prior to 1921 more than one-third of all the plants on the list belonged in this group, while in 1926 there were only 3 such plants out of 49. The other side of the situation is shown by the number of mechanically-filled, machine-cast plants. There was a steady increase in the number of these plants during the period 1917 to 1920, but the greatest change in this respect took place after the depression of 1921. Many plants which had had little opportunity for plant improvement during the war took advantage of the shutdown to enlarge their stacks and modernize their equipment. Since 1922 the number of mechanically-filled, machine-cast plants has increased as rapidly as the number of hand-filled, sand-cast plants has declined. The "hybrid" plants (mechanically-filled and sand-cast, or hand-filled and machine-cast) constitute a kind of transition group through which plants pass on their way from hand methods to machine methods. The combination of hand filling and machine casting has been comparatively rare in the industry throughout the whole period from 1911 to 1927 but the combination of mechanical filling and sand casting has remained quite common until the last three years. These facts indicate that the skip hoist preceded the pig machine as a labor-saving device in the industry.

The effect of these methods of charging and casting on productivity is evident from Table B. Plants which are hand filled or sand cast are common in the lower half of the list in 1926, but in the upper 25 plants there is only one which is either hand filled or sand cast, and that one is a hybrid—being hand filled and machine cast. The best mechanically-filled, sand-cast plant ranks thirty-first in productivity, while the best hand-filled, sand-cast plant ranks thirty-seventh. The latter plant, No. 48, when compared with the mechanically-filled, machine-cast plants, shows a lower productivity record than 30 of them, and a higher productivity record than 3. Further comparisions can be drawn, but those which have been made are sufficient to demonstrate the fact that the use of machinery has been a most important factor in improving productivity in the merchant blast-furnace industry.

The four general factors affecting productivity have been enumerated, but in addition to these there are frequently specific factors which are peculiar to individual plants. A multitude of minor variations in plant layout, yard transportation, and auxiliary equipment may affect the amount of labor required to operate different plants, and may thus influence productivity. One plant, for example, is wedged in between a river and a railroad, with a county highway running right through the plant. Naturally, operations are cramped by lack of space, and more labor is required than would otherwise be necessary. Many little details of plant organization are peculiar to the plant having them; these details must be kept in mind in comparing one plant with another. Not that these minor variations would have a very important effect on productivity, but they might have sufficient influence to cause a difference in the productivity of two plants which in all other respects are practically alike.

CHAPTER 4.—METHODS BY WHICH PRODUCTIVITY HAS BEEN INCREASED

INCREASING OUTPUT AND DECREASING LABOR TIME

The output per man-hour of a given establishment or of an industry can be increased (*a*) by increasing the output, (*b*) by decreasing the labor time, or (*c*) by a combination of both methods. Applying this principle to merchant blast furnaces, it is evident that the changes in productivity have been brought about in all these ways.

(*a*) Production per furnace per day (output per stack-day) may be increased, either as a result of an increase in the size of the furnace or because of an advance in technical knowledge, engineering skill, operating efficiency, etc.

(*b*) Labor time (man-hours) per furnace per day may be reduced, as a result of improved labor management, greater effort and skill on the part of the workers, or the introduction of new methods and machinery which directly displace labor.

(*c*) It frequently happens in individual establishments that the stack is enlarged at the same time that labor-saving machinery is installed, so that the increase in output per stack-day coincides with the decrease in labor time. In fact, this is the most economical method of making the change, for the larger production is essential to support financially the costs of installing the machinery.

The first method of increasing productivity will be found mostly in plants which are strictly modern in equipment. In plant No. 9, for example, the stack has been enlarged with each rebuilding, and the output per stack-day has steadily increased, but the changes in output per man-hour correspond very closely to the changes in the output per stack-day, thus indicating that the total daily man-hours of labor have remained about constant during the period.

When the output per man-hour and the output per stack-day rise and fall together it shows that the man-hours of labor time are unchanged. The output per man-hour is the total annual production of pig iron divided by the total annual man-hours of labor, but the result is the same of course if put on a daily basis—that is, the output per man-hour is equal to the average output of pig iron per stack-day divided by the average man-hours of labor per stack-day. It follows that if the man-hours per day remain absolutely constant the output per stack-day will determine increases or decreases in the output per man-hour and the two will vary in exact proportion to each other—that is, whenever the changes in output per man-hour closely follow the changes in output per stack-day, it indicates that the man-hours of labor time are remaining about constant; the changes in productivity are being brought about by changes in the output of the stack and not by changes in labor time.

With this preliminary explanation it is now possible to draw conclusions from the data for plant No. 9. In 1918 a daily output of 286 tons was accompanied by a man-hour output of 0.283 ton, while in 1927 the daily output had increased to 404.7 tons and the man-hour output to 0.439 ton. In other words, practically the whole increase in productivity which took place in this plant was brought about by increasing the daily output of the stack while the crews remained the same as before.

Plant No. 13 furnishes an equally good illustration. The decline in output per man-hour in 1923 indicates the existence of larger labor crews in that year, but for all other years the extremely close correspondence between the output per stack-day and the output per man-hour presents a clear case of an increase in productivity being brought about by increasing the daily output of the stack while maintaining the labor force constant.

In plant No. 32 there is another example of very close correspondence between changes in productivity and in output per stack-day for the period 1917 to 1922. In the last two years of operation (1923–24) the output per man-hour increased out of all proportion to the changes in stack-day output, showing that at this time there must have been some important reductions in the labor crews. The change which was actually taking place was the substitution of the 8-hour, 3-shift system for the old 12-hour, 2-shift system; in the reorganization the labor time was reduced.

The above plants were entirely modern throughout the period for which data are available. It is much more difficult to find cases of old hand-filled, sand-cast plants which show an upward trend of output per stack-day with constant crews. There are numerous examples of such plants with unchanging labor time, but in the majority of cases the output per stack-day either varied within narrow limits or else actually declined. Plant No. 73, however, can be cited as an example of increasing output per stack-day with practically constant labor time. Here the variations in output per man-hour are very largely the result of changes in output per stack-day, except in one year (1923) when labor crews were abnormally low.

The second method of increasing productivity is to cut down the labor time while maintaining the same output. Plant No. 43 illustrates this method. Disregarding the figures on stack-day output for 1917 and 1921 as not being representative, it is evident that the daily output of pig iron varied within very narrow limits all through the period, but the man-hours per ton decreased from 7.585 hours in 1918 to 5.614 hours in 1925. Thus the increased productivity was brought about by a reduction of the labor crews.

Plant No. 47 is another example. The output per stack-day in 1918 was almost exactly the same as in 1925, the last full year of operation. But in the meantime the output per man-hour had risen from 0.089 ton to 0.122 ton, an increase which came about through the reduction in labor time from 11.285 hours per ton to 8.191 hours.

Still another case is Plant No. 48, in which the output per stack-day at the end of the period was lower than in the beginning, while the output per man-hour increased from 0.148 ton in 1911 to 0.201 ton in 1926; this represents a reduction in labor time from 6.773 hours per ton to 4.985 hours.

Plant No. 57 experienced very little change in output per stack-day from 1919 to 1926, but the man-hours per ton decreased from 7.696 hours to 4.392 hours. The installation of a skip hoist in 1924 was an important factor in producing the result.

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By far the most common way of increasing productivity is the combination of both methods. It is not confined to any one class of plants but may be found under almost all conditions. Plant No. 5 is an example of its operation in a plant with modern equipment. Each rebuilding or relining produced an increase in output per stack-day, but at the same time there was a steady decline in the labor time required to operate the furnaces. Since the equipment was already modern this reduction could not have been brought about by the installation of the major labor-saving machines; it was largely the result of crew reorganization and labor management.

Another excellent example of the operation of this method in a modernized plant is shown by plant No. 21, in which the output per stack-day doubled between 1919 and 1926 while the output per man-hour was tripled. The labor time was being rigorously cut down at the same time that the stacks were being enlarged.

Plant No. 22 makes another good case. From 1911 to 1920 the output per man-hour coincides very closely with the output per stack-day, but between 1920 and 1922 the rebuilding of the stack caused an increase of 30 per cent in the daily output, while the man-hour output was being doubled. The labor force was thoroughly reorganized after the depression and many positions were cut off.

This combination method of increasing productivity is also found among old plants which change over to modern equipment. Plant No. 2 shows a decline in output per stack-day and some rather indifferent results in productivity during the period 1914 to 1921, but when the pig machine was introduced the stack was also enlarged. The saving of labor by use of the pig machine combined with the increased output per stack-day resulted in doubling the productivity between 1921 and 1923.

Plant No. 12 was only partly modern in the pre-war period, and both the output per man-hour and the output per stack-day remained fairly constant. The introduction of the pig machine in 1916 caused an immediate improvement in output per man-hour, and a remodeling of the stacks four years later raised the putput per stack-day to a higher level. Since 1920 both man-hour output and stack-day output have increased steadily, the former at a much faster rate than the latter, thus indicating a progressive reduction in labor time.

Plant No. 27 is a striking example of the point under discussion. From 1914 to 1921, inclusive, the changes in output per man-hour and the output per stack-day correspond closely to each other, indicating little or no change in labor crews. A skip hoist and a pig machine were installed in 1922, and at the same time the stack was enlarged. Output per stack-day was increased 50 per cent, and by 1926 the output per man-hour had increased more than that amount. Other plants which illustrate the point are Nos. 19, 20, and 33.

Enough cases have been cited to show conclusively that the usual method of increasing productivity in the merchant blast-furnace industry has been that of installing labor-saving machinery and methods at the same time that the stack was being enlarged and technical operating efficiency increased. It is not unusual to find a continual stepping up of stack-day output while labor crews remain constant, but it is rarely indeed that a plant increases its productivity by cutting down its labor time while the output per stack-day remains constant.

In view of the above facts it is not at all surprising that the increase in productivity for the industry as a whole should exhibit the characteristics of the combination method prevalent among individual plants. Table 6 shows the total productivity increase for the industry in relation to the increase in output and the reduction in labor time. While data available for 1915, 1916, and the first six months of 1927 are published, they represent so few establishments that they can hardly be considered fairly representative of the whole industry; therefore, they are ignored in the following discussion of the table:

TABLE 6.—*Average output per man-hour, output per stack-day, and man-hours per stack-day, together with index numbers thereof, by years, 1911 to 1927*

[Average for 1912=100.0]

Year	Number of plants	Output per man-hour (all plants)	Plants for which data on stack-days are available						
			Number	Average output per man-hour		Average output per stack-day		Average man-hours per stack-day	
				Amount	Index number	Amount	Index number	Number	Index number
		Gross ton		*Gross ton*		*Gross tons*			
1927 [1]	21	0.300	21	0.300	188.5	397.5	152.1	1,323.3	80.7
1926	49	.296	49	.296	185.7	369.1	141.2	1,247.2	76.0
1925	43	.285	43	.285	178.7	353.5	135.2	1,241.4	75.7
1924	49	.244	49	.244	153.2	327.2	125.2	1,339.9	81.7
1923	60	.213	58	.213	133.5	294.9	112.8	1,385.6	84.5
1922	40	.232	40	.232	145.9	329.8	126.2	1,418.7	86.5
1921	36	.178	34	.179	112.1	287.1	109.8	1,606.6	98.0
1920	57	.157	54	.157	98.8	247.5	94.7	1,571.9	95.8
1919	50	.144	48	.143	89.5	246.6	94.3	1,729.3	105.4
1918	48	.131	44	.132	82.8	225.6	86.3	1,708.7	104.2
1917	45	.150	41	.155	97.3	249.8	95.6	1,611.3	98.2
1916	9	.147	9	.147	92.4	231.9	88.7	1,574.5	96.0
1915	10	.159	10	.159	100.0	252.5	96.6	1,585.0	96.6
1914	27	.160	24	.158	99.4	262.3	100.3	1,655.4	100.9
1913	28	.151	25	.155	97.5	256.0	97.9	1,648.1	100.5
1912	27	.150	22	.159	100.0	261.4	100.0	1,640.2	100.0
1911	22	.140	19	.143	89.7	260.5	99.7	1,823.4	111.2

[1] Data for 6 months.

The year 1912 is used as a base for the index numbers instead of 1911 for two reasons: (1) It contains many more plants and therefore is a much more representative year than 1911, and (2) the year 1911 shows a relationship of stack-day output and labor time that is out of line with all later years, which would have the effect of throwing the two indexes far apart all during the period 1912 to 1920 when the true relationship is best indicated by keeping the indexes close together.

In this table it is seen that in the plants for which stack-days are available output per man-hour changed from 0.159 ton in 1912 to 0.296 ton in 1926, which as shown in the corresponding index number makes an increase of 85.7 per cent in output per man-hour.

The output per stack-day increased from 261.4 tons in 1912 to 369.1 tons in 1926, which the corresponding index number shows to be an increase of 41.2 per cent. The man-hours per stack-day in 1912 were 1,640.2. This was reduced to 1,247.2 man-hours in 1926, a reduction of 24.0 per cent as shown by the index number.

The differences in the two columns on output per man-hour are negligible as far back as 1917 when the first real difference occurs; in all pre-war years, 1911 to 1913, the output per man-hour in plants that reported stack-days is higher than for all plants, thus indicating that the plants not furnishing stack-days were somewhat below the average in productivity. The adjusted figures, however, do not materially change the general trend of productivity as previously indicated. The putput per man-hour changed very little between 1912 and 1917, inclusive, but there was a pronounced drop in 1918 and 1919, followed by a rise to pre-war levels in 1920. Since the latter year the trend has been steadily upward with the exception of 1923.

The trend of output per stack-day very closely approximates that of output per man-hour, although it is not so steep in recent years. Throughout the entire period 1911 to 1920, the output per stack-day remained about constant in the neighborhood of 250 to 260 tons, except in 1918 when the daily output dropped to 225 tons. This was due largely to the inclusion of a number of small plants in the averages for that year. Since 1920 the average output per stack-day has increased every year with the exception of 1923.

The data on labor time per stack-day show the extent to which the labor force has been cut by new machinery and improved methods. The exceptionally high figure for 1911 is due to the particular plants which are included in that year. The table indicates that the average daily man-hours of labor required to operate a blast-furnace plant ranged from 1,640 to 1,655 hours in the pre-war years 1912–1914. There was a slight decrease in the average for 1917, but this was followed by sharp increases in the following years, the high point being reached in 1919 with 1,729 hours of labor per day. This was the highest number of hours in any year except 1911. To some extent the figures for 1918 and 1919 are due to the particular plants which furnished data for those years, plants which are not represented in the averages for the pre-war years. Had these plants been included in 1912, 1913, and 1914, the man-hours per day in those years would have been considerably higher. However, the disorganization of labor brought about by war conditions in 1918 and by the strike in 1919 caused some inflation of man-hours in those years. The daily man-hours for 1920 fall so far below the averages for the three previous years that some explanation must be sought. A check of the particular plants represented in each year shows that the average for 1920 is heavily weighted with two types of plants which are not so fully represented in the previous years. One of these types is the very efficient, high-productivity large plant which requires from 1,000 to 1,200 hours of labor per stack-day, and the other is the very small low-productivity plant which on account of its small size does not require more than 1,200 hours of labor per stack-day. A considerable number of both types of plants are to be found in the 1920 average although they were missing from the previous years. Since both types are below the average of the rest of the industry in daily man-hours, the two together lower the average for 1920 considerably.

From 1921 to 1925 the decline in labor time per stack-day was very rapid, reflecting the modernization of plants which took place during that period. Since 1925 labor time has remained about constant.

It is of interest to express the reduction in labor in a different way. If the man-hours per stack-day decrease, then it is obvious that a given number of man-hours of labor will operate a stack for a greater length of time. If 1,640.2 man-hours of labor are required to operate a stack-day in 1912 and 1,247.2 man-hours are required in 1926, then there has been a saving of 393 man-hours of labor per day, which would be available for operating another stack-day. These 393 man-hours constitute 31.5 per cent of 1,247.2, which means that the amount of labor required to operate a stack for 100 days in 1912 would have operated the same stack 131.5 days in 1926. It will be noted that this is the reciprocal of the index of man-hours per stack-day. Thus, if the reciprocals of these indexes are calculated, the resulting indexes will show the stack-days which can be operated with a given number of man-hours.

The chief point of interest, however, is the way in which the three series changed in relation to each other. Prior to 1918 there is nothing of importance to note, but in that year the sharp decline in output per man-hour is seen to be the result of a decline in output per stack-day, accompanied by an increase in the labor time required per day. The former resulted from the inclusion in the averages of a number of small plants missing from previous years; the latter is the result of a general increase in the number of men per plant. In 1919 the output per man-hour rose in response to an increase in output per stack-day, with labor time increasing slightly over the average for 1918, but in 1920 the case was exactly the reverse—output per stack-day remained constant, but the output per man-hour increased in proportion to the reduction in labor time. Since 1920 the stack-day output has risen and the labor time has declined. In only two years were the trends reversed. In 1921 the hours of labor time failed to decline as output per stack-day increased, while in 1923 the output per stack-day decreased while the labor time declined as usual. In both years, however, the output per stack-day proved to be a more important factor in determining productivity than the labor time, for in 1921 output per man-hour increased in response to the change in stack-day output, while in 1923 the output per man-hour declined along with the stack-day output; the changes in labor time were more than counterbalanced by the influence of the daily output of the stack.

RELATIVE INFLUENCE OF OUTPUT PER STACK-DAY AND MAN-HOURS OF LABOR TIME ON PRODUCTIVITY

It is clear that the increased productivity in the merchant blast-furnace industry has been brought about by an increase in the average output per stack-day *and* by a reduction in the average man-hours of labor per stack-day. The extent of the change in output per man-hour is the sum of the changes which have taken place in these two factors, as represented by the index numbers in Table 6.

Each series of index numbers measures the effect upon productivity of a fairly distinct set of active factors operating upon productivity independently; that is, changes in output per stack-day, and consequently in output per man-hour, are determined by one set of factors, while changes in labor time per day, with a corresponding effect on productivity, are determined by quite a different set. These sets of factors while complementary are separate and distinct.

The pig-casting machine is a clear illustration of the distinct and independent character of factors operating upon productivity through changes in labor time per day. This machine is introduced for the purpose of saving labor, which it does by eliminating the sand cutters and iron carriers working around the casting beds. To the extent that the pig machine reduces the labor time per day it causes an increased output per man-hour; on the other hand, the machine is completely dissociated from the furnace itself and has little influence upon the daily production of the furnace. It can not improve the quality of the iron, nor cause more iron to flow from the hearth, nor in any way affect the smelting process. It merely *handles* whatever output the furnace makes, and unless changes are made in furnace operation independently the output per stack-day remains the same as before the installation of the pig machine.

The other machines saving common labor have the same effect. The skip hoist with larry car and bins has had a most important influence on the number of men required in charging the stock into the furnace and therefore upon productivity. While directly employed in filling the furnace, this auxiliary equipment has only an indirect connection with the smelting process or the daily furnace output. In the main, automatic filling affects productivity through a reduction in labor time, *not* through increasing output; although, of course, it must be pointed out that the use of the skip hoist has made possible the construction of larger stacks than could ever have been filled by hand labor. Other examples may be cited, such as the locomotive cranes in the yard, the ore bridge, motor trucks which displace horse carts, etc. Of the same character is the direct reduction in the number of men required for operating existing equipment. All these are methods used in eliminating a certain amount of labor time, and they cause an increase in productivity as a result of that elimination. None of them have any direct relation to the production of the furnace or to productivity as affected by stack-day output.

On the other hand, the increased daily production of a blast furnace ordinarily has comparatively little effect upon the labor time required for operating the furnace plant. When a stack is "down" for relining it may be rebuilt with different lines and enlarged cubical contents. The rebuilt stack may be capable of producing 50 per cent more pig iron per day than the old one, but the effect on the labor crew may be comparatively slight. Although larger quantities of materials must be charged into the furnace the ore bridge, trestle, stockhouse, and skip do not require more men, but merely more continuous operation or larger loads. Likewise, exactly the same crews will operate the enlarged furnace. Whatever change in practice is required by the larger stack is a matter of technical knowledge not of human brawn. Although more metal is cast from the furnace a larger crew is not required in the cast house or in hauling larger ladles to the pig-casting machine, while the casting is done by the same number of men per turn as before. The power, pumping, and blowing machinery will be operated by unchanged crews. In the yard there may be some slight increase in the labor required to handle the larger amounts of pig iron, and the steadier operation of machinery may necessitate some increase in maintenance and mechanical labor. However, it is obvious that an increase of 50 per cent in output per stack-day may have a relatively small effect on the labor time per day.

It is evident that changes in output per stack-day and in labor time per day represent two distinct ways in which productivity may be changed. Daily furnace output is increased by purely technical factors such as a change in the lines of the stack, the use of better raw materials, the employment of higher blast pressure rather than by employing more men, etc. In an average plant a small amount of additional indirect or auxiliary labor would be necessary to handle the additional product, but this increase in labor would not be in any way proportional to the increase in tonnage.

The reduction of labor time, fully as useful in increasing productivity as an increase in output, is attained by methods quite distinct from those associated with greater furnace output. Labor-saving machines, the shorter workday, and the combination or elimination of jobs are changes which neither increase nor interfere with the daily production of iron.

There is only one class of plants in which an increase in daily output has a marked effect upon the crew. These are the old hand-filled, sand-cast plants. Heavier production will require, for example, more fillers' helpers on the charging side and more iron carriers on the casting side, with perhaps some additional labor in the iron yard and in materials unloading. In fact, it is just this direct relationship in such plants between volume of production and amount of labor required which brought about the introduction of labor-saving machinery whenever the daily output of the stack was greatly increased. It is the modernization of a blast furnace plant which brings about the fairly complete segregation of the two sets of factors; under hand methods of operation labor time is tied very closely to production.

However, these hand-filled, sand-cast plants with old equipment do not necessitate any modification in the previous general conclusion that for the industry as a whole the increase in stack-day output is comparatively independent of the reductions in labor time. From Table A, page 71, there have been selected 12 plants which remained hand-filled and sand-cast down to 1927, or until they ceased operating. These are plants Nos. 15, 41, 48, 60, 61, 65, 69, 70, 71, 73, 75, and 77. There are other hand-filled, sand-cast plants, but they do not cover a sufficient span of years to give evidence of a trend. Each of the above plants furnished data over a period of at least four years. These are the plants in which any increased volume of production would be expected to result in an increase in labor time, with very minor changes in output per man-hour. But the facts are that all these furnaces are very small, nine being under 200 tons per day all the time while the other three occasionally reached 300 tons; and in practically none of them is there any pronounced upward trend of output per stack-day.

Plant No. 15 shows a large variation in output per stack-day, but the high record in 1927 represents one-furnace operation, while the older, smaller furnace was being rebuilt. The low record of about 210 tons per day in 1918 should be compared with the record of 250.5 tons in 1926 with full two-furnace operation in both years. The increased output represents improvements in operating efficiency rather than increases in the size of the stacks.

Plant No. 41, like No. 15, furnishes evidence of low operating efficiency in 1918, when output per stack-day was 260.6 tons. In contrast to that year, there was an exceptionally high output in 1925, 329.7 tons, but this was due to a considerable use of scrap in cleaning up the plant for a final shutdown. This stack rated at about 290 tons per day throughout the period of its operation.

Plant No. 48, throughout the entire period from 1911 to 1926, ranged very closely around 250 tons per day. The relining in 1917–18 increased the production to 300 tons in the latter year, but a relining in 1923 brought a reduced capacity again.

All the other nine plants are very small; a few of them show slight increases in output per stack-day over the period, but the great majority range within quite narrow limits.

The conclusion is further strengthened by data for 12 hand-filled, sand-cast plants which were partly or wholly modernized some time during the period. These are plants Nos. 14, 18, 19, 27, 28, 39, 45, 52, 53, 54, 57, and 66. Three of these, Nos. 14, 19, and 28, had quite large stacks in the period before mechanization took place; No. 28 made a record of more than 400 tons per day. But considering the group as a whole, it is evident that the output per stack-day was increased only slightly during the period of hand filling and sand casting; on the other hand the general increase in stack-day output following modernization is unmistakable.

The final conclusion to be drawn is that to a very considerable extent at least the hand-filled, sand-cast plants, in which the changes in production would be likely to produce corresponding changes in man-hours of labor time, did not increase their production. It is probable that the close connection between volume of production and labor time in these plants is in itself a deterrent to any pronounced increase in stack size. So far as the averages for the industry are concerned, the general conclusions set forth above still hold; that is, increases in output per stack-day and reductions in labor time affect productivity separately and independently. The only group of plants which forms an exception to the principle did not experience any marked increase in stack-day output.

A comparison of the two indexes on output per stack-day and man-hours per stack-day indicates that in recent years the increase in output per stack-day has had a somewhat greater influence on productivity than has reduction in the labor force. The data for 1927 need not be considered, since they cover only half a year and a much smaller number of plants. But since 1920 the changing daily output of the stack has been of more importance in determining the changes in the final productivity average. It would appear from the data for the last three years that the increase in productivity due to labor saving and crew reduction has come to a stop. The majority of existing plants are now fairly well modernized, and further important reductions in labor time by means of pig machines, skip hoists, and cranes appear unlikely. However, the output per stack-day continues to increase steadily, and this is causing corresponding increases in productivity.

INCREASE IN OUTPUT PER STACK-DAY

The importance of increased daily furnace output in relation to productivity has been discussed fully, and it has been shown that recent progress has been by means of greater output per stack-day rather than through reduction of crews. It has further been shown that output per stack-day summarizes mathematically the combined effect of such changes in operation and in equipment as are calculated to increase production. This section will be devoted to a discussion of the more important ways in which output per stack-day has been increased.

Unquestionably the most important single factor in the increase in daily production per furnace has been the change in furnace dimensions—that is, the enlargement of the stacks and the modification of the relative dimensions of the different sections of the stack. Up to the eighties the typical blast furnace had a bosh halfway up the stack and a hearth perhaps only half as wide as the bosh. Some of the largest stacks in the entire iron industry were almost as tall as those of to-day, and the boshes were almost as wide, but the width of the hearth, which limits the furnace output, was usually 10 feet or less. This earlier construction originated during the period when charcoal and anthracite were the fuels used in smelting. With the introduction of coke, heavier burdens could be upheld in the stacks and greater blast pressure was not only made possible by the more porous mix but was actually required in smelting the fine Mesabi ores. Since this period the industry has witnessed a steady and consistent development in furnace lines. The stacks have been built with wider and wider sections; boshes have been lowered, and hearths have been widened until they almost approximate the boshes in diameter as the lines of the entire crucible are made more nearly vertical. It is not unusual now to find hearths of 18 to 20 feet diameter, while there are a few even wider than 20 feet. The purpose of furnace designers is to bring about the most rapid movement of material through the stack without impairing the chemical efficiency of the smelting process. This means that the lines of the furnace itself must offer the least possible resistance to the flow of material.

By far the most important determinant of output per stack-day is, of course, the size of the stack or stacks. The size of a stack can best be expressed in terms of the "furnace volume," which is measured from the bottom of the hearth upward to the bottom of the closed bell, representing the total interior capacity of the stack in cubic feet. This is the figure which is used in this bulletin in measuring the size of the blast furnaces. Ideally, a more restricted figure for actual "working volume" should be used if greatest accuracy is desired in comparing furnaces. Working volume is the smelting zone in which actual reduction of the ores takes place. It is measured from the top of the column of stocked materials (usually about 2 feet below the bottom of the closed bell) to the center line of the tuyeres. This excludes the idle open space at the top of stack which is not an effective part of furnace volume and the cylindrical section of the hearth below the tuyere line in which the molten metal and slag accumulates below the smelting zone. The bureau has not been able to obtain figures for working volume from a sufficient number of plants to make possible a significant comparison between plants, so the closely analogous figure for total furnace volume has been used instead.

Table 7 shows the relationship between output per stack-day and size of stack for all plants furnishing data on both points.

TABLE 7.—*Average output per stack-day, together with furnace volume, by plants, 1926*

Plant number	Output per stack-day	Furnace volume (in thousands of cubic feet)	Plant number	Output per stack-day	Furnace volume (in thousands of cubic feet)	Plant number	Output per stack-day	Furnace volume (in thousands of cubic feet)
1	2	3	1	2	3	1	2	3
	Gross tons			*Gross tons*			*Gross tons*	
3	648.7	Over 24	22	386.0	18 to 21	14	300.8	15 to 18
1	617.0	Over 24	9	380.9	12 to 15	38	299.9	12 to 15
4	527.3	Over 24	20	378.0	15 to 18	45	298.2	12 to 15
13	520.5	18 to 21	35	370.0	15 to 18	39	278.2	12 to 15
5	506.2	18 to 21	25	368.3	12 to 15	58	261.0	12 to 15
21	486.2	18 to 21	26	366.1	15 to 18	15	250.5	15 to 18
17	474.6	15 to 18	27	360.5	21 to 24	51	248.3	12 to 15
28	454.4	15 to 18	6	359.1	18 to 21	48	247.0	9 to 12
34	442.7	18 to 21	30	354.6	15 to 18	52	242.1	15 to 18
19	432.5	15 to 18	2	345.6	15 to 18	18	233.1	12 to 15
56	411.0	21 to 24	36	334.9	12 to 15	43	220.8	12 to 15
37	401.0	Over 24	41	329.7	12 to 15	49	207.6	9 to 12
12	396.7	12 to 15	33	325.0	9 to 12	31	203.7	12 to 15
7	392.8	15 to 18	32	323.1	15 to 18	11	193.0	12 to 15
16	392.3	18 to 21	40	317.9	15 to 18	73	119.7	9 to 12

Columns 1 and 2 are self-explanatory, and column 3 shows the total operated furnace volume in thousands of cubic feet of the stack or stacks in each plant. In the case of plants with more than one stack the furnace volumes are averaged, the volume of each being weighted according to the number of days each stack operated during the year. Thus, the figures show actual operated volume which may not be the same as capacity volume in plants having more than one stack in operation; stacks which were idle throughout the year do not appear in the average at all. For the most part the records in Table 7 cover the year 1926, but in the case of plants which did not operate in 1926 the record is for the last year of operation, even though this may have been as far back as 1923. The particular year is not as important as the number of plants which can be brought into the table.

The output per stack-day is very largely determined by the size of the stack. The three largest stacks have the highest average daily output, while the smallest stack has the lowest output. Down through the list the relationship between size and daily output continues very close.

However, there are some notable exceptions to the general rule. Three plants with medium sized stacks, Nos. 17, 28, and 19, have a much higher daily output than many larger stacks. Plant No. 12, whose stacks are relatively small, shows an average daily output which compares favorably with that of stacks twice the size. Plant No. 9 also has a very high output for stacks of that size. The wide range of output which exists between stacks of the same size is best shown by the class of stacks between 12,000 and 15,000 cubic feet furnace volume. The highest daily output of a plant in this class was 396.7 tons, while the lowest was 193 tons. In the class of stacks between 15,000 and 18,000 cubic feet, the highest output was 474.6 tons and the lowest 242.1 tons. There are sufficient data in Table 7 to constitute clear evidence of the fact that while output per stack-day is very largely due to the size of the stack, nevertheless there are other factors which have some influence in determining the final output per day. The more important of these other factors are the shape of the stack, the quality of materials, and smelting efficiency.

For the purposes of this study it is not necessary to make any detailed analysis of the influence of each of the above factors on output per stack-day. It is of interest, however, to rate the blast furnaces according to their daily output, independent of their size. Such a comparison supplements the data in Table 7 by summarizing the influence of all factors, except size, on the daily output. The element of size of the stack is eliminated by using a uniform unit of volume, arbitrarily selected as 100 cubic feet of furnace volume, hereafter called the "volume unit." The total daily output of each plant is divided by the number of volume units contained in the operated stack or stacks; or, to put it another way, the output per stack-day shown in Table 7, column 2, is divided by the number of cubic feet of average furnace volume shown in column 3, and the result is multiplied by 100. It would be much simpler to use 1 cubic foot as a volume unit, but the result has so many decimal places that the larger unit is necessary in order to get a significant figure.

Table 8 shows the plants with a given output per 100 cubic feet of furnace volume classified according to size. The first column shows the output per stack-day per 100 cubic feet of furnace volume; the second column shows the number of plants in each group; the remaining columns show the classification of plants according to size.

TABLE 8.—*Number of plants distributed according to their furnace volume and to their output in a stack-day, 1926*

Gross tons of output per stack-day per 100 cubic feet of furnace volume	Total number of plants	Number of plants having an average operated furnace volume of each specified number of cubic feet					
		Less than 12,000	12,000 and under 15,000	15,000 and under 18,000	18,000 and under 21,000	21,000 and under 24,000	24,000 and over
3.2	1		1				
3.1	1	1					
2.9	1		1				
2.8	2			2			
2.7	1		1				
2.6	5		2	1	2		
2.5	1						1
2.4	5		1	2	1		1
2.3	1			1			
2.2	3	1	1	1			
2.1	5		1	1	3		
2.0	4		1	2			1
1.9	3		1	1	1		
1.8	4	1	1	1		1	
1.7	1					1	
1.6	3		1	2			
1.5	3		2				1
1.3	1	1					

This table shows the variation in output of plants of the same size. In the class of plants with a furnace volume less than 12,000 cubic feet one had an average daily output of 3.1 tons per volume unit, while at the other extreme was a plant with only 1.3 tons. In the 12,000 to 15,000 class the plants ranged from a high of 3.2 tons to a low of 1.5. As the plants increase in size the range narrows considerably, a point which required some further analysis. It is significant that the best output records were made by small or medium-sized plants. The best daily output per 100 cubic feet of furnace volume was made by a plant with an average operated stack volume between 12,000 and 15,000 cubic feet; the next best output came from a stack of less than 12,000 cubic feet volume. Six of the eleven best plants have stacks averaging less than 15,000 cubic feet, while three others are between 15,000 and 18,000 cubic feet. On the other hand the best output record among the plants with large stacks, that is, 2.5 tons per 100 cubic feet, ranks below the records of 11 smaller plants.

These illustrations are sufficient to indicate that furnace performance is determined by other factors than mere size of stack. It seems clear that stacks of medium size have a distinct advantage as a smelter over the extremely large stack. No matter how efficiently the large stacks are run, they can not turn out pig iron proportionately to their size in comparison with efficiently operated stacks having a volume of 12,000 to 18,000 cubic feet. This suggests a nice problem in blast-furnace operation. There is a very fine balance between various considerations in determining operating policy with reference to high daily output. While at first glance (Table 7) it would appear that the spectacular contrast in daily yield furnishes conclusive evidence that the large furnace has the advantage, this is by no means clearly the case, particularly among merchant furnaces which can not be driven for long periods at high speed in the uninterrupted production of a single grade of iron. It must be remembered that large furnaces and hard driving necessarily go together. Increased stack size beyond a certain limit appears to make possible greater output only at the expense of good control of materials. Taking the industry as a whole with the technical knowledge and skill available at any given time, there is doubtless always some point beyond which it is bad economy to increase output per stack-day—a point at which the advantages of large-furnace tonnage are counterbalanced by high consumption of materials and greater hazards of hard driving. This point is at a lower level for merchant blast furnaces than for steel-works stacks, because the former must frequently shift from one grade of iron to another instead of driving steadily ahead on basic iron.

The daily output per 100 cubic feet of furnace volume is, of course, a summary figure which shows the influence on furnace output of a large number of operating factors such as quality of materials, efficiency of smelting, etc. In order to complete the picture the more important of these are shown in Table 9.

Table 9.—*Average output per stack-day, average consumption of materials, and average volume of air blown, by plants, 1926*

Plant	Average output per stack-day	Average consumption of—			Average volume of air blown per minute
		Coke per ton of iron produced	Ore per ton of iron produced	Scrap per ton of iron produced	
1	2	3	4	5	6
	Gross tons	*Pounds*	*Pounds*	*Pounds*	*Cubic feet*
No. 5	506.2	1,663	3,470	475	33,954
No. 41 [1]	329.7	1,720	4,081	(2)	(2)
No. 3	648.7	1,792	3,821	437	46,859
No. 12	396.7	1,820	4,090	(2)	28,758
No. 34	442.7	1,898	3,518	58	36,000
No. 17	474.6	1,901	3,860	325	35,000
No. 56	411.3	1,922	4,278	121	(4)
No. 6	359.1	1,952	3,943	23	31,903
No. 28	454.4	1,985	3,768	421	36,000
No. 13	520.5	1,990	4,467	(2)	38,000
No. 25	368.3	2,008	3,909	(2)	48,000
No. 37	401.3	2,014	3,544	349	32,000
No. 32 [3]	323.1	2,035	2,197	1,552	(2)
No. 4	527.3	2,040	4,140	(2)	(2)
No. 21	486.2	2,040	3,922	234	30,000
No. 7	392.8	2,042	3,618	372	34,747
No. 35 [4]	370.0	2,042	4,137	40	(2)
No. 1	617.0	2,070	4,377	132	44,096
No. 51 [1]	248.3	2,076	3,804	----------	(2)
No. 45	298.2	2,076	3,947	(2)	32,000
No. 36	334.9	2,084	3,575	392	25,000
No. 19	432.6	2,110	4,303	241	36,866
No. 22	386.0	2,120	3,897	325	34,785
No. 27	360.5	2,124	2,858	757	38,000
No. 20	378.0	2,167	3,147	851	34,735
No. 26	366.1	2,214	4,252	----------	32,501
No. 9	380.9	2,218	4,316	278	31,458
No. 14	300.8	2,218	4,260	(2)	33,850
No. 33	325.0	2,262	4,126	259	25,939
No. 16	392.3	2,282	4,070	73	36,713
No. 2	345.6	2,315	4,202	165	(2)
No. 52	242.1	2,326	(2)	(2)	24,000
No. 39	278.2	2,331	2,802	916	32,000
No. 48	247.0	2,348	4,182	(2)	32,700
No. 11 [3]	193.0	2,498	3,954	289	(2)
No. 30	354.6	2,680	5,598	432	(2)
No. 31	203.7	2,804	5,139	----------	(2)
No. 15	250.5	2,930	5,772	----------	34,000
No. 58	261.0	3,050	5,092	----------	31,500
No. 18	233.1	3,072	5,564	----------	34,000
No. 38	299.9	3,082	4,525	2	40,000
No. 40	317.9	3,143	4,312	388	45,000
No. 49 [4]	207.6	3,335	4,722	----------	(2)
No. 43 [1]	220.8	3,414	4,661	9	(2)

[1] Data for 1925. [2] No data. [3] Data for 1924. [4] Data for 1923.

The first two columns of the table show the individual plants and their output per stack-day. These plants are rated according to the average consumption of coke as shown in column 3, since this is the best single index of smelting efficiency. The next two columns show the average consumption of iron ore and of scrap, but it has not been possible to subdivide the metallic charge in all plants. Theoretically, column 4 shows only the amount of iron ore proper, while column 5 shows the amount of scrap, mill cinder, scale, borings, and other ore equivalents; but where no data are available on the amount of scrap or ore equivalents, the figures for the whole metallic charge are shown in column 4. For present purposes mill cinder, scale, turnings, and other such ore equivalents [1] are listed in column 5 as scrap, although their iron content is considerably lower than that of scrap. The latter ordinarily yields from 90 to 95 per cent iron, which means that it makes pig iron at the rate of ton for ton; pig iron runs about 94 per cent iron. But the other ore equivalents, such as cinder, scale, etc., usually range from about 65 to 90 per cent iron, and so rank somewhere in between scrap and ore in iron content. Column 6 of Table 9 shows the average amount of the blast in cubic feet of air blown per minute.

In a stack of a given size the daily output of pig iron is determined by the quality of the raw material charged and by the speed at which these materials are smelted. Efficiency of operation consists in the establishment and maintenance of the most economical balance between these factors. As far as ore and ore equivalents are concerned the main problem is their bulk; at a given rate of driving the material can pass through the stack only about so fast, and therefore the amount of pig iron produced will depend upon the amount of iron in a given volume of iron-bearing material. On the other hand, the smelting process can be speeded up by blowing a stronger blast, but beyond a certain point this causes a heavier consumption of coke per ton of product and thus becomes uneconomical.

Plant No. 5 has a remarkable record for coke consumption, only 1,663 pounds per ton of pig iron produced, but it is clear that this record is at least partly due to the large amount of scrap charged. This is mostly real scrap, which consumes a very small amount of coke in passing through the stack. Therefore nearly all the 1,663 pounds of coke consumed at this plant were used in smelting the 3,470 pounds of iron ore.

Plant No. 41 charged some scale and mill cinder, but the exact amount was not reported, so it is impossible to show the extent to which coke consumption was affected by their use. The scrap charge in plant No. 3 consisted of borings and turnings only, consequently the saving in iron ore proper was not so great as in plant No. 5, and the amount of coke required was considerably larger. Plant No. 12 also made an exceptionally good record of coke per ton of product. Here, too, cinder and scale were charged, but the exact amounts were not reported. It is important to note that the amount of blast blown in plant No. 12 is among the lowest in the whole list of plants. The good record in plant No. 34 can be ascribed to the very rich ore charged, for the amount of scrap used was quite small.

The above figures are in sharp contrast with those at the other end of the list, where the last nine plants all consumed more than 2,600 pounds of coke per ton of product. One important cause of this is found in the ore consumption figures. All these plants have a total metallic charge greater than 4,500 pounds and five of them run above 5,000 pounds. It is clear that the daily output in these plants is much smaller than it is in plants of the same size which are using only 4,000 pounds of ore and 2,000 pounds of coke per ton of product. The plants with heavy ore and coke consumption apparently use a somewhat stronger blast than the others, as is shown by

[1] It must be noted that flue dust and remelt scrap are never counted as part of the metallic charge. Flue dust consists of fine ore particles which are blown out of the stack with the blast furnace gas and which are caught in the dust catchers. Remelt consists of runner and ladle scrap which is formed when the cast is being made. Both the flue dust and the scrap are charged back into the stack again, but they have already been counted once and must not be counted again.

the records for plants Nos. 15, 18, 38, and 40. In general, the amount of blast varies directly with the size of the stack, but the use of scrap and rich ore makes possible a lighter blast, while lean ores require a much heavier blast.

To understand the importance of materials consumption more clearly and to see how it is linked up with output per stack-day and productivity over a period of time, it is necessary to turn to the records of individual blast-furnace plants (Table A), where all the factors which enter into the changes are shown in detail. During the period covered by this study certain plants show remarkable improvement in productivity largely as a result of better smelting efficiency and the use of better materials. Plant No. 17 was taken over by new management prior to 1922, and within four and one-half years coke requirements were reduced 25 per cent. There has been a moderate increase in the use of scrap, but the chief reason for the improvement can be found in the richer ore charged each year. This improvement expressed itself in higher output per stack-day and ultimately in productivity.

The four-year record of plant No. 23 is a striking illustration of improved operation. With a new furnace in 1923 this plant has since been operated continuously with a remarkable improvement in yield, decreasing ore consumption from 4,113 pounds to 3,212 pounds per ton as the result of an average charge of about 500 pounds of scrap per ton of iron, beginning in 1924. Coke consumption fell from 2,200 pounds to 1,800 pounds per ton, while flux shows a corresponding reduction from about 1,200 pounds to 900 pounds per ton. This improvement is paralleled by increased output per day from 253 to 377 tons without any change in equipment.

Steady progress in coke practice is shown in the record of plant No. 12, which exhibits a reduction in coke per ton of iron from 2,425 pounds per ton in 1912 to about 1,800 pounds in 1,926. At this plant special attention has been given to the quality of the coke used, both with reference to its physical characteristics and its fixed carbon content. The management at this plant considers coke consumption one of the most important factors in furnace efficiency and has worked out a formula for determining the ideal consumption of standard coke under the best operating practice. This plant has an output per stack-day 20 per cent larger than the next best furnace of its size in the country and a much larger output than many furnaces with volumes from 5,000 to 10,000 feet greater.

The influence of greatly improved smelting efficiency in the case of plant No. 3 has been very important though obscured by other factors such as rebuilding and enlarging of furnaces, etc. Reduction in coke from 2,400 pounds to 1,800 pounds per ton of iron tallies closely with the improvement in plant No. 12, while an increased use of scrap since 1922 has contributed to better yield. Flux consumption shows a remarkable reduction from 1,200 pounds to 750 pounds per ton of iron. Reference to the history of this plant shows remarkable increase in furnace output, while productivity has increased at a still faster rate over the entire period

Plant No. 5 shows a remarkable improvement in coke practice, to which the consumption of from 350 to 500 pounds of scrap per ton of iron has contributed. This lavish use of scrap has also brought about a shrinkage in the flux used from 1,100 to 800 pounds per ton and in ore from 4,621 to 3,576 pounds per ton over a period of eight years.

A marked improvement in yield and coke consumption in the case of plant No. 21 is found to account largely for improvement in furnace output and productivity. Coke requirements have been cut about 400 pounds per ton, partly due to the increased use of scrap.

In one plant, No. 15, there appears a clear case of improved output per stack-day as a result of better operation. By 1926 coke consumption per ton of iron had been reduced 400 pounds below the high figure in 1919, and in 1927 an additional 300 pounds was clipped from this record. The great decrease in the use of flux has been due to a change in the mixture of the ores, a larger proportion of self-fluxing ores being used in recent years. No major labor-saving devices have been introduced and there has been no important change in the size of the furnaces. Although production has been concentrated somewhat more steadily in the larger of the two stacks, it may be said that the change in productivity, almost entirely due to greater stack-day output, has been ultimately due to better smelting efficiency and richer ores.

Plant No. 43 furnishes an excellent illustration of the use of mixed ores in the South. Data for 1917 should be disregarded in making comparisons, for they represent the operation of the old furnace. Since 1917 the furnace has been relined only once and then without change in size. Output per stack-day has fluctuated widely, showing no clear trend in any direction but following the variations in the amount of flux used. Daily production is above normal when flux consumption is high and below normal when flux consumption is low. This variation in the use of flux furnished a clue to the variations in stack-day output, for the amount of flux used depends upon the proportion of the two kinds of ore charged. Low flux consumption indicated the use of large proportion of the leaner self-fluxing ores, while high flux consumption in all recent years but one shows the presence in the charge of the much larger proportion of the richer ores which are not self-fluxing. This change in the quality of the ore, of course, influences very markedly the output per stack-day. It is noticeable that the amount of coke required also varies in direct relation to the changing mixture of the ores. Plants in the Birmingham district of the South always have this possibility of mixing ores in such a way as to get the best possible results in smelting efficiency. While output per stack-day has shown very little increase over this period, productivity has shown a pronounced upward trend, due to the reduction in labor crews which took place.

New management in 1920 at plant No. 7 brought about rapid improvement in operation as evidenced in the reduction in ore consumption per ton of iron from 4,450 pounds to 3,618 pounds while scrap consumption increased from about 20 pounds to over 370 pounds per ton, coke requirements falling from 2,400 pounds to about 2,000 pounds per ton of iron, and flux from over 1,200 pounds to less than 1,000 pounds.

Further analysis of changes in consumption of materials for certain plants with long histories may be found in Appendix 2, page 116.

In conclusion, it is clear that output per stack-day is largely determined by the size of the stack, and consequently the increased daily output in the industry in recent years has been due mostly to the enlargement of the stacks. In addition, however, stack-day output has been influenced to some extent by changes in materials and methods of operation. The most important of these changes has been the rapid growth in the use of scrap, and this together with the increase in stack size should account for nearly 90 per cent of the changes in output per stack-day. The remainder is mostly a matter of the efficiency of operation through the use of better coke, a better adjusted blast, and so on. However, while individual plants may have made some remarkable records along this line and thus expanded the daily output of the stack considerably beyond the average for its size as far as the merchant industry as a whole is concerned, efficiency of operation by the management has been of secondary importance in increasing the output per stack-day.

REDUCTION IN LABOR TIME

MEANS EMPLOYED TO REDUCE LABOR TIME IN INDIVIDUAL ESTABLISHMENTS

The second group of factors influencing productivity are those which affect the amount of labor necessary to operate the blast furnace.

The number of men required to operate a one-stack blast-furnace plant varies widely; one northern plant operates regularly on a crew of less than 90 men, while there is one southern plant which employs almost exactly twice that many men. However, because of the varying conditions with reference to layout, equipment, and so on, it is difficult to make any very detailed comparisons between plants. But in any one plant the changes in the labor force can be definitely related to the changes in operation and equipment. In general, the factors which have been responsible for reducing the number of men required to operate a blast-furnace plant may be summarized as follows:[2]

1. Joint or integrated operation, either of several stacks in one plant or of a blast furnace in connection with a coke plant or other manufacturing process.
2. Introduction of machinery, particularly the pig-casting machine, the skip hoist and its auxiliary equipment, and the power cranes, both locomotive and electric.
3. The reorganization of the crew, particularly that which took place as a result of the change from the 12-hour to the 8-hour day.

Joint operation usually makes possible a considerable saving in indirect or auxiliary labor, especially in repair labor, yard labor, and transportation labor. The single isolated blast furnace must carry men for certain occupations even though it is difficult to keep them busy all the time; it must have a sufficiently large mechanical crew to take care of all the ordinary repairs—there must be at least one blacksmith, a carpenter, a welder, a master mechanic, etc. Likewise, the single-furnace plant requires a yard crew sufficiently large to meet the needs of the plant in the rush periods, though it is sometimes quite a problem to keep all these men busy during the whole day. It is not at all unusual to find the yard railway crews waiting an hour for the cinder run. On the other hand, if the plant is operating more than one stack, or if there is a coke plant operated in con-

[2] See ch. 3, p. 20.

junction with the furnace, the indirect labor is spread over more continuous operation. In handling materials, an ore bridge and unloading equipment can serve two or more stacks as well as one; casting machines can be kept busy more continuously; pumping, power, and blowing equipment can be better and more cheaply operated, while floating labor crews can handle maintenance and certain phases of operations to advantage with fewer man-hours per furnace than in a single-stack plant.

This is illustrated by a number of individual plant histories. Plant 15 (p. 78) shows very clearly for the period 1922 to 1927 the effect of single-furnace and double-furnace operation. The best productivity record was attained in 1925 and 1926, when there was full two-furnace operation. The full significance of the figures, however, becomes evident only when the output of the furnace crew labor is compared with the output of the "all other" labor. Until 1927 there was little change in the productivity of the furnace crew labor, regardless of whether one stack or both stacks were operating, showing that there was no saving in this type of labor in two-stack operation. But there was a marked change in the productivity of "all other" labor. It required 3.512 man-hours of "all other" labor to produce a ton of pig iron in 1924 with one stack, but this was reduced to 2.275 hours in 1925 and 2.378 hours in 1926 in operating two stacks. A return to one-furnace operation in 1927 brought the figures back up to 3.271 hours per ton. The saving in indirect labor under two-furnace operation is very striking in this case.

Somewhat similar is the case of plant No. 10 (p. 76), which became integrated with a steel plant after operating as a merchant furnace for many years. Here it is not a matter of one or two furnace operation but of joint operation with an auxiliary manufacturing process. No data are presented in this report for this plant after 1918 as this is the last year it operated as a merchant furnace. Several changes took place after it became identified with the steel-stack division of the industry. In 1919 a stack was rebuilt and in a more recent year a change in plant management was made which introduced many labor economies. Man-hours per ton were reduced from 8.920 in 1918 to 3.560 in 1923 and further reduced to 2.705 for the first half of 1927.

It is only intended to point out here that joint operation makes possible certain labor economies; it does not follow that all plants which have the advantage of such operation are able to obtain these economies. There are plants in this study which show an actual decrease in productivity upon the introduction of joint operation. This is sometimes partly due to a failure to divide the indirect labor fairly between the two operations, as in the case of plants which arbitrarily split such labor with a coke plant or auxiliary manufacturing process on a 50–50 basis. (However, this explanation does not apply to plants with two-furnace operation where all indirect labor is charged against pig-iron output anyway.) There are plants in which joint operation did not result in any improvement in productivity at all, whether because of peculiar conditions surrounding the operations at those plants or because of failure to take advantage of the opportunities.

The second important factor influencing the amount of labor time necessary to operate a blast furnace is the introduction of labor-saving machines.

Mechanical filling has been brought about by means of the skip hoist, which is merely a short term covering a whole series of improvements in the method of charging the furnace. The old system of charging by hand was a very cumbersome process, requiring a large number of men. The ore, coke, and limestone had first to be brought over from the stock piles or bins in cabs or cars. The bottom fillers and their helpers loaded the materials into wheelbarrows and wheeled these over to the cage or elevator, which lifted them to the top of the stack. Here another group of men called top fillers dumped the barrow loads into the furnace. Hand filling was hard, unpleasant work requiring very little skill on the part of the worker.

Mechanical filling changes the whole process of charging. First, there is built a high trestle on which loaded cars can be run and dumped, the materials falling through into a long set of bins situated directly beneath the trestle. The bins are V-shaped structures built sufficiently far above the ground that a larry car or scale car can pass along underneath them. The car operator, by means of a series of levers, opens the bins at the bottom and allows the materials to fall into the car, which then delivers the load to the skip hoist itself. The skip usually consists of two alternating hoists which convey the materials to the top of the stack and automatically dump them into the furnace. There is a bell-shaped device at the top of the stack for the purpose of distributing the stock evenly in the furnace. The whole structure results in a great reduction in charging labor—the skip itself eliminates the top fillers, the larry car eliminates the bottom fillers and fillers' helpers, and the trestle eliminates most of the labor engaged in delivering materials. The labor which remains is that of operating the skip and the larry car and of dumping the cars on top of the trestle.

There are several striking examples of the effect of installing a skip hoist. In plant No. 20 (p. 80) one was installed in 1924. Although the effect on productivity is somewhat obscured by the relining of the stack which took place at the same time, nevertheless it is possible to get a fairly definite measure of the increased output per man-hour due to the reduction in charging labor. After relining the stack the output of pig iron per stack-day increased from 346 gross tons to 418 gross tons, causing a proportionate increase in productivity estimated at about 20 per cent. But the output per man-hour of the furnace crew in 1925 was more than double that in 1924, so that the skip hoist would account for an increase in furnace-crew productivity of approximately 80 per cent. It required 1.651 man-hours of furnace-crew labor to produce a gross ton of pig iron in 1924, but only 0.800 man-hour in 1925.

Plant No. 36 (p. 87) changed over from hand filling to mechanical filling in 1919, but here too the effect of the change on productivity is obscured by the relining of the stack at the same time. However, the output per stack-day was not increased appreciably in the following year, while the man-hours of furnace-crew labor per ton of product decreased from 3.477 hours to 1.805 hours, which reduction roughly corresponds to that shown in the plant mentioned above.

A third case of the installation of a skip hoist is plant No. 57 (p. 96). As is usual when important improvements are introduced the stack was relined at the same time, but this latter may be disregarded for there was no real change in the size of the stack and the output per stack-day after relining was scarcely higher than before. The furnace-crew labor, however, was reduced from 2.704 man-hours per ton of product to 1.818 man-hours, and nearly all of this can be ascribed to the influence of the mechanical system of charging.

The installation of the skip at plant No. 19 (p. 80) is also worth mentioning because it is not complicated by any relining of the stack, although there was a slight increase in output per stack-day after the change. The skip was installed in 1924 and the furnace-crew labor was reduced from 2.992 man-hours per ton of product in 1923 to 1.472 man-hours in 1924, a decrease of over 50 per cent. While it is too much to say that all of this can be attributed to the labor saving of the skip, this was the only important machine introduced at this time.

Plant No. 18 (p. 79) furnishes an excellent illustration of the installation of a skip hoist in the southern district. In 1920 with a hand-filling system it required 6.705 man-hours of furnace-crew labor to produce a ton of pig iron, while in 1922 after the skip and its auxiliary equipment had been installed it required only 2.613 man-hours. The skip was installed in 1921, but the partial operation during that year was not representative. The output per stack-day is somewhat lower in 1922 than in 1920 so that nearly all of the reduction in the furnace-crew labor can be attributed to the installation of the skip. There was also a great reduction in "all other" labor between the same two years, and some of this is undoubtedly due indirectly to the skip, for there was considerable saving of labor in delivery of ore under the new system.

The influence of the pig-casting machine on productivity can not be measured as definitely as that of the skip, because it does not result in saving as much labor as the change from hand to mechanical charging and a large part of the saving which is accomplished is in indirect rather than direct labor. The pig machine does directly displace a considerable number of sand cutters and iron carriers in the furnace crew, and to the extent of this displacement its effect on productivity can be measured by the increase in output per man-hour of the furnace crew or by the reduction in man-hours per ton of furnace-crew labor. However, it also exerts considerable influence on the indirect labor required in the iron yard, a saving which does not show in the furnace-crew labor and which is frequently obscured by other factors affecting the indirect labor. The pig machine brings about a saving of labor in the iron yard because of the fact that it elevates the pigs in the process of cooling and permits them to drop into gondolas and open cars from which they can be unloaded by a locomotive crane in the iron yard. When the pig iron is sand cast it is frequently loaded by hand into closed cars from which it must be unloaded by hand in the iron yard, thus requiring a very large unloading and piling crew.

The following plant histories are shown to illustrate the effect of the pig machine, but in most cases it can not be traced beyond the furnace-crew labor.[3]

A pig machine was introduced by plant No. 50 (p. 93) toward the end of the year 1923, and a small percentage of metal was machine cast in that year but not enough to affect the productivity figures

[3] For data on effect of pig machine on iron-yard labor see ch. 4, p. 49.

seriously. However, the furnace-crew labor was reduced from 3.136 man-hours per gross ton of pig iron in 1923 to 1.669 man-hours in 1924, which means cutting the furnace crew very nearly in half. The "all other" labor does not appear to have been influenced at all by the machine, probably because the plant was using a full complement of locomotive cranes already.

Plant No. 59 (p. 97) furnishes a striking illustration of the effect of the pig machine on productivity, but unfortunately the results of its introduction are mixed up with the results of some other improvements which took place at the same time, particularly a change in the bins and an increase in the size of the stack. The machine was introduced in 1922, but this was a year of very inefficient operation all around, and the full effect of the change is not noticeable until the following year. The furnace-crew labor was reduced from 5.232 man-hours per ton of product in 1920 to 2.570 man-hours in 1923, and at the same time the "all other" labor was reduced from 6.527 man-hours per ton of product to 3.629 man-hours. The increase in output per stack-day from 137 gross tons of pig iron in 1920 to 182.1 in 1923 accounts for a considerable part of the decreased labor per ton in both sections of the crew; but the remaining decrease, which is still very great, must be attributed jointly to the improvement in the bins and the use of the pig machine. The pig machine, however, was undoubtedly responsible for a greater saving in labor than the change in bins.

Plant No. 51 (p. 93) also furnishes a good illustration of the effect of the pig machine on productivity, although in this case the results were less marked than in the previous cases. The furnace-crew labor was reduced from 2.289 man-hours per ton of product in 1924 to 1.772 man-hours in 1925 when the pig machine was operating. Since the output per stack-day in both years was exactly the same, and no other changes in equipment took place, this decrease in labor was entirely the result of the installation of the pig machine. In fact, the above figures do not adequately measure the influence of the machine on productivity, for the "all other" labor shows a reduction from 3.398 man-hours per ton in 1924 to 2.900 man-hours in the following year, and much of this also is probably due to the use of the machine.

There are many other cases showing the effect of the installation of the pig machine, but it often happens that the results are not clearly shown, being lost among the results of numerous other influences. A detailed study of Table A (p. 71), however, will furnish considerable material on the subject of the pig machine in relation to productivity.

There are no clear cases of the influence of the crane on productivity, for this has not had such a marked effect as the two machines previously mentioned, and in addition cranes have usually been introduced one at a time, so that their full effect in displacing hand labor in the yard and floating gangs is extended over a period of years and is thus lost in the general mixture of other changes. For the purposes of this discussion, however, it is sufficient to point out that the locomotive crane has been of considerable importance in displacing labor, particularly in the iron yard and in ore unloading. There was a time, comparatively recent in some sections of the country, when ore cars were unloaded by a crew of 20 to 40 men under contract at so many cents per ton, and the iron in the yard was moved and piled by another crew of about 20 men. At the present time, in every modernized plant, the ore is unloaded by means of a car dumper or a locomotive crane, and nearly all the handling of the iron is done by a crane. The locomotive crane has been largely responsible for the great reduction in the unskilled labor gangs working around the plant. Electric overhead cranes in the cast house and in various parts of the plant have also played an important part in the elimination of hand labor.

It would be possible to go on calling attention to other machines which have been instrumental in displacing large amounts of hand labor but it is not necessary to go further into details on this point. However, there are two important machines which have played an important part in ore unloading in the larger plants—the ore bridge and the car dumper. In one sense these two machines represent a second stage of progress in ore handling, for in the same way that the locomotive crane displaced hand labor these two items of equipment are eliminating the locomotive crane itself. A car dumper with a crew of two men can handle all the ore for a one or two furnace plant as fast as it can be brought in. Then the ore bridge, with a crew of two operators and two oilers, removes the ore to the stock pile and at the same time keeps the bins supplied with ore for immediate use. This method of ore handling eliminates the use of several locomotive cranes, reduces the amount of railroad transportation in the plant, and cuts the labor force. However, the use of these two machines is mostly confined to fairly large blast-furnace plants or to those along the Great Lakes, for they are expensive to install and would burden the plant with a large overhead cost unless they are used to capacity. Few of the smaller merchant furnaces use either one of them.

Another factor affecting labor is skill, willingness, and ability of the laborer himself. The difficulty is that there is no satisfactory way of gauging the influence of this most important factor. Nearly all furnace operators realize that the good will of the workers is of great importance in determining the output of the plant and the quality of the product, but this good will operates in such subtle ways that its results can not be measured statistically. However, there did occur during the period covered by this study one specific change which has had some effect on the efficiency of the worker himself, in the absence of any improvements in equipment or organization. This was the substitution of the 3-shift for the 2-shift system in 1923, the elimination of the 12-hour day, and the establishment of the 8-hour day for workers on continuous processes. Before this change took place it was confidently expected by many that there would be a considerable increase in labor cost because of the increase in the number of men required to operate the furnace. It is therefore of particular interest to note the results of the change in the shift system in individual plants.

Theoretically, the substitution of the 8-hour day for the 12-hour day would have no effect on productivity; that is, each position requiring two men at 12 hours each would require three men at 8 hours each and the output per man-hour of labor would remain the same. In actual practice, of course, it would be expected that the output per man-hour would be somewhat higher in the latter case, for it is evident that a man can work at higher speed for 8 hours than he can for 12 hours. But the actual results in the blast-furnace industry following 1923 far exceeded anything that might have been expected. There are numerous cases of plants in which, within a year after the change was made, the total labor force was back again at the same number of men that had been employed under the 12-hour system.

In plant No. 12 (p. 77) the steady increase in productivity was accelerated by the introduction of the 8-hour day. The old system of 10 and 12 hours was abolished at the end of 1923, and a new universal 8-hour system was substituted. The total labor time expended per ton of product was 2.917 man-hours in 1923 and 2.227 man-hours in 1924. There was about a 10 per cent increase in output per stack-day, which accounts for a small part of the increased productivity, but even when this is allowed for there still remains a further substantial increase in productivity, or to put it conversely a reduction in labor time. Of course, this plant shows a steady increase in productivity in every year since 1919, but when the effect of the increase in stack-day output has been eliminated the rate of increase between 1923 and 1924 was greater than in any other two years.

Another even better case is that of Plant 32 (p. 85). Eliminating 1923 as the year of transition from the 2-shift to the 3-shift system, a comparison can be drawn between 1922 with the 10-hour and the 12-hour day and 1924 with the universal 8-hour day. No mechanical improvements of any importance were made in the interval, the output per stack-day was nearly the same in the two years, and even the length of time operated was almost identical. In other words, the only important difference in the two years is in the hours per day. Yet in 1922 it required 3.270 man-hours of labor to produce a ton of pig iron, and in 1924 only 2.662 man-hours.

Another plant which furnishes a good illustration of this point is No. 36 (p. 87) in which the transition to the 3-shift system was made in 1923. In 1920, with the 10-hour and the 12-hour day, the labor time per ton of product was 3.470 hours, while in 1924, after a universal 8-hour day had been put into effect, the labor time was 2.245 hours. Allowance must be made for the increase in output per stack-day from 267.3 tons in 1920 to 329.6 tons in 1924; but giving full consideration to the increased output of the stack, the great reduction in the crew following the introduction of the 8-hour day is obvious.

PRODUCTIVITY BY OCCUPATIONS AND LABOR GROUPS

The labor force in the various blast-furnace plants has previously been studied as a unit or at least in large groups. The annual averages of productivity, however, whether for the whole labor force or for the blast-furnace crew, do not show the changes which have occurred in particular labor groups or individual occupations. Minor improvements in machinery or small reductions in the labor force are taking place all the time, but the effect is not evident in the output per man-hour for the whole year. For the purpose of illustrating in detail the slow but steady growth in productivity as it relates to each small group or occupation throughout the plant, special data were collected from a few plants.

Productivity by Labor Groups in a Southern Plant.

Table 10 shows the complete classification of the crew of a southern merchant furnace over the entire period covered by this study. The labor has been divided into 13 groups, each containing as nearly as possible all labor engaged in performing a single operation. In the cast house are included the keepers, the fall men or cinder snappers, the stove tenders, and the scrappers working around the stack itself. The pig-machine labor consists of all those engaged in operating the pig-casting machine; these superseded the iron carriers, sand cutters, and scrappers, who formerly took care of the iron from the time it was cast in sand until the pigs were loaded on the cars for transportation to the iron yard. The stocking and charging labor consists of such occupational groups as weighmen, skipmen, larrymen, and coke punchers; in general, it includes all labor around the trestle and stock house. The next group consists of labor engaged in delivering ore from the stock piles to the bins; this was formerly done by means of small cars, and numerous men were required to load these cars at the stock piles and deliver them to the bins. In later years most of this labor has been abolished. Ore-unloading crews are engaged in emptying the ore cars when they come in from the mines. In the South there is no summer ore season because the climate makes it possible to deliver ore from the mines all through the year; consequently, there is no necessity for storing a winter's supply of ore in the yard, and as many of the ore cars as possible are dumped directly into the bins as they come in from the mines.

The general labor consists largely of the floating gangs which work wherever necessary around the yard, on the tracks, etc. In former years a large crew of men were kept busy in the iron yard unloading pigs from the cars which came from the casting floor, piling iron, loading up iron for shipment, etc. Now all of this is done by means of locomotive cranes, and the only labor needed in the iron yard is that of a shipping clerk, who gets a salary and is classified in the salaried group. Locomotive cranes were first used in this plant in 1917, when one crane was bought. This was soon followed by another, and since 1919 there have always been at least two cranes in operation at the plant. The only labor required is that of the cranemen and their firemen.

The railway switching crew is confined to those who take charge of the "cinder run"—that is, the cinder engineers, the couplers or switchmen, and the ladle dumpers. These engines also do considerable switching around the furnace, such as taking loaded cars out to the iron yard, etc. There is a railroad which runs out to the mines, but these crews are not considered to be part of the blast-furnace labor. The mechanical crew consists of the master mechanic, the machinists, carpenters, pipe fitters, blacksmiths, and bricklayers working on current repairs. In the power-house labor are included the blowing engineers, oilers, boiler men, and boiler cleaners. The final group consists of salaried employees—superintendents, foremen (those on a salary), clerks, timekeepers, and chemists.

TABLE 10.—*Labor productivity in man-hours per ton of pig iron produced, in a typical merchant blast-furnace plant, by labor groups and years, 1910 to 1927*

Year	Cast house	Pig-machine labor	Iron carriers, sand cutters, scrappers, etc.	Stocking and charging	Delivery labor (ore from stock pile to bins)	Ore unloading	General labor	Iron-yard labor	Locomotive cranemen	Railway switching	Mechanical crew	Power house (including blowing engineers)	Superintendents, foremen, clerks, and other salaried employees	Total	Average full-time furnaces active during year
	Man-hours	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hours*	*Man-hours*	*Man-hour*	*Man-hour*	*Man-hours*	*Man-hour*	*Man-hour*	*Man-hours*	
1927 [1]	0.936	0.465	----------	0.581	0.039	0.242	0.959	(2)	0.162	0.233	0.639	0.465	0.284	5.005	1.0
1926	.826	.474	----------	.592	.059	.252	1.050	(2)	.136	.237	.641	.474	.281	5.023	1.0
1925	.915	.525	----------	.656	.197	.282	.720	(2)	.341	.263	.797	.525	.318	5.539	1.0
1924	1.012	.445	0.221	.677	.203	.293	1.096	0.193	.303	.271	.771	.542	.359	6.387	1.0
1923	.892	----------	.865	.597	.435	.288	1.529	.874	.218	.265	.725	.531	.323	7.542	1.0
1922	.832	----------	.598	.643	.325	.200	1.572	.614	.172	.278	.655	.541	.362	6.784	.6
1921	1.013	----------	.802	.695	.463	.346	1.894	.743	.292	.294	.567	.586	.367	8.192	.1
1920	.815	----------	.699	.629	.280	.483	2.677	.945	.160	.280	.910	.559	.282	8.718	1.0
1919	.722	----------	.798	.697	.373	.389	2.952	.874	.102	.293	1.028	.492	.261	8.981	1.2
1918	.709	----------	.768	.614	.491	.358	2.204	.787	.067	.283	.640	.324	.193	7.439	1.7
1917	.682	----------	.749	.517	.464	.260	2.155	.772	.057	.273	.507	.273	.142	6.851	2.0
1916	.833	----------	.884	.588	.635	.308	2.309	.856	----------	.287	.480	.353	.207	7.740	1.6
1915	.875	----------	.909	.602	.719	.494	2.005	1.003	----------	.251	.541	.534	.279	8.212	1.0
1914	.858	----------	.889	.530	.594	.461	1.870	.936	----------	.250	.549	.498	.260	7.695	1.0
1913	.858	----------	.924	.660	.726	.488	1.868	.991	----------	.264	.578	.530	.275	8.158	1.0.
1912	.826	----------	.758	.627	.509	.414	1.917	.877	----------	.304	.539	.455	.250	7.477	1.3
1911	.986	----------	.893	.759	.854	.435	2.517	1.091	----------	.304	.625	.612	.316	9.392	1.0
1910	.885	----------	.751	.544	.797	.334	2.556	1.037	----------	.311	.525	.468	.259	8.467	1.3

[1] First 6 months.
[2] Upon installation of pig machine, iron piling was handled by locomotive cranes and switching crews.

For each of these groups there is shown for every year the total man-hours of labor required to produce a gross ton of pig iron. The total man-hours given in the final column at the right corresponds to the figures in Table A showing the man-hours per ton of pig iron for the plant as a whole. From 1911 to 1920 the productivity remained about constant, although there were minor variations chiefly due to the relative amount of one and two furnace operation. In 1917, when there was full 2-furnace operation, 6.85 man-hours were required to produce a gross ton of pig iron, while in 1911, with only one stack operating, it required 9.39 hours. However, there does not appear to have been any general upward trend of productivity during this period. The figures for 1921 are for only one month of operation previous to closing down, so that they are not at all representative of conditions and need not be considered. When the plant was started up again in the spring of 1922, a much smaller force could be used, as a large amount of the repair work and necessary preparation had already been done by the men who had been kept on the pay roll during the shutdown. It was not until 1923 that the plant was again operating with a full crew, and from that year down to 1927, with steady 1-furnace operation, there has been a marked reduction in the man-hours per ton of pig iron. The best pre-war record for single-furnace operation was made in 1914, with 7.70 man-hours per ton, and this is the figure which should be compared with 5.02 hours in 1926.

The changes within the different labor groups present some sharp contrasts. The cast-house crew shows very little change over the whole 17-year period. The economy of 2-furnace operation is clearly shown by the low record of 0.68 hour per ton, made in 1917; but for 1-furnace operation the 0.83 hour in 1926 shows very little improvement over the 0.86 hour of 1914, and barring the year 1921 for reasons given above the year 1924, with 1.01 hours per ton, shows a higher time cost than any pre-war year. Thus, the cast-house crew has remained fairly well stabilized throughout the period, and the only real improvement shown was brought about by double-furnace operation.

The influence of the pig machine can be seen in the complete elimination of two labor groups—the iron carriers and sand cutters engaged in sand casting and the iron-yard labor engaged in handling iron in the yard. Therefore the net effect of the pig machine can be obtained by combining these two groups in the years prior to its introduction. In making the comparison the years 1921 and 1922 should be excluded, since they are not representative. A considerable amount of piling and shipping was done by the yard crew while the furnace was down, which of course does not show in the figures. However, in 1923 the total hours required by these two groups were 1.74, as compared with 0.53 hour for the pig machine in 1925 and 0.47 hour in 1926.

The stocking and charging group shows no important changes. Like the cast-house crew, this group was not affected by any influence other than that of single or double furnace operation. In 1917, with 2-furnace operation, the low point of 0.52 hour per ton was reached, the single-furnace operation in 1914 resulting in the very good record of 0.53 hour, while in 1926 the figure was 0.59 hour.

Ore delivery labor has been cut down almost to nothing in recent years—0.06 hour in 1926 and 0.04 hour in the first six months of

1927. The amount of this labor needed at the plant has fluctuated widely, but in the best pre-war year (1912) it was 0.51 hour. There was a good record of 0.28 hour for this labor group in 1920, but this should not be accepted at its face value, for the labor saved here was counterbalanced by a large amount of ore unloading labor—0.48 hour. More ore cars were unloaded directly into the bins in this year than in others immediately preceding and following. The bins have been recently modernized, and the large number of car loaders and drivers is no longer needed.

The general labor force has been cut in half since pre-war days. This type of labor reflects very closely the relative prosperity of the industry, for in years when the industry is prospering these general yard laborers are taken on freely in order to speed up operations and keep things in first-class shape; but when times are bad this crew is cut as much as possible and only the most essential kinds of work done. There was a steady decline in the hours required for this labor from 1912 to 1914; then in 1915 the man-hours turned sharply upward, indicating much larger crews, and this trend continued for the next five years; the figures for 1917 and 1918, because of double-furnace operation, obscure the actual expansion in the crew at that time. The crew was larger in these years than it had been previously, but the man-hours were spread over a greater output of pig iron. The turn in 1920 is clearly shown, and since that time the general labor has been reduced in almost every year. The low figure in 1925 is partly explained by the increase in locomotive-crane labor, but apparently the plant was able to run with a very small crew for one year. This could not be done continuously.

The locomotive-crane labor fluctuates widely, depending not so much on the number of cranes working but more on what the cranes are doing. It requires an engineer and fireman to operate a locomotive crane ordinarily, but when a groundman or hook-on is needed the total man-hours are increased by one-half. There were no cranes at all in use at this plant until 1917 and then only one crane for several years. These cranes have been responsible for a great deal of labor saving in the iron yard and in general labor.

The railway switching hours vary but little from year to year; in general the trend has been slightly downward and it is apparently quite independent of the number of furnaces operated. The best record on this class of labor prior to 1926 was made in 1914 with 0.25 hour per ton, while the 2-furnace operation of 1917 resulted in 0.27 hour per ton.

For the most part the mechanical crew has remained fairly constant during the period. The amount of mechanical work required is to a large extent independent of the operation of the stacks but is apt to depend largely on the nature of the difficulties encountered. If a serious breakdown occurs, the plant is likely to close down and the repair work will not appear as operating labor; therefore, it is only the minor repairs which are included in these man-hours.

The power-house crew remains practically constant all the time regardless of the changes in operation, so that the man-hours per ton vary inversely to the production. Thus 1917 is the year of the lowest record, while the single-furnace operation of recent years has produced the highest records.

In general the salaried labor has increased slightly over the period. This is not a specific labor group, however, as it represents a combination of employees from various other labor groups; thus, it may be increased by the transfer of employees to a salary basis.

The above discussion shows that the labor saving in this plant took place both in the furnace crew proper and in the general overhead labor and was the direct result of the introduction of important machines or equipment. Some groups did not participate to any extent at all in the reduced man-hours of labor per ton of pig iron, and there is only one case (ore unloading) of steady reduction in the absence of a new machine. The iron carriers and iron-yard laborers were replaced by the pig machine and the locomotive cranes, the ore-delivery laborers were reduced by a new system of bins, and the general yard labor by locomotive cranes. The saving in ore-unloading labor can be traced to better integration of operations.

Productivity by Occupations in a Pennsylvania Plant.

A more detailed analysis of the labor required to operate a blast furnace is shown in Table 11. This is a Pennsylvania furnace for which the man-hours per ton of pig iron produced have been calculated by occupations and labor groups. The table shows the labor conditions in 1920 at the peak of the boom operations of that year; in 1921 the data cover only partial operation in a year of extreme depression when crews were reduced to the very minimum, while 1926 shows the condition of the crew in a full year of operation after the plant had been thoroughly modernized.

TABLE 11.—*Labor productivity in a typical merchant blast-furnace plant, by occupations and labor groups, for the years 1920, 1921, and 1926*

Occupation and labor group	Man-hour per gross ton of pig iron produced		
	1920	1921	1926
Stocking and charging:			
Stone breakers	0.282		
Crusher engineers	.058	0.056	0.046
Coke sweepers and helpers	.282		
Ore loaders	.408	.316	.290
Fillers	1.971		
Top fillers	.427		
Weighmasters	.116		
Scale-car operators		.130	.116
Skip engineers		.130	.116
Total	3.544	.632	.568
Casting:			
Keepers and helpers	.990	1.018	.465
Cindermen	.281	.254	.232
Foundrymen (blowers)	.146	.130	.116
Stove tenders	.146	.130	.116
Blowing engineers	.146	.130	.232
Water tenders	.146	.130	.116
Crane runners	.058	.161	.290
Iron weighers	.146		
Iron carriers	.592	.534	
Iron loaders	.650	.372	
Casting-machine labor			.581
Molders and helpers			.116
Total	3.301	2.859	2.264
Yard switching:			
Yard foremen	.058	.056	.046
Locomotive engineers	.204	.192	.174
Brakemen and firemen	.349	.316	.290
Yard switching—Contd.			
Trackmen	0.175	0.161	0.145
Car inspectors	.058	.056	.046
Total	.844	.781	.701
Mechanical:			
Master mechanic	.058	.056	.046
Structural engineer	.058	.056	
Machinists	.175	.211	.343
Blacksmiths and helpers	.116	.105	.099
Carpenters	.291	.161	.099
Bricklayers			.046
Total	.698	.589	.633
Power:			
Boiler firemen	.146	.130	.116
Electrician		.056	.046
Total	.146	.186	.162
General:			
Laborers	.932	.935	1.289
Timekeeper			.046
Chemist and assistant	.116	.105	.099
Night watchmen	.068	.062	
Storekeeper	.058	.056	.046
Total	1.184	1.179	1.451
Grand total	9.707	6.205	5.808

The appearance and disappearance of certain occupations upon the introduction of machinery is clearly shown in the record of this plant. In the stocking and charging group the stone breakers, coke sweepers, fillers, and weighmasters all disappeared when the skip was installed in 1921, and the new occupations of skip engineers and scale-car operators replaced them. The eliminated occupations required a total of 3.078 man-hours per ton of pig iron in 1920, while the new machine operators required only 0.260 hour in 1921 and 0.232 hour in 1926. The crusher engineers and the ore loaders who remained throughout all three years, show a gradual reduction in man-hours per ton of pig iron, a change which is due entirely to the increasing daily output of the stack, for the actual number of men in these occupations remained constant. Had the skip been in place in 1920, the same proportionate reduction would have taken place in the man-hours per ton for the scale-car operators and the skip engineers as actually did take place for the ore loaders and the crusher engineers. An estimate on this basis shows that the man-hours per ton in 1920 for the scale-car operators and the skip men would have been 0.146 hour for each occupation or 0.292 hour for both. The net effect of introducing the skip can thus be calculated: 3.078 man-hours of labor per gross ton of pig iron for the occupations formerly necessary minus 0.292 man-hour of labor for the scale-car operators and the skip men equals 2.786 man-hours of labor saved by the skip.

The same situation can be seen in the casting labor when the pig machine was introduced between 1921 and 1926. The iron carriers, iron loaders, and a large part of the keepers' helpers disappeared from the furnace crew while their places were taken by the casting-machine labor and the molders. It is a little more difficult to estimate the net effect of the pig machine, but by applying the same principles of estimation that were applied to the skip it is calculated that the man-hours per ton required for a pig machine in 1921 would have been about 0.780 hour; the keepers and helpers labor would amount to 0.520 hour instead of 1.018, thus leaving 0.498 hour of keepers and helpers' labor that was eliminated by the use of the machine. The total sand-casting labor displaced by the machine was, therefore, keepers' helpers, 0.498 hour; iron carriers, 0.534 hour; and iron loaders, 0.372 hour—a total of 1.404 man-hours per ton of pig iron produced. From this amount must be subtracted the amount necessary to run the pig machine, or 0.780 hour, leaving the net saving in labor of 0.624 hour per ton. The saving here compares very favorably with that at the southern plant first mentioned.

So far as the other occupations are concerned, there is a clear-cut decline in nearly every case. However, this is not due to any saving of labor, but to the increased output of the stack which resulted in a larger tonnage of pig iron over which to spread the man-hours of labor. An important exception to this rule was the general labor, which increased each year; the machinists also showed considerable increase, although the mechanical group apart from the machinists showed a decrease each year. The increase in machinists can be explained by the increased amount of machinery in the plant after the introduction of the skip and the pig machine. The increase in general yard labor is probably due almost entirely to the ore-unloading crew. Both in 1920 and 1921 there was plenty of opportunity to stock ore while the plant was not in operation, while in 1926 it had all to be done when the furnace was in blast. Hence, the general labor man-hours are larger in 1926. There is no corrective measure for this situation; it is always possible for a plant to do a great deal of repair and general yard work while the furnace is down, and there is no way of taking account of this in operating labor hours.

Productivity by Labor Groups in a Blast Furnace with a Coke Plant.

Another case of a detailed classification of labor time within a plant is that of a high-productivity blast furnace which is combined with a coke plant It has many points of contrast with the two preceding cases in that it is a lakeside plant, it has the advantages of joint operation, and it is equipped with the most modern machinery, including an ore bridge. The classification of the labor into groups is not quite on a comparable basis with the other two. The furnace crew, with the exception of the pig-machine labor, has been lumped together into a single group, thus the variation between occupations within this group is not available; also the furnace crew includes the full-time mechanical men who are attached to the furnaces and not to the shops; the latter cover only the work done in the shops for the blast furnaces. Thus the absolute figures for furnace-crew time can not be directly compared with the figures in the other two plants. However, all the other labor charged against the blast furnace in this plant is shown in complete detail.

Table 12 shows the man-hours required to produce a ton of pig iron by each group specified as well as the total man-hours per ton of the plant as a whole.

The detailed data on labor time in this plant shows clearly the effect of full operation on labor economy. The furnace crew proper shows a pronounced increase in man-hours per ton of output whenever there is less than two-stack operation. Also many of the other labor groups exhibit the same tendency during the two years of limited production—the ore bridge labor, locomotive cranes, water, electricity, steam and boilers, laboratory, and general works labor. All these groups require more man-hours per ton of product in years of partial operation. The reason of course is clear. Labor groups which have a comparatively fixed number of positions regardless of the furnaces in operation will make the best record in labor time when the production is highest—that is, when the overhead is spread over a larger tonnage. Single-furnace operation does not lead to much of a saving in labor while the production is cut in half. This explains why, under identical conditions, a two-furnace plant has an advantage in productivity over a single-furnace plant.

The efficiency of operation made possible by integration with a coke plant is shown by the figures for the indirect labor groups. Nine separate labor groups in this plant have their time distributed between the blast furnace and the coke plant. This explains the astonishingly low man-hours per ton in some of these groups. If figures on yard switching, locomotive cranes, steam and boilers, and general works are compared with corresponding figures for the other two plants previously discussed the contrast will be evident. While this plant is efficiently operated, it still remains a fact that a most important factor in causing this low labor time is the coke plant which shares the use of the indirect labor groups. Some allowance must be made for the fact that the indirect labor in this plant does not include the full-time mechanical men, but on the whole this would have little weight.

TABLE 12.—*Labor productivity in man-hours per ton of pig iron produced in an integrated merchant blast-furnace plant on the Great Lakes, by labor groups and years, 1922 to 1927*

Year	Number of full-time furnaces active during the year	Blast-furnace crew proper	Pig-machine labor	Ore-bridge operators	Dock labor	Locomotive cranes 1	Yard switching 2	Mechanical shops 3	Water 4	Electric generators 5	Steam and boilers 6	Laboratory 7	Stores and supplies 8	General works 9	Total (all groups)
		Man-hours	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hour*	*Man-hours*
1927	2.0	0.826	0.164	0.065	0.048	0.050	0.096	0.005	0.019	0.001	0.097	0.052	0.011	0.153	1.587
1926	2.0	.908	.188	.074	.096	.053	.094	.007	.022	.001	.087	.048	.011	.157	1.746
1925	2.0	.899	.265	.077	.130	.072	.145	.009	.035	.003	.090	.042	.019	.168	1.954
1924	1.5	1.160	.240	.102	.141	.101	.162	.011	.062	.004	.111	.058	.025	.226	2.403
1923	2.0	.968	.283	.098	.160	.071	.204	.011	.040	.003	.104	.047	.025	.178	2.194
1922	1.3	1.573	.329	.113	.244	.206	.222	.008	.062	.004	.146	.048	.030	.196	3.181

EXPLANATION

Columns 1, 2, 3, 4, 5, 6, 7, 8, 9 do not show the full force in the plant performing these operations, but only the amount charged against the blast furnace in each year. This is a coke-plant furnace and the overhead is distributed between the two operations.

The ore bridge eliminates considerable locomotive crane and switching labor, but the cost of installing and operation is so great that only the larger plants use them. The dock labor in this plant corresponds to the ore-unloading labor in an inland plant, but there are differences as regards productivity which should be noted. The existence of the dock requires the operation of an ore bridge and thus forces the plant to a high productivity level in the subsequent handling of the ore, but as far as ore unloading itself is concerned a plant with dock facilities is probably under a handicap with reference to productivity. Unloading ore from a vessel is much more efficient in labor time than unloading from railroad cars by hand or with locomotive cranes. However, an inland plant using a car dumper in connection with an ore bridge would probably show a considerably higher productivity in ore handling than the lakeside plant with a dock, because the man-hours per ton on a car dumper would run lower than the man-hours per ton on the docks. Yet in one sense this is not a fair comparison, for the ore delivered at the inland plant (if it is ore shipped from Minnesota) has already been unloaded at the docks and then reloaded into cars, but with labor not charged to the blast furnace. Therefore, the unloading which does take place at an inland plant is the second one, and the first one is not counted in labor time.

It is difficult to compare blast furnaces operating under different conditions. For purposes of comparison it would be desirable to eliminate the ore unloading as a process in blast-furnace operation and treat it as a part of the delivery of the raw materials, beginning the blast-furnace operation with the stocking and charging. In actual practice this is not possible because the blast-furnace plants take charge of the ore when it is delivered in the yard or at the dock, and the labor of unloading is in most cases mixed up with all the other labor in the plant. As far as ore unloading is concerned blast-furnace plants can be divided into three groups: (1) Lakeside plants which have their ore delivered at a dock, (2) inland northern plants which have the ore delivered in cars from which it must be removed to the stock piles, and (3) southern plants which can have the ore delivered regularly throughout the year, and so can unload many of their cars directly into the charging bins of the furnace. Each of these groups of plants has its own problem of ore handling, and it is not easy to compare one group with any of the other groups. It is obvious that the southern plants have the decided advantage in that they have to handle the ore only once instead of twice.

ANALYSIS OF PRODUCTIVITY CHANGES IN INDIVIDUAL PLANTS

The influence of various factors in causing changes in productivity can best be brought out by the analysis of individual plant histories. Varieties and extremes of productivity changes in individual plants are completely hidden in the general averages for the districts and for the industry. The relation in the industry as a whole between output per man-hour and output per stack-day or reduction in labor time can best be understood through an examination of the relationship between these factors in individual cases.

The labor productivity record of each plant covered in this study is shown in Table A. In addition to productivity figures, the table furnishes data on production, full-time furnaces active, output per stack-day, consumption of raw materials, and plant equipment—in short, all available data explaining the trend in productivity for each plant. Thus the changes in productivity may be studied in relation to the more important factors influencing them.

Particular attention is called to the column showing the *average number of full-time furnaces active during the year*, which measures the regularity of operation. Regular operation is essential for good productivity, since a furnace can not maintain good performance when alternately blown in and blown out at frequent intervals. The steady flow of materials through the stacks and the best daily output depend upon regular operation, and proper labor economy is impossible without the routine of steady production. A plant having several furnaces is much more economically operated when all its furnaces are active.

In the case of materials consumption the individual plant schedules are much more important than the combined averages for an understanding of the changes in the industry. The relation between the output per stack-day and the increased use of scrap in the furnace burden, for example, can be studied much more easily from the history of an individual plant.

A very significant item in Table A is tne enumeration of important changes in plant equipment as shown in the last column. Only through case studies of individual plants can the effect of such detailed changes be analyzed.

In the table the productivity of all labor at the plant has been subdivided into two parts—productivity of the "furnace crew" and productivity of "all other" labor. This subdivision into "furnace crew" and "all other" has been made on as uniform a basis as possible, but minor labor groups are classified differently in various plants, and in some cases it has been necessary to make a somewhat arbitrary reclassification of the labor divisions furnished by the plant. The two labor groups used in this study, however, include substantially the same labor groups in all plants, and the minor inclusions and exclusions in most of them do not materially affect the comparisons.

PLANTS MAKING EXTREME INCREASES IN PRODUCTIVITY

Plant No. 12 (p. 77).

From 1911 to 1926 this plant made one of the best productivity records in the industry, reducing the man-hours of labor required to produce a ton of pig iron from 6.67 in 1911 to 1.89 in 1926. Even more striking is the fact that by far the greater part of the increase in productivity took place since 1919, for in that year it still required 5.82 man-hours of labor per ton of product. The output per man-hour in 1926 was slightly more than three times as much as it was in 1919.

The factors which were instrumental in causing this increase in productivity are clearly shown in the data. The sizes of the two stacks remained about the same throughout the period 1911 to 1919, the decline in output per stack-day during the war years being due primarily to the poor quality of the coke available for use at that time. The stacks were enlarged considerably in the rebuilding of 1919–20, so that the daily output in 1920 was about 25 per cent greater than in 1919. Since this rebuilding there have been no important changes in the size of the stacks, practically the entire increase in daily output since 1920 being the result of improved furnace operation. The general increase in efficiency of operation is evident from the data on coke consumption. The poor quality of the coke used during the war is shown by the high consumption per ton of product, 2,386 pounds per ton in 1917. The rebuilding of the stacks brought about a reduction to 1,973 pounds per ton in 1920, and in 1925 the low record of 1,808 pounds was reached. This low consumption of coke was accompanied by a steadily increasing daily production of pig iron. On the labor side there were two important changes—the installation of the pig machine in 1916–17, and the introduction of the universal 8-hour day in the beginning of 1924. The effect of the former on man-hours per stack-day is obscured by the increase in general labor which took place during the war. The exceptionally large increase in productivity from 1923 to 1924 can be attributed to the reorganization of the labor crews upon the introduction of the 8-hour day.

This plant is very efficiently operated; in 1926 it ranked third in productivity in the entire industry, and in 1924 and 1925 it ranked second.

Plant No. 59 (p. 97).

This southern one-furnace plant reduced its labor requirements per ton of iron from 14.69 hours in 1917 to 6.40 hours in 1924, an even more rapid rate of increase in productivity than that shown by Plant No. 12. However, it is noticeable that the productivity of Plant No. 59 at the time of its closing down in 1924 had just reached the point at which Plant No. 12 started out in 1911—that is, about 6½ hours of labor per ton. The stack was mechanically filled, but sand-cast, in the first period 1917 to 1920; there were no improvements of importance during that time, and the productivity varied directly with the output per stack-day. The extremely high rate of consumption of materials is evidence of the lean ores and poor quality of coke in use at this plant. In 1921 the stack was rebuilt and considerably enlarged, and a pig machine was installed at the same time. Practically the whole of 1922 was spent in getting the plant equipment to operate properly, so no results of the change are apparent. In 1923 however, the daily output of the stack rose to 182 tons and the labor force was greatly reduced by the pig machine, with the result that productivity was almost doubled as compared to the record of 1920. The improved operating efficiency of the new stack is evident in the data on coke consumption for 1922–1924.

Plant No. 17 (p. 79).

This plant shows the most striking increase in productivity in the whole industry. In 1918, as a hand-filled, sand-cast plant, it required 9⅔ man-hours of labor to produce a ton of pig iron. Many changes took place before the next record was available—a pig machine was installed at the end of 1918, one stack was abandoned in 1921, and the other was rebuilt in 1922. The first year of operation with the new stack (1923) shows a very poor efficiency record, but even so the output per man-hour was approximately 50 per cent higher than in 1918. In 1924 the stack was rebuilt again on much larger lines and at the same time a skip hoist was installed. The results in that year were rather indifferent, but in 1925 the full effect of the improvements is evident. Productivity was nearly three times greater than in 1923 and the output per stack-day rose to 432.3 tons. In the last two years there have been a further increase in stack-day output and a corresponding increase in productivity. For the first six months of 1927 it required only 2.06 man-hours of labor to produce a ton of pig iron, as contrasted with the 9.67 hours of 1918. The change in productivity is accompanied by a decline in the consumption of iron ore from 4,420 pounds per ton of product in 1923 to 3,821 pounds in 1927 and also by a corresponding decline in coke from 2,462 pounds to 1,859 pounds and in flux from 1,196 pounds to 874 pounds.

Plant No. 21 (p. 81).

The productivity record at this plant is particularly interesting because the plant was mechanically filled and machine cast from the beginning. Its performance in 1919–20 was poor all around. Productivity was at a low level, varying from 7.14 hours per ton in 1919 to 8.61 hours in 1920, and the high consumption of ore and coke is evidence of low operating efficiency. In 1921–22 the stack was rebuilt and practically doubled in size. The one-month operation in 1922 was too short to furnish any significant data, but in 1923 the full effects of the rebuilding became apparent. Stack-day output increased to 448 tons and productivity was practically doubled, from 0.116 ton per man-hour in 1920 to 0.224 ton in 1923.

In 1925 the stack was relined and its size slightly increased, but the tremendous increase in productivity since 1923 must be explained on other grounds. The explanation is to be found in the introduction of the 8-hour day. This led to the reorganization of the labor force and the reduction in men which caused the man-hours per ton to drop from 4.47 hours in 1923 to 2.19 hours in 1926. Between 1920 and 1926 productivity at this plant was increased four times, from 8.61 man-hours per ton to 2.19 hours.

Plant No. 50 (p. 93).

This plant furnishes another illustration of extremely rapid increase in productivity in a short time. It was mechanically filled and sand-cast during 1917 and 1918 when records first become available. The man-hours per ton varied from 7.13 in 1917 to 7.90 in 1918. In the following year the stack was increased in size by about one-third and by 1923 productivity had increased to almost double this amount. The pig machine installed at the end of 1923 showed its influence on labor time in 1924 when the man-hours per ton were reduced from 4.56 to 3.08 in one year. The best productivity record made by this plant was 2.47 hours per ton in 1925. The improved operating efficiency of the new stack is shown by the coke consumption which was reduced from 2,507 pounds per ton in 1918 to 2,101 pounds in 1923.

Plant No. 33 (p. 86).

The continuity of the record for this plant makes the data unusually important. This is a case where productivity remained practically stationary for 10 years, and then much more than doubled itself in 7 years. During the pre-war years 1911 to 1914 the man-hours per ton varied from 5.99 to 7.13; while in 1917 to 1920, with a slightly higher output per stack-day, the variation was from 5.01 to 7.41 hours. The latter figure, however, may be disregarded for it contains some relining-labor hours. Between 1920 and 1922 the output per stack-day was increased somewhat, but the important factor influencing productivity at this time was the cut in labor crews after the depression of 1921; the man-hours per ton dropped from 6.59 in 1920 to 3.81 in 1922. In 1923 the 8-hour day was introduced, in 1924 the stack was rebuilt and the pig machine installed, and in the following year the man-hours per ton fell to 2.69. The remarkable increase in productivity at this plant in the last 7 years is shown by the reduction in man-hours per ton from 6.59 in 1920 to 2.41 in 1927.

Plant No. 20 (p. 80).

This plant is quite unique in that it was hand filled and machine cast for many years. During the war years productivity was low, the labor requirements per ton of product being 6.14 hours in 1917 and 7.39 hours in 1918. The rebuilding of 1919 did not change the size of the stack but labor efficiency was increased, for the man-hours per ton fell to 5.47. In the next few years productivity steadily increased with only a slight increase in stack-day output. Then three important changes occurred at about the same time—the 8-hour day was introduced toward the end of 1923, the stack was relined and enlarged in 1924, and a skip hoist was installed while the stack was down for relining. The results became obvious in the following year when the output per stack-day increased to 418 tons and the output per man-hour rose from 0.207 ton to 0.345 ton. There was a noticeable decline in general operating efficiency in 1926, but a complete recovery took place in the first half of 1927 when productivity reached the high point—0.393 ton per man-hour or 2.55 man-hours per ton. The low coke consumption shown in the data for 1925 and 1927 gives evidence of high smelting efficiency during those years.

Plant No. 34 (p. 86).

In the pre-war years 1911 to 1914 plant No. 34 had a fairly good productivity record for a hand-filled, sand-cast plant. The figures for 1912 and 1914 must be discounted for the relining labor hours are included in the totals; the man-hours per ton in 1911 were 7.66 and in 1913, 8.21. During the war productivity declined to very low levels, reaching 11.02 hours per ton in 1918. The pig machine installed in 1919 began to show results in productivity in the following year. While the stack was being rebuilt in 1921 a new trestle and bins were added. Two years later a skip hoist was installed on this stack, and a new stack of much larger size was put in operation. In 1925 the old stack was abandoned. These improvements led to the establishment of a high-productivity record in 1923 of 5 man-hours per ton. Two years later the output per stack-day had more than doubled but productivity had not increased in proportion, which means that the economies of two-furnace operation aided in establishing the record of 1923. In 1926 the man-hours per ton were reduced to 2.98.

Plant No. 54 (p. 95).

This small Pennsylvania blast furnace, hand filled and sand cast, required 14.65 man-hours of labor to produce a ton of pig iron in 1911. Since that year its increase in productivity has been both steady and rapid. The stack was slightly enlarged in the rebuilding of 1915, which accounts for the improved productivity in 1918. A later relining made a further slight increase in the size of the stack, but the steady increase in productivity in this plant must be attributed largely to the reduction in the number of men required to operate the furnace. Mechanical filling, installed in 1921, reduced the labor time per ton from 9.71 hours in 1920 to 7.21 hours in 1922. The data for 1921 are for such a short time of operation that the figures may be disregarded. The pig machine does not appear to have had much effect on the productivity in 1923, but this is because the saving of labor in this direction is obscured by increases in other labor groups. In 1926 this plant required 5.81 man-hours of labor to produce a ton of pig iron.

Plant No. 3 (p. 72).

This plant made an exceptionally good productivity record throughout the period 1911–1927. It has always had some of the largest stacks in the merchant-furnace industry and has always ranked near the top in output per man-hour and output per stack-day. Productivity increased from an output of 0.18 ton per man-hour in 1911 to 0.63 ton in the first six months of 1927, which is equivalent to a reduction in labor time from 5.48 man-hours per ton to 1.59 man-hours per ton. A new and larger stack was built in 1919 and another one was added in 1925, but this alone is not responsible for the increased output per stack-day. The steady improvement in productivity is accompanied by the declining consumption of ore, coke, and flux, and the increase in the use of scrap accounts for part of the increase in stack-day output. The productivity data for 1919 must be discounted because in that particular year the rebuilding labor is included in the total man-hours.

PLANTS SHOWING MODERATE INCREASES IN PRODUCTIVITY

Plant No. 53 (p. 94).

The productivity record for this plant is of special interest because it took place entirely through changes in labor time. There were no data available on output per stack-day in years prior to 1919, but from that year down to 1924 there was no upward trend in daily output, the figures actually declining from 207.9 tons in 1919 to 204.2 tons in 1924. Yet during this same interval the man-hours per ton decreased from 8.08 to 4.63. Probably the larger part of the labor-saving was due to the installation of the skip hoist in 1921, which resulted in a reduction in labor time from 8.46 hours per ton to 6.29 hours.

Plant No. 31 (p. 85).

The changes in labor productivity in this plant have been almost wholly determined by three factors—(1) the alternation between one and two furnace operation, (2) changes in output per stack-day, and (3) the installation of a pig machine in 1924. The productivity record is interesting because of the wide fluctuations from year to year. Much the larger part of the increase in productivity has occurred in the last three years. The pig machine undoubtedly is responsible for this, although a slightly increased output per stack-day accompanied by decreased consumption of ore and coke gives evidence of improved efficiency in operation.

Plant No. 23 (p. 82).

The stack at this plant was completely rebuilt in 1923. It is a very efficient plant with reference to both productivity and operating practice. The output per man-hour increased from 0.329 ton in 1923 to 0.526 ton in 1926, largely as a result of an increase in output per stack-day from 253.4 tons to 376.8 tons. The unusual feature of the increased daily output is that it has come about through the use of scrap and improved operating efficiency and not through any enlargement of the stack. The data on consumption of materials bring out the striking decline in ore, coke, and flux and the great increase in scrap.

Plant No. 52 (p. 94).

For the period 1911 to 1916, inclusive, this plant showed little change in productivity, the output per man-hour varying between 0.085 and 0.095 ton. The rebuilding of 1917 enlarged the stack slightly, and the productivity increased correspondingly in the following four years. Mechanical filling was installed in 1921–22 with the result that man-hours per ton decreased from 9.89 hours in 1920 to 6.22 hours in 1923. The productivity in recent years has been somewhat lower, partly due to a lower output per stack-day.

Plant No. 46 (p. 91).

This is another plant in which the output per stack-day has had no important part in the increased productivity. Although the daily output has fluctuated quite widely over the period there has been no upward trend, the output in 1911 being 281 tons and in 1926, 270 tons. The one important labor-saving device installed was the pig machine, but the results of this are not apparent in any one year. However, this machine undoubtedly had considerable influence in reducing the man-hours per ton from the previous best record of 7.47 hours in 1911 to the high record of 4.82 in 1924. It is noticeable that this plant nearly always made its best record in years of partial operation. This was due to the practice of running for only a few months with skeleton crews and then doing a good deal of the auxiliary iron and materials handling after the stack was shut down

PLANTS SHOWING CONSTANT OR DECLINING PRODUCTIVITY

Plant No. 30 (p. 84).

Productivity at this plant increased slightly from 1914 to 1926 but not enough to show any distinct upward trend. As a matter of fact the output per man-hour did not increase so much as did the output per stack-day, which rose from 297 tons in 1914 to 354.6 tons in 1926. The effect of the pig machine is seen in the data for 1927, when the best productivity record was made. The influence of this machine on productivity would probably show to much better advantage were data for the whole year 1927 available. The decline in operating efficiency during the war is shown by the rise in consumption of coke, and the improvements in recent years are marked by the steady fall in pounds of coke consumed per ton. Some facts to be noted in explaining the stack-day output of recent years are the fall in consumption of ore, increased use of scrap, and complete elimination of flux.

Plant No. 14 (p. 77).

The decline in productivity shown at this plant from 5.48 hours per ton in 1911 to 7 hours per ton in 1926 is only apparent for the latter was not a year of typical operation. Barring the 1912 data, which show unaccountably low productivity, the average for the pre-war period would be 5.47 hours per ton while the best recent record was that in 1924—4.57 hours per ton. This can not be called a very marked improvement but at least it does not show a decline in productivity. Data for 1918 and 1921 must be discounted because the relining-labor hours are included in the totals. It is clear that the increase in productivity has been largely due to the installation of the pig machine in the beginning of 1917, for this immediately caused a reduction in labor time from 5.46 hours per ton to 4.8 hours. The higher output per stack-day in the following years does not appear to have had much influence on productivity for productivity has never since reached the high mark set in 1917.

Plant No. 32 (p. 85).

This was a modern plant in the beginning, which fact partially accounts for the very small increase in productivity over the period covered. The output per stack-day declined from 356.6 tons in 1917 to 323.1 tons in 1924. From 1917 to 1922 productivity fluctuated closely in accordance with output per stack-day, but in the last two years of operation daily output declined while productivity increased. This was due almost entirely to the introduction in September, 1923, of the 8-hour day in place of the old 10-hour and 12-hour systems. The full effect of the change is shown by comparing the data for 1922 and 1924; labor time was reduced from 3.27 hours per ton to 2.66 hours.

Plant No. 73 (p. 101).

This is a case of a sharp decline in productivity followed by a complete recovery of the lost ground though with very little net advance for the period. The year 1911 was one of full operation and good output and the daily average production of 98 tons was the highest with one exception up to 1923. Also man-hours per ton in 1911, 9.39, represent the highest record of productivity prior to 1923. In recent years, 1925 to 1927, the output per stack-day was increased steadily and the man-hours per ton declined in proportion. The year 1923 is the only exceptional one in the whole period; for some reason the labor crews were very short that year and productivity reached a level which has not been attained since.

CHAPTER 5.—GENERAL CONCLUSIONS

This bulletin is devoted to the measurement and analysis of productivity changes from 1911 to 1927 in merchant blast-furnace plants. It is impossible, however, to fully understand the productivity changes in those plants unless such changes are considered in relation to the development of the entire pig-iron industry. The annual production of pig iron has greatly increased during the period studied, but the total output of strictly merchant plants has not materially changed. In other words, the "steel works" branch of the industry has been rapidly expanding and the proportion of the total pig iron manufactured in merchant plants has steadily declined. It may be helpful, therefore, to review briefly the historical and the present relation of merchant furnaces to the industry as a whole in so far as it concerns productivity.

At one time all pig iron was produced in merchant furnaces which were generally located near ore banks, coal seams, or limestone beds. In a few exceptional cases forges or puddling and rolling mills were operated in connection with blast furnaces during the years before the Bessemer process caused a revolution in the entire iron and steel industry. Such early integration as existed was not important from a productivity point of view, however, as the "continuous process" of using blast furnace metal for further manufacture while still in molten condition was impossible with the earlier technique. Before the expansion of the steel industry pig iron was generally produced by individual smelters in isolated plants where the output was sold for further manufacture.

The transition from the old decentralized condition of the industry to the present large scale integrated operation has been both steady and rapid. The number of stacks has been cut in half since 1860 while their total capacity has increased tenfold. To an increasing extent production has been concentrated in greater batteries of furnaces in steel plants and the number of merchant producers has steadily declined.

Throughout the history of pig-iron manufacture since the early stacks the essential principles of smelting have remained unchanged. Modifications have been made in the rapidity and flexibility of material handling, the character of auxiliary equipment, and the size of the producing unit rather than with the fundamentals of smelting. Thus it remains practical, where the data are available, to compare conditions under which a ton of pig iron was produced in the early blast furnaces with those in later periods.

The progress which has been made in the blast-furnace industry since 1880 is divided into two distinct stages:

1. The drive to increase tonnage at any cost to meet the mounting requirements of the steel industry. This drive has been reflected in the practice of merchant producers as well as of steel works producers.

2. The effort to reduce costs per ton of iron which has followed the attainment of large tonnages and the tapering off of rate of growth in iron and steel production. This effort to reduce costs has been particularly noticeable since the depression of 1921.

During the first stage iron makers enlarged their stacks and resorted to hard driving by means of a greater volume of blast heated to higher temperatures in order to increase production. With this increase in output, crews were inflated in plants without labor-saving machinery to aid in caring for the increased product and greater volume of raw materials.

During recent years the primary emphasis in making pig iron has been shifted from increase in production to the reduction of costs. Since the war pig-iron prices have been steadily declining and rigid economies in furnace operation have taken place. The high wage rates in many plants forced the development of mechanical methods of charging and casting in order that the number of men required per furnace might be reduced. Of course furnace men have gone ahead enlarging stacks and driving more rapidly, making it possible for fewer and fewer furnaces to turn out the total output of iron. This concentration of production has brought lower costs and has been accompanied by a keen competition among merchant producers, intensified by the increasing supply of iron coming from integrated "steel works" furnaces. This has helped to bring about the recent improvements in productivity but decreasing profits have brought renewed pressure for still lower costs and further improvement is to be expected.

It is worth noting at this point that a blast furnace is not merely a smelter of iron ores in the manufacture of pig iron; it is a gas producer and a slag producer as well. Both gas and slag were formerly wasted at all plants. Slag may now be sold for road ballast, cement manufacture, and other uses, while blast-furnace gas is caught, washed, and used in furnishing power not only for the operation of blowing engines and other auxiliary equipment for the blast-furnace department but also for steel mills and industrial concerns. Not ordinarily rich enough to be used as fuel without further treatment, surplus blast-furnace gas is commonly wasted by nonintegrated merchant plants although it is possible to mix it with coke-oven gas to obtain a satisfactory fuel. An increasing number of merchant producers of pig iron now operate by-product coke plants as an essential part of their plant layout, furnishing gas for local, industrial, or municipal purposes. This integration between coking and smelting creates several "joint products"—pig iron, slag, tar, benzol, toluol, etc. In extreme cases it is often difficult to determine whether pig iron is a primary product or a by-product. However, it may be stated that the blast-furnace industry has attained a higher level of productivity by utilizing its by-products and developing joint products than in the days when the sale of pig iron was the only possible source of income to iron makers.

The use of scrap in the blast furnace, a recent development since the war, has increased output per day and the yield of iron per ton of metal bearing materials in the furnace burden. This is a very important development which has influenced recent progress in daily output very materially. Some conservative makers catering to a discriminating foundry trade willing to pay high prices for good product may not use scrap. The average merchant maker, however, finds it advantageous to charge as much of it as good furnace practice and the current price situation will permit.

Merchant blast-furnace plants which have continued to operate in competition with "steel works" furnaces may be classified as follows:[1]

1. Old plants that can no longer be operated at a profit but the dismantling or abandoning of which would result in almost a complete loss of capital. Thus they are operated as long as they will run without repair, in order to liquidate as much of the investment as possible. Of course, these plants will gradually drop out of the industry from time to time as their equipment becomes unusable.

2. Plants which have been included as merchant furnaces in this study but are actually owned and operated by steel companies consuming pig iron in further manufacture.

3. Integrated merchant plants operated in conjunction with coke plants which sell by-products, and coke-oven gas for local, industrial, or municipal purposes.

4. Isolated nonintegrated plants protected by geographical location or grade of product from severe competition by other producers; for example, plants producing special grades of iron such as high-phosphorus iron or those located near a particular market at great distance from other producers.

The migration of merchant-iron makers westward and the decline of old producing districts in the East or South (outside the Birmingham district) have been described in an earlier chapter. Inability of old districts to survive has meant hardship not only for stockholders and owners, but whole communities have sometimes virtually disappeared. In such localities the workers have had no alternative other than migration not merely to new communities but to new industries, since progress in productivity among the remaining plants has meant that fewer stacks and fewer workmen can without difficulty turn out the product formerly made by the industry with the larger number of furnaces. The effect of increased productivity on employment in pig-iron manufacturing has taken this form, primarily causing permanent shut-downs and displacement of entire furnace crews rather than the laying-off of men for a short time by an operating plant.

The trend in the industry is toward concentration of employment in large plants controlled by fewer and fewer employers and the centralized control of the production of merchant iron in integrated steel-works plants and a limited number of semiintegrated or otherwise advantageously situated merchant plants. This centralization means greater stability of employment and higher productivity in the industry as a whole.

Increasing production of merchant iron by steel-works stacks and the diminishing number of merchant furnaces does not at all imply the disappearance of the merchant producer. It does mean, however, that the independently operated merchant plants are coming to be dependent upon some kind of integrated operation. This integration has led to steadier employment in better equipped and more highly productive plants located in the large industrial centers. Standardization of pig-iron specifications would also aid the merchant makers in maintaining regular production.

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[1] Former merchant plants, now acquired by adjacent steel mills, have maintained continuous existence but to-day are no longer a part of the merchant pig-iron industry.

APPENDIXES

APPENDIX 1.—GENERAL TABLES

LABOR PRODUCTIVITY, OUTPUT PER STACK-DAY, CONSUMPTION OF MATERIALS CHARGED, AND CHANGES IN EQUIPMENT, IN MERCHANT BLAST FURNACES, BY PLANTS AND YEARS, 1911 TO 1927

Table A contains all plants covered by the bureau in this study. The years are shown in reverse order, that is, 1927 to 1911 as the later years are of more importance. Data for 1927 cover the first 6 months only. The average full-time furnaces active have been computed on that basis. Only those plants visited after July 1, 1927, have furnished data for that year. In practically all cases the description of equipment applies to one stack in a plant in any one year. However, in a few plants having more than one stack the change in equipment, particularly the pig machine, applies to all stacks.

When figures do not appear in the table for any year from 1911 up to the last year for which data are shown, it is because data were not obtainable or the plant was not in operation. In the case of a few new plants entering the industry after 1911 the figures for the first year shown cover their first year of operation. Footnotes show the plants which have been idle since the last year for which data are reported.

The first column of the table shows in round-number classification the output of pig iron of the plant in each year; exact data are not given because this might lead to identification of the plant, but the production groups are small enough to give a close approximation of the actual figures. The next column shows the average number of full-time stacks which were active throughout the year. If a stack ran 365 days a year it will be listed as 1 full-time furnace, while if 1 stack in a 2-stack plant ran 300 days and the other 150 days, the total for the plant would be 450 days divided by 365 or 1.2 full-time furnaces. The data in this column are independent of the number of stacks in the plant, thus 1 full-time furnace may mean that one stack ran all year or that two stacks operated part of a year each, or even that three or four stacks were in operation in the course of the year but that their total stack-days approximated only 365.

The next three columns show the output per man-hour and the three succeeding columns the man-hours per ton of output. The output per man-hour is obtained by dividing the total annual production of pig iron in gross tons by the total annual man-hours of labor; the man-hours per ton of product are obtained by doing just the reverse—dividing the total annual man-hours of labor by the total annual production of pig iron. The former shows what fraction of a ton of pig iron can be produced by one man-hour of labor, while the latter shows the number of man-hours of labor required to produce a ton of pig iron in this particular plant. For purposes of these computations the total man-hours of labor have been divided into two parts—the hours worked by the furnace crew proper and the hours worked by all men outside the furnace crew. The furnace crew has been defined for these purposes to include all labor directly concerned with the operation of the stack itself, beginning with the charging labor and ending with the casting labor. In the case of a modern skip-filled machine-cast plant, the furnace crew would begin with larrymen and skipmen and possibly a few laborers in the stock house, and would include all men in the cast-house such as foremen, keepers, keepers' helpers, stove tenders, water tenders, blowers, mechanical men permanently attached to the furnace, etc. The blowing engineers and oilers, the boiler-house labor, and the pump-house crew, while directly auxiliary to the operation of the stack, are excluded from the furnace crew proper, not so much for logical reasons but in a great majority of the plants in the industry these groups could not be separated from the general or miscellaneous labor. The pig-machine labor has been included as part of the furnace crew. In some plants it was not possible to make any segregation of the total labor into furnace crew and "all other" labor.

In the hand-filled sand-cast plants the same line of division has been followed, although sometimes the dividing line has been a little more difficult to draw. On the charging side, it is necessary to include in the furnace crew all bottom fillers and their helpers, but to exclude all transportation or delivery of material from stock piles to bins. On the casting side, the furnace crew would include the sand cutters, the pig breakers, and the iron carriers who load the iron into cars for delivery to the yard. In some cases it has been rather difficult to maintain the proper dividing line and the furnace-crew hours represent only a fair approximation.

The next column shows the average output of pig iron per stack-day of operation, and is obtained by dividing the total annual production by the total number of days the stack was in blast during the year. This figure should be used in connection with the productivity figure.

The following four columns show the consumption of materials in the plant, expressed in terms of pounds per ton of pig iron produced. The figures are obtained by reducing the annual consumption of ore, scrap, coke, and limestone or dolomite to pounds, and then dividing the total by the number of tons of pig iron produced. For purposes of the table, ore is defined to include all flue dust that is purchased as well as the ore itself; scrap includes not only pure iron or steel scrap, but also cinder, scale, borings, turnings, pyrites, and all other such material rich in iron; coke includes coal, if any such is used, but the amount of coal used in the industry is negligible; flux includes all material used for fluxing the ore, but it consists ordinarily of limestone, with occasionally the addition of some dolomite or phosphorous rock.

The next column shows the per cent of pig iron output which was machine cast. In most cases, once the pig machine was introduced, this becomes 100 per cent, though there are some important exceptions. The iron which is not machine cast may be either sandcast or run as hot metal to a foundry or open hearth. This last situation is exceptional, and exists in only two or three plants; as a general rule, it may be assumed that the metal which is not machine cast is sand-cast.

The last column shows technical improvements which have taken place during the period. This is designed to cover all the more important changes which may have affected productivity. It includes the installation of skip hoists, pig machines, the building of a new stack or the relining of an old one, the abandonment of stack, etc.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*

PLANT NO. 1

Year	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	Gross tons per man-hour: All other labor	Gross tons per man-hour: Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	Man-hours per gross ton: All other labor	Man-hours per gross ton: Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1926	450–475	2.0	0.838	1.222	0.497	1.193	0.818	2.012	617.0	4,377	132	2,070	862	100	
1925	525–550	2.5	.742	1.083	.440	1.347	.923	2.271	578.7	4,377	159	2,031	824	100	
1924	275–300	1.4	.781	1.140	.464	1.280	.877	2.157	531.9	4,278	228	2,141	876	100	Remodeled; relined.
1923	500–525	2.7	.872	.981	.462	1.147	1.019	2.166	508.3	4,222	177	1,958	889	100	
1922	400–425	2.0	.835	.940	.442	1.197	1.064	2.262	557.3	4,211	134	1,882	838	100	
1921	200–225	1.0	.809	.910	.428	1.236	1.099	2.334	574.4	4,153	125	1,942	962	100	Abandoned.
1920	475–500	2.9	.843	.948	.446	1.186	1.054	2.241	464.7	5,083	73	1,934	1,159	100	Relined in 1919.
1914	225–250	1.8	(1)	(1)	.243	(1)	(1)	4.115	333.4	(2)	(2)	(2)	(2)	100	Mechancially filled; pig machine.

PLANT NO. 2

Year	Production in thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	Gross tons per man-hour: All other labor	Gross tons per man-hour: Total labor	Man-hours per gross ton: Furnace crew labor	Man-hours per gross ton: All other labor	Man-hours per gross ton: Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1926	275–300	2.3	1.152	0.524	0.360	0.868	1.909	2.777	345.6	4,202	165	2,315	(2)	86	
1924	350–375	3.0	.663	.433	.262	1.509	2.312	3.821	326.0	4,460	120	2,434	(2)	62	
1923	425–450	3.7	.579	.421	.244	1.726	2.376	4.102	330.8	4,162	233	2,415		39	Pig machine.
1921	100–125	1.0	.295	.202	.120	3.388	4.947	8.335	284.8	4,769	(2)	2,905	(2)		
1920	325–350	3.5	.410	.286	.168	2.439	3.502	5.941	265.6	4,861	(2)	3,071	(2)		
1919	300–325	3.0	.530	.347	.210	1.887	2.880	4.767	291.7	4,791	(2)	2,751	(2)		
1918	425–450	4.0	.492	.301	.187	2.033	3.322	5.355	295.2	4,823	(2)	2,794	(2)		
1914	400–425	3.7	.552	(1)	(1)	1.917	(1)	(1)	302.9	4,652	(2)	2,869	(2)		Mechanically filled; sand cast.

1 Detail not available.
2 Not reported.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 3

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	Average labor productivity: Gross tons of pig iron produced per man-hour: All other labor	Average labor productivity: Gross tons of pig iron produced per man-hour: Total labor	Average labor productivity: Man-hours per gross ton of pig iron produced: Furnace crew labor	Average labor productivity: Man-hours per gross ton of pig iron produced: All other labor	Average labor productivity: Man-hours per gross ton of pig iron produced: Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Consumption of materials per gross ton of pig iron produced: Scrap	Consumption of materials per gross ton of pig iron produced: Coke	Consumption of materials per gross ton of pig iron produced: Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1927 [3]	225-250	2.0	1.060	1.552	0.630	0.943	0.644	1.587	657.9	(2)	(2)	(2)	(2)	100	
1926	450-475	2.0	.969	1.400	.573	1.032	.714	1.746	648.7	3,821	437	1,792	741	100	
1925	425-450	2.0	.890	1.205	.512	1.125	.830	1.954	596.7	4,072	249	1,872	862	100	New furnace built.
1924	275-300	1.5	.714	.997	.416	1.400	1.003	2.403	524.1	3,774	403	1,902	744	100	
1923	325-350	2.0	.889	1.060	.456	1.251	.943	2.194	477.5	3,804	363	2,100	896	100	
1922	225-250	1.3	.526	.782	.314	1.902	1.279	3.181	509.3	3,954	376	2,068	921	100	
1921	175-200	1.0	(1)	(1)	.340	(1)	(1)	2.943	525.5	4,518	63	2,148	941	100	
1920	325-350	1.9	(1)	(1)	.315	(1)	(1)	3.173	476.7	4,514	9	2,206	1,077	100	
1919	175-200	1.4	(1)	(1)	.197	(1)	(1)	5.070	399.8	4,610	28	2,220	965	100	Do.
1918	275-300	2.0	(1)	(1)	.264	(1)	(1)	3.784	397.4	4,679	9	2,216	970	100	
1917	275-300	2.0	(1)	(1)	.282	(1)	(1)	3.551	408.1	4,702	13	2,158	871	100	
1914	150-175	1.2	(1)	(1)	.172	(1)	(1)	5.819	477.8	4,554	73	2,422	1,156	100	
1913	250-275	1.9	(1)	(1)	.196	(1)	(1)	5.099	353.9	4,675	4	2,428	1,203	100	
1912	200-225	1.5	(1)	(1)	.220	(1)	(1)	4,549	397.7	4,536	--------	2,230	1,102	100	
1911	150-175	1.0	(1)	(1)	.182	(1)	(1)	5.483	417.5	4,437	43	2,388	1,194	100	Mechanically filled; pig machine.

PLANT NO. 4

1927 [3]	100–125	1.0	(1)	(1)	0.572	(1)	(1)	1.749	564.0	(2)	(2)	(2)	(2)	(2)	
1926	275–300	1.5	1.731	0.599	.445	0.578	1.669	2.246	527.3	4,140	(2)	2,004	(2)	[4] 32	
1925	275–300	1.3	1.868	.639	.476	.535	1.565	2.100	617.8	4,019	(2)	1,986	(2)	[4] 27	
1924	250–275	1.3	1.907	.510	.402	.524	1.962	2.486	549.2	4,028	(2)	2,112	(2)	[4] 26	
1923	300–325	1.7	1.795	.532	.411	.557	1.877	2.434	517.7	4,075	(2)	2,072	(2)	[4] 33	Abandoned.
1922	175–200	1.2	(1)	(1)	.243	(1)	(1)	4.108	416.0	4,072	(2)	2,068	(2)	[4] 11	Rebuilt.
1921	25– 50	0.4	(1)	(1)	.214	(1)	(1)	4.630	351.2	4,128	(2)	2,108	(2)	[4] 8	
1920	300–325	2.1	(1)	(1)	.189	(1)	(1)	5.278	389.3	4,198	(2)	2,084	(2)	[4] 35	
1919	225–250	1.8	(1)	(1)	.237	(1)	(1)	4.216	373.0	4,108	(2)	2,034	(2)	[4] 44	Relined.
1917	400–425	2.9	(1)	(1)	.326	(1)	(1)	3.071	376.8	3,972	(2)	2,022	(2)	[4] 25	Rebuilt in 1916.
1914	175–200	1.9	(1)	(1)	.217	(1)	(1)	4.612	283.9	4,476	(2)	2,332	(2)	[5] 34	Rebuilt.
1912	225–250	2.6	(1)	(1)	.222	(1)	(1)	4.503	251.0	4,196	(2)	2,366	(2)	[5] 27	Mechanically filled; pig machine.

PLANT NO. 5

1927 [3]	125–150	1.6	1.213	0.366	0.281	0.824	2.736	3.560	498.9	3,576	484	1,613	806	100	
1926	350–375	1.9	1.252	.377	.290	.799	2.651	3.450	506.2	3,470	475	1,663	777	100	
1925	325–350	2.0	1.026	.414	.295	.975	2.416	3.390	457.7	3,683	363	1,803	831	100	
1924	150–175	1.0	.890	.284	.215	1.124	3.517	4.641	451.3	3,555	517	1,773	750	100	Relined.
1923	300–325	2.0	(1)	(1)	.318	(1)	(1)	3.141	444.6	3,667	437	1,848	784	100	
1922	200–225	1.2	(1)	(1)	.235	(1)	(1)	4.248	450.0	3,900	352	1,870	961	100	
1921	50– 75	.5	(1)	(1)	.181	(1)	(1)	5.512	395.4	4,424	16	2,178	1,203	100	Rebuilt.
1919	175–200	1.4	(1)	(1)	.137	(1)	(1)	7.276	362.2	4,621	(2)	2,280	1,107	100	Rebuilt; relined in 1915.
1913	175–200	1.5	(1)	(1)	.161	(1)	(1)	6.226	320.8	4,411	(2)	(2)	(2)	100	
1912	125–150	1.1	(1)	(1)	.148	(1)	(1)	6.742	351.7	4,639	(2)	(2)	(2)	100	Relined.
1911	150–175	1.3	(1)	(1)	.158	(1)	(1)	6.330	341.8	4,491	(2)	(2)	(2)	100	Mechanically filled; pig machine.

[1] Detail not available. [2] Not reported. [3] First 6 months only.
[4] Production not shown as machine cast, used molten. [5] Production not shown as machine cast, is partly used molten or sand cast.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 6

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1927 [3]	125–150	2.0	1.216	0.610	0.406	0.822	1.640	2.463	408.5	(2)	(2)	(2)	(2)	100	
1926	225–250	1.8	1.006	.393	.283	.994	2.543	3.536	359.1	3,943	23	1,952	860	100	Relined.
1925	275–300	2.2	.924	.475	.314	1.082	2.104	3.187	341.7	4,086	29	2,071	896	100	Do.
1924	225–250	2.0	(1)	(1)	.251	(1)	(1)	3.982	317.2	4,368	76	2,268	1,051	100	
1923	300–325	2.5	(1)	(1)	.248	(1)	(1)	4.033	325.4	4,325	58	2,244	1,004	100	
1922	150–175	1.4	(1)	(1)	.241	(1)	(1)	4.155	322.5	4,173	44	2,234	1,039	100	
1921	100–125	1.0	(1)	(1)	.143	(1)	(1)	7.002	312.6	4,267	36	2,181	1,021	100	Do.
1920 [6]	300–325	2.6	.597	.288	.194	1.675	3.472	5.147	319.8	4,341	30	2,367	1,089	100	
1919 [6]	250–275	2.5	.556	.218	.157	1.799	4.579	6.379	279.6	4,359	101	2,499	1,077	100	Do.
1918 [6]	250–275	2.8	.444	.209	.142	2.251	4.773	7.023	253.4	4,384	26	2,619	1,100	100	
1917 [6]	200–225	2.3	.469	.204	.142	2.134	4.905	7.039	261.6	4,274	29	2,393	1,039	100	Relined pig machine.
1916 [7]	75–100	2.9	.529	.255	.172	1.891	3.927	5.818	285.2	4,097	11	(2)	934		
1915	275–300	2.9	.549	.271	.181	1.822	3.693	5.514	285.2	(2)	(2)	2,140	(2)		
1914	200–225	2.0	.498	.201	.143	2.009	4.985	6.994	286.8	4,191	8	2,120	862		Rebuilt.
1913	225–250	2.5	.436	.239	.154	2.291	4.192	6.484	270.2	4,213	47	2,243	1,024		Mechanically filled; sand cast.

PLANT NO. 7

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1927 [3]	125–150	2.0	0.848	0.515	0.321	1.179	1.940	3.119	410.0	(2)	(2)	(2)	(2)	100	
1926	250–275	1.9	.816	.424	.279	1.226	2.358	3.584	392.8	3,618	372	2,042	993	100	
1925	250–275	2.0	(1)	(1)	.270	(1)	(1)	3.703	363.1	3,774	237	2,146	1,111	100	Relined.
1924	250–275	1.9	(1)	(1)	.250	(1)	(1)	3.999	375.5	3,718	262	2,088	999	100	
1923	225–250	1.8	(1)	(1)	.231	(1)	(1)	4.322	346.8	4,234	45	2,209	1,030	100	Do.
1922	150–175	1.2	.736	.308	.217	1.359	3.249	4.607	350.3	4,231	103	2,148	1,030	100	

1921	Under 25	.2	(1)	(1)	.155	(1)	(1)	6.444	375.5	4,390	22	2,050	1,131	100	
1920	200–225	1.8	(1)	(1)	.151	(1)	(1)	6.633	317.0	4,451	22	2,407	1,239	100	
1919	175–200	1.6	(1)	(1)	.128	(1)	(1)	7.793	304.3	(2)	(2)	(2)	(2)	100	Do.
1918	200–225	2.0	(1)	(1)	.153	(1)	(1)	6.554	297.9	(2)	(2)	(2)	(2)	100	
1917	225–250	2.0	.616	.227	.166	1.624	4.405	6.029	314.0	(2)	(2)	(2)	(2)	100	Rebuilt in 1914.
1913	175–200	1.7	.523	.326	.201	1.914	3.067	4.981	291.5	(2)	(2)	(2)	(2)	100	
1912	175–200	1.8	.544	.332	.206	1.837	3.016	4.853	289.5	(2)	(2)	(2)	(2)	100	
1911	125–150	1.2	.440	.267	.166	2.272	3.750	6.023	318.5	(2)	(2)	(2)	(2)	100	Mechanically filled; pig machine; rebuilt.

[6] Fiscal year May 1 to Apr. 30.

[7] Jan. 1 to Apr. 30 only.

PLANT NO. 8

1926	100–125	0.7	0.520	1.223	0.365	1.921	0.818	2.739	441.1	3,750	482	2,239	(2)	100	
1925	50–75	.4	.522	1.227	.366	1.915	.815	2.731	453.5	3,837	197	2,297	(2)	100	
1924	75–100	.4	.375	1.135	.263	2.669	.881	3.804	566.3	4,090	104	2,290	(2)	100	
1923	150–175	1.1	(1)	(1)	.294	(1)	(1)	3.407	382.0	4,137	28	2,301	(2)	100	Mechanically filled; pig machine; relined in 1918 and 1922.
1914	100–125	1.0	(1)	(1)	.170	(1)	(1)	5.886	314.3	(2)	(2)	(2)	(2)		
1913	200–225	2.0	(1)	(1)	.162	(1)	(1)	6.171	288.2	(2)	(2)	(2)	(2)		Sand cast; method of charging not reported.

PLANT NO. 9

1927 [3]	75–100	1.1	0.988	0.790	0.439	1.012	1.265	2.277	404.7	4,041	255	2,024	632	100	
1926	175–200	1.3	.910	.785	.421	1.099	1.274	2.375	380.9	4,316	278	2,218	632	100	
1925	150–175	1.0	.984	.800	.441	1.016	1.250	2.266	431.7	4,171	251	1,938	515	100	
1924	125–150	1.0	.930	.762	.419	1.075	1.312	2.388	430.0	4,458	405	2,079	544	100	Rebuilt in 1923.
1922	125–150	1.0	.784	.642	.353	1.276	1.557	2.833	378.1	4,122	115	1,895	737	100	
1920	250–275	2.0	.883	.724	.398	1.132	1.381	2.513	350.1	4,081	48	2,006	806	100	
1919	175–200	1.7	.728	.597	.328	1.373	1.676	3.049	308.0	(2)	(2)	(2)	(2)	100	Rebuilt.
1918	175–200	1.9	.629	.515	.283	1.590	1.941	3.531	286.0	(2)	(2)	(2)	(2)	100	Mechanically filled; pig machine; rebuilt.

[1] Detail not available.

[2] Not reported.

[3] First 6 months only.

PLANT NO. 10[8]

Table A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour			Average labor productivity: Man-hours per gross ton of pig iron produced			Average output per stack-day	Consumption of materials per gross ton of pig iron produced				Per cent of production machine cast	Changes in stack, and charging and casting equipment
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Iron ore	Scrap	Coke	Flux		
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1918	225–250	1.8	(1)	(1)	0.112	(1)	(1)	8.920	345.5	3,459	190	2,214	930	100	Rebuilt.
1914 [9]	125–150	1.3	(1)	(1)	.117	(1)	(1)	8.523	287.6	4,500	42	2,732	1,347	100	
1913 [9]	175–200	1.7	(1)	(1)	.120	(1)	(1)	8.303	316.2	4,303	106	2,512	1,130	100	
1912 [9]	100–125	1.0	(1)	(1)	.087	(1)	(1)	11.434	312.8	4,211	166	2,514	1,223	100	
1911 [9]	125–150	1.0	(1)	(1)	.119	(1)	(1)	8.382	374.2	4,288	90	2,748	1,318	100	Mechanically filled; pig machine.

PLANT NO. 11

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1924	Under 25	0.3	0.295	0.267	0.140	3.385	3.748	7.133	193.0	3,954	289	2,498	(2)	100	Rebuilt; idle since 1924.
1923	50– 75	.9	.214	.206	.105	4.664	4.845	9.509	171.1	4,552	125	2,657	(2)	61	Remodeled.
1922	Under 25	.2	.218	.225	.111	4.586	4.436	9.021	206.5	4,075	92	2,614	(2)	100	
1921	25– 50	1.1	.148	.153	.075	6.744	6.523	13.267	127.6	4,608	132	3,558	(2)	100	Abandoned.
1920	150–175	3.4	.146	.139	.071	6.830	7.215	14.045	136.0	3,526	426	2,911	(2)	79	
1919	75–100	1.5	.134	.115	.062	7.451	8.694	16.146	141.0	3,828	379	2,798	(2)	85	
1918	200–225	4.7	.141	.128	.067	7.082	7.792	14.874	120.7	4,299	361	3,082	(2)	81	Rebuilt; hand filled; sand cast; mechanically filled; pig machine.

PLANT NO. 12

1926	225–250	1.7	(1)	(1)	0.529	(1)	(1)	1.890	396.7	4,090	(2)	1,820	726	100	
1925	200–225	1.4	(1)	(1)	.478	(1)	(1)	2.093	391.1	4,030	(2)	1,808	750	100	
1924	200–225	1.5	(1)	(1)	.449	(1)	(1)	2.227	366.5	4,050	(2)	1,887	865	100	
1923	175–200	1.6	(1)	(1)	.343	(1)	(1)	2.917	330.7	(2)	(2)	2,103	(2)	100	
1922	125–150	1.1	(1)	(1)	.290	(1)	(1)	3.447	324.8	(2)	(2)	2,240	(2)	100	
1921	25–50	.4	(1)	(1)	.249	(1)	(1)	4.011	311.7	4,296	(2)	1,972	1,165	100	
1920	175–200	1.6	(1)	(1)	.231	(1)	(1)	4.327	323.6	(2)	(2)	1,973	(2)	100	Remodeled.
1919	100–125	1.2	(1)	(1)	.172	(1)	(1)	5.824	241.4	(2)	(2)	2,174	(2)	100	
1918	150–175	2.0	(1)	(1)	.171	(1)	(1)	5.846	213.2	(2)	(2)	2,341	(2)	97	
1917	150–175	2.0	(1)	(1)	.168	(1)	(1)	5.959	232.8	(2)	(2)	2,386	(2)	51	Pig machine installed in 1916.
1914	75–100	1.0	(1)	(1)	.149	(1)	(1)	6.697	266.6	(2)	(2)	2,391	(2)	---------	
1913	150–175	2.0	(1)	(1)	.162	(1)	(1)	6.171	229.8	(2)	(2)	2,292	(2)	---------	
1912	100–125	1.4	(1)	(1)	.152	(1)	(1)	6.588	240.8	(2)	(2)	2,425	(2)	---------	
1911	75–100	.9	(1)	(1)	.150	(1)	(1)	6.667	249.3	(2)	(2)	2,250	(2)	---------	Mechanically filled; sand cast.

PLANT NO. 13

1926	225–250	1.2	(1)	(1)	0.465	(1)	(1)	2.149	520.5	4,467	(2)	1,990	1,196	[4] 84	
1925	175–200	1.0	0.766	1.122	.455	1.305	.891	2.197	503.3	4,296	(2)	1,932	1,196	[4] 79	
1924	125–150	.9	.720	1.032	.424	1.390	.969	2.358	464.1	4,384	(2)	1,960	1,288	[4] 88	
1923	150–175	1.0	.674	.975	.398	1.484	1.026	2.510	462.6	4,245	(2)	1,997	1,252	[4] 88	
1922	150–175	1.0	.786	.977	.436	1.272	1.024	2.296	460.3	4,229	(2)	1,909	1,331	[4] 74	Mechanically filled; pig machine.

PLANT NO. 14

1926	25–50	0.4	0.423	0.216	0.143	2.362	4.635	6.997	300.8	4,260	(2)	2,218	1,277	100	
1924	75–100	.6	.516	.380	.219	1.938	2.630	4.568	354.5	4,308	(2)	2,124	1,191	100	
1923	200–225	1.7	.497	.388	.218	2.010	2.578	4.588	341.0	4,426	(2)	2,119	1,328	100	
1921	50–75	.5	.342	.325	.167	2.924	3.073	5.997	395.9	4,406	(2)	1,995	1,192	100	Relined.
1920	175–200	1.6	.426	.403	.207	2.345	2.480	4.825	347.8	4,386	(2)	2,155	1,409	100	
1919	200–225	1.7	.421	.398	.205	2.376	2.512	4.888	353.5	(2)	(2)	(2)	(2)	100	
1918	175–200	1.7	.359	.340	.175	2.782	2.942	5.724	285.5	4,296	(2)	2,174	1,644	100	Do.
1917	175–200	1.7	.429	.405	.208	2.333	2.467	4.800	300.0	4,442	(2)	2,138	1,463	100	Relined; pig machine.
1914	150–175	1.6	.376	.356	.183	2.656	2.807	5.463	284.4	4,411	(2)	2,375	1,530	---------	
1913	200–225	2.0	.335	.403	.183	2.988	2.480	5.467	286.7	4,375	(2)	2,297	1,401	---------	
1912	125–150	1.4	.361	.307	.166	2.770	3.255	6.025	286.0	4,337	(2)	2,173	1,230	---------	
1911	25–50	.5	(1)	(1)	.182	(1)	(1)	5.483	289.0	4,406	(2)	2,143	1,118	---------	Hand filled; sand cast.

[1] Detail not available.
[2] Not reported.
[4] Production not shown as machine cast, used molten.
[8] Merchant furnace 1911 to 1918, inclusive. Integrated with steel plant 1919 to 1927, inclusive.
[9] Fiscal year.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 15

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1927 [3]	50- 75	1.0	0.310	0.306	0.154	3.226	3.271	6.497	316.2	5,237	--------	2,699	181	--------	Rebuilt.
1926	175-200	2.0	.263	.421	.162	3.803	2.378	6.181	250.5	5,772	--------	2,930	210	--------	
1925	175-200	2.0	.259	.439	.163	3.855	2,275	6.130	247.2	5,918	2	2,970	260	--------	
1924	75-100	0.9	.273	.285	.139	3.665	3.512	7.177	278.2	6,003	4	2,994	217	--------	
1923	75-100	1.1	.239	.303	.133	4.190	3.304	7.494	237.3	6,124	--------	3,300	578	--------	Relined.
1922	50- 75	.6	.265	.273	.134	3.777	3.667	7.444	256.5	6,030	11	3,328	502	--------	
1921	Under 25	.1	.137	.121	.064	7.318	8,279	15.597	218.1	5,649	--------	3,376	780	--------	
1920	150-175	1.9	.189	.177	.091	5.290	5.656	10.946	223.3	5,755	63	3,310	730	--------	
1919	100-125	1.6	.180	.157	.084	5.542	6.384	11.926	212.5	5,938	54	3,398	526	--------	
1918	150-175	2.0	.188	.169	.089	5.313	5.911	11.224	209.8	5,824	2	3,228	446	--------	
1917	150-175	1.9	[1]	[1]	.106	[1]	[1]	9.457	229.5	5,701	43	3,204	750	--------	Hand filled; sand cast.

PLANT NO. 16

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1926	75-100	0.7	0.854	0.685	0.380	1.171	1.461	2.632	392.3	4,070	73	2,282	[2]	100	
1924	50- 75	.3	1.105	.429	.309	.905	2.329	3.233	512.0	3,913	199	1,996	912	100	
1923	125-150	.7	[1]	[1]	.280	[1]	[1]	3.566	493.4	3,792	249	2,120	900	100	Relined.
1922	50- 75	.2	[1]	[1]	.371	[1]	[1]	2.697	613.0	[2]	[2]	[2]	[2]	100	
1921	Under 25	.1	[1]	[1]	.332	[1]	[1]	3.016	513.1	4,084	170	2,101	965	100	
1920	125-150	.9	[1]	[1]	.246	[1]	[1]	4.066	438.3	3,922	242	2,092	1,055	100	
1919	100-125	.6	[1]	[1]	.269	[1]	[1]	3.717	455.7	[2]	[2]	[2]	[2]	100	
1918	150-175	1.0	[1]	[1]	.272	[1]	[1]	3.672	452.3	[2]	[2]	[2]	[2]	100	

1917	175–200	1.0	(1)	(1)	.314	(1)	(1)	3.180	489.5	(2)	(2)	(2)	(2)	100	
1916	100–125	.7	(1)	(1)	.294	(1)	(1)	3.404	445.9	(2)	(2)	(2)	(2)	100	
1915	125–150	.9	(1)	(1)	.313	(1)	(1)	3.197	450.9	3,882	108	2,024	1,064	100	
1914	125–150	1.0	(1)	(1)	.274	(1)	(1)	3.653	382.4	(2)	(2)	(2)	(2)	100	
1913	125–150	.9	(1)	(1)	.308	(1)	(1)	3.252	389.0	(2)	(2)	(2)	(2)	100	
1912	125–150	.9	(1)	(1)	.299	(1)	(1)	3.340	385.3	(2)	(2)	(2)	(2)	100	
1911	100–125	.9	(1)	(1)	.313	(1)	(1)	3.200	385.0	(2)	(2)	(2)	(2)	100	Mechanically filled; pig machine.

PLANT NO. 17

1927 [3]	75–100	1.0	1.562	0.706	0.486	0.640	1.416	2.056	492.2	3,821	343	1,859	874	100	
1926	150–175	1.0	1.507	.673	.465	.664	1.486	2.149	474.6	3,860	325	1,901	831	100	
1925	150–175	1.0	1.372	.615	.425	.729	1.625	2.354	432.3	4,043	242	2,047	755	100	
1924	50–75	.4	(1)	(1)	.222	(1)	(1)	4.509	335.2	4,144	159	2,211	918	100	Rebuilt; mechanically filled.
1923	50–75	.7	(1)	(1)	.154	(1)	(1)	6.474	265.0	4,420	376	2,462	1,196	100	Abandoned in 1921; remodeled in 1922.
1918	100–125	1.7	(1)	(1)	.103	(1)	(1)	9.666	176.7	(2)	(2)	(2)	(2)	6	Hand filled; sand cast; pig machine.

PLANT NO. 18

1927 [3]	75–100	1.9	0.509	0.390	0.221	1.964	2.566	4.530	252.4	5,667	11	2,990	468	----------	
1926	100–125	1.4	.455	.278	.173	2.197	3.599	5.796	233.1	5,564	----------	3,072	392	----------	Relined.
1925	150–175	2.0	.429	.326	.185	2.330	3.064	5.395	210.8	5,864	32	3,228	502	----------	
1924	150–175	2.0	.471	.361	.204	2.124	2.774	4.898	233.0	6,061	16	2,888	282	----------	
1923	150–175	2.0	.422	.392	.203	2.369	2.551	4.919	226.5	5,916	4	3,028	600	----------	
1922	75–100	1.2	.383	.287	.164	2.613	3.484	6.097	205.4	6,001	16	3,290	533	----------	
1921	25–50	.5	.532	.334	.205	1.879	2.998	4.877	243.8	5,658	----------	3,002	591	----------	Mechanically filled.
1920	75–100	1.0	.149	.184	.082	6.705	5.442	12.147	215.1	5,582	18	3,446	786	----------	
1919	25–50	.5	.171	.203	.093	5.856	4.937	10.793	233.7	6,102	13	3,602	524	----------	Rebuilt.
1918	100–125	1.5	.156	.213	.090	6.409	4.692	11.101	194.3	6,171	----------	3,828	831	----------	
1917	125–150	1.8	(1)	(1)	.111	(1)	(1)	9.009	215.9	5,690	20	3,444	739	----------	Rebuilt; hand filled; sand cast.

[1] Detail not available. [2] Not reported. [3] First 6 months only.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 19

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charing and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1927 [3]	50- 75	1.0	0.707	0.713	0.355	1.415	1.402	2.817	414.8	4,455	206	2,180	932	100	
1926	150-175	1.0	.727	.668	.348	1.375	1.498	2.873	432.5	4,303	211	2,110	983	100	
1925	75-100	.6	.708	.813	.379	1.412	1.229	2.642	387.1	4,426	103	2,285	1,060	100	Rebuilt.
1924	25- 50	.3	.679	.877	.383	1.472	1.140	2.612	367.2	4,319	143	2,173	1,093	100	Mechanically filled.
1923	100-125	.9	.334	.518	.203	2.992	1.932	4.924	344.8	3,956	327	2,300	1,245	100	
1922	75-100	.7	.338	.562	.211	2.963	1.779	4.741	336.5	4,115	244	2,196	1,068	100	
1921	25- 50	.3	.237	.411	.150	4.222	2.431	6.653	321.3	4,657	(2)	2,516	1,537	100	
1920	75-100	.7	.232	.421	.150	4.305	2.377	6.682	314.0	4,516	(2)	2,543	1,185	100	
1919	100-125	1.0	.270	.441	.167	3.704	2.267	5.971	333.2	4,563	(2)	2,334	992	100	
1918	100-125	1.0	(1)	(1)	.147	(1)	(1)	6.785	342.5	4,415	(2)	2,272	1,048	100	
1917	125-150	1.0	(1)	(1)	.167	(1)	(1)	6.001	352.9	4,413	(2)	2,236	905	100	Pig machine installed in 1915.
1914	50- 75	.5	(1)	(1)	.161	(1)	(1)	6.209	317.2	(2)	(2)	(2)	(2)	----	
1913	75-100	.8	.297	.399	.170	3.369	2.507	5.876	274.3	(2)	(2)	(2)	(2)	----	Hand filled; sand cast.

PLANT NO. 20

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charing and casting equipment
1927 [3]	50-75	1.0	1.289	0.565	0.393	0.776	1.770	2.546	412.0	3,622	645	2,015	925	100	
1926	75-100	.6	1.226	.427	.317	.816	2.342	3.157	378.0	3,147	851	2,167	1,084	100	
1925	150-175	1.0	1.250	.477	.345	.800	2.099	2.898	418.0	3,293	627	2,060	1,033	100	
1924	75-100	.8	.606	.314	.207	1,651	3.187	4.837	346.0	3,848	435	2,265	1,068	100	Relined, mechanically filled.
1923	125-150	1.0	.526	.356	.212	1.900	2.808	4.708	377.0	3,770	676	2,210	1,102	100	
1922	75-100	.8	.471	.409	.219	2.121	2.445	4.566	356.0	3,940	517	2,233	1,107	100	
1921	75-100	.7	(1)	(1)	.178	(1)	(1)	5.613	367.0	4,254	237	2,209	1,205	100	

1920	100–125	1.0	(1)	(1)	0.183	(1)	(1)	5.472	341.0	4,030	468	2,245	1,098	100	Rebuilt in 1919.
1918	100–125	1.0	(1)	(1)	.135	(1)	(1)	7.391	315.0	3,958	452	2,387	1,109	100	
1917	125–150	1.0	(1)	(1)	.163	(1)	(1)	6.140	366.0	4,151	166	2,217	995	100	Hand filled; pig machine.

PLANT NO. 21

1926	100–125	0.7	1.202	0.736	0.456	0.833	1.359	2.193	486.2	3,922	234	2,040	(2)	100	
1925	100–125	.6	1.119	.686	.425	.893	1.458	2.351	505.8	4,234	128	1,994	(2)	100	Relined.
1924	150–175	.8	1.011	.620	.384	.988	1.612	2.600	504.6	3,992	172	2,018	(2)	100	
1923	100–125	.7	(1)	(1)	.224	(1)	(1)	4.466	448.0	3,839	125	2,121	(2)	100	
1922	Under 25	.1	(1)	(1)	.227	(1)	(1)	4.412	340.6	4,232	(2)	2,356	(2)	100	Rebuilt.
1920	50– 75	.8	(1)	(1)	.116	(1)	(1)	8.605	242.8	4,778	35	2,451	(2)	100	
1919	50– 75	.7	(1)	(1)	.140	(1)	(1)	7.141	243.7	4,487	11	2,386	(2)	100	Mechanically filled; pig machine.

PLANT NO. 22

1926	125–150	0.9	(1)	(1)	0.294	(1)	(1)	3.401	386.0	3,897	325	2,120	999	[4] 48	
1925	125–150	1.0	(1)	(1)	.326	(1)	(1)	3.066	392.0	3,883	336	2,091	1,077	[4] 44	
1924	100–125	.8	(1)	(1)	.229	(1)	(1)	4.364	381.0	3,671	363	2,123	1,077	100	Relined.
1923	100–125	.7	(1)	(1)	.327	(1)	(1)	3.055	431.0	4,043	314	2,245	1,179	100	
1922	100–125	.7	(1)	(1)	.312	(1)	(1)	3.203	419.0	4,140	161	2,224	1,219	100	
1920	100–125	1.0	(1)	(1)	.155	(1)	(1)	6.464	324.0	4,153	347	2,481	1,326	100	
1918	100–125	1.0	(1)	(1)	.136	(1)	(1)	7.374	296.0	3,947	340	2,340	1,118	100	Remodeled.
1917	100–125	.9	.400	.300	.172	2.500	3.330	5.830	370.0	4,496	57	2,390	1,239	100	
1913	100–125	.8	.519	.324	.200	1.926	3.085	5.011	335.0	4,321	163	2,264	1,277	100	
1912	100–125	1.0	.501	.350	.206	1.997	2.854	4.851	330.0	4,254	175	2,340	1,219	100	
1911	25– 50	.4	.522	.215	.152	1.915	4.647	6.562	337.0	4,496	71	2,292	1,301	100	Mechanically filled; pig machine.

[1] Detail not available. [2] Not reported. [3] First 6 months only. [4] Production not shown as machine cast is used molten.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 23

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity						Average output per stack-day	Consumption of materials per gross ton of pig iron produced				Per cent of production machine cast	Changes in stack, and charging and casting equipment
			Gross tons of pig iron produced per man-hour			Man-hours per gross ton of pig iron produced									
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Iron ore	Scrap	Coke	Flux		
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1926	125–150	1.0	1.353	0.861	0.526	0.739	1.161	1.900	376.8	3,212	585	1,821	912	100	
1925	75–100	.8	1.120	.713	.436	.893	1.403	2.295	323.6	3,373	452	2,173	1,122	100	
1924	50– 75	.6	1.197	.762	.466	.835	1.312	2.147	320.7	3,530	473	2,172	1,012	100	
1923	25– 50	.5	.847	.539	.329	1.181	1.855	3.037	253.4	4,113	16	2,201	1,183	100	Rebuilt; mechanically filled; pig machine.

PLANT NO. 24

Year	Production of thousands of gross tons	Average full-time furnaces active during year	GT/MH Furnace crew labor	GT/MH All other labor	GT/MH Total labor	MH/GT Furnace crew labor	MH/GT All other labor	MH/GT Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1923	25– 50	(2)	(1)	(1)	0.268	(1)	(1)	3.729	(2)	4,341	114	2,471	1,210	100	Idle since 1923.
1921	Under 25	(2)	(1)	(1)	.131	(1)	(1)	7.645	(2)	(2)	(2)	(2)	(2)	100	
1920	125–150	(2)	(1)	(1)	.211	(1)	(1)	4.744	(2)	3,994	150	2,327	1,149	100	
1919	100–125	(2)	(1)	(1)	.222	(1)	(1)	4.508	--------	(2)	(2)	(2)	(2)	100	Mechanically filled; pig machine.

PLANT NO. 25

Year	Production of thousands of gross tons	Average full-time furnaces active during year	GT/MH Furnace crew labor	GT/MH All other labor	GT/MH Total labor	MH/GT Furnace crew labor	MH/GT All other labor	MH/GT Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1926	125–150	1.0	(1)	(1)	0.536	(1)	(1)	1.866	368.3	3,909	(2)	2,008	(2)	100	
1925	125–150	.9	(1)	(1)	.473	(1)	(1)	2.116	374.8	3,909	(2)	2,070	(2)	100	Relined.
1924	100–125	.8	(1)	(1)	.389	(1)	(1)	2.570	408.9	4,001	(2)	2,113	(2)	100	
1923	125–150	1.0	(1)	(1)	.459	(1)	(1)	2.179	356.0	3,976	(2)	2,218	(2)	100	Remodeled in 1922.
1920	75–100	.8	.383	.586	.232	2.610	1.707	4.318	286.4	4,079	(2)	2,391	--------	100	Mechanically filled; pig machine.

PLANT NO. 26

1927 [3]	50–75	1.0	1.011	0.710	0.417	0.989	1.408	2.397	383.0	4,489		2,095	815	100	
1926	125–150	1.0	.971	.659	.393	1.030	1.517	2.547	366.1	4,252		2,214	977	100	Mechanically filled; pig machine.

PLANT NO. 27

1926	125–150	1.0	0.751	0.393	0.258	1.331	2.543	3.874	360.5	2,858	757	2,124	(2)	100	
1925	Under 25	(10)	.412	.216	.142	2.424	4.630	7.054	185.0	3,297	896	3,075	(2)	100	Relined.
1924	50–75	.5	.534	.280	.184	1.871	3.574	5.445	332.7	2,925	909	2,275	(2)	100	
1923	125–150	1.0	.741	.278	.202	1.350	3.592	4.942	360.7	3,111	811	2,214	(2)	100	Rebuilt in 1922. Also pig machine and skip hoist installed.
1921	Under 25	.1	.559	.221	.159	1.789	4.518	6.307	249.9	3,546	332	2,250	(2)		
1920	75–100	1.0	.458	.181	.130	2.183	5.512	7.695	220.9	3,651	408	2,227	(2)		
1919	100–125	1.2	.505	.200	.143	1.979	4.998	6.977	237.3	3,235	614	2,487	(2)		
1918	100–125	1.6	.474	.209	.145	2.109	4.790	6.899	205.5	3,344	540	2,562	(2)		Rebuilt.
1917	75–100	1.0	.480	.198	.140	2.084	5.053	7.137	226.1	3,862	119	2,547	(2)		
1916	100–125	1.4	.393	.224	.143	2.543	4.470	7.014	208.6	3,689	240	2,062	(2)		
1915	50–75	.8	.598	.171	.133	1.673	5.855	7.527	206.0	3,907	262	2,524	(2)		
1914	25–50	.6	.498	.198	.142	2.006	5.058	7.064	212.1	4,070	96	2,622	(2)		Hand filled; sand cast.

PLANT NO. 28

1926	125–150	0.8	0.631	0.672	0.326	1.585	1.488	3.072	454.4	3,768	421	1,985	1,046	100	
1925	75–100	.6	(1)	(1)	.321	(1)	(1)	3.117	441.5	3,734	419	2,092	1,066	100	
1924	75–100	.5	(1)	(1)	.278	(1)	(1)	3.601	444.4	3,703	390	2,053	1,068	35	Pig machine.
1923	100–125	.7	(1)	(1)	.241	(1)	(1)	4.150	402.4	3,683	401	2,253	1,035		Rebuilt.
1922	75–100	.5	.381	.642	.239	2.625	1.558	4.183	416.0	3,588	426	2,138	1,010		
1921	50–75	.5	.365	.655	.234	2.741	1.526	4.267	398.5	3,658	444	2,251	1,084		
1920	100–125	.8	.361	.443	.199	2.769	2.260	5.028	394.4	3,732	430	2,283	1,138		
1919	75–100	.6	.355	.456	.200	2.813	2.193	5.007	396.7	3,772	421	2,220	1,310		
1918	75–100	.7	.291	.309	.150	3.439	3.231	6.670	324.5	3,904	450	2,489	1,501		Do.
1917	100–125	1.0	.291	.456	.178	3.431	2.195	5.625	318.3	3,801	444	2,439	1,478		
1913	75–100	.7	(1)	(1)	.152	(1)	(1)	6.561	319.6	(2)	(2)	(2)	(2)		
1912	75–100	.6	(1)	(1)	.172	(1)	(1)	5.830	359.7	3,833	336	2,233	1,301		
1911	75–100	.6	(1)	(1)	.163	(1)	(1)	6.136	360.2	(2)	(2)	(2)	(2)		Hand filled; sand cast.

[1] Detail not available.
[2] Not reported.
[10] Plant operated less than 18 days during the year.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 29[11]

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1914 [9]	100–125	0.8	(1)	(1)	0.231	(1)	(1)	4.336	368.0	4,133	212	2,103	1,212	[4] 100	
1913 [9]	125–150	1.0	(1)	(1)	.242	(1)	(1)	4.130	360.0	4,316	(2)	2,282	1,174	[4] 100	
1912 [9]	100–125	.9	(1)	(1)	.219	(1)	(1)	4.570	347.0	3,857	333	2,186	1,271	[4] 100	Pig machine; hand filled.

PLANT NO. 30

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1927 [3]	125–150	2.0	(1)	(1)	0.152	(1)	(1)	6.597	380.5	5,564	379	2,682	(2)	100	
1926	250–275	2.0	(1)	(1)	.130	(1)	(1)	7.669	354.6	5,598	432	2,680	(2)	31	Pig machine.
1925	200–225	1.9	(1)	(1)	.135	(1)	(1)	7.403	315.8	5,748	405	2,784	20		Relined.
1924	225–250	2.0	(1)	(1)	.144	(1)	(1)	6.956	321.9	5,858	414	2,984	40		
1923	225–250	2.0	(1)	(1)	.139	(1)	(1)	7.204	319.1	6,120	321	3,032	181		
1922	200–225	1.7	(1)	(1)	.149	(1)	(1)	6.711	337.8	6,044	316	2,886	211		Do.
1921	50– 75	.4	(1)	(1)	.137	(1)	(1)	7.307	337.8	5,967	255	2,712	258		Do.
1920	175–200	1.9	(1)	(1)	.125	(1)	(1)	8.019	273.2	6,205	222	3,204	567		
1919	175–200	1.8	(1)	(1)	.112	(1)	(1)	8.940	277.5	6,241	215	3,228	553		Do.
1918	175–200	2.4	(1)	(1)	.098	(1)	(1)	10.180	209.4	6,100	305	3,362	925		Do.
1917	250–275	3.0	(1)	(1)	.123	(1)	(1)	8.136	248.1	6,115	269	3,202	903		
1916	275–300	2.7	(1)	(1)	.136	(1)	(1)	7.328	283.6	5,956	228	2,890	564		Rebuilt.
1915	200–225	2.2	(1)	(1)	.137	(1)	(1)	7.280	270.8	6,308	211	3,074	260		Do.
1914	200–225	2.0	(1)	(1)	.127	(1)	(1)	7.891	297.0	5,593	184	2,874	437		Mechanically filled; sand cast.

PLANT NO. 31

1927 [3]	25- 50	1.0	0.504	0.331	0.200	1.982	3.023	5.005	206.4	5,277	--------	2,836	242	100	
1926	50- 75	1.0	.529	.319	.199	1.892	3.131	5.023	203.7	5,139	--------	2,804	316	100	
1925	50- 75	1.0	.477	.290	.181	2.096	3.443	5.539	182.8	6,075	--------	3,024	18	100	Relined.
1924	50- 75	1.0	.425	.248	.157	2.355	4.032	6.387	177.2	6,200	--------	3,168	(2)	82	Relined; pig machine.
1923	50- 75	1.0	.425	.193	.133	2.353	5.188	7.542	181.0	6,234	--------	3,022	22	--------	Relined.
1922	25- 50	.6	.483	.212	.147	2.072	4.712	6.784	177.2	6,001	--------	3,134	157	--------	
1921	Under 25	.1	.398	.176	.122	2.510	5.683	8.192	163.0	5,613	--------	3,386	683	--------	
1920	50- 75	1.0	.467	.152	.115	2.143	6.575	8.718	171.7	5,790	--------	3,300	573	--------	
1919	50- 75	1.2	.451	.148	.111	2.217	6.764	8.981	164.8	5,867	--------	3,406	403	--------	Do.
1918	100-125	1.7	.478	.187	.134	2.091	5.348	7.439	171.6	5,531	--------	3,188	724	--------	Do.
1917	125-150	2.0	.513	.204	.146	1.948	4.901	6.851	175.7	5,457	--------	2,978	412	--------	
1916	75-100	1.6	.434	.184	.129	2.305	5.435	7.740	167.4	5,656	--------	3,042	(2)	--------	Do.
1915	50- 75	1.0	.419	.172	.122	2.386	5.826	8.212	179.4	5,604	--------	3,205	(2)	--------	Do.
1914	50- 75	1.0	.439	.185	.130	2.277	5.418	7.695	192.4	5,535	--------	2,996	(2)	--------	
1913	50- 75	1.0	.409	.175	.123	2.443	5.716	8.158	181.8	5,649	--------	3,168	(2)	--------	
1912	75-100	1.3	.452	.190	.134	2.211	5.266	7.477	164.8	5,757	--------	3,256	224	--------	Do.
1911	50- 75	1.0	.379	.148	.106	2.639	6.753	9.392	158.1	5,616	--------	3,484	486	--------	Mechanically filled; sand cast.

PLANT NO. 32

1924	25- 50	0.4	0.898	0.646	0.376	1.114	1.547	2.662	323.1	2,197	1,552	2,035	952	100	Idle since 1924.
1923	100-125	.9	.730	.692	.355	1.371	1.445	2.816	336.1	2,948	974	2,142	1,055	100	
1922	25- 50	.4	.627	.597	.306	1.595	1.676	3.270	318.5	4,231	255	2,466	1,351	100	
1921	50- 75	.5	.677	.639	.329	1.478	1.564	3.043	347.1	4,189	244	2,354	1,445	100	
1920	75-100	.8	.631	.572	.300	1.585	1.749	3.334	340.3	4,328	(2)	2,311	1,248	100	
1919	100-125	.9	.611	.571	.295	1.638	1.752	3.390	319.9	3,886	211	2,286	1,272	100	
1918	100-125	1.0	.635	.606	.310	1.576	1.650	3.225	337.6	4,269	(2)	2,108	1,384	100	
1917	100-125	.8	.686	.599	.320	1.458	1.670	3.128	356.6	4,229	30	2,005	1,201	100	Mechanically filled; pig machine.

[1] Detail not available.
[2] Not reported.
[3] Fiscal year.
[4] First 6 months only.
[5] Merchant furnace plant 1911–1916, inclusive; integrated with steel plant 1917.
[6] Production not shown as machine cast is used molten.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 33

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and chargin and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1927 [3]	25- 50	0.6	0.917	0.758	0.415	1.091	1.319	2.410	359.0	4,243	305	2,000	668	100	
1926	100-125	1.0	.736	.636	.341	1.359	1.573	2.932	325.0	4,126	259	2,262	670	100	
1925	100-125	1.0	.717	.771	.371	1.394	1.298	2.692	321.0	4,216	176	2,262	767	100	
1924	75-100	.7	.485	.688	.284	2.063	1.453	3.516	303.0	4,446	136	2,316	815	33	Rebuilt; pig machine.
1923	100-125	1.0	.418	.733	.266	2.395	1.365	3.760	308.0	4,209	193	2,300	1,010	---------	
1922	50- 75	.5	.415	.717	.263	2.412	1.394	3.806	303.0	4,341	143	2,334	1,149	---------	
1920	75-100	.9	.229	.449	.152	4.365	2.229	6.594	264.0	4,639	41	2,308	1,192	---------	
1919	75-100	1.0	.238	.527	.164	4.202	1.898	6.100	253.0	4,101	127	2,302	945	---------	
1918	75-100	.9	.197	.428	.135	5.077	2.335	7.412	245.0	4,128	170	2,302	874	---------	Relined.
1917	75-100	.9	.293	.627	.200	3.412	1.595	5.006	258.0	3,824	174	2,296	1,167	---------	
1914	50- 75	.8	.209	.481	.145	4.795	2.078	6.873	203.0	3,956	64	2,290	921	---------	Rebuilt.
1913	50- 75	.9	.245	.524	.167	4.077	1.910	5.987	221.0	4,180	74	2,492	1,102	---------	
1912	25- 50	.5	.206	.440	.140	4.855	2.274	7.129	227.0	4,075	85	2,344	916	---------	
1911	50- 75	1.0	.218	.464	.148	4.597	2.153	6.750	198.0	4,325	634	2,156	1,068	---------	Mechanically filled; sand cast.

PLANT NO. 34

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and chargin and casting equipment
1926	100-125	0.7	0.685	0.659	0.336	1.460	1.518	2.978	442.7	3,518	58	1,898	694	100	
1925	25- 50	.3	.577	.687	.314	1.732	1.456	3.188	439.9	3,548	54	1,945	773	100	Abandoned.
1923	75-100	1.2	.368	.437	.200	2.714	2.286	5.000	197.1	3,839	226	3,055	1,176	100	New furnace; mechanically filled.
1922	Under 25	.1	.394	.309	.173	2.539	3.232	5.772	213.6	3,407	197	2,671	1,072	100	
1921	25- 50	.5	.352	.279	.156	2.843	3.586	6.428	219.9	3,815	119	2,615	1,006	100	Rebuilt.

1920	50–75	.9	.268	.205	.116	3.735	4.891	8.626	171.4	3,098	370	2,584	1,263	100	
1919	Under 25	.2	.217	.169	.095	4.609	5.925	10.534	171.1	(2)	(2)	(2)	(2)	100	Pig machine.
1918	50–75	(2)	(1)	(1)	.091	(1)	(1)	11.012	(2)	(2)	(2)	(2)	(2)		
1917	50–75	(2)	(1)	(1)	.097	(1)	(1)	10.313	(2)	(2)	(2)	(2)	(2)	(2)	
1914	25–50	(2)	(1)	(1)	.104	(1)	(1)	9.565	(2)	(2)	(2)	(2)	(2)		Relined.
1913	50–75	(2)	(1)	(1)	.122	(1)	(1)	8.208	(2)	(2)	(2)	(2)	(2)		
1912	25–50	(2)	(1)	(1)	.090	(1)	(1)	11.168	(2)	(2)	(2)	(2)	(2)		Do.
1911	50–75	(2)	(1)	(1)	.131	(1)	(1)	7.659	(2)	(2)	(2)	(2)	(2)		Hand filled; sand cast.

PLANT NO. 35

1923	25–50	0.3	(1)	(1)	0.198	(1)	(1)	5.041	370.0	4,137	40	2,042	1,116	100	Rebuilt 1920; idle since 1923; abandoned in 1927.
1918	75–100	.9	(1)	(1)	.100	(1)	(1)	10.021	267.0	3,860	394	2,342	1,172	100	
1917	100–125	1.0	0.247	0.249	.125	4.045	3.985	8.030	287.0	3,985	298	2,367	1,107	100	Pig machine; method of charging not reported.

PLANT NO. 36

1926	100–125	0.9	0.929	0.789	0.427	1.077	1.268	2.345	334.9	3,575	392	2,084	724	100	
1925	75–100	.8	.893	.828	.430	1.120	1.120	2.328	317.9	3,250	768	2,119	737	100	
1924	75–100	.8	(1)	(1)	.445	(1)	(1)	2.245	329.6	2,516	1,245	2,047	757	100	
1923	Under 25	.3	.620	.614	.309	1.612	1.628	3.240	260.5	3,338	703	2,364	916	100	
1920	75–100	.8	.554	.601	.288	1.805	1.665	3.470	267.3	3,846	459	2,613	1,382	100	
1919	50–75	.6	.288	.552	.189	3.477	1.811	5.288	241.0	3,620	730	2,652	1,472	100	Relined; mechanically filled.
1918	50–75	.9	.299	.496	.187	3.345	2.017	5.362	217.7	3,510	788	2,497	1,351	100	
1917	75–100	1.0	.279	.475	.176	3.580	2.103	5.683	213.5	2,782	1,467	2,588	1,241	76	Pig machine; hand filled, sand cast.

PLANT NO. 37

1927 [3]	50–75	0.8	1.185	0.451	0.327	0.844	2.217	3.061	459.7	3,241	435	1,878	820	100	
1926	100–125	.8	.740	.282	.204	1.351	3.551	4.902	401.0	3,544	349	2,014	999	100	Mechanically filled; pig machine.

[1] Detail not available. [2] Not reported. [3] First 6 months only.

Table A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 38

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charing and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1927 [3]	50– 75	1.0	0.525	0.339	0.206	1.906	2.947	4.851	289.6	4,800	4	3,200	1,828		
1926	100–125	1.0	.543	.352	.214	1.841	2.837	4.678	299.9	4,525	2	3,082	1,637		
1925	75–100	.9	.546	.373	.222	1.830	2.682	4.513	299.8	4,776		3,186	1,398		
1924	25– 50	.4	.400	.263	.159	2.503	3.800	6.303	219.5	5,210		3,931	1,891		Relined.
1923	25– 50	.5	.407	.247	.154	2.455	4.054	6.509	223.1	5,103		3,385	2,000		Mechanically filled; sand cast.

PLANT NO. 39

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charing and casting equipment
1926	25– 50	0.4	0.466	0.391	0.212	2.157	2.556	4.713	278.2	2,802	916	2,331	(2)	100	
1925	75–100	1.0	.451	.381	.207	2.215	2.626	4.841	268.4	2,484	1,129	2,598	(2)	100	
1924	50– 75	.8	.466	.407	.217	2.147	2.459	4.605	241.6	2,807	936	2,499	(2)	100	
1923	75–100	.8	.458	.400	.213	2.185	2.503	4.688	255.1	2,876	685	2,417	(2)	100	Relined.
1922	75–100	1.0	.467	.422	.222	2.423	2.367	4.507	263.5	2,760	885	2,492	(2)	100	
1921	Under 25	.2	.473	.428	.225	2.112	2.338	4.451	261.0	2,489	1,191	2,485	(2)	100	
1920	50– 75	.8	.412	.372	.196	2.427	2.686	5.113	249.7	2,636	1,026	2,515	(2)	100	
1919	50– 75	.6	.444	.402	.211	2.250	2.490	4.739	260.1	2,531	1,133	2,473	(2)	100	Do.
1918	50– 75	.8	.406	.367	.193	2.462	2.725	5.187	241.7	2,536	1,232	2,685	(2)	100	
1917	50– 75	.6	(1)	(1)	.202	(1)	(1)	4.960	285.2	2,536	1,149	2,516	(2)	100	Pig machine in 1916.
1915	100–125	1.0	(1)	(1)	.214	(1)	(1)	4.684	282.4	2,374	1,230	2,544	(2)		
1912	50– 75	.5	(1)	(1)	.144	(1)	(1)	6.967	294.7	(2)	(2)	(2)	(2)		Rebuilt; mechanically filled.
1911	50– 75	.7	(1)	(1)	.095	(1)	(1)	10.535	249.8	(2)	(2)	(2)	(2)		Hand filled; sand cast.

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PLANT NO. 40

1927 [3]	50–75	1.0	0.350	0.255	0.147	2.857	3.929	6.786	322.7	3,763	473	2,808	1,165	----------	
1926	50–75	.6	.345	.251	.145	2.900	3.989	6.889	317.9	4,312	388	3,143	1,160	----------	Relined.
1925	50–75	.8	.248	.181	.105	4.025	5.535	9.560	229.1	4,941	311	3,586	1,351	----------	
1924	100–125	1.0	.318	.231	.134	3.144	4.324	7.468	293.3	4,614	414	3,111	1,172	----------	
1923	75–100	1.0	.292	.212	.123	3.427	4.713	8.139	269.1	5,275	208	3,786	1,626	----------	Mechanically filled; sand cast.

PLANT NO. 41

1925	50–75	0.5	0.283	0.497	0.180	3.536	2.014	5.550	329.7	4,081	(2)	1,720	1,138	----------	Idle since 1925.
1924	100–125	1.0	.268	.440	.166	3.736	2.273	6.009	293.0	4,213	(2)	2,011	1,124	----------	
1923	100–125	1.0	.263	.403	.159	3.798	2.484	6.282	290.9	4,182	(2)	2,179	1,243	----------	Relined in 1921.
1919	50–75	.5	.180	.270	.108	5.560	3.707	9.267	286.0	4,202	(2)	1,994	1,292	----------	
1918	75–100	.9	.202	.303	.121	4.948	3.299	8.247	260.6	4,274	(2)	2,458	1,496	----------	
1917	75–100	.8	.239	.334	.139	4.181	2.990	7.171	289.0	4,334	(2)	2,207	1,243	----------	Hand filled; sand cast; relined.

PLANT NO. 42

1926	100–125	1.0	0.695	0.363	0.239	1.438	2.754	4.192	283.4	(3)	(2)	(2)	(2)	100	
1925	50–75	.6	.541	.283	.186	1.848	3.540	5.388	247.0	(2)	(2)	(2)	(2)	100	Relined; skip hoist installed in 1924.
1923	50–75	.8	.202	.257	.113	4.943	3.884	8.827	230.8	(2)	(2)	(2)	(2)	100	Rebuilt in 1922.
1920	25–50	.8	(1)	(1)	.072	(1)	(1)	13.941	169.9	(2)	(2)	(2)	(2)	100	
1919	50–75	1.0	(1)	(1)	.085	(1)	(1)	11.819	194.6	(2)	(2)	(2)	(2)	100	
1918	50–75	.9	(1)	(1)	.082	(1)	(1)	12.186	189.4	(2)	(2)	(2)	(2)	100	
1917	50–75	(2)	(1)	(1)	.075	(1)	(1)	13.245	(2)	(2)	(2)	(2)	(2)	100	Rebuilt; pig machine.
1914	50–75	(2)	(1)	(1)	.093	(1)	(1)	10.720	(2)	(2)	(2)	(2)	(2)	----------	
1913	50–75	(2)	(1)	(1)	.092	(1)	(1)	10.849	(2)	(2)	(2)	(2)	(2)	----------	
1912	50–75	(2)	(1)	(1)	.119	(1)	(1)	8.383	(2)	(2)	(2)	(2)	(3)	----------	
1911	50–75	(2)	(1)	(1)	.124	(1)	(1)	8.066	(2)	(2)	(2)	(2)	(2)	----------	Hand filled; sand cast.

[1] Detail not available. [2] Not reported. [3] First 6 months only.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 43

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1925	25- 50	0.3	0.406	0.317	0.178	2.461	3.153	5.614	220.8	4,661	9	3,414	1,767	------	Idle since 1925.
1924	50- 75	.7	.429	.291	.173	2.330	3.441	5.772	236.1	4,583	16	3,147	1,644	------	
1923	25- 50	.7	.364	.261	.152	2,745	3.826	6.571	192.4	4,829	------	3,309	204	------	Relined.
1922	75-100	1.0	.421	.313	.180	2.372	3.197	5.569	220.9	4,771	------	3,086	1,557	------	
1921	Under 25	(10)	.324	.233	.136	3.083	4.286	7.369	169.5	5,320	------	3,121	887	------	
1920	25- 50	.6	.365	.281	.159	2.739	3.560	6.299	217.7	4,782	4	2,907	1,024	------	
1919	50- 75	.9	.266	.281	.137	3.757	3.563	7.320	204.3	4,723	------	3,006	904	------	
1918	75-100	1.0	.269	.259	.132	3.722	3.863	7.585	206.3	4,809	------	2,947	1,516	------	
1917	75-100	.9	.259	.286	.136	3.859	3.491	7.351	252.5	4,422	------	2,536	1,366	------	New furnace, mechanically filled; sand cast.

PLANT NO. 44

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1923	Under 25	0.2	(1)	(1)	0.145	(1)	(1)	6.904	281.6	3,033	327	2,195	(2)	100	Relined in 1919; pig machine installed in 1920; furnace abandoned in 1924.
1917	100-125	1.0	(1)	(1)	.147	(1)	(1)	6.792	280.3	3,987	99	2,181	(2)	------	
1913	25- 50	.6	(1)	(1)	.110	(1)	(1)	9.104	203.9	(2)	(2)	(2)	(2)	------	Method of charging not reported; sand cast.

PLANT NO. 45

1926	75-100	0.9	(1)	(1)	0.259	(1)	(1)	3.856	298.2	3,947	(2)	2,076	(2)	100	Relined.
1925	100-125	1.0	(1)	(1)	.288	(1)	(1)	3.471	276.8	3,904	(2)	2,309	(2)	100	
1924	50- 75	.6	(1)	(1)	.255	(1)	(1)	3.923	293.3	3,916	(2)	2,234	(2)	100	
1923	50- 75	.6	(1)	(1)	.224	(1)	(1)	4.459	287.5	3,873	(2)	2,263	(2)	100	
1920	75-100	.8	0.377	0.592	.230	2.651	1.689	4.340	267.6	4,146	(2)	2,344	(2)	100	Relined and pig machine installed in 1918.
1914	75-100	1.0	(1)	(1)	.188	(1)	(1)	5.311	216.7	(2)	(2)	(2)	(2)		Hand filled; sand cast.

PLANT NO. 46

1926	25- 50	0.5	0.442	0.367	0.200	2.264	2.727	4.991	270.0	3,985	201	2,206	1,080	100	Abandoned in 1927.
1925	25- 50	.3	.435	.390	.206	2.300	2.566	4.865	291.9	3,951	323	2,212	1,136	100	
1924	Under 25	.2	.460	.379	.208	2.174	2.641	4.815	144.3	3,994	370	2,170	1,149	100	
1923	50- 75	.6	.360	.374	.184	2.777	2.670	5.447	298.1	3,824	181	2,216	1,080	100	
1922	Under 25	.1	.396	.412	.202	2.525	2.429	4.954	281.8	3,689	383	2,316	1,012	100	
1920	75-100	.9	.315	.327	.161	3.175	3.054	6.229	283.8	3,976	139	2,225	1,185	100	
1919	75-100	.8	.300	.312	.153	3.332	3.204	6.536	262.6	3,868	392	2,248	1,279	100	
1918	75-100	1.0	.319	.332	.163	3.132	3.011	6.141	279.4	3,985	314	2,229	1,234	100	
1917	75-100	.9	.300	.312	.153	3.337	3.209	6.545	264.9	3,860	390	2,288	(2)	100	
1916	75-100	1.0	.297	.309	.151	3.369	3.240	6.608	259.7	3,868	367	2,280	1,216	100	
1915	50- 75	.6	.272	.314	.146	3.677	3.186	6.863	245.6	3,967	340	2,380	1,389	75	Pig machine.
1914	50- 75	.7	.217	.325	.130	4.603	3.074	7.677	275.1	3,580	611	2,390	1,254		Rebuilt.
1913	25- 50	.4	.187	.281	.112	5.337	3.564	8.901	235.9	3,821	661	2,541	1,404		
1912	75-100	.8	.198	.297	.119	5.048	3.372	8.420	249.4	3,774	656	2,366	1,512		
1911	25- 50	.5	.223	.334	.134	4.479	2.992	7.471	281.1	(2)	(2)	(2)	(2)		Mechanically filled; sand cast.

PLANT NO. 47

1926	Under 25	0.1	(1)	(1)	0.115	(1)	(1)	8.693	124.2	5,604	2,663	3,631	(2)		
1925	25- 50	1.0	(1)	(1)	.122	(1)	(1)	8.191	133.1	5,609	2,489	3,772	(2)		
1924	25- 50	.9	(1)	(1)	.096	(1)	(1)	10.450	132.6	(2)	(2)	(2)	(2)		Relined.
1923	50- 75	1.0	(1)	(1)	.122	(1)	(1)	8.218	155.8	4,995	2,424	3,155	(2)		
1922	Under 25	.2	(1)	(1)	.117	(1)	(1)	8.567	148.9	5,342	2,426	3,386	(2)		
1921	Under 25	.2	(1)	(1)	.119	(1)	(1)	8.371	155.1	(2)	(2)	(2)	(2)		
1920	25- 50	1.0	(1)	(1)	.112	(1)	(1)	8.960	130.0	(2)	(2)	(2)	(2)		Do.
1919	50- 75	.9	(1)	(1)	.099	(1)	(1)	10.096	155.1	(2)	(2)	(2)	(2)		Rebuilt.
1918	75-100	2.0	(1)	(1)	.089	(1)	(1)	11.285	132.9	4,406	1,508	2,836	(2)		Hand filled; sand cast; mechanically filled.

[1] Detail not available. [2] Not reported. [10] Plant operated less than 18 days during the year.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 48

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1926	25- 50	0.4	[1]	[1]	0.201	[1]	[1]	4.985	247.0	4,182	[2]	2,348	1,127	....	
1923	50- 75	.7	0.274	0.313	0.146	3.645	3.196	6.841	250.0	4,294	[2]	2,493	883	....	Relined.
1918	75-100	.9	.284	.365	.160	3.523	2.740	6.264	300.0	4,256	[2]	2,212	1,026	....	
1917	50- 75	.7	[1]	[1]	.115	[1]	[1]	8.702	248.0	4,357	[2]	2,306	1,093	....	Do.
1914	50- 75	.7	.275	.401	.163	3.636	2.496	6.132	244.0	4,415	[2]	2,331	1,210	....	
1913	25- 50	.5	.283	.425	.168	3.529	2.352	5.952	252.0	4,346	[2]	2,482	1,098	....	
1912	75-100	1.0	.293	.431	.174	3.416	2.320	5.736	266.0	4,325	[2]	2,374	1,039	....	
1911	50- 75	.7	.249	.362	.148	4.012	2.761	6.773	258.0	4,310	[2]	2,280	1,026	....	Hand filled; sand cast.

PLANT NO. 49

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1923	50- 75	0.7	0.291	0.320	0.152	3.439	3.127	6.566	207.6	4,722	....	3,335	1,855	....	Idle since 1923.
1922	25- 50	.6	.288	.311	.150	3.470	3.211	6.681	210.1	4,621	....	3,227	1,684	....	Relined.
1920	50- 75	.8	.301	.290	.148	3.320	3.445	6.765	229.5	4,883	2	3,018	1,012	....	
1919	Under 25	.2	.280	.298	.144	3.570	3.358	6.928	213.5	4,308	....	3,182	1,012	....	
1918	50- 75	.7	.251	.266	.129	3.989	3.765	7.753	186.4	4,305	....	3,103	1,460	....	
1917	50- 75	1.0	.261	.283	.137	3.774	3.540	7.314	186.0	4,372	18	3,219	1,568	....	Relined; mechanically filled; sand cast.

PLANT NO. 50

1926	75–100	0.9	0.735	0.800	0.383	1.360	1.250	2.610	262.1	3,996	170	2,149	820	100	
1925	75–100	.9	.767	.859	.405	1.303	1.164	2.468	259.4	(2)	(2)	(2)	(2)	100	
1924	25– 50	.5	.599	.709	.325	1.669	1.410	3.080	215.2	(2)	(2)	(2)	(2)	100	
1923	50– 75	.7	.319	.703	.219	3.136	1.423	4.559	212.5	4,041	38	2,101	1,151	13	Pig machine; rebuilt in 1919.
1918	25– 50	.9	(1)	(1)	.127	(1)	(1)	7.896	145.5	4,084	52	2,507	1,230		
1917	50– 75	1.0	(1)	(1)	.140	(1)	(1)	7.133	151.3	3,916	72	2,383	1,198		Mechanically filled; sand cast.

PLANT NO. 51

1927[3]	25– 50	0.9	0.587	0.504	0.271	1.705	1.984	3.689	262.8	3,624		2,028	965	100	
1925	25– 50	.5	.564	.344	.214	1.772	2.900	4.672	248.3	3,804		2,076	1,062	100	Pig machine.
1924	25– 50	.4	.437	.294	.176	2.289	3.398	5.687	248.1	4,081		2,228	1,053		
1923	50– 75	.7	.366	.171	.117	2.732	5.843	8.575	209.0	4,059		2,295	1,281		
1921	Under 25	.3	.352	(2)	(2)	2.837	(2)	(2)	195.9	2,148	1,980	2,593	1,532		Relined.
1920	50– 57	1.0	.333	.129	.093	3.004	7.754	10.758	189.1	2,659	1,680	2,586	1,478		
1919	50– 75	.7	(1)	(1)	.123	(1)	(1)	8,132	223.7	2,715	1,559	2,408	1,396		
1918	50– 75	.7	(1)	(1)	.102	(1)	(1)	9.798	192.6	3,100	1,046	2,494	1,420		Do.
1917	50– 75	1.0	(1)	(1)	.111	(1)	(1)	9.031	192.7	4,193		2,475	1,398		
1914	75–100	1.0	.393	.167	.117	2.546	5.983	8.528	223.9	4,169	92	2,426	1,434		
1913	50– 75	.8	(1)	(1)	.102	(1)	(1)	9.817	201.4	3,998	103	2,433	1,519		
1912	75–100	1.0	(1)	(1)	.131	(1)	(1)	7.650	208.3	3,349	692	2,342	1,443		
1911	75–100	1.0	(1)	(1)	.136	(1)	(1)	7.335	215.7	4,229	(2)	2,357	1,373		Mechanically filled; sand cast.

[1] Detail not available. [2] Not reported. [3] First 6 months only.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 52

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1926	75-100	0.9	(1)	(1)	0.149	(1)	(1)	6.730	242.1	(2)	--------	2,326	(2)	--------	
1925	50- 75	.9	(1)	(1)	.124	(1)	(1)	8.086	197.9	(2)	--------	2,670	(2)	--------	
1924	Under 25	.1	(1)	(1)	.126	(1)	(1)	7.968	192.0	(2)	--------	3,482	(2)	--------	Relined.
1923	50- 75	.7	(1)	(1)	.158	(1)	(1)	6.216	224.8	(2)	--------	2,853	(2)	--------	
1922	Under 25	.2	(1)	(1)	.125	(1)	(1)	7.999	172.5	(2)	--------	3,711	(2)	--------	Skip hoist installed in 1921.
1920	25- 50	.5	(1)	(1)	.101	(1)	(1)	9.891	218.4	(2)	--------	3,209	(2)	--------	
1919	50- 75	1.0	(1)	(1)	.099	(1)	(1)	10.100	196.0	(2)	--------	3,145	(2)	--------	
1918	75-100	1.0	(1)	(1)	.113	(1)	(1)	8.872	221.9	(2)	--------	2,890	(2)	--------	
1917	25- 50	.4	(1)	(1)	.109	(1)	(1)	9.191	205.8	(2)	--------	2,792	(2)	--------	Rebuilt.
1916	50- 75	1.0	(1)	(1)	.095	(1)	(1)	10.494	182.4	(2)	--------	2,717	(2)	--------	
1915	50- 75	1.0	(1)	(1)	.088	(1)	(1)	11.355	190.2	(2)	--------	2,680	(2)	--------	
1914	50- 75	.9	(1)	(1)	.089	(1)	(1)	11.193	174.9	(2)	--------	2,861	(2)	--------	
1913	50- 75	.9	(1)	(1)	.087	(1)	(1)	11.494	172.2	(2)	--------	3,012	(2)	--------	
1912	50- 75	.9	(1)	(1)	.085	(1)	(1)	11.722	168.0	(2)	--------	3,028	(2)	--------	
1911	50- 75	1.0	(1)	(1)	.090	(1)	(1)	11.122	168.1	(2)	--------	3,094	(2)	--------	Hand filled; sand cast.

PLANT NO. 53

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Furnace crew labor (gross tons per man-hour)	All other labor	Total labor	Furnace crew labor (man-hours per gross ton)	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1924	50- 75	0.8	0.389	0.486	0.216	2.570	2.061	4.630	204.2	4,140	(2)	2,000	2,372	--------	Relined; idle since 1924.
1923	50- 75	.7	.354	.441	.196	2.826	2.266	5.092	212.1	4,025	(2)	2,391	1,378	--------	
1922	25- 50	.5	.353	.440	.200	2.832	2.271	5.103	235.2	4,131	(2)	2,414	1,555	--------	

1921	Under 25	.3	.286	.357	.159	3.491	2.799	6.290	203.5	(2)	(2)	(2)	(2)	------	Mechanically filled.
1920	75–100	1.0	.213	.266	.118	4.697	3.766	8.464	212.7	(2)	(2)	(2)	(2)	------	
1919	25–50	.5	.223	.278	.124	4.486	3.597	8.082	207.9	(2)	(2)	(2)	(2)	------	
1918	50–75	(2)	.238	.297	.132	4.197	3.365	7.562	(2)	(2)	(2)	(2)	(2)	------	
1917	50–75	(2)	.234	.291	.130	4.273	3.420	7.693	(2)	(2)	(2)	(2)	(2)	------	
1912	50–75	(2)	.177	.245	.103	5.655	4.075	9.730	(2)	(2)	------	(2)	(2)	------	Hand filled; sand cast.

PLANT NO. 54

1926	75–100	1.0	0.472	0.271	0.172	2.121	3.687	5.808	217.7	(2)	(2)	2,486	(2)	100	
1925	50–75	1.0	.399	.230	.146	2.503	4,353	6.856	176.5	(2)	(2)	2,522	(2)	100	
1924	50–75	1.0	.425	.244	.155	2.354	4,093	6.447	196.1	(2)	(2)	2,610	(2)	100	
1923	25–50	.6	.392	.225	.143	2.551	4,435	6.986	159.0	(2)	(2)	2,862	(2)	100	Relined; pig machine.
1922	25–50	.5	.304	.255	.139	3,285	3,922	7.207	167.6	(2)	(2)	2,836	(2)	------	
1921	Under 25	.3	.354	.296	.161	2.828	3.377	6.205	178.0	(2)	(2)	2,900	(2)	------	Mechanically filled.
1920	50–75	.9	.174	.253	.103	5.747	3.960	9.707	167.0	(2)	(2)	2,818	(2)	------	
1919	50–75	.9	.186	.270	.110	5.365	3.697	9.062	178.9	(2)	(2)	2,742	(2)	------	
1918	50–75	.8	.164	.237	.097	6.122	4.218	10.340	165.7	(2)	(2)	3,020	(2)	------	Rebuilt in 1915.
1914	25–50	1.0	.148	.215	.088	6.756	4.655	11.410	134.7	(2)	(2)	3,186	(2)	------	
1913	25–50	1.0	.139	.202	.083	7.169	4.940	12.109	129.2	(2)	(2)	3,264	(2)	------	
1912	25–50	.8	.127	.185	.075	7.850	5.409	13.259	140.2	(2)	(2)	3,052	(2)	------	
1911	25–50	.7	.115	.167	.068	8.673	5.976	14.648	138.1	(2)	(2)	2,648	(2)	------	Hand filled; sand cast.

PLANT NO. 55

1926	50–75	0.9	0.369	0.326	0.173	2.709	3.066	5.775	176.4	3,700	1,357	2,920	(2)	100	
1925	25–50	.4	.279	.385	.162	3.583	2.598	6.181	212.3	3,561	1,118	2,400	(2)	100	
1924	25–50	.7	.262	.328	.146	3.818	3.048	6.866	191.2	3,477	1,142	2,408	(2)	100	Relined.
1923	50–75	1.0	.240	.307	.135	4.163	3.258	7.421	183.9	3,288	1,413	2,430	(2)	100	
1922	50–75	.9	.289	.372	.163	3.460	2.689	6.149	204.9	3,358	1,122	2,168	(2)	100	
1921	75–100	1.0	.281	.377	.161	3.556	2.652	6.208	212.6	3,409	1,142	2,242	(2)	100	
1920	50–75	.9	.266	.302	.141	3.757	3.313	7.069	165.3	3,620	1,272	2,786	(2)	100	
1919	50–75	.9	.273	.309	.145	3.668	3.235	6.903	162.6	3,593	1,272	2,666	(2)	100	Relined in 1918.
1917	50–75	.9	.225	.255	.120	4.443	3.918	8.360	157.0	3,615	1,286	2,588	(2)	100	
1913	25–50	.8	.239	.271	.127	4.186	3.691	7.877	160.0	4,075	1,940	3,102	(2)	100	
1912	50–75	1.0	.232	.263	.123	4.319	3.809	8.128	147.3	3,956	1,696	2,620	(2)	100	Hand filled; pig machine.

[1] Detail not available.

[2] Not reported.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 56

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1927 [3]	50- 75	0.8	1.437	0.587	0.417	0.696	1.705	2.400	495.4	3,557	264	1,709	381	100	
1926	25- 50	.3	1.194	.544	.374	.837	1.838	2.676	411.0	4,278	121	1,922	542	100	Mechanically filled; pig machine.

PLANT NO. 57

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1926	50- 75	0.9	0.550	0.389	0.229	1.818	2.574	4.392	209.5	4,164	1,315	2,497	(2)		Relined and skip hoist installed in 1924.
1923	50- 75	1.0	.370	.261	.153	2.704	3.827	6.531	199.7	4,178	1,236	2,499	(2)		
1922	Under 25	.3	.392	.277	.162	2.548	3.607	6.156	195.0	4,348	1,315	2,537	(2)		
1921	Under 25	.1	.384	.272	.159	2.604	3.686	6.290	190.8	(2)	(2)	(2)	(2)		
1920	50- 75	1.0	.350	.247	.144	2.866	4.057	6.923	184.9	(2)	(2)	(2)	(2)		
1919	25- 50	.4	.314	.222	.130	3.186	4.510	7.696	194.9	(2)	(2)	(2)	(2)		Rebuilt.
1918	50- 75	(2)	.374	.264	.155	2.677	3.790	6.467	(2)	(2)	(2)	(2)	(2)		
1914	Under 25	(2)	.307	.217	.127	3.255	4.607	7.863	(2)	(2)	(2)	(2)	(2)		
1912	50- 75	(2)	.300	.211	.123	3.381	4.780	8.160	(2)	(2)	(2)	(2)	(2)		Hand filled; sand cast.

PLANT NO. 58

1926	50- 75	0.7	0.518	0.347	0.208	1.931	2.881	4.813	261.0	5,092	--------	3,050	524	100	
1925	25- 50	.5	.467	.348	.199	2.143	2.872	5.015	235.2	5,363	38	3,351	569	100	
1924	Under 25	.1	.462	.333	.194	2.162	3.000	5.162	238.6	5,107	188	2,949	829	100	Mechanically filled; pig machine.

PLANT NO. 59

1924	50- 75	0.9	0.377	0.267	0.156	2.654	3.745	6.399	180.9	3,412	1,216	2,704	1,248	100	Idle since 1924.
1923	50- 75	1.0	.389	.276	.161	2.570	3.629	6.198	182.1	4,296	551	2,742	1,340	100	
1922	25- 50	.6	.242	.193	.107	4.133	5.174	9.307	136.6	4,449	777	3,154	1,548	100	Pig machine; rebuilt in 1921.
1920	25- 50	.8	.191	.153	.085	5.232	6.527	11.759	137.0	4,352	956	3,597	1,624	--------	
1919	25- 50	.7	.160	.135	.073	6.240	7.433	13.673	117.3	4,269	1,187	3,590	2,025	--------	
1918	25- 50	1.0	.181	.153	.083	5.530	6.556	12.086	132.4	4,404	981	3,547	1,727	--------	
1917	25- 50	.9	.151	.124	.068	6.634	8.055	14.689	108.6	4,464	903	3,808	1,868	--------	Mechanically filled; sand cast.

PLANT NO. 60

1924	Under 25	0.5	0.223	0.184	0.101	4.488	5.424	9.912	122.1	4,957	--------	2,849	(2)	--------	Idle since 1924.
1923	25- 50	.7	.239	.197	.108	4.191	5.066	9.257	130.7	4,906	--------	3,013	(2)	--------	Relined.
1921	Under 25	.4	.235	.194	.106	4.263	5.152	9.415	134.4	4,540	--------	3,168	(2)	--------	
1920	25- 50	1.0	.244	.201	.110	4.102	4.958	9.060	135.9	4,574	--------	3,136	(2)	--------	
1919	Under 25	.2	.237	.196	.107	4.220	5.100	9.321	129.8	4,238	--------	3,127	(2)	--------	
1917	50- 75	1.0	.271	.224	.123	3.693	4.463	8.156	139.8	4,467	--------	3,132	(2)	--------	Hand filled; sand cast.

PLANT NO. 61

1920	25- 50	0.6	(1)	(1)	0.134	(1)	(1)	7.477	134.8	2,827	903	3,155	(2)	--------	Relined; idle since 1920.
1919	25- 50	.6	(1)	(1)	.155	(1)	(1)	6.446	162.0	3,221	580	2,949	(2)	--------	
1918	25- 50	.7	(1)	(1)	.131	(1)	(1)	7.636	141.4	3,129	676	2,766	(2)	--------	
1917	50- 75	1.0	(1)	(1)	.146	(1)	(1)	6.856	155.1	3,096	703	3,078	(2)	--------	
1916	25- 50	.8	(1)	(1)	.171	(1)	(1)	5.843	173.5	2,858	851	2,654	(2)	--------	
1915	Under 25	.3	(1)	(1)	.129	(1)	(1)	7.764	184.6	2,547	1,315	2,928	(2)	--------	
1913	25- 50	.7	(1)	(1)	.151	(1)	(1)	6.609	163.4	(2)	(2)	(2)	(2)	--------	
1912	50- 75	1.0	(1)	(1)	.151	(1)	(1)	6.602	158.1	(2)	(2)	(2)	(2)	--------	
1911	50- 75	1.0	(1)	(1)	.164	(1)	(1)	6.105	169.0	(2)	(2)	(2)	(2)	--------	Hand filled; sand cast.

[1] Detail not available. [2] Not reported. [3] First 6 months only.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 62

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity						Average output per stack-day	Consumption of materials per gross ton of pig iron produced				Per cent of production machine cast	Changes in stack, and charging and casting equipment
			Gross tons of pig iron produced per man-hour			Man-hours per gross ton of pig iron produced									
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Iron ore	Scrap	Coke	Flux		
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1918	50- 75	(2)	(1)	(1)	0.079	(1)	(1)	12.690	(2)	(2)	(2)	(2)	(2)		Skip hoist and pig machine installed in 1920. Furnace abandoned in 1927.
1917	50- 75	(2)	(1)	(1)	.069	(1)	(1)	14.535	(2)	(2)	(2)	(2)	(2)		
1913	25- 50	(2)	(1)	(1)	.082	(1)	(1)	12.141	(2)	(2)	(2)	(2)	(2)		
1912	25- 50	(2)	(1)	(1)	.052	(1)	(1)	19.051	(2)	(2)	(2)	(2)	(2)		
1911	Under 25	(2)	(1)	(1)	.051	(1)	(1)	19.529	(2)	(2)	(2)	(2)	(2)		Hand filled; sand cast.
PLANT NO. 63															
1919	Under 25	0.3	0.166	0.171	0.084	6.035	5.837	11.873	125.1	4,525		3,164	(2)		Rebuilt in 1920; idle since.
1917	50- 75	1.0	.255	.264	.130	3.921	3.792	7.713	155.0	4,903		3,554	(2)		Hand filled; sand cast.
PLANT NO. 64															
1920	25- 50	0.8	0.270	0.155	0.098	3.699	6.461	10.160	140.8	4,608		3,266	(2)		Idle since 1920.
1919	Under 25	.3	.242	.138	.088	4.136	7.225	11.361	145.2	3,649		3,348	(2)		
1917	25- 50	.8	.241	.138	.088	4.152	7.251	11.403	149.1	4,375		3,374	(2)		Relined; hand filled; sand cast.

PLANT NO. 65

1923	25- 50	0.6	0.140	0.220	0.085	7.169	4.544	11.713	136.2	4,467		2,899	(2)		Idle since 1923.
1922	Under 25	.2	.149	.236	.091	6.699	4.246	10.945	145.7	4,684		3,069	(2)		
1920	25- 50	.9	.141	.223	.086	7.084	4.491	11.575	139.9	4,592		3,329	(2)		
1919	50- 75	1.0	.145	.228	.089	6.913	4.382	11.294	147.1	4,480		3,297	(2)		Relined in 1918.
1917	25- 50	.8	.146	.231	.090	6.831	4.330	11.161	143.0	4,323		3,145	(2)		Hand filled; sand cast.

PLANT NO. 66

1926	50- 75	1.0	0.503	0.386	0.218	1.988	2.592	4.581	142.7	(2)	(2)	(2)	(2)		
1925	25- 50	1.0	.460	.362	.203	2.172	2.760	4.932	133.6	(2)	(2)	(2)	(2)		
1924	25- 50	1.0	.408	.336	.184	2.448	2.980	5.429	120.0	(2)	(2)	(2)	(2)		
1923	25- 50	.7	.350	.287	.158	2.858	3.480	6.338	120.8	(2)	(2)	(2)	(2)		
1922	Under 25	.2	.412	.418	.207	2.428	2.390	4.819	148.7	(2)	(2)	(2)	(2)		Relined.
1921	25- 50	.6	.312	.310	.155	3.210	3.227	6.436	112.5	(2)	(2)	(2)	(2)		
1920	Under 25	.6	.244	.227	.118	4.106	4.402	8.508	100.8	(2)	(2)	(2)	(2)		
1919	Under 25	.5	.212	.180	.097	4.723	5.545	10.268	93.1	(2)	(2)	(2)	(2)		
1918	Under 25	.8	.194	.157	.087	5.156	6.365	11.521	81.1	(2)	(2)	(2)	(2)		Do
1917	25- 50	.9	.286	.252	.134	3.495	3.974	7.469	96.0	(2)	(2)	(2)	(2)		
1916	25- 50	.9	.263	.296	.139	3.809	3.378	7.187	88.2	(2)	(2)	(2)	(2)		
1915	25- 50	.9	.270	.326	.148	3.706	3.066	6.772	90.8	(2)	(2)	(2)	(2)		Mechanically filled.
1914	Under 25	.5	.120	.227	.078	8.329	4.414	12.743	72.0	(2)	(2)	(2)	(2)		
1913	25- 50	.9	.141	.265	.092	7.110	3.768	10.879	89.0	(2)	(2)	(2)	(2)		Hand filled; sand cast.

PLANT NO. 67

1920	25- 50	(2)	(1)	(1)	0.117	(1)	(2)	8.542	(2)	(2)	(2)	(2)	(2)		Mechanically filled; sand cast; idle since 1920; abandoned in 1925.

PLANT NO. 68

1923	25- 50	0.6	0.203	0.276	0.117	4.917	3.619	8.536	198.7	4,818		2,800	(2)		Idle since 1923.
1922	Under 25	.1	.201	.273	.116	4.982	3.667	8.649	131.0	4,854		2,615	(2)		Rebuilt.
1920	25- 50	.9	.214	.291	.124	4.664	3.433	8.097	140.2	4,415		2,564	(2)		Relined.
1919	25- 50	1.0	.145	.197	.083	6.902	5.081	11.983	85.0	3,844		(2)	(2)		
1918	25- 50	.8	.121	.165	.070	8.236	6.063	14.299	90.0	4,399		3,801	(2)		Hand filled; sand cast.

[1] Detail not available.

[2] Not reported.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 69

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity						Average output per stack-day	Consumption of materials per gross ton of pig iron produced				Per cent of production machine cast	Changes in stack, and charging and casting equipment
			Gross tons of pig iron produced per man-hour			Man-hours per gross ton of pig iron produced									
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Iron ore	Scrap	Coke	Flux		
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1920	25- 50	0.9	0.117	0.139	0.063	8.544	7.218	15.762	115.2	4,879	--------	3,531	(2)	---------	Relined in 1918 and 1921; idle since 1920.
1919	25- 50	.9	.111	.131	.060	9.015	7.615	16.630	109.1	5,006	--------	3,686	(2)	---------	
1917	25- 50	1.0	.109	.129	.059	9.200	7.772	16.972	109.1	5,701	--------	3,858	(2)	---------	Hand filled; sand cast.

PLANT NO. 70

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1921	25- 50	0.6	(1)	(1)	0.108	(1)	(1)	9.301	122.8	(2)	--------	(2)	(2)	---------	Idle since 1921; relined in 1923.
1920	25- 50	1.0	(1)	(1)	.091	(1)	(1)	10.961	110.8	(2)	--------	(2)	(2)	---------	
1919	Under 25	.7	(1)	(1)	.083	(1)	(1)	11.980	96.0	(2)	--------	(2)	(2)	---------	
1918	25- 50	.9	(1)	(1)	.083	(1)	(1)	12.090	90.1	(2)	--------	(2)	(2)	---------	Hand filled; sand cast.

PLANT NO. 71

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1923	Under 25	0.5	(1)	(1)	0.069	(1)	(1)	14.405	77.7	5,331	--------	3,023	2,460	---------	Idle since 1923.
1922	Under 25	.3	(1)	(1)	.077	(1)	(1)	12.913	86.9	4,726	--------	2,659	2,126	---------	
1920	Under 25	.8	(1)	(1)	.072	(1)	(1)	13.920	80.0	4,621	--------	3,047	2,023	---------	
1919	Under 25	.4	(1)	(1)	.079	(1)	(1)	12.637	85.5	4,442	--------	2,935	1,720	---------	
1918	25- 50	1.0	(1)	(1)	.085	(1)	(1)	11.700	93.7	4,437	--------	2,672	1,586	---------	
1917	25- 50	.8	(1)	(1)	.082	(1)	(1)	12.208	91.6	4,596	--------	2,736	1,886	---------	Hand filled; sand cast.

PLANT NO. 72

1926	25- 50	0.6	0.446	0.468	0.229	2.240	2.135	4.376	174.3	3,488	347	2,029	791	100	Mechanically filled; pig machine.

PLANT NO. 73

1927 [3]	Under 25	0.9	0.193	0.333	0.122	5.170	2.999	8.169	124.0	(2)	--------	(2)	(2)	--------	
1926	Under 25	.2	.183	.312	.115	5.456	3.210	8.666	119.7	(2)	--------	(2)	(2)	--------	
1925	Under 25	.2	(1)	(1)	.112	(1)	(1)	8.893	116.6	(2)	--------	(2)	(2)	--------	
1923	25- 50	.8	.221	.375	.139	4.535	2.663	7.199	104.1	(2)	--------	(2)	(2)	--------	
1920	25- 50	1.0	(2)	(2)	.078	(1)	(1)	12.785	80.4	(2)	--------	(2)	(2)	--------	
1919	Under 25	.5	(2)	(2)	.084	(1)	(1)	11.947	102.2	(2)	--------	(2)	(2)	--------	Relined.
1918	25- 50	1.0	(2)	(2)	.070	(1)	(1)	14.194	88.6	(2)	--------	(2)	(2)	--------	
1917	25- 50	.9	(2)	(2)	.070	(1)	(1)	14.220	87.9	(2)	--------	(2)	(2)	--------	
1914	25- 50	.9	(2)	(2)	.094	(1)	(1)	10.604	89.5	(2)	--------	(2)	(2)	--------	
1913	25- 50	.9	(2)	(2)	.082	(1)	(1)	12.157	81.9	(2)	--------	(2)	(2)	--------	
1912	25- 50	.8	(2)	(2)	.102	(1)	(1)	9.812	95.0	(2)	--------	(2)	(2)	--------	
1911	25- 50	1.0	(2)	(2)	.107	(1)	(1)	9.385	98.0	(2)	--------	(2)	(2)	--------	Hand filled; sand cast.

PLANT NO. 74

1922	Under 25	0.1	(1)	(1)	0.138	(1)	(1)	7.222	106.6	(2)	(2)	(2)	(2)	--------	Idle since 1922.
1921	Under 25	.2	(1)	(1)	.139	(1)	(1)	7.173	116.8	(2)	(2)	(2)	(2)	--------	Mechanically filled.
1920	25- 50	1.0	(1)	(1)	.081	(1)	(1)	12.276	75.9	(2)	(2)	(2)	(2)	--------	Hand filled; sand cast.

PLANT NO. 75

1922	Under 25	0.3	(1)	(1)	0.105	(1)	(1)	9.509	70.0	(2)	(2)	(2)	(2)	--------	Idle since 1922.
1921	Under 25	.1	(1)	(1)	.082	(1)	(1)	12.169	54.2	(2)	(2)	(2)	(2)	--------	
1920	Under 25	1.2	(1)	(1)	.081	(1)	(1)	12.385	52.9	(2)	(2)	(2)	(2)	--------	Hand filled, sand cast.

[1] Detail not available. [2] Not reported. [3] First 6 months only.

TABLE A.—*Labor productivity, production, output per stack-day, consumption of materials charged, and changes in equipment, in merchant blast furnaces, by plants and by years, 1911 to 1927*—Continued

PLANT NO. 76

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour			Average labor productivity: Man-hours per gross ton of pig iron produced			Average output per stack-day	Consumption of materials per gross ton of pig iron produced				Per cent of production machine cast	Changes in stack, and charging and casting equipment
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Iron ore	Scrap	Coke	Flux		
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1924	Under 25	0.4	[1]	[1]	0.121	[1]	[1]	8.233	131.2	[2]	[2]	[2]	[2]	--------	Idle since 1924.
1923	25–50	.6	[1]	[1]	.106	[1]	[1]	9.471	114.0	[2]	[2]	[2]	[2]	--------	Hand filled; sand cast.

PLANT NO. 77

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1921	Under 25	0.4	0.133	0.251	0.087	7.494	3.982	11.476	71.9	4,945	--------	3,159	[2]	--------	Idle since 1921.
1920	Under 25	.9	.132	.248	.086	7.591	4.034	11.625	75.7	4,545	--------	2,749	[2]	--------	
1919	Under 25	.5	.122	.229	.079	8.220	4.368	12.588	80.4	4,471	--------	2,832	[2]	--------	
1818	Under 25	.8	.124	.233	.081	8.080	4.294	12.374	79.1	4,798	--------	2,879	[2]	--------	Hand filled; sand cast.

PLANT NO. 78

Year	Production of thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Iron ore	Scrap	Coke	Flux	Per cent of production machine cast	Changes in stack, and charging and casting equipment
1923	Under 25	0.4	[1]	[1]	0.086	[1]	[1]	11.574	119.2	[2]	--------	[2]	[2]	--------	Hand filled; sand cast; idle since 1923.

PLANT NO. 79

1920	Under 25	0.4	(1)	(1)	0.079	(1)	(1)	12.734	76.0	(2)	----	(2)	(2)	----	Hand filled; sand cast; idle since 1920.

PLANT NO. 80

1920	Under 25	(2)	(2)	(1)	0.214	(1)	(1)	4.667	(2)	(2)	(2)	(2)	(2)	100	Pig machine; method of charging not reported; idle since 1920; abandoned in 1925.

[1] Detail not available.

[2] Not reported.

LABOR PRODUCTIVITY, PRODUCTION, CASTING, IN MERCHANT BLAST FURNACES, BY YEARS AND BY PLANTS, 1911 TO 1927

In Table B all plants covered in this study are classified by years; in each year are included all plants having productivity data available for that year; the plants are listed in the order of their productivity record, from the highest to the lowest. The data included in this table are the same as those in Table A except that data covering consumption of material are omitted from Table B. For explanation of items see explanation of Table A, page 69.

TABLE B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour			Average labor productivity: Man-hours per gross ton of pig iron produced			Average output per stack-day (gross tons)	Method of—	
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Charging	Casting
1927 (FIRST SIX MONTHS)											
3	225–250	2.0	1.060	1.552	0.630	0.943	0.644	1.587	657.9	Mechanical	Machine.
4	100–125	1.0	(1)	(1)	.572	(1)	(1)	1.749	564.0	do	Do.
17	75–100	1.0	1.562	.706	.486	.640	1.416	2.056	492.2	do	Do.
9	75–100	1.1	.988	.790	.439	1.012	1.265	2.277	404.7	do	Do.
26	50–75	1.0	1.011	.710	.417	.989	1.408	2.397	383.0	do	Do.
56	50–75	.8	1.437	.587	.417	.696	1.705	2.400	495.4	do	Do.
33	25–50	.6	.917	.758	.415	1.091	1.319	2.410	359.0	do	Do.
6	125–150	2.0	1.216	.610	.406	.822	1.640	2.463	408.5	do	Do.
20	50–75	1.0	1.289	.565	.393	.776	1.770	2.546	412.0	do	Do.
19	50–75	1.0	.707	.713	.355	1.415	1.402	2.817	414.8	do	Do.
37	50–75	.8	1.185	.451	.327	.844	2.217	3.061	459.7	do	Do.
7	125–150	2.0	.848	.515	.321	1.179	1.940	3.119	410.0	do	Do.
5	125–150	1.6	1.213	.366	.281	.824	2.736	3.560	498.9	do	Do.
51	25–50	.9	.587	.504	.271	1.705	1.984	3.689	262.8	do	Do.
18	75–100	1.9	.509	.390	.221	1.964	2.566	4.530	252.4	do	Sand.
38	50–75	1.0	.525	.339	.206	1.906	2.947	4.851	289.6	do	Do.
31	25–50	1.0	.504	.331	.200	1.982	3.023	5.005	206.4	do	Machine.
15	50–75	1.0	.310	.306	.154	3.226	3.271	6.497	316.2	Hand	Sand.
30	125–150	2.0	(1)	(1)	.152	(1)	(1)	6.597	380.5	Mechanical	Machine.
40	50–75	1.0	.350	.255	.147	2.857	3.929	6.786	222.7	do	Sand.
73	Under 25	.9	.193	.333	.122	5.170	2.999	8.169	124.0	Hand	Do.
1926											
3	450–475	2.0	0.969	1.400	0.573	1.032	0.714	1.746	648.7	Mechanical	Machine.
25	125–150	1.0	(1)	(1)	.536	(1)	(1)	1.866	368.3	do	Do.
12	225–250	1.7	(1)	(1)	.529	(1)	(1)	1.890	396.7	do	Do.
23	125–150	1.0	1.353	.861	.526	.739	1.161	1.900	376.8	do	Do.
1	450–475	2.0	.838	1.222	.497	1.193	.818	2.012	617.0	do	Do.
17	150–175	1.0	1.507	.673	.465	.664	1.486	2.149	474.6	do	Do.
13	225–250	1.2	(1)	(1)	.465	(1)	(1)	2.149	520.5	do	Do.
21	100–125	.7	1.202	.736	.456	.833	1.359	2.193	486.2	do	Do.
4	275–300	1.5	1.731	.599	.445	.578	1.669	2.246	527.3	do	Do.
36	100–125	.9	.929	.789	.427	1.077	1.268	2.345	334.9	do	Do.
9	175–200	1.3	.910	.785	.421	1.099	1.274	2.375	380.9	do	Do.
26	125–150	1.0	.971	.659	.393	1.030	1.517	2.547	366.1	do	Do.
50	75–100	.9	.735	.800	.383	1.360	1.250	2.610	262.1	do	Do.
16	75–100	.7	.854	.685	.380	1.171	1.461	2.632	392.3	do	Do.
56	25–50	.3	1.194	.544	.374	.837	1.838	2.676	411.0	do	Do.

[1] Detail not available.

Table B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1926—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity						Average output per stack-day (gross tons)	Method of—	
			Gross tons of pig iron produced per man-hour			Man-hours per gross ton of pig iron produced					
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Charging	Casting
8	100–125	0.7	0.520	1.223	0.365	1.921	0.818	2.739	441.1	Mechanical	Machine.
2	275–300	2.3	1.152	.524	.360	.868	1.909	2.777	345.6	do	Sand and machine.
19	150–175	1.0	.727	.668	.348	1.375	1.498	2.873	432.5	do	Machine.
33	100–125	1.0	.736	.636	.341	1.359	1.573	2.932	325.0	do	Do.
34	100–125	.7	.686	.659	.336	1.460	1.518	2.978	442.7	do	Do.
28	125–150	.8	.631	.672	.326	1.585	1.488	3.072	454.4	Hand	Do.
20	75–100	.6	1.226	.427	.317	.816	2.342	3.157	378.0	Mechanical	Do.
22	125–150	.9	[1]	[1]	.294	[1]	[1]	3.401	386.0	do	Do.
5	350–375	1.9	1.252	.377	.290	.799	2.651	3.450	506.2	do	Do.
6	225–250	1.8	1.006	.393	.283	.994	2.543	3.536	359.1	do	Do.
7	250–275	1.9	.816	.424	.279	1.226	2.358	3.584	392.8	do	Do.
45	75–100	.9	[1]	[1]	.259	[1]	[1]	3.856	298.2	Hand	Do.
27	125–150	1.0	.751	.393	.258	1.331	2.543	3.874	360.5	Mechanical	Do.
42	100–125	1.0	.695	.363	.239	1.438	2.754	4.192	283.4	do	Do.
72	25–50	.6	.446	.468	.229	2.240	2.135	4.376	174.3	do	Do.
57	50–75	.9	.550	.389	.229	1.818	2.574	4.392	209.5	do	Sand.
66	50–75	1.0	.503	.386	.218	1.988	2.592	4.581	142.7	do	Do.
38	100–125	1.0	.543	.352	.214	1.841	2.837	4.678	299.9	do	Do.
39	25–50	.4	.466	.391	.212	2.157	2.556	4.713	278.2	do	Machine.
58	50–75	.7	.518	.347	.208	1.931	2.881	4.813	261.0	do	Do.
37	100–125	.8	.740	.282	.204	1.351	3.551	4.902	401.0	do	Do.
48	25–50	.4	[1]	[1]	.201	[1]	[1]	4.985	247.0	Hand	Sand.
46	25–50	.5	.442	.367	.200	2.264	2.727	4.991	270.0	Mechanical	Machine.
31	50–75	1.0	.529	.319	.199	1.892	3.131	5.023	203.7	do	Do.
55	50–75	.9	.369	.326	.173	2.709	3.066	5.775	176.4	Hand	Do.
18	100–125	1.4	.455	.278	.173	2.197	3.599	5.796	233.1	Mechanical	Sand.
54	75–100	1.0	.472	.271	.172	2.121	3.687	5.808	217.7	do	Machine.
15	175–200	2.0	.263	.421	.162	3.803	2.378	6.181	250.5	Hand	Sand.
52	75–100	.9	[1]	[1]	.149	[1]	[1]	6.730	242.1	Mechanical	Do.
40	50–75	.6	.345	.251	.145	2.900	3.989	6.889	317.9	do	Do.
14	25–50	.4	.423	.216	.143	2.362	4.635	6.997	300.8	Hand	Machine.
30	250–275	2.0	[1]	[1]	.130	[1]	[1]	7.669	354.6	Mechanical	Sand.
73	Under 25	.2	.183	.312	.115	5.456	3.210	8.666	119.7	Hand	Do.
47	Under 25	.1	[1]	[1]	.115	[1]	[1]	8.693	124.2	Hand and mechanical.	Do.

1925

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Charging	Casting
3	425–450	2.0	0.890	1.205	0.512	1.124	0.830	1.954	596.7	Mechanical	Machine.
12	200–225	1.4	[1]	[1]	.478	[1]	[1]	2.093	391.1	do	Do.
4	275–300	1.3	1.868	.639	.476	.535	1.565	2.100	617.8	do	Do.
25	125–150	.9	[1]	[1]	.473	[1]	[1]	2.116	374.8	do	Do.
13	175–200	1.0	.766	1.122	.455	1.305	.891	2.197	503.3	do	Do.
9	150–175	1.0	.984	.800	.441	1.016	1.250	2.266	431.7	do	Do.
1	525–550	2.5	.742	1.083	.440	1.347	.923	2.271	578.7	do	Do.
23	75–100	.8	1.120	.713	.436	.893	1.403	2.295	323.6	do	Do.
36	75–100	.8	.893	.828	.430	1.120	1.208	2.328	317.9	do	Do.
21	100–125	.6	1.119	.686	.425	.893	1.458	2.351	505.8	do	Do.
17	150–175	1.0	1.372	.615	.425	.729	1.625	2.354	432.3	do	Do.
50	75–100	.9	.767	.859	.405	1.303	1.164	2.468	259.4	do	Do.
19	75–100	.6	.708	.813	.379	1.412	1.229	2.642	387.1	do	Do.
33	100–125	1.0	.717	.771	.371	1.394	1.298	2.692	321.0	do	Do.
8	50–75	.4	.522	1.227	.366	1.915	.815	2.731	453.5	do	Do.
20	150–175	1.0	1.250	.477	.345	.800	2.099	2.898	418.0	do	Do.
22	125–150	1.0	[1]	[1]	.326	[1]	[1]	3.066	392.0	do	Do.
28	75–100	.6	[1]	[1]	.321	[1]	[1]	3.117	441.5	Hand	Do.
6	275–300	2.2	.924	.475	.314	1.082	2.104	3.187	341.7	Mechanical	Do.
34	25–50	.3	.577	.687	.314	1.732	1.456	3.188	439.9	do	Do.
5	325–350	2.0	1.026	.414	.295	.975	2.416	3.390	457.7	do	Do.
45	100–125	1.0	[1]	[1]	.288	[1]	[1]	3.471	276.8	Hand	Do.
7	250–275	2.0	[1]	[1]	.270	[1]	[1]	3.703	363.1	Mechanical	Do.

[1] Detail not available.

5421°—29——8

TABLE B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1925—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour			Average labor productivity: Man-hours per gross ton of pig iron produced			Average output per stack-day (gross tons)	Method of—	
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Charging	Casting
38	75–100	0.9	0.546	0.373	0.222	1.830	2.682	4.513	299.8	Mechanical	Sand.
51	25– 50	.5	.564	.344	.214	1.772	2.900	4.672	248.3	do	Machine.
39	75–100	1.0	.451	.381	.207	2.215	2.626	4.841	268.4	do	Do.
46	25– 50	.3	.435	.390	.206	2.300	2.566	4.865	291.9	do	Do.
66	25– 50	1.0	.460	.362	.203	2.172	2.760	4.932	133.6	do	Sand.
58	25– 50	.5	.467	.348	.199	2.143	2.872	5.015	235.2	do	Machine.
42	50– 75	.6	.541	.283	.186	1.848	3.540	5.388	247.0	do	Do.
18	150–175	2.0	.429	.326	.185	2.330	3.064	5.395	210.8	do	Sand.
31	50– 75	1.0	.477	.290	.181	2.096	3.443	5.539	182.8	do	Machine.
41	50– 75	.5	.283	.497	.180	3.536	2.014	5.550	329.7	Hand	Sand.
43	25– 50	.3	.406	.317	.178	2.461	3.153	5.614	220.8	Mechanical	Do.
15	175–200	2.0	.259	.439	.163	3.855	2.275	6.130	247.2	Hand	Do.
55	25– 50	.4	.279	.385	.162	3.583	2.598	6.181	212.3	do	Machine.
54	50– 75	1.0	.399	.230	.146	2.503	4.353	6.856	176.5	Mechanical	Do.
27	Under 25	[2] .0	.412	.216	.142	2.424	4.630	7.054	185.0	do	Do.
30	200–225	1.9	[1]	[1]	.135	[1]	[1]	7.403	315.8	do	Sand.
52	50– 75	.9	[1]	[1]	.124	[1]	[1]	8.086	197.9	do	Do.
47	25– 50	1.0	[1]	[1]	.122	[1]	[1]	8.191	133.1	Hand and mechanical.	Do.
73	Under 25	.2	[1]	[1]	.112	[1]	[1]	8.893	116.6	Hand	Do.
40	50– 75	.8	.248	.181	.105	4.025	5.535	9.560	229.1	Mechanical	Do.

1924

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Charging	Casting
23	50– 75	0.6	1.197	0.762	0.466	0.835	1.312	2.147	320.7	Mechanical	Machine.
1	275–300	1.4	.781	1.140	.464	1.280	.877	2.157	531.9	do	Do.
12	200–225	1.5	[1]	[1]	.449	[1]	[1]	2.227	366.5	do	Do.
36	75–100	.8	[1]	[1]	.445	[1]	[1]	2.245	329.6	do	Do.
13	125–150	.9	.720	1.032	.424	1.390	.969	2.358	464.1	do	Do.
9	125–150	1.0	.930	.762	.419	1.075	1.312	2.388	430.0	do	Do.
3	275–300	1.5	.714	.997	.416	1.400	1.003	2.403	524.1	do	Do.
4	250–275	1.3	1.907	.510	.402	.524	1.962	2.486	549.2	do	Do.
25	100–125	.8	[1]	[1]	.389	[1]	[1]	2.570	408.9	od	Do.
21	150–175	.8	1.011	.620	.384	.988	1.612	2.600	504.6	do	Do.
19	25– 50	.3	.679	.877	.383	1.472	1.140	2.612	367.2	do	Do.
32	25– 50	.4	.898	.646	.376	1.114	1.547	2.662	323.1	do	Do.
50	25– 50	.5	.599	.709	.325	1.669	1.410	3.080	215.2	do	Do.
16	50– 75	.3	1.105	.429	.309	.905	2.329	3,233	512.0	do	Do.
33	75–100	.7	.485	.688	.284	2.063	1.453	3.516	303.0	do	Sand.
28	75–100	.5	[1]	[1]	.278	[1]	[1]	3.601	444.4	Hand	Do.
8	75–100	.4	.375	1.135	.263	2.669	.881	3.804	566.3	Mechanical	Machine.
2	350–375	3.0	.663	.433	.262	1.509	2.312	3.821	326.0	do	Sand and machine.
45	50– 75	.6	[1]	[1]	.255	[1]	[1]	3.923	293.3	Hand	Machine.
6	225–250	2.0	[1]	[1]	.251	[1]	[1]	3.982	317.2	Mechanical	Do.
7	250–275	1.9	[1]	[1]	.250	[1]	[1]	3.999	375.5	do	Do.
22	100–125	.8	[1]	[1]	.229	[1]	[1]	4.364	381.0	do	Do.
17	50– 75	.4	[1]	[1]	.222	[1]	[1]	4.509	335.2	do	Do.
14	75–100	.6	.516	.380	.219	1.938	2.630	4.568	354.5	Hand	Do.
39	50– 75	.8	.466	.407	.217	2.147	2.459	4.605	241.6	Mechanical	Do.
53	50– 75	.8	.389	.486	.216	2.570	2.061	4.630	204.2	do	Sand.
5	150–175	1.0	.890	.284	.215	1.124	3.517	4,641	451.3	do	Machine.
46	Under 25	.2	.460	.379	.208	2.174	2.641	4,815	144.3	do	Do.
20	75–100	.8	.606	.314	.207	1.651	3.187	4.837	346.0	do	Do.
18	150–175	2.0	.471	.361	.204	2.124	2.774	4.898	233.0	do	Sand.
58	Under 25	.1	.462	.333	.194	2.162	3.000	5.162	238.6	do	Machine.
66	25– 50	1.0	.408	.336	.184	2.448	2.980	5.429	120.0	do	Sand.
27	50– 75	.5	.534	.280	.184	1.871	3.574	5.445	332.7	do	Machine.
51	25– 50	.4	.437	.294	.176	2.289	3.398	5.687	248.1	do	Sand.
43	50– 75	.7	.429	.291	.173	2.330	3.441	5.772	236.1	do	Do.

[1] Detail not available.
[2] Plant operated less than 18 days during the year.

TABLE B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1924—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Method of—: Charging	Casting
41	100-125	1.0	0.268	0.440	0.166	3.736	2.273	6.009	293.0	Hand	Sand.
38	25- 50	.4	.400	.263	.159	2.503	3.800	6.303	219.5	Mechanical	Do.
31	50- 75	1.0	.425	.248	.157	2.355	4.032	6.387	177.2	do	Machine.
59	50- 75	.9	.377	.267	.156	2.654	3.745	6.399	180.9	do	Do.
54	50- 75	1.0	.425	.244	.155	2.354	4.093	6.447	196.1	do	Do.
55	25- 50	.7	.262	.328	.146	3.818	3.048	6.866	191.2	Hand	Do.
30	225-250	2.0	(1)	(1)	.144	(1)	(1)	6.956	321.9	Mechanical	Sand.
11	Under 25	.3	.295	.267	.140	3.385	3.748	7.133	193.0	Hand and mechanical.	Sand and machine.
15	75-100	.9	.273	.285	.139	3.665	3.512	7.177	278.2	Hand	Sand.
40	100-125	1.0	.318	.231	.134	3.144	4.324	7.468	293.3	Mechanical	Do.
52	Under 25	.1	(1)	(1)	.126	(1)	(1)	7.968	192.0	do	Do.
76	Under 25	.4	(1)	(1)	.121	(1)	(1)	8.233	131.2	Hand	Do.
60	Under 25	.5	.223	.184	.101	4.488	5.424	9.912	122.1	do	Do.
47	25- 50	.9	(1)	(1)	.096	(1)	(1)	10.450	132.6	Hand and mechanical.	Do.

1923

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Charging	Casting
1	500-525	2.7	0.872	0.981	0.462	1.147	1.019	2.166	508.3	Mechanical	Machine.
25	125-150	1.0	(1)	(1)	.459	(1)	(1)	2.179	356.0	do	Do.
3	325-350	2.0	.889	1.060	.456	1.251	.943	2.194	477.5	do	Do.
4	300-325	1.7	1.795	.532	.411	.557	1.877	2.434	517.7	do	Do.
13	150-175	1.0	.674	.975	.398	1.484	1.026	2.510	462.6	do	Do.
32	100-125	.9	.730	.692	.355	1.371	1.445	2.816	336.1	do	Do.
12	175-200	1.6	(1)	(1)	.343	(1)	(1)	2.917	330.7	do	Do.
23	25- 50	.5	.847	.539	.329	1.181	1.855	3.037	253.4	do	Do.
22	100-125	.7	(1)	(1)	.327	(1)	(1)	3.055	431.0	do	Do.
5	300-325	2.0	(1)	(1)	.318	(1)	(1)	3.141	444.6	do	Do.
36	Under 25	.3	.620	.614	.309	1.612	1.628	3.240	260.5	do	Do.
8	150-175	1.1	(1)	(1)	.294	(1)	(1)	3.407	382.0	do	Do.
16	125-150	.7	(1)	(1)	.280	(1)	(1)	3.566	493.4	do	Do.
24	25- 50	(3)	(1)	(1)	.268	(1)	(1)	3.729	(3)	do	Do.
33	100-125	1.0	.418	.733	.266	2.395	1.365	3.760	308.0	do	Sand.
6	300-325	2.5	(1)	(1)	.248	(1)	(1)	4.033	325.4	do	Machine.
2	425-450	3.7	.579	.421	.244	1.726	2.376	4.102	330.8	do	Sand and machine.
28	100-125	.7	(1)	(1)	.241	(1)	(1)	4.150	402.4	Hand	Sand.
7	225-250	1.8	(1)	(1)	.231	(1)	(1)	4.322	346.8	Mechanical	Machine.
45	50- 75	.6	(1)	(1)	.224	(1)	(1)	4.459	287.5	Hand	Do.
21	100-125	.7	(1)	(1)	.224	(1)	(1)	4.466	448.0	Mechanical	Do.
50	50- 75	.7	.319	.703	.219	3.136	1.423	4.559	212.5	do	Sand.
14	200-225	1.7	.497	.388	.218	2.010	2.578	4.588	341.0	Hand	Machine.
39	75-100	.8	.458	.400	.213	2.185	2.503	4.688	255.1	Mechanical	Do.
20	125-150	1.0	.526	.356	.212	1.900	2.808	4.708	377.0	Hand	Do.
18	150-175	2.0	.422	.392	.203	2.369	2.551	4.919	226.5	Mechanical	Sand.
19	100-125	.9	.334	.518	.203	2.992	1.932	4.924	344.8	Hand	Machine.
27	125-150	1.0	.741	.278	.202	1.350	3.592	4.942	360.7	Mechanical	Do.
34	75-100	1.2	.368	.437	.200	2.714	2.286	5.000	197.1	Hand and mechanical.	Do.
35	25- 50	.3	(1)	(1)	.198	(1)	(1)	5.041	370.0	(3)	Do.
53	50- 75	.7	.354	.441	.196	2.826	2.266	5.092	212.1	Mechanical	Sand.
46	50- 75	.6	.360	.374	.184	2.777	2.670	5.447	298.1	do	Machine.
59	50- 75	1.0	.389	.276	.161	2.570	3.629	6.198	182.1	do	Do.
41	100-125	1.0	.263	.403	.159	3.798	2.484	6.282	290.9	Hand	Sand.
52	50- 75	.7	(1)	(1)	.158	(1)	(1)	6.316	224.8	Mechanical	Do.
66	25- 50	.7	.350	.287	.158	2.858	3.480	6.338	120.8	do	Do.
17	50- 75	.7	(1)	(1)	.154	(1)	(1)	6.474	265.0	Hand	Machine.
38	25- 50	.5	.407	.247	.154	2.455	4.054	6.509	223.1	Mechanical	Sand.
57	50- 75	1.0	.370	.261	.153	2.704	3.827	6.531	199.7	Hand	Do.
49	50- 75	.7	.291	.320	.152	3.439	3.127	6.566	207.6	Mechanical	Do.
43	25- 50	.7	.364	.261	.152	2.745	3.826	6.571	192.4	do	Do.
48	50- 75	.7	.274	.313	.146	3.645	3.196	6.841	250.0	Hand	Do.
44	Under 25	.2	(1)	(1)	.145	(1)	(1)	6.904	281.6	(3)	Machine.

1 Detail not reported.

3 Not reported.

TABLE B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1923—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Method of—: Charging	Casting
54	25- 50	0.6	0.392	0.225	0.143	2.551	4.435	6.986	159.0	Mechanical	Machine.
73	25- 50	.8	.221	.375	.139	4.535	2.663	7.199	104.1	Hand	Sand.
30	225-250	2.0	(1)	(1)	.139	(1)	(1)	7.204	319.1	Mechanical	Do.
55	50- 75	1.0	.240	.307	.135	4.163	3.258	7.421	183.9	Hand	Machine.
15	75-100	1.1	.239	.303	.133	4.190	3.304	7.494	237.3	do	Sand.
31	50- 75	1.0	.425	.193	.133	2.353	5.188	7.542	181.0	Mechanical	Do.
40	75-100	1.0	.292	.212	.123	3.427	4.713	8.139	269.1	do	Do.
47	50- 75	1.0	(1)	(1)	.122	(1)	(1)	8.218	155.8	Hand and mechanical.	Do.
68	25- 50	.6	.203	.276	.117	4.917	3.619	8.536	198.7	Hand	Do.
51	50- 75	.7	.366	.171	.117	2.732	5.843	8.575	209.0	Mechanical	Do.
42	50- 75	.8	.202	.257	.113	4.943	3.884	8.827	230.8	Hand	Machine.
60	25- 50	.7	.239	.197	.108	4.191	5.066	9.257	130.7	do	Sand.
76	25- 50	.6	(1)	(1)	.106	(1)	(1)	9.471	114.0	do	Do.
11	50- 75	.9	.214	.206	.105	4.664	4.845	9.509	171.1	Hand and mechanical.	Sand and machine.
78	Under 25	.4	(1)	(1)	.086	(1)	(1)	11.574	119.2	Hand	Sand.
65	25- 50	.6	.140	.220	.085	7.169	4.544	11.713	136.2	do	Do.
71	Under 25	.3	(1)	(1)	.069	(1)	(1)	14.405	77.7	do	Do.
1922											
1	400-425	2.0	0.835	0.940	0.442	1.197	1.064	2.262	557.3	Mechanical	Machine.
13	150-175	1.0	.786	.977	.436	1.272	1.024	2.296	460.3	do	Do.
16	50- 75	.2	(1)	(1)	.371	(1)	(1)	2.697	613.0	do	Do.
9	125-150	1.0	.784	.642	.353	1.276	1.557	2.833	378.1	do	Do.
3	225-250	1.3	.526	.782	.314	1.902	1.279	3.181	509.3	do	Do.
22	100-125	.7	(1)	(1)	.312	(1)	(1)	3.203	419.0	do	Do.
32	25- 50	.4	.627	.597	.306	1.595	1.676	3.270	318.5	do	Do.
12	125-150	1.1	(1)	(1)	.290	(1)	(1)	3.447	324.8	do	Do.
33	50- 75	.5	.415	.717	.263	2.412	1.394	3.806	303.0	do	Sand.
4	175-200	1.2	(1)	(1)	.243	(1)	(1)	4.108	416.0	do	Machine.
6	175-200	1.4	(1)	(1)	.241	(1)	(1)	4.155	322.5	do	Do.
28	75-100	.5	.381	.642	.239	2.625	1.558	4.183	416.0	Hand	Sand.
5	200-225	1.2	(1)	(1)	.235	(1)	(1)	4.248	450.0	Mechanical	Machine.
21	Under 25	.1	(1)	(1)	.227	(1)	(1)	4.412	340.6	do	Do.
39	75-100	1.0	.467	.422	.222	2.423	2.367	4.507	263.5	do	Do.
20	75-100	.8	.471	.409	.219	2.121	2.445	4.566	356.0	Hand	Do.
7	150-175	1.2	.736	.308	.217	1.359	3.249	4.607	350.3	Mechanical	Do.
19	75-100	.7	.338	.562	.211	2.963	1.779	4.741	336.5	Hand	Do.
66	Under 25	.2	.412	.418	.207	2.428	2.390	4.819	148.7	Mechanical	Sand.
46	Under 25	.1	.396	.412	.202	2.525	2.429	4.954	281.8	do	Machine.
53	25- 50	.5	.353	.440	.200	2.832	2.271	5.103	235.2	do	Sand.
43	75-100	1.0	.421	.313	.180	2.372	3.197	5.569	220.9	do	Do.
34	Under 25	.1	.394	.309	.173	2.539	3.232	5.772	213.6	Hand	Machine.
18	75-100	1.2	.383	.287	.164	2.613	3.484	6.097	205.4	Mechanical	Sand.
55	50- 75	.9	.289	.372	.163	3.460	2.689	6.149	204.9	Hand	Machine.
57	Under 25	.3	.392	.277	.162	2.548	3.607	6.156	195.0	do	Sand.
49	25- 50	.6	.288	.311	.150	3.470	3.211	6.681	210.1	Mechanical	Do.
30	200-225	1.7	(1)	(1)	.149	(1)	(1)	6.711	337.8	do	Do.
31	25- 50	.6	.483	.212	.147	2.072	4.712	6.784	177.2	do	Do.
54	25- 50	.5	.304	.255	.139	3.285	3.922	7.207	167.6	do	Do.
74	Under 25	.1	(1)	(1)	.138	(1)	(1)	7.222	106.6	do	Do.
15	50- 75	.6	.265	.273	.134	3.777	3.667	7.444	256.5	Hand	Do.
52	Under 25	.2	(1)	(1)	.125	(1)	(1)	7.999	172.5	Mechanical	Do.
47	Under 25	.2	(1)	(1)	.117	(1)	(1)	8.567	148.9	Hand and mechanical.	Do.
68	Under 25	.1	.201	.273	.116	4.982	3.667	8.649	131.0	Hand	Do.
11	Under 25	.2	.218	.225	.111	4.586	4.436	9.021	206.5	Hand and mechanical.	Sand and machine.
59	25- 50	.6	.242	.193	.107	4.133	5.174	9.307	136.6	Mechanical	Machine.
75	Under 25	.3	(1)	(1)	.105	(1)	(1)	9.509	70.0	Hand	Sand.
65	Under 25	.2	.149	.236	.091	6.699	4.246	10.945	145.7	do	Do.
71	Under 25	.3	(1)	(1)	.077	(1)	(1)	12.913	86.9	do	Do.

[1] Detail not available.

TABLE B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1921

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Method of—: Charging	Casting
1	200–225	1.0	0.809	0.910	0.428	1.236	1.099	2.334	574.4	Mechanical	Machine.
3	175–200	1.0	(1)	(1)	.340	(1)	(1)	2.943	525.5	do	Do.
16	Under 25	.1	(1)	(1)	.332	(1)	(1)	3.016	513.1	do	Do.
32	50–75	.5	.677	.639	.329	1.478	1.564	3.043	347.1	do	Do.
12	25–50	.4	(1)	(1)	.249	(1)	(1)	4.011	311.7	do	Do.
28	50–75	.5	.365	.655	.234	2.741	1.526	4.267	398.5	Hand	Sand.
39	Under 25	.2	.473	.428	.225	2.112	2.338	4.451	261.0	Mechanical	Machine
4	25–50	.4	(1)	(1)	.214	(1)	(1)	4.680	351.2	do	Do.
18	25–50	.5	.532	.334	.205	1.879	2.998	4.877	243.8	do	Sand.
5	50–75	.5	(1)	(1)	.181	(1)	(1)	5.512	395.4	do	Machine.
20	75–100	.7	(1)	(1)	.178	(1)	(1)	5.613	367.0	Hand	Do.
14	50–75	.5	.342	.325	.167	2.924	3.073	5.997	395.9	do	Do.
54	Under 25	.3	.354	.296	.161	2.828	3.377	6.205	178.0	Mechanical	Sand.
55	75–100	1.0	.281	.377	.161	3.556	2.652	6.208	212.6	Hand	Machine.
57	Under 25	.1	.384	.272	.159	2.604	3.686	6.290	190.8	do	Sand.
53	Under 25	.3	.286	.357	.159	3.491	2.799	6.290	203.5	Mechanical	Do.
27	Under 25	.1	.559	.221	.159	1.789	4.518	6.307	249.9	Hand	Do.
34	25–50	.5	.352	.279	.156	2.843	3.586	6.428	219.9	do	Machine.
66	25–50	.6	.312	.310	.155	3.210	3.227	6.436	112.5	Mechanical	Sand.
7	Under 25	.2	(1)	(1)	.155	(1)	(1)	6.444	375.5	do	Machine.
19	25–50	.3	.237	.411	.150	4.222	2.431	6.653	321.3	Hand	Do.
6	100–125	1.0	(1)	(1)	.143	(1)	(1)	7.002	312.6	Mechanical	Do.
74	Under 25	.2	(1)	(1)	.139	(1)	(1)	7.173	116.8	do	Sand.
30	50–75	.4	(1)	(1)	.137	(1)	(1)	7.307	337.8	do	Do.
43	Under 25	(2)	.324	.233	.136	3.083	4.286	7.369	169.5	do	Do.
24	Under 25	(3)	(1)	(1)	.131	(1)	(1)	7.645	(3)	do	Machine.
31	Under 25	.1	.398	.176	.122	2.510	5.683	8.192	163.0	do	Sand.
2	100–125	1.0	.295	.202	.120	3.388	4.947	8.335	284.8	do	Do.
47	Under 25	.2	(1)	(1)	.119	(1)	(1)	8.371	155.1	Hand and mechanical.	Do.
70	25–50	.6	(1)	(1)	.108	(1)	(1)	9.301	122.8	Hand	Do.
60	Under 25	.4	.235	.194	.106	4.263	5.152	9.415	134.4	do	Do.
77	Under 25	.4	.133	.251	.087	7.494	3.982	11.476	71.9	do	Do.
75	Under 25	.1	(1)	(1)	.082	(1)	(1)	12.169	54.2	do	Do.
11	25–50	1.1	.148	.153	.075	6.744	6.523	13.267	127.6	Hand and mechanical.	Sand and machine.
15	Under 25	.1	.137	.121	.064	7.318	8.279	15.597	218.1	Hand	Sand.
51	Under 25	.3	.352	(3)	(3)	2.837	(3)	(3)	195.9	Mechanical	Do.

1920

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Charging	Casting
1	475–500	2.9	0.843	0.948	0.446	1.186	1.054	2.241	464.7	Mechanical	Machine.
9	250–275	2.0	.883	.724	.398	1.132	1.381	2.513	350.1	do	Do.
3	325–350	1.9	(1)	(1)	.315	(1)	(1)	3.173	476.7	do	Do.
32	75–100	.8	.631	.572	.300	1.585	1.749	3.334	340.3	do	Do.
36	75–100	.8	.554	.601	.288	1.805	1.665	3.470	267.3	do	Do.
16	125–150	.9	(1)	(1)	.246	(1)	(1)	4.066	438.3	do	Do.
25	75–100	.8	.383	.586	.232	2.610	1.707	4.318	286.4	do	Do.
12	175–200	1.6	(1)	(1)	.231	(1)	(1)	4.327	323.6	do	Do.
45	75–100	.8	.377	.592	.230	2.651	1.689	4.340	267.6	Hand	Do.
80	Under 25	(3)	(1)	(1)	.214	(1)	(1)	4.667	(3)	(3)	Do.
24	125–150	(3)	(1)	(1)	.211	(1)	(1)	4.744	(3)	Mechanical	Do.
14	175–200	1.6	.426	.403	.207	2.345	2.480	4.825	347.8	Hand	Do.
28	100–125	.8	.361	.443	.199	2.769	2.260	5.028	394.4	do	Sand.
39	50–75	.8	.412	.372	.196	2.427	2.686	5.113	249.7	Mechanical	Machine.
6	[4] 300–325	2.6	.597	.288	.194	1.675	3.472	5.147	319.8	do	Do.
4	300–325	2.1	(1)	(1)	.189	(1)	(1)	5.278	389.3	do	Do.
20	100–125	1.0	(1)	(1)	.183	(1)	(1)	5.472	341.0	Hand	Do.
2	325–350	3.5	.410	.286	.168	2.439	3.502	5.491	265.6	Mechanical	Sand.
46	75–100	.9	.315	.327	.161	3.175	3.054	6.229	283.8	do	Machine.

[1] Detail not available.
[2] Plant operated less than 18 days during year.
[3] Not reported.
[4] Fiscal year May 1, 1919, to Apr. 30, 1920.

TABLE B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1920—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Method of—: Charging	Casting
43	25- 50	0.6	0.365	0.281	0.159	2.739	3.560	6.299	217.7	Mechanical	Sand.
22	100-125	1.0	(1)	(1)	.155	(1)	(1)	6.464	324.0	do	Machine.
33	75-100	.9	.229	.449	.152	4.365	2.229	6.594	264.0	do	Sand.
7	200-225	1.8	(1)	(1)	.151	(1)	(1)	6.633	317.0	do	Machine.
19	75-100	.7	.232	.421	.150	4.305	2.377	6.682	314.0	Hand	Do.
49	50- 75	.8	.301	.290	.148	3.320	3.445	6.765	229.5	Mechanical	Sand.
57	50- 75	1.0	.350	.247	.144	2.866	4.057	6.923	184.9	Hand	Do.
55	50- 75	.9	.266	.302	.141	3.757	3.313	7.069	165.3	do	Machine.
61	25- 50	.6	(1)	(1)	.134	(1)	(1)	7.477	134.8	do	Sand.
27	75-100	1.0	.458	.181	.130	2.183	5.512	7.695	220.9	do	Do.
30	175-200	1.9	(1)	(1)	.125	(1)	(1)	8.019	273.2	Mechanical	Do.
68	25- 50	.9	.214	.291	.124	4.664	3.433	8.097	140.2	Hand	Do.
53	75-100	1.0	.213	.266	.118	4.697	3.766	8.464	212.7	do	Do.
66	Under 25	.6	.244	.227	.118	4.106	4.402	8.508	100.8	Mechanical	Do.
67	25- 50	(3)	(1)	(1)	.117	(1)	(1)	8.542	(3)	do	Do.
21	50- 75	.8	(1)	(1)	.116	(1)	(1)	8.605	242.8	do	Machine.
34	50- 75	.9	.268	.205	.116	3.735	4.891	8.626	171.4	Hand	Do.
31	50- 75	1.0	.467	.152	.115	2.143	6.575	8.718	171.7	Mechanical	Sand.
47	25- 50	1.0	(1)	(1)	.112	(1)	(1)	8.960	130.0	Hand and mechanical	Do.
60	25- 50	1.0	.244	.201	.110	4.102	4.958	9.060	135.9	Hand	Do.
54	50- 75	.9	.174	.253	.103	5.747	3.960	9.707	167.0	do	Do.
52	25- 50	.5	(1)	(1)	.101	(1)	(1)	9.891	218.4	do	Do.
64	25- 50	.8	.270	.155	.098	3.699	6.461	10.160	140.8	do	Do.
51	50- 75	1.0	.333	.129	.093	3.004	7.754	10.758	189.1	Mechanical	Do.
15	150-175	1.9	.189	.177	.091	5.290	5.656	10.946	223.3	Hand	Do.
70	25- 50	1.0	(1)	(1)	.091	(1)	(1)	10.961	110.8	do	Do.
77	Under 25	.9	.132	.248	.086	7.591	4.034	11.625	75.7	do	Do.
65	25- 50	.9	.141	.223	.086	7.084	4.491	11.575	139.9	do	Do.
59	25- 50	.8	.191	.153	.085	5.232	6.527	11.759	137.0	Mechanical	Do.
18	75-100	1.0	.149	.184	.082	6.705	5.442	12.147	215.1	Hand	Do.
74	25- 50	1.0	(1)	(1)	.081	(1)	(1)	12.276	75.9	do	Do.
75	Under 25	1.2	(1)	(1)	.081	(1)	(1)	12.385	52.9	do	Do.
79	Under 25	.4	(1)	(1)	.079	(1)	(1)	12.734	76.0	do	Do.
73	25- 50	1.0	(1)	(1)	.078	(1)	(1)	12.785	80.4	do	Do.
71	Under 25	.8	(1)	(1)	.072	(1)	(1)	13.920	80.0	do	Do.
42	25- 50	.8	(1)	(1)	.072	(1)	(1)	13.941	169.9	do	Machine.
11	150-175	3.4	.146	.139	.071	6.830	7.215	14.045	136.0	Hand and mechanical.	Sand and machine.
69	25- 50	.9	.117	.139	.063	8.544	7.218	15.762	115.2	Hand	Sand.

1919

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Charging	Casting
9	175-200	1.7	0.728	0.597	0.328	1.373	1.676	3.049	308.0	Mechanical	Machine.
32	100-125	.9	.611	.571	.295	1.638	1.752	3.390	319.9	do	Do.
16	100-125	.6	(1)	(1)	.269	(1)	(1)	3.717	455.7	do	Do.
4	225-250	1.8	(1)	(1)	.237	(1)	(1)	4.216	373.0	do	Do.
24	100-125	(3)	(1)	(1)	.222	(1)	(1)	4.508	(3)	do	Do.
39	50- 75	.6	.444	.402	.211	2.250	2.490	4.739	260.1	do	Do.
2	300-325	3.0	.530	.347	.210	1.887	2.880	4.767	291.7	do	Sand.
14	200-225	1.7	.421	.398	.205	2.376	2.512	4.888	353.5	Hand	Machine.
28	75-100	.6	.355	.456	.200	2.813	2.193	5.007	396.7	do	Sand.
3	175-200	1.4	(1)	(1)	.197	(1)	(1)	5.070	399.8	Mechanical	Machine.
36	50- 75	.6	.288	.552	.189	3.477	1.811	5.288	241.0	do	Do.
12	100-125	1.2	(1)	(1)	.172	(1)	(1)	5.824	241.4	do	Do.
19	100-125	1.0	.270	.441	.167	3.704	2.267	5.971	333.2	Hand	Do.
33	75-100	1.0	.238	.527	.164	4.202	1.898	6.100	253.0	Mechanical	Sand.
6	(5) 250-275	2.5	.556	.218	.157	1.799	4.579	6.379	279.6	do	Machine.
61	25- 50	.6	(1)	(1)	.155	(1)	(1)	6.446	162.0	Hand	Sand.
46	75-100	.8	.300	.312	.153	3.332	3.204	6.536	262.6	Mechanical	Machine.

(1) Detail not available. (3) Not reported. (5) Fiscal year May 1, 1918, to Apr. 30, 1919.

Table B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1919—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour			Average labor productivity: Man-hours per gross ton of pig iron produced			Average output per stack-day (gross tons)	Method of—	
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Charging	Casting
55	50–75	0.9	0.273	0.309	0.145	3.668	3.235	6.903	162.6	Hand	Machine.
49	Under 25	.2	.280	.298	.144	3.570	3.358	6.928	213.5	Mechanical	Sand.
27	100–125	1.2	.505	.200	.143	1.979	4.998	6.977	237.3	Hand	Do.
21	50–75	.7	(1)	(1)	.140	(1)	(1)	7.141	243.7	Mechanical	Machine.
5	175–200	1.4	(1)	(1)	.137	(1)	(1)	7.276	362.2	do	Do.
43	50–75	.9	.266	.281	.137	3.757	3.563	7.320	204.3	do	Sand.
57	25–50	.4	.314	.222	.130	3.186	4.510	7.696	194.9	Hand	Do
7	175–200	1.6	(1)	(1)	.128	(1)	(1)	7.793	304.3	Mechanical	Machine.
53	25–50	.5	.223	.278	.124	4.486	3.597	8.082	207.9	Hand	Sand.
51	50–75	.7	(1)	(1)	.123	(1)	(1)	8.132	223.7	Mechanical	Do.
30	175–200	1.8	(1)	(1)	.112	(1)	(1)	8.940	277.5	do	Do.
31	50–75	1.2	.451	.148	.111	2.217	6.764	8.981	164.8	do	Do.
54	50–75	.9	.186	.270	.110	5.365	3.697	9.062	178.9	Hand	Do.
41	50–75	.5	.180	.270	.108	5.560	3.707	9.267	286.0	do	Do.
60	Under 25	.2	.237	.196	.107	4.220	5.100	9.321	129.8	do	Do.
47	50–75	.9	(1)	(1)	.099	(1)	(1)	10.096	155.1	Hand and mechanical.	Do.
52	50–75	1.0	(1)	(1)	.099	(1)	(1)	10.100	196.0	Hand	Do.
66	Under 25	.5	.212	.180	.097	4.723	5.545	10.268	93.1	Mechanical	Do.
34	Under 25	.2	.217	.169	.095	4.609	5.925	10.534	171.1	Hand	Machine.
18	25–50	.5	.171	.203	.093	5.856	4.937	10.793	233.7	do	Sand.
65	50–75	1.0	.145	.228	.089	6.913	4.382	11.294	147.1	do	Do.
64	Under 25	.3	.242	.138	.088	4.136	7.225	11.361	145.2	do	Do.
42	50–75	1.0	(1)	(1)	.085	(1)	(1)	11.819	194.6	do	Machine.
63	Under 25	.3	.166	.171	.084	6.035	5.837	11.873	125.1	do	Sand.
15	100–125	1.6	.180	.157	.084	5.542	6.384	11.926	212.5	do	Do.
73	Under 25	.5	(1)	(1)	.084	(1)	(1)	11.947	102.2	do	Do.
70	Under 25	.7	(1)	(1)	.083	(1)	(1)	11.980	96.0	do	Do.
68	25–50	1.0	.145	.197	.083	6.902	5.081	11.983	85.0	do	Do.
77	Under 25	.5	.122	.229	.079	8.220	4.368	12.588	80.4	do	Do.
71	Under 25	.4	(1)	(1)	.079	(1)	(1)	12.637	85.5	do	Do.
59	25–50	.7	.160	.135	.073	6.240	7.433	13.673	117.3	Mechanical	Do.
11	75–100	1.5	.134	.115	.062	7.451	8.694	16.146	141.0	Hand and mechanical.	Sand and machine.
69	25–50	.9	.111	.131	.060	9.015	7.615	16.630	109.1	Hand	Sand.

1918

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour			Average labor productivity: Man-hours per gross ton of pig iron produced			Average output per stack-day (gross tons)	Method of—	
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Charging	Casting
32	100–125	1.0	0.635	0.606	0.310	1.576	1.650	3.225	337.6	Mechanical	Machine.
9	175–200	1.9	.629	.515	.283	1.590	1.941	3.531	286.0	do	Do.
16	150–175	1.0	(1)	(1)	.272	(1)	(1)	3.672	452.3	do	Do.
3	275–300	2.0	(1)	(1)	.264	(1)	(1)	3.784	397.4	do	Do.
39	50–75	.8	.406	.367	.193	2.462	2.725	5.187	241.7	do	Do.
2	425–450	4.0	.492	.301	.187	2.033	3.322	5.355	295.2	do	Sand.
36	50–75	.9	.299	.496	.187	3.345	2.017	5.362	217.7	Hand	Machine.
14	175–200	1.7	.359	.340	.175	2.782	2.942	5.724	285.5	do	Do.
12	150–175	2.0	(1)	(1)	.171	(1)	(1)	5.846	213.2	Mechanical	Do.
46	75–100	1.0	.319	.332	.163	3.132	3.011	6.141	279.4	do	Do.
48	75–100	.9	.284	.365	.160	3.523	2.740	6.264	300.0	Hand	Sand.
57	50–75	(3)	.374	.264	.155	2.677	3.790	6.467	(3)	do	Do.
7	200–225	2.0	(1)	(1)	.153	(1)	(1)	6.554	297.9	Mechanical	Machine.
28	75–100	.7	.291	.309	.150	3.439	3.231	6.670	324.5	Hand	Sand.
19	100–125	1.0	(1)	(1)	.147	(1)	(1)	6.785	342.5	do	Machine.
27	100–125	1.6	.474	.209	.145	2.109	4.790	6.899	205.5	do	Sand.
6	[6] 250–275	2.8	.444	.209	.142	2.251	4.773	7.023	253.4	Mechanical	Machine.
22	100–125	1.0	(1)	(1)	.136	(1)	(1)	7.374	296.0	do	Do.
20	100–125	1.0	(1)	(1)	.135	(1)	(1)	7.391	315.0	Hand	Do.
33	75–100	.9	.197	.428	.135	5.077	2.335	7.412	245.0	Mechanical	Sand.
31	100–125	1.7	.478	.187	.134	2.091	5.348	7.439	171.6	do	Do.
53	50–75	(3)	.238	.297	.132	4.197	3.365	7.562	(3)	Hand	Do.
43	75–100	1.0	.269	.259	.132	3.722	3.863	7.585	206.3	Mechanical	Do.

[1] Detail not available. [3] Not reported. [6] Fiscal year May 1, 1917, to Apr. 30, 1918.

TABLE B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1918—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Method of—: Charging	Casting
61	25- 50	0.7	(1)	(1)	0.131	(1)	(1)	7.636	141.4	Hand	Sand.
49	50- 75	.7	0.251	0.266	.129	3.989	3.765	7.753	186.4	Mechanical	Do.
50	25- 50	.9	(1)	(1)	.127	(1)	(1)	7.896	145.5	do	Do.
41	75-100	.9	.202	.303	.121	4.948	3.299	8.247	260.6	Hand	Do.
52	75-100	1.0	(1)	(1)	.113	(1)	(1)	8.872	221.9	do	Do.
10	225-250	1.8	(1)	(1)	.112	(1)	(1)	8.920	345.5	Mechanical	Machine.
17	100-125	1.7	(1)	(1)	.103	(1)	(1)	9.666	176.7	Hand	Sand.
51	50- 75	.7	(1)	(1)	.102	(1)	(1)	9.798	192.6	Mechanical	Do.
35	75-100	.9	(1)	(1)	.100	(1)	(1)	10.021	267.0	(3)	Machine.
30	175-200	2.4	(1)	(1)	.098	(1)	(1)	10.180	209.4	Mechanical	Sand.
54	50- 75	.8	.164	.237	.097	6.122	4.218	10.340	165.7	Hand	Do.
34	50- 75	(3)	(1)	(1)	.091	(1)	(1)	11.012	(3)	do	Do.
18	100-125	1.5	.156	.213	.090	6.409	4.692	11.101	194.3	do	Do.
15	150-175	2.0	.188	.169	.089	5.313	5.911	11.224	209.8	do	Do.
47	75-100	2.0	(1)	(1)	.089	(1)	(1)	11.285	132.9	Hand and mechanical.	Do.
66	Under 25	.8	.194	.157	.087	5.156	6.365	11.521	81.1	Mechanical	Do.
71	25- 50	1.0	(1)	(1)	.085	(1)	(1)	11.700	93.7	Hand	Do.
59	25- 50	1.0	.181	.153	.083	5.530	6.556	12.086	132.4	Mechanical	Do.
70	25- 50	.9	(1)	(1)	.083	(1)	(1)	12.090	90.1	Hand	Do.
42	50- 75	.9	(1)	(1)	.082	(1)	(1)	12.186	189.4	do	Machine.
77	Under 25	.8	.124	.233	.081	8.080	4.294	12.374	79.1	do	Sand.
62	50- 75	(3)	(1)	(1)	.079	(1)	(1)	12.690	(3)	do	Do.
73	25- 50	1.0	(1)	(1)	.070	(1)	(1)	14.194	88.6	do	Do.
68	25- 50	.8	.121	.165	.070	8.236	6.063	14.299	90.0	do	Do.
11	200-225	4.7	.141	.128	.067	7.082	7.792	14.874	120.7	Hand and mechanical.	Sand and machine.

1917

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Charging	Casting
4	400-425	2.9	(1)	(1)	0.326	(1)	(1)	3.071	376.8	Mechanical	Machine.
32	100-125	.8	0.686	0.599	.320	1.458	1.670	3.128	356.6	do	Do.
16	175-200	1.0	(1)	(1)	.314	(1)	(1)	3.180	489.5	do	Do.
3	275-300	2.0	(1)	(1)	.282	(1)	(1)	3.551	408.1	do	Do.
14	175-200	1.7	.429	.405	.208	2.333	2.467	4.800	300.0	Hand	Do.
39	50- 75	.6	(1)	(1)	.202	(1)	(1)	4.960	285.2	Mechanical	Do.
33	75-100	.9	.293	.627	.200	3.412	1.595	5.006	258.0	do	Sand.
28	100-125	1.0	.291	.456	.178	3.431	2.195	5.625	318.3	Hand	Do.
36	75-100	1.0	.279	.475	.176	3.580	2.103	5.683	213.5	do	Machine.
22	100-125	.9	.400	.300	.172	2.500	3.330	5.830	370.0	Mechanical	Do.
12	150-175	2.0	(1)	(1)	.168	(1)	(1)	5.959	232.8	do	Do.
19	125-150	1.0	(1)	(1)	.167	(1)	(1)	6.001	352.9	Hand	Do.
7	225-250	2.0	.616	.227	.166	1.624	4.405	6.029	314.0	Mechanical	Do.
20	125-150	1.0	(1)	(1)	.163	(1)	(1)	6.140	366.0	Hand	Do.
46	75-100	.9	.300	.312	.153	3.337	3.209	6.545	264.9	Mechanical	Do.
44	100-125	1.0	(1)	(1)	.147	(1)	(1)	6.792	280.3	(3)	Sand.
31	125-150	2.0	.513	.204	.146	1.948	4.901	6.851	175.7	Mechanical	Do.
61	50- 75	1.0	(1)	(1)	.146	(1)	(1)	6.856	155.1	Hand	Do.
6	[7] 200-225	2.3	.469	.204	.142	2.134	4.905	7.039	261.6	Mechanical	Machine.
50	50- 75	1.0	(1)	(1)	.140	(1)	(1)	7.133	151.3	do	Sand.
27	75-100	1.0	.480	.198	.140	2.084	5.053	7.137	226.1	Hand	Do.
41	75-100	.8	.239	.334	.139	4.181	2.990	7.171	289.0	do	Do.
49	50- 75	1.0	.261	.283	.137	3.774	3.540	7.314	186.0	Mechanical	Do.
43	75-100	.9	.259	.286	.136	3.859	3.491	7.351	252.5	do	Do.
66	25- 50	.9	.286	.252	.134	3.495	3.974	7.469	96.0	do	Do.
53	50- 75	(3)	.234	.291	.130	4.273	3.420	7.693	(3)	Hand	Do.
63	50- 75	1.0	.255	.264	.130	3.921	3.792	7.713	155.0	do	Do.
35	100-125	1.0	.247	.249	.125	4.045	3.985	8.030	287.0	(3)	Machine.
30	250-275	3.0	(1)	(1)	.123	(1)	(1)	8.136	248.1	Mechanical	Sand.
60	50- 75	1.0	.271	.224	.123	3.693	4.463	8.156	139.8	Hand	Do.
55	50- 75	.9	.225	.255	.120	4.443	3.918	8.360	157.0	do	Machine.

[1] Detail not available. [3] Not reported. [7] Fiscal year from May 1, 1916, to Apr. 30, 1917.

Table B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1917—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Method of—: Charging	Casting
48	50- 75	0.7	(1)	(1)	0.115	(1)	(1)	8.702	248.0	Hand	Sand.
18	125-150	1.8	(1)	(1)	.111	(1)	(1)	9.009	215.9	do	Do.
51	50- 75	1.0	(1)	(1)	.111	(1)	(1)	9.031	192.7	Mechanical	Do.
52	25- 50	.4	(1)	(1)	.109	(1)	(1)	9.191	205.8	Hand	Do.
15	150-175	1.9	(1)	(1)	.106	(1)	(1)	9.457	229.5	do	Do.
34	50- 75	(3)	(1)	(1)	.097	(1)	(1)	10.313	(3)	do	Do.
65	25- 50	.8	0.146	0.231	.090	6.831	4.330	11.161	143.0	do	Do.
64	25- 50	.8	.241	.138	.088	4.152	7.251	11.403	149.1	do	Do.
71	25- 50	.8	(1)	(1)	.082	(1)	(1)	12.208	91.6	do	Do.
42	50- 75	(3)	(1)	(1)	.075	(1)	(1)	13.245	(3)	do	Machine.
73	25- 50	.9	(1)	(1)	.070	(1)	(1)	14.220	87.9	do	Sand.
62	50- 75	(3)	(1)	(1)	.069	(1)	(1)	14.535	(3)	do	Do.
59	25- 50	.9	.151	.124	.068	6.634	8.055	14.689	108.6	Mechanical	Do.
69	25- 50	1.0	.109	.129	.059	9.200	7.772	16.972	109.1	Hand	Do.

1916

Plant No.	Production	Furnaces	Gross tons: Furnace crew	All other	Total	Man-hours: Furnace crew	All other	Total	Output per stack-day	Charging	Casting
16	100-125	0.7	(1)	(1)	0.294	(1)	(1)	3.404	445.9	Mechanical	Machine.
6	[8] 75-100	2.9	0.529	0.255	.172	1.891	3.927	5.818	285.2	do	Do.
61	25- 50	.8	(1)	(1)	.171	(1)	(1)	5.843	173.5	Hand	Do.
46	75-100	1.0	.297	.309	.151	3.369	3.240	6.608	259.7	Mechanical	Do.
27	100-125	1.4	.393	.224	.143	2.543	4.470	7.014	208.6	Hand	Do.
66	25- 50	.9	.263	.296	.139	3.809	3.378	7.187	88.2	Mechanical	Do.
30	275-300	2.7	(1)	(1)	.136	(1)	(1)	7.328	283.6	do	Do.
31	75-100	1.6	.434	.184	.129	2.305	5.435	7.740	167.4	do	Do.
52	50- 75	1.0	(1)	(1)	.095	(1)	(1)	10.494	182.4	Hand	Do.

1915

Plant No.	Production	Furnaces	Gross tons: Furnace crew	All other	Total	Man-hours: Furnace crew	All other	Total	Output per stack-day	Charging	Casting
16	125-150	0.9	(1)	(1)	0.313	(1)	(1)	3.197	450.9	Mechanical	Machine.
39	100-125	1.0	(1)	(1)	.214	(1)	(1)	4.684	282.4	do	Sand.
6	275-300	2.9	0.549	0.271	.181	1.822	3.693	5.514	285.2	do	Do.
66	25- 50	.9	.270	.326	.148	3.706	3.066	6.772	90.8	do	Do.
46	50- 75	.6	.272	.314	.146	3.677	3.186	6.863	245.6	do	Machine.
30	200-225	2.2	(1)	(1)	.137	(1)	(1)	7.280	270.8	do	Sand.
27	50- 75	.8	.598	.171	.133	1.673	5.855	7.527	206.0	Hand	Do.
61	Under 25	.3	(1)	(1)	.129	(1)	(1)	7.764	184.6	do	Do.
31	50- 75	1.0	.419	.172	.122	2.386	5.826	8.212	179.4	Mechanical	Do.
52	50- 75	1.0	(1)	(1)	.088	(1)	(1)	11.355	190.2	Hand	Do.

1914

Plant No.	Production	Furnaces	Gross tons: Furnace crew	All other	Total	Man-hours: Furnace crew	All other	Total	Output per stack-day	Charging	Casting
16	125-150	1.0	(1)	(1)	0.274	(1)	(1)	3.653	382.4	Mechanical	Machine.
1	225-250	1.8	(1)	(1)	.243	(1)	(1)	4.115	333.4	do	Do.
29	[9] 100-125	.8	(1)	(1)	.231	(1)	(1)	4.336	368.0	Hand	Do.
4	175-200	1.9	(1)	(1)	.217	(1)	(1)	4.612	283.9	Mechanical	Do.
45	75-100	1.0	(1)	(1)	.188	(1)	(1)	5.311	216.7	Hand	Sand.
14	150-175	1.6	0.376	0.356	.183	2.656	2.807	5.463	284.4	do	Do.
3	150-175	1.2	(1)	(1)	.172	(1)	(1)	5.819	477.8	Mechanical	Machine.
8	100-125	1.0	(1)	(1)	.170	(1)	(1)	5.886	314.3		Sand.
48	50- 75	.7	.275	.401	.163	3.636	2.496	6.132	244.0	Hand	Do.
19	50- 75	.5	(1)	(1)	.161	(1)	(1)	6.209	317.2	do	Do.
12	75-100	1.0	(1)	(1)	.149	(1)	(1)	6.697	266.6	Mechanical	Do.

[1] Detail not available. [3] Not reported. [8] Jan. 1, 1916, to Apr. 30, 1916. [9] Fiscal year.

TABLE B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1914—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	Gross tons per man-hour: All other labor	Gross tons per man-hour: Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	Man-hours per gross ton: All other labor	Man-hours per gross ton: Total labor	Average output per stack-day (gross tons)	Method of—: Charging	Method of—: Casting
33	50- 75	0.8	0.209	0.481	0.145	4.795	2.078	6.873	203.0	Mechanical	Sand.
6	200-225	2.0	.498	.201	.143	2.009	4.985	6.994	286.8	do	Do.
27	25- 50	.6	.498	.198	.142	2.006	5.058	7.064	212.1	Hand	Do.
46	50- 75	.7	.217	.325	.130	4.603	3.074	7.677	275.1	Mechanical	Do.
31	50- 75	1.0	.439	.185	.130	2.277	5.418	7.695	192.4	do	Do.
57	Under 25	(3)	.307	.217	.127	3.255	4.607	7.863	(3)	Hand	Do.
30	200-225	2.0	(1)	(1)	.127	(1)	(1)	7.891	297.0	Mechanical	Do.
10	[9] 125-150	1.3	(1)	(1)	.117	(1)	(1)	8.523	287.6	do	Machine.
51	75-100	1.0	.393	.167	.117	2.546	5.983	8.528	223.9	do	Sand.
34	25- 50	(3)	(1)	(1)	.104	(1)	(1)	9.565	(3)	Hand	Do.
73	25- 50	.9	(1)	(1)	.094	(1)	(1)	10.604	89.5	do	Do.
42	50- 75	(3)	(1)	(1)	.093	(1)	(1)	10.720	(3)	do	Do.
52	50- 75	.9	(1)	(1)	.089	(1)	(1)	11.193	174.9	do	Do.
54	25- 50	1.0	.148	.215	.088	6.756	4.655	11.410	134.7	do	Do.
66	Under 25	.5	.120	.227	.078	8.329	4.414	12.743	72.0	do	Do.
2	400-425	3.7	.552	(3)	(3)	1.917	(3)	(3)	302.9	Mechanical	Do.

1913

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	Gross tons per man-hour: All other labor	Gross tons per man-hour: Total labor	Man-hours per gross ton: Furnace crew labor	Man-hours per gross ton: All other labor	Man-hours per gross ton: Total labor	Average output per stack-day (gross tons)	Charging	Casting
16	125-150	0.9	(1)	(1)	0.308	(1)	(1)	3.252	389.0	Mechanical	Machine.
29	[9] 125-150	1.0	(1)	(1)	.242	(1)	(1)	4.130	360.0	Hand	Do.
7	175-200	1.7	0.523	0.326	.201	1.914	3.067	4.981	291.5	Mechanical	Do.
22	100-125	.8	.519	.324	.200	1.926	3.085	5.011	335.0	do	Do.
3	250-275	1.9	(1)	(1)	.196	(1)	(1)	5.099	353.9	do	Do.
14	200-225	2.0	.335	.403	.183	2.988	2.480	5.467	286.7	Hand	Sand.
19	75-100	.8	.297	.399	.170	3.369	2.507	5.876	274.3	do	Do.
48	25- 50	.5	.283	.425	.168	3.529	2,352	5,952	252.0	do	Do.
33	50- 75	.9	.245	.524	.167	4.077	1.910	5.987	221.0	Mechanical	Do.
12	150-175	2.0	(1)	(1)	.162	(1)	(1)	6,171	229.8	do	Do.
8	200-225	2.0	(1)	(1)	.162	(1)	(1)	6.171	288.2	(3)	Do.
5	175-200	1.5	(1)	(1)	.161	(1)	(1)	6.226	320.8	Mechanical	Machine.
6	225-250	2.5	.436	.239	.154	2.291	4.192	6.484	270.2	do	Sand.
28	75-100	.7	(1)	(1)	.152	(1)	(1)	6.561	319.6	Hand	Do.
61	25- 50	.7	(1)	(1)	.151	(1)	(1)	6.609	163.4	do	Do.
55	25- 50	.8	.239	.271	.127	4.186	3.691	7.877	160.0	do	Machine.
31	50- 75	1.0	.409	.175	.123	2.443	5.716	8.158	181.8	Mechanical	Sand.
34	50- 75	(3)	(1)	(1)	.122	(1)	(1)	8.208	(3)	Hand	Do.
10	[9] 175-200	1.7	(1)	(1)	.120	(1)	(1)	8.303	316.2	Mechanical	Machine.
46	25- 50	.4	.187	.281	.112	5.337	3.564	8.901	235.9	do	Sand.
44	25- 50	.6	(1)	(1)	.110	(1)	(1)	9.104	203.9	(3)	Do.
51	50- 75	.8	(1)	(1)	.102	(1)	(1)	9.817	201.4	Mechanical	Do.
42	50- 75	(3)	(1)	(1)	.092	(1)	(1)	10.849	(3)	Hand	Do.
66	25- 50	.9	.141	.265	.092	7.110	3.768	10.879	89.0	do	Do.
52	50- 75	.9	(1)	(1)	.087	(1)	(1)	11.494	172.2	do	Do.
54	25- 50	1.0	.139	.202	.083	7.169	4.940	12.109	129.2	do	Do.
62	25- 50	(3)	(1)	(1)	.082	(1)	(1)	12.141	(3)	do	Do.
73	25- 50	.9	(1)	(1)	.082	(1)	(1)	12.157	81.9	do	Do.

1912

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Gross tons per man-hour: Furnace crew labor	Gross tons per man-hour: All other labor	Gross tons per man-hour: Total labor	Man-hours per gross ton: Furnace crew labor	Man-hours per gross ton: All other labor	Man-hours per gross ton: Total labor	Average output per stack-day (gross tons)	Charging	Casting
16	125-150	0.9	(1)	(1)	0.299	(1)	(1)	3.340	385.3	Mechanical	Machine.
4	225-250	2.6	(1)	(1)	.222	(1)	(1)	4.503	251.0	do	Do.
3	200-225	1.5	(1)	(1)	.220	(1)	(1)	4.549	397.7	do	Do.
29	[9] 100-125	.9	(1)	(1)	.219	(1)	(1)	4.570	347.0	Hand	Do.
22	100-125	1.0	0.501	0.350	.206	1.997	2.854	4.851	330.0	Mechanical	Do.
7	175-200	1.8	.544	.332	.206	1.837	3.016	4.853	289.5	do	Do.
48	75-100	1.0	.293	.431	.174	3.416	2.320	5.736	266.0	Hand	Sand.
28	75-100	.6	(1)	(1)	.172	(1)	(1)	5.830	359.7	do	Do.
14	125-150	1.4	.361	.307	.166	2.770	3.255	6.025	286.0	do	Do.

[1] Detail not available. [3] Not reported. [9] Fiscal year.

TABLE B.—*Labor productivity, production, output per stack-day and methods of charging and casting in merchant blast furnaces in the United States, by years and by plants, 1911 to 1927*—Continued

1912—Continued

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Method of—: Charging	Casting
12	100-125	1.4	(1)	(2)	0.152	(1)	(1)	6.588	240.8	Mechanical	Sand.
61	50-75	1.0	(1)	(1)	.151	(1)	(1)	6.602	158.1	Hand	Do.
5	125-150	1.1	(1)	(1)	.148	(1)	(1)	6.742	351.7	Mechanical	Machine.
39	50-75	.5	(1)	(1)	.144	(1)	(1)	6.967	294.7	do	Sand.
33	25-50	.5	0.206	0.440	.140	4.855	2.274	7.129	227.0	do	Do.
31	75-100	1.3	.452	.190	.134	2.211	5.266	7.477	164.8	do	Do.
51	75-100	1.0	(1)	(1)	.131	(1)	(1)	7.650	208.3	do	Do.
55	50-75	1.0	.232	.263	.123	4.319	3.809	8.128	147.3	Hand	Machine.
57	50-75	(3)	.300	.211	.123	3.381	4.780	8.160	(3)	do	Sand.
42	50-75	(3)	(1)	(1)	.119	(1)	(1)	8.383	(3)	do	Do.
46	75-100	.8	.198	.297	.119	5.048	3.372	8.420	249.4	Mechanical	Do.
53	50-75	(3)	.177	.245	.103	5.655	4.075	9.730	(3)	Hand	Do.
73	25-50	.8	(1)	(1)	.102	(1)	(1)	9.812	95.0	do	Do.
34	25-50	(3)	(1)	(1)	.090	(1)	(1)	11.168	(3)	do	Do.
10	[9] 100-125	1.0	(1)	(1)	.087	(1)	(1)	11.434	312.8	Mechanical	Machine.
52	50-75	.9	(1)	(1)	.085	(1)	(1)	11.722	168.0	Hand	Sand.
54	25-50	.8	.127	.185	.075	7.850	5.409	13.259	140.2	do	Do.
62	25-50	(3)	(1)	(1)	.052	(1)	(1)	19.051	(3)	do	Do.

1911

Plant No.	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day (gross tons)	Method of—: Charging	Casting
16	100-125	0.9	(1)	(1)	0.313	(1)	(1)	3.200	385.0	Mechanical	Machine.
14	25-50	.5	(1)	(1)	.182	(1)	(1)	5.483	289.0	Hand	Sand.
3	150-175	1.0	(1)	(1)	.182	(1)	(1)	5.483	417.5	Mechanical	Machine.
7	125-150	1.2	0.440	0.267	.166	2.272	3.750	6.023	318.5	do	Do.
61	50-75	1.0	(1)	(1)	.164	(1)	(1)	6.105	169.0	Hand	Sand.
28	75-100	.6	(1)	(1)	.163	(1)	(1)	6.136	360.2	do	Do.
5	150-175	1.3	(1)	(1)	.158	(1)	(1)	6.330	341.8	Mechanical	Machine.
22	25-50	.4	.522	.215	.152	1.915	4.647	6.562	337.0	do	Do.
12	75-100	.9	(1)	(1)	.150	(1)	(1)	6.667	249.3	do	Sand.
33	50-75	1.0	.218	.464	.148	4.597	2.153	6.750	198.0	do	Do.
48	50-75	.7	.249	.362	.148	4.012	2.761	6.773	258.0	Hand	Do.
51	75-100	1.0	(1)	(1)	.136	(1)	(1)	7.335	215.7	Mechanical	Do.
46	25-50	.5	.223	.334	.134	4.479	2.992	7.471	281.1	do	Do.
34	50-75	(3)	(1)	(1)	.131	(1)	(1)	7.659	(3)	Hand	Do.
42	50-75	(3)	(1)	(1)	.124	(1)	(1)	8.066	(3)	do	Do.
10	[9] 125-150	1.0	(1)	(1)	.119	(1)	(1)	8.382	374.2	Mechanical	Machine.
73	25-50	1.0	(1)	(1)	.107	(1)	(1)	9.385	98.0	Hand	Sand.
31	50-75	1.0	.379	.148	.106	2.639	6.753	9.392	158.1	Mechanical	Do.
39	50-75	.7	(1)	(1)	.095	(1)	(1)	10.535	249.8	Hand	Do.
52	50-75	1.0	(1)	(1)	.090	(1)	(1)	11.122	168.1	do	Do.
54	25-50	.7	.115	.167	.068	8.673	5.976	14.648	136.1	do	Do.
62	Under 25	(3)	(1)	(1)	.051	(1)	(1)	19.529	(3)	do	Do.

[1] Detail not available. [3] Not reported. [9] Fiscal year.

APPENDIX 2.—INDIVIDUAL PLANT STUDIES IN EARLY YEARS

Data in Table C represent long histories for six selected plants. They bring out the character of certain changes in the industry prior to 1911. The items in the table are not complete but all available material has been tabulated.

Output per stack day for plant No. 28 represents the spectacular progress of 60 years. With the exception of 1880, operating data and man-hours for this plant are not available for years prior to 1902. Daily furnace output is shown by blast periods (i. e., the interval between blowing in and blowing out for rebuilding or relining) prior to 1902. Productivity in 1880 is particularly interesting in contrast with 1911 when examined in connection with output per stack day. Productivity doubled while furnace output increased eightfold during this period; it is therefore evident that crews were very small during these early years of small scale operation, while it is quite likely that productivity may have actually decreased during some of the intermediate years as production increased without mechanical aids in handling materials.

A remarkably complete operating record is shown for plant No. 29 over a long term of years. It will be noted that no man-hours are available prior to 1907; it will be profitable therefore to examine this plant's history in relation to that of plant 28, which includes man-hours for an early year without a continuous operating record. Increasing output per day since 1880 runs closely parallel in both cases. The man-hours for plant No. 28 may be regarded as typical of conditions in both plants, since they were operated along similar lines and were located in the same district where labor conditions were analagous. Likewise, the operating record of plant No. 29 may be taken as representative of plant No. 28 during this early period. Steady progress in daily output and in coke consumption are the two outstanding features of early operating records. The primary cause of increased output is seen in the frequency of relining and rebuilding. This plant began in 1915 to dispose of product as hot metal.

Plant No. 16 is of interest as one of the first merchant furnace plants to install a pig casting machine. The marked reduction in man-hours per ton between 1897 and 1903 is explained by the elimination of sand casting, and the sudden decrease in hours in 1910 was due directly to the introduction of mechanical filling and the displacement of top and bottom fillers. Except as a direct result of these labor-saving changes, this plant shows no improvement in productivity comparable with the increase in daily furnace output. It seems that an increase in production was usually paralleled by larger pay rolls, an unusual condition in blast furnace operation.

The first skip hoist in its district was installed by plant No. 51, but there was no important effect on productivity since the skips were hand filled and the only men displaced were the top fillers. The installation of bins and larry car in 1909 illustrates the usual drastic reduction of crews which accompanies the modernization of the stockhouse side of the furnace. This small furnace produces a special grade of pig iron, and no efforts have been made to push its daily production to high levels.

Data on early history are also shown for plants Nos. 6 and 7. It is of interest to compare the 1905 productivity record of these two plants and plant No. 51.

TABLE C.—*Labor productivity, output per stack-day, consumption of materials charged, and changes in equipment in six merchant blast-furnace plants reporting for earlier years*

PLANT NO. 28

Year	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Remarks
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*	
1926	125–150	0.8	0.631	0.672	0.326	1.585	1.488	3.072	454.4	3,768	421	1,985	1,046	
1925	75–100	.6	(1)	(1)	.321	(1)	(1)	3.117	441.5	3,734	419	2,092	1,066	
1924	75–100	.5	(1)	(1)	.278	(1)	(1)	3.601	444.4	3,703	390	2,053	1,068	Pig-casting machine installed.
1923	100–125	.7	(1)	(1)	.241	(1)	(1)	4.150	402.4	3,683	401	2,253	1,035	Stack rebuilt.
1922	75–100	.5	.381	.642	.239	2.625	1.558	4.183	416.0	3,588	426	2,138	1,010	
1921	50–75	.5	.365	.655	.234	2.741	1.526	4.267	398.5	3,658	444	2,251	1,084	
1920	100–125	.8	.361	.443	.199	2.769	2.260	5.028	394.4	3,732	430	2,283	1,138	
1919	75–100	.6	.355	.456	.200	2.813	2.193	5.007	396.7	3,772	421	2,220	1,310	
1918	75–100	.7	.291	.309	.150	3.439	3.231	6.670	324.5	3,904	450	2,489	1,501	Do.
1917	100–125	1.0	.291	.456	.178	3.431	2.195	5.625	318.3	3,801	444	2,439	1,478	
1916	125–150	.9	(1)	(1)	(1)	(1)	(1)	(1)	358.3	3,736	439	2,345	1,422	
1915	75–100	.7	(1)	(1)	(1)	(1)	(1)	(1)	393.8	3,721	421	2,209	1,263	
1914	50–75	.5	(1)	(1)	(1)	(1)	(1)	(1)	357.0	3,532	553	2,129	1,257	
1913	75–100	.7	(1)	(1)	.152	(1)	(1)	6.561	319.6	(1)	(1)	(1)	(1)	
1912	75–100	.6	(1)	(1)	.172	(1)	(1)	5.830	359.7	3,833	336	2,233	1,301	
1911	75–100	.6	(1)	(1)	.163	(1)	(1)	6.136	360.2	(1)	(1)	(1)	(1)	
1910	50–75											2,376		
1909	100–125											2,324		
1908	50–75	(1)	(1)	(1)	(1)	(1)	(1)	(1)	330.0	(1)	(1)	2,406	(1)	
1907	100–125											2,444		
1906	75–100											2,349		
1905	100–125											2,307		
1904	75–100	(1)	(1)	(1)	(1)	(1)	(1)	(1)	292.0	(1)	(1)	2,162	(1)	
1903	75–100											2,389		
1902	100–125											2,211		
1896–1901 [2]	425–450	(1)	(1)	(1)	(1)	(1)	(1)	(1)	272.0	(1)	(1)	(1)	(1)	
1892–1896	225–250	(1)	(1)	(1)	(1)	(1)	(1)	(1)	168.0	(1)	(1)	(1)	(1)	
1886–1891	250–275	(1)	(1)	(1)	(1)	(1)	(1)	(1)	156.0	(1)	(1)	(1)	(1)	
1885–1886	50–75	(1)	(1)	(1)	(1)	(1)	(1)	(1)	124.0	(1)	(1)	(1)	(1)	

1882–1884	50– 75	([1])	([1])	([1])	([1])	([1])	([1])	([1])	99.0	([1])	([1])	([1])	([1])	First blast with coke only.
1881–1882	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	58.0	([1])	([1])	([1])	([1])	
1879–1880	Under 25	([1])	([1])	([1])	.076	([1])	([1])	13.149	48.0	3,116	1,360	[3] 4,211	1,868	
1877–1879	25– 50	([1])	([1])	([1])	([1])	([1])	([1])	([1])	47.0	([1])	([1])	([1])	([1])	
1876–1877	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	46.0	([1])	([1])	([1])	([1])	
1875–1876	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	42.0	([1])	([1])	([1])	([1])	
1874–1875	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	34.0	([1])	([1])	([1])	([1])	
1871–1874	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	24.0	([1])	([1])	([1])	([1])	
1870–1871	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	22.0	([1])	([1])	([1])	([1])	
1869–1870	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	23.0	([1])	([1])	([1])	([1])	
1868–1869	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	25.0	([1])	([1])	([1])	([1])	
1867–1868	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	24.0	([1])	([1])	([1])	([1])	
1867	Under 25	([1])	([1])	([1])	([1])	([1])	([1])	([1])	19.0	([1])	([1])	([1])	([1])	

[1] Not reported. [2] Data for 1867 to 1901, inclusive, are for blast periods and not for fiscal or calendar years. [3] Both coal and coke.

TABLE C.—*Labor productivity, output per stack-day, consumption of materials charged, and changes in equipment in six merchant blast-furnace plants reporting for earlier years*—Continued

PLANT NO. 29

Year	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Per cent of yield from ores and equivalent	Per cent of metal used in molten condition	Remarks
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*			
1927 [4]	75–100	1.0	0.673	0.665	0.334	1.486	1.504	2.990	431.0	3,893	240	1,917	1,033	54.2	(1)	
1926	150–175	1.0	.658	.650	.327	1.519	1.537	3.056	426.0	4,034	287	1,876	968	51.9	93	
1925	125–150	.9	.679	.671	.337	1.473	1,491	2.963	393.0	4,247	184	1,963	979	48.6	96	Stack relined.
1924	125–150	1.0	.533	.526	.265	1.877	1.899	3.776	371.0	4,283	206	2,075	1,028	49.9	90	
1923	100–125	1.0	(1)	(1)	.249	(1)	(1)	4.018	340.0	4,222	195	1,855	1,219	50.7	97	
1922	50–75	.6	.446	.511	.240	2.245	1.928	4.173	327.0	4,039	121	2,197	1,252	53.8	82	
1921	50–75	.4	(1)	(1)	(1)	(1)	(1)	(1)	366.0	4,442	45	2,022	1,169	49.9	45	
1920	100–125	.8	(1)	(1)	(1)	(1)	(1)	(1)	356.0	4,476	(1)	2,097	1,239	50.1	77	
1919	75–100	.8	(1)	(1)	(1)	(1)	(1)	(1)	341.0	4,572	(1)	2,201	1,250	49.0	59	Do.
1918	75–100	.6	(1)	(1)	(1)	(1)	(1)	(1)	396.0	3,996	(1)	1,899	1,084	56.1	(1)	New management.
1917	125–150	1.0	(1)	(1)	.260	(1)	(1)	3.846	366.0	(1)	(1)	(1)	(1)	(1)	(1)	
1916	100–125	.9	(1)	(1)	(1)	(1)	(1)	(1)	365.0	4,110	271	1,995	1,187	51.6	(1)	
1915	100–125	.8	(1)	(1)	(1)	(1)	(1)	(1)	365.0	4,211	267	2,161	1,292	50.0	(1)	First disposal of hot metal to adjacent steel plant.
1914	100–125	.8	(1)	(1)	.231	(1)	(1)	4.336	368.0	4,133	213	2,103	1,212	51.5	--------	
1913	125–150	1.0	(1)	(1)	.242	(1)	(1)	4.130	360.0	4,316	(1)	2,282	1,174	51.9	--------	
1912	100–125	.9	(1)	(1)	.219	(1)	(1)	4.570	347.0	3,857	333	2,186	1,271	53.4	--------	
1911	75–100	.8	(1)	(1)	(1)	(1)	(1)	(1)	342.0	4,180	103	2,153	1,212	53.3	--------	
1910	75–100	.7	(1)	(1)	(1)	(1)	(1)	(1)	327.0	4,321	(1)	2,212	1,416	49.8	--------	Pig-casting machine installed.
1909	50–75	.6	(1)	(1)	(1)	(1)	(1)	(1)	262.0	4,693	(1)	2,485	1,505	47.7	--------	Stack relined.
1908	50–75	.7	(1)	(1)	(1)	(1)	(1)	(1)	303.0	4,444	47	2,328	1,387	49.8	--------	
1907	100–125	.9	(1)	(1)	.181	(1)	(1)	5.517	309.0	(1)	(1)	(1)	(1)	(1)	--------	Pig breaker installed, saving 18 men daily.
1906	100–125	.9	(1)	(1)	(1)	(1)	(1)	(1)	351.0	4,372	(1)	2,112	1,147	51.2	--------	
1905	75–100	.8	(1)	(1)	(1)	(1)	(1)	(1)	300.0	3,270	(1)	2,232	905	53.2	--------	New casting house, new Tod engine.
1904	50–75	.6	(1)	(1)	(1)	(1)	(1)	(1)	328.0	4,236	(1)	2,168	1,129	53.0	--------	
1903	75–100	.8	(1)	(1)	(1)	(1)	(1)	(1)	313.0	4,283	(1)	2,102	1,122	52.3	--------	
1902	50–75	.8	(1)	(1)	(1)	(1)	(1)	(1)	259.0	4,178	36	2,269	1,272	53.1	--------	Electric slag conveyer saves 13 men daily.
1901	75–100	.8	(1)	(1)	(1)	(1)	(1)	(1)	274.0	3,868	195	(1)	1,084	(1)	--------	
1900	75–100	1.0	(1)	(1)	(1)	(1)	(1)	(1)	273.0	4,025	110	2,135	1,073	54.2	--------	New Tod engine, new boilers.
1899	50–75	.6	(1)	(1)	(1)	(1)	(1)	(1)	255.0	3,620	208	(1)	1,028	55.5	--------	Furnace enlarged.

1898	50–75	.9	(1)	(1)	(1)	(1)	(1)	(1)	217.0	3,564	170	2,148	878	59.8	New bosh, new pumping engine, etc.
1897	25–50	.6	(1)	(1)	(1)	(1)	(1)	(1)	202.0	3,692	219	2,249	894	57.3	New coke and limestone bins, chills for casting.
1896	50–75	.9	(1)	(1)	(1)	(1)	(1)	(1)	168.0	3,627	204	2,210	860	58.5	Stack relined; new boilers and new Tod blowing engine.
1895	25–50	.8	(1)	(1)	(1)	(1)	(1)	(4)	151.0	3,537	184	2,311	894	60.2	New Julian Kennedy stoves.
1894	25–50	.5	(1)	(1)	(1)	(1)	(1)	(1)	144.0	(1)	517	2,745	833	60.0	Stack relined; coal strike.
1893	25–50	.8	(1)	(1)	(1)	(1)	(1)	(1)	136.0	3,331	468	2,722	950	59.0	
1892	50–75	1.0	(1)	(1)	(1)	(1)	(1)	(1)	143.0	3,638	219	2,603	974	58.0	
1891	25–50	.6	(1)	(1)	(1)	(1)	(1)	(1)	114.0	3,680	172	2,936	1,021	58.1	Plant overhauled, engines rebuilt.
1890	25–50	.7	(1)	(1)	(1)	(1)	(1)	(1)	114.0	3,501	251	2,883	1,055	59.2	
1889	25–50	1.0	(1)	(1)	(1)	(1)	(1)	(1)	112.0	3,553	224	2,699	1,006	59.3	Stack relined.
1888	25–50	1.0	(1)	(1)	(1)	(1)	(1)	(1)	95.0	(1)	(1)	2,728	(1)	60.4	
1887	25–50	1.0	(1)	(1)	(1)	(1)	(1)	(1)	82.0	(1)	(1)	(1)	(1)	(1)	
1886	Under 25	1.0	(1)	(1)	(1)	(1)	(1)	(1)	59.0	(1)	(1)	(1)	(1)	(1)	
1885	25–50	1.0	(1)	(1)	(1)	(1)	(1)	(1)	75.0	(1)	(1)	2,112	(1)	(1)	
1884	25–50	1.0	(1)	(1)	(1)	(1)	(1)	(1)	85.0	(1)	(1)	(1)	(1)	(1)	
1883	Under 25	.3	(1)	(1)	(1)	(1)	(1)	(1)	29.0	(1)	(1)	(1)	(1)	(1)	Stack rebuilt, new auxiliary equipment.
1882	Under 25	1.0	(1)	(1)	(1)	(1)	(1)	(1)	28.0	(1)	(1)	(1)	(1)	(1)	
1881	Under 25	.6	(1)	(1)	(1)	(1)	(1)	(1)	27.0	(1)	(1)	(1)	(1)	(1)	

[1] Not reported.

[4] First 6 months only.

PLANT NO. 16

TABLE C.—*Labor productivity, output per stack-day, consumption of materials charged, and changes in equipment in six merchant blast-furnace plants reporting for earlier years*—Continued

Year	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	Average labor productivity: Gross tons of pig iron produced per man-hour: All other labor	Average labor productivity: Gross tons of pig iron produced per man-hour: Total labor	Average labor productivity: Man-hours per gross ton of pig iron produced: Furnace crew labor	Average labor productivity: Man-hours per gross ton of pig iron produced: All other labor	Average labor productivity: Man-hours per gross ton of pig iron produced: Total labor	Average output per stack-day	Consumption of materials per gross ton of pig iron produced: Iron ore	Consumption of materials per gross ton of pig iron produced: Scrap	Consumption of materials per gross ton of pig iron produced: Coke	Consumption of materials per gross ton of pig iron produced: Flux	Average number of men per day	Remarks
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1926	75-100	0.7	0.854	0.685	0.380	1.171	1.461	2.632	392.3	4,070	72	2,282	(1)	118	
1924	50- 75	.3	1.105	.429	.309	.905	2.329	3.233	512.0	3,913	199	1,996	912	182	3-shift system introduced.
1923	125-150	.7	(1)	(1)	.280	(1)	(1)	3.566	493.4	3,792	249	2,120	900	166	
1922	50- 75	.2	(1)	(1)	.371	(1)	(1)	2.697	613.0	(1)	(1)	(1)	(1)	156	
1921	Under 25.	.1	(1)	(1)	.332	(1)	(1)	3.016	513.1	4,084	170	2,101	965	146	
1920	125-150	.9	(1)	(1)	.246	(1)	(1)	4.066	438.3	3,922	242	2,092	1,055	162	
1919	100-125	.6	(1)	(1)	.269	(1)	(1)	3.717	455.7	(1)	(1)	(1)	(1)	154	
1918	150-175	1.0	(1)	(1)	.272	(1)	(1)	3.672	452.3	(1)	(1)	(1)	(1)	151	
1917	175-200	1.0	(1)	(1)	.314	(1)	(1)	3.180	489.5	(1)	(1)	(1)	(1)	142	
1916	100-125	.7	(1)	(1)	.294	(1)	(1)	3.404	445.9	(1)	(1)	(1)	(1)	141	
1915	125-150	.9	(1)	(1)	.313	(1)	(1)	3.197	450.9	3,882	108	2,024	1,064	131	
1914	125-150	1.0	(1)	(1)	.274	(1)	(1)	3.653	382.4	(1)	(1)	(1)	(1)	127	
1913	125-150	.9	(1)	(1)	.308	(1)	(1)	3.252	389.0	(1)	(1)	(1)	(1)	115	
1912	125-150	.9	(1)	(1)	.299	(1)	(1)	3.340	385.3	(1)	(1)	(1)	(1)	117	
1911	100-125	.9	(1)	(1)	.313	(1)	(1)	3.200	385.0	(1)	(1)	(1)	(1)	112	
1910	125-150	1.0	(1)	(1)	.310	(1)	(1)	3.226	381.9	4,108	(1)	2,190	874	112	
1909	25- 50	.5	.368	.348	.179	2.718	2.876	5.593	279.3	(1)	(1)	(1)	(1)	142	New skip, larry, and bins replace hand filling; furnace rebuilt.
1908	25- 50	.5	.376	.355	.183	2.658	2.817	5.476	277.2	(1)	(1)	(1)	(1)	138	
1907	75-100	.8	.360	.341	.175	2.778	2.932	5.709	285.1	(1)	(1)	(1)	(1)	148	
1906	100-125	1.0	.389	.319	.175	2.572	3.136	5.708	312.2	(1)	(1)	(1)	(1)	162	
1905	75-100	.9	.381	.340	.180	2.622	2.941	5.563	310.4	3,900	(1)	2,064	1,077	157	
1904	50- 75	.5	.375	.396	.192	2.670	2.528	5.198	309.0	(1)	(1)	(1)	(1)	146	
1903	75-100	.9	.375	.333	.176	2.669	3.002	5.671	296.8	(1)	(1)	(1)	(1)	153	
1902	50- 75	.8	(1)	(1)	(1)	(1)	(1)	(1)	255.1	(1)	(1)	(1)	(1)	(1)	
1901	75-100	.9	(1)	(1)	(1)	(1)	(1)	(1)	250.4	(1)	(1)	(1)	(1)	(1)	
1900	50- 75	.7	(1)	(1)	(1)	(1)	(1)	(1)	232.5	3,709	(1)	2,144	1,254	(1)	

1899	50- 75	.8	(1)	(1)	(1)	(1)	(1)	(1)	220.6	(1)	(1)	(1)	(1)	(1)	Pig-casting machine installed.
1898	75-100	1.0	(1)	(1)	(1)	(1)	(1)	(1)	241.7	(1)	(1)	(1)	(1)	(1)	
1897	25- 50	.6	(1)	(1)	.131	(1)	(1)	7.643	215.9	(1)	(1)	(1)	(1)	150	
1896	Under 25.	.3	(1)	(1)	.119	(1)	(1)	8.400	189.9	(1)	(1)	(1)	(1)	145	

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1927 [4]	25- 50	0.9	0.587	0.504	0.271	1.705	1.984	3.689	262.8	3,624	--------	2,028	965	117	
1925	25- 50	.5	.564	.344	.214	1.772	2.900	4.672	248.3	3,804	--------	2,076	1,062	140	Pig-casting machine installed.
1924	25- 50	.4	.437	.294	.176	2.289	3.398	5.687	248.1	4,081	--------	2,228	1,053	170	
1923	50- 75	.7	.366	.171	.117	2.732	5.843	8.575	209.0	4,059	--------	2,295	1,281	185	8-hour day introduced.
1921	Under 25.	.3	.352	(1)	(1)	2.837	(1)	(1)	195.9	2,148	1,980	2,593	1,532	186	Stack relined.
1920	50- 75	1.0	.333	.129	.093	3.004	7.754	10.758	189.1	2,659	1,680	2,586	1,478	180	Abnormal labor conditions.
1919	50- 75	.7	(1)	(1)	.123	(1)	(1)	8.132	223.7	2,715	1,559	2,408	1,396	161	
1918	50- 75	.7	(1)	(1)	.102	(1)	(1)	9.798	192.6	3,100	1,046	2,494	1,420	(1)	Stack relined.
1917	50- 75	1.0	(1)	(1)	.111	(1)	(1)	9.031	192.7	4,193	--------	2,475	1,398	(1)	
1916	75-100	1.0	(1)	(1)	(1)	(1)	(1)	(1)	207.3	(1)	(1)	(1)	(1)	(1)	
1915	75-100	1.0	(1)	(1)	(1)	(1)	(1)	(1)	225.5	(1)	(1)	(1)	(1)	(1)	
1914	75-100	1.0	.393	.167	.117	2.546	5.983	8.528	223.9	4,169	92	2,426	1,434	169	
1913	50- 75	.8	(1)	(1)	.102	(1)	(1)	9.817	201.4	3,998	103	2,433	1,519	175	
1912	75-100	1.0	(1)	(1)	.131	(1)	(1)	7.650	208.3	3,349	692	2,342	1,443	141	
1911	75-100	1.0	(1)	(1)	.136	(1)	(1)	7.335	215.7	[5] 4,229	(5)	2,357	1,373	140	
1910	75-100	1.0	(1)	(1)	.118	(1)	(1)	8.497	210.1	[5] 4,162	(5)	2,218	1,429	158	
1909	25-100	.7	(1)	(1)	.067	(1)	(1)	14.826	168.4	[5] 4,061	(5)	2,324	1,499	221	Larry car, bins, and cast-house crane installed.
1908	50- 75	.8	(1)	(1)	.079	(1)	(1)	12.654	180.4	[5] 4,334	(5)	2,734	1,516	202	Stack rebuilding at end of 1908.
1907	50- 75	.8	(1)	(1)	.074	(1)	(1)	13.580	184.7	[5] 4,140	(5)	2,442	1,393	222	
1906	50- 75	1.0	(1)	(1)	.096	(1)	(1)	10.439	208.8	[5] 4,081	(5)	1,914	1,391	193	
1905	50- 75	.9	(1)	(1)	.095	(1)	(1)	10.525	208.3	[5] 3,882	(5)	2,364	1,243	194	
1904	50- 75	1.0	(1)	(1)	.096	(1)	(1)	10.453	203.2	[5] 3,860	(5)	2,274	1,223	188	Slack times required much piling of iron and inflated yard gangs.
1903	25- 50	.6	(1)	(1)	.082	(1)	(1)	12.205	96.3	[5] 3,868	(5)	2,230	1,210	212	Stack relined; new boilers installed.
1902	50- 75	.9	(1)	(1)	.091	(1)	(1)	10.985	191.3	[5] 3,779	(5)	2,236	1,129	186	
1901	50- 75	1.0	(1)	(1)	.091	(1)	(1)	11.010	164.2	[5] 3,734	(5)	2,316	1,163	160	
1900	50- 75	.9	(1)	(1)	.085	(1)	(1)	11.763	153.7	[5] 3,792	(5)	2,502	965	160	
1899	25- 50	.7	(1)	(1)	.079	(1)	(1)	12.672	142.7	[5] 3,844	(5)	2,246	1,205	160	Skip hoist and new engines installed.
1898	50- 75	1.0	(1)	(1)	.100	(1)	(1)	10.019	174.8	[5] 3,566	(5)	2,340	1,136	155	
1897	50- 75	1.0	(1)	(1)	.111	(1)	(1)	9.000	190.8	[5] 3,692	(5)	2,164	1,075	152	

[1] Not reported. [4] First 6 months only. [5] Any scrap inseparably combined with ore.

PLANT NO. 6

Table C—*Labor productivity, output per stack-day, consumption of materials charged, and changes in equipment in six merchant blast-furnace plants reporting for earlier years*—Continued

Year	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity: Gross tons of pig iron produced per man-hour: Furnace crew labor	All other labor	Total labor	Man-hours per gross ton of pig iron produced: Furnace crew labor	All other labor	Total labor	Average output per stack day	Consumption of material per gross ton of pig iron produced: Iron ore	Scrap	Coke	Flux	Average cubic feet of air blown per minute	Average number of men per day	Remarks
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*			
1927 [4]	125–150	2.0	1.216	0.610	0.406	0.822	1.640	2.463	408.5	(1)	(1)	(1)	(1)	30,629	241	
1926	225–250	1.8	1.006	.393	.283	.994	2.543	3.536	359.1	3,943	23	1,952	860	31,903	240	
1925	275–300	2.2	.924	.475	.314	1.082	2.104	3.187	341.7	4,086	29	2,071	896	31,469	283	
1924	225–250	2.0	(1)	(1)	.251	(1)	(1)	3.982	317.2	4,368	76	2,268	1,051	33,040	278	
1923	300–325	2.5	(1)	(1)	.248	(1)	(1)	4.033	325.4	4,325	58	2,244	1,004	33,986	300	
1922	150–175	1.4	(1)	(1)	.241	(1)	(1)	4.155	322.5	4,173	44	2,234	1,039	36,284	168	
1921	100–125	1.0	(1)	(1)	.143	(1)	(1)	7.002	312.6	4,267	36	2,181	1,021	29,432	188	
1920 [6]	300–325	2.6	.597	.288	.194	1.675	3.472	5.147	319.8	4,341	30	2,367	1,089	(1)	388	
1919 [6]	250–275	2.5	.556	.218	.157	1.799	4.579	6.379	279.6	4,359	101	2,499	1,077	28,937	401	
1918 [6]	250–275	2.8	.444	.209	.142	2.251	4.773	7.023	253.4	4,384	26	2,619	1,100	29,472	441	
1917 [6]	200–225	2.3	.469	.204	.142	2.134	4.905	7.039	261.6	4,274	29	2,393	1,039	29,593	389	
1916 [7]	75–100	2.9	.529	.255	.172	1.891	3.927	5.818	285.2	4,097	11	(1)	934	28,219	(1)	
1915	275–300	2.9	.549	.271	.181	1.822	3.693	5.514	285.2	(1)	(1)	2,140	(1)	28,215	405	
1914	200–225	2.0	.498	.201	.143	2.009	4.985	6.994	286.8	4,191	8	2,120	862	29,403	366	
1913	225–250	2.5	.436	.239	.154	2.291	4.192	6.484	270.2	4,213	47	2,243	1,024	30,910	390	
1912	250–275	2.7	(1)	(1)	(1)	(1)	(1)	(1)	273.5	4,343	--------	2,261	1,163	31,376	(1)	
1911	225–250	2.3	(1)	(1)	(1)	(1)	(1)	(1)	290.7	4,252	29	2,215	1,095	32,695	(1)	
1910	250–275	2.7	(1)	(1)	(1)	(1)	(1)	(1)	277.6	4,338	9	2,182	1,004	(1)	(1)	
1909	225–250	2.3	(1)	(1)	(1)	(1)	(1)	(1)	267.3	4,321	38	2,114	(1)	(1)	(1)	
1908	150–175	2.0	(1)	(1)	(1)	(1)	(1)	(1)	216.4	4,285	4	(1)	(1)	(1)	(1)	
1907	200–225	2.7	(1)	(1)	(1)	(1)	(1)	(1)	214.4	4,119	128	(1)	(1)	(1)	(1)	
1906	175–200	2.7	(1)	(1)	(1)	(1)	(1)	(1)	200.5	4,314	67	(1)	(1)	(1)	(1)	
1905	200–225	3.0	.243	.165	.098	4.111	6.059	10.170	202.7	4,220	13	2,402	1,037	(1)	540	
1904	75–100	0.8	(1)	(1)	(1)	(1)	(1)	(1)	251.4	(1)	(1)	(1)	(1)	(1)	(1)	
1903	125–150	2.7	(1)	(1)	(1)	(1)	(1)	(1)	151.4	(1)	(1)	(1)	(1)	(1)	(1)	
1902	175–200	2.8	(1)	(1)	(1)	(1)	(1)	(1)	176.0	(1)	(1)	(1)	(1)	(1)	(1)	
1901	75–100	1.5	(1)	(1)	(1)	(1)	(1)	(1)	170.5	(1)	(1)	(1)	(1)	(1)	(1)	

[1] Not reported. [4] First 6 months only. [6] Fiscal year May 1 to Apr. 30. [7] Jan. 1 to Apr. 30 only.

PLANT NO. 7

TABLE C—*Labor productivity, output per stack-day, consumption of materials charged, and changes in equipment in six merchant blast-furnace plants reporting for earlier years*—Continued

Year	Production in thousands of gross tons	Average full-time furnaces active during year	Average labor productivity						Average output per stack-day	Consumption of material per gross ton of pig iron produced				Average cubic feet of air blown per minute	Remarks
			Gross tons of pig iron produced per man-hour			Man-hours per gross ton of pig iron produced									
			Furnace crew labor	All other labor	Total labor	Furnace crew labor	All other labor	Total labor		Iron ore	Scrap	Coke	Flux		
									Gross tons	*Pounds*	*Pounds*	*Pounds*	*Pounds*		
1927[4]	125–150	2.0	0.848	0.515	0.321	1.179	1.940	3.119	410.0	(1)	(1)	(1)	(1)	35,514	
1926	250–275	1.9	.816	.424	.279	1.226	2.358	3.584	392.8	3,618	372	2,042	993	34,747	
1925	250–275	2.0	(1)	(1)	.270	(1)	(1)	3.703	363.1	3,774	237	2,146	1,111	34,379	Relined.
1924	250–275	1.9	(1)	(1)	.250	(1)	(1)	3.999	375.5	3,718	262	2,088	999	35,037	
1923	225–250	1.8	(1)	(1)	.231	(1)	(1)	4.322	346.8	4,234	45	2,209	1,030	35,387	Do.
1922	150–175	1.2	.736	.308	.217	1,359	3.249	4.607	350.3	4,231	103	2,148	1,030	(1)	
1921	Under 25	.2	(1)	(1)	.155	(1)	(1)	6.444	375.5	4,390	22	2,050	1,131	(1)	
1920	200–225	1.8	(1)	(1)	.151	(1)	(1)	6.633	317.0	4,451	22	2,407	1,239	(1)	
1919	175–200	1.6	(1)	(1)	.128	(1)	(1)	7.793	304.3	(1)	(1)	(1)	(1)	(1)	Do.
1918	200–225	2.0	(1)	(1)	.153	(1)	(1)	6.554	297.9	(1)	(1)	(1)	(1)	(1)	
1917	225–250	2.0	.616	.227	.166	1.624	4.405	6.029	314.0	(1)	(1)	(1)	(1)	(1)	
1916	200–225	1.8	(1)	(1)	(1)	(1)	(1)	(1)	331.5	(1)	(1)	(1)	(1)	(1)	
1915	225–250	2.0	(1)	(1)	(1)	(1)	(1)	(1)	328.7	(1)	(1)	(1)	(1)	(1)	
1914	150–175	1.4	(1)	(1)	(1)	(1)	(1)	(1)	306.2	(1)	(1)	(1)	(1)	(1)	One stack rebuilt.
1913	175–200	1.7	.523	.326	.201	1,914	3.067	4.981	291.5	(1)	(1)	(1)	(1)	(1)	Pig machine installed.
1912	175–200	1.8	.544	.332	.206	1.837	3.016	4.853	289.5	(1)	(1)	(1)	(1)	(1)	
1911	125–150	1.2	.440	.267	.166	2.272	3.750	6.023	318.5	(1)	(1)	(1)	(1)	(1)	Stack rebuilt.
1910	125–150	1.4	(1)	(1)	(1)	(1)	(1)	(1)	261.5	(1)	(1)	(1)	(1)	(1)	Pig machine installed; "B" stack built.
1909	50–75	.8	(1)	(1)	(1)	(1)	(1)	(1)	246.9	(1)	(1)	(1)	(1)	(1)	
1908	50–75	.7	(1)	(1)	(1)	(1)	(1)	(1)	261.4	(1)	(1)	(1)	(1)	(1)	
1907	50–75	.9	(1)	(1)	(1)	(1)	(1)	(1)	236.5	(1)	(1)	(1)	(1)	(1)	
1906	75–100	1.0	(1)	(1)	(1)	(1)	(1)	(1)	227.2	(1)	(1)	(1)	(1)	(1)	
1905	75–100	.9	.232	.189	.104	4.297	5.300	9.597	235.5	(1)	(1)	(1)	(1)	(1)	
1904	50–75	.9	(1)	(1)	(1)	(1)	(1)	(1)	228.2	(1)	(1)	(1)	(1)	(1)	

[1] Not reported.

First 6 months only.

APPENDIX 3.—REPRESENTATIVE FORCE REPORTS ANALYZED AND COMPARED

In an effort to keep the number of men employed at a minimum, the management in most blast furnace plants makes a daily record of the number of men actually working, by labor groups and occupations. These daily records are frequently recapitulated on a weekly or monthly basis. From these records it is easy to determine the minimum number of men with which the plant can be efficiently operated, and the effort is being made continually to reduce this minimum. On the basis of the experience thus recorded a standard or "bogie" is constructed for each department. This standard then becomes an upper limit, each foreman being strictly limited to his quota except in special situations. This standard of course is not a fixed one, but is reduced from time to time as fewer and fewer workers are able to operate the plant.

The relationship between the standard force and the number of men actually employed from day to day differs between plants in accordance with the way the standard is applied, and the care and frequency with which it is revised. A standard to which foremen must rigidly conform can not too closely approximate the minimum daily force without danger of hampering operations. On the other hand, the standard may be a guide to best practice—a goal to be attained. This second type of standard is frequently exceeded by the actual daily force, and can not be strictly compared with the former type.

Modern blast furnace plants are essentially similar, and the same basic processes must be performed, although the auxiliary equipment and the division of labor by occupations differs widely. All blast furnace force reports will necessarily include certain essential labor groups, but there is a marked lack of uniformity in the way individual occupations are classified in different force reports. For example, the blowing engineers and helpers are sometimes listed with the power-house crew and sometimes with the cast house.

The force reports presented in this appendix include only those labor groups and occupations which have actually been used in constructing the man-hours for productivity purposes. That part of the report which covers the office force, a nodulizing plant, sintering plant, or other auxiliary operation not included as part of the blast furnace plant proper has been omitted. Thus these reports give an excellent idea of the labor which has been included in measuring productivity in a few typical plants.

Force report No. 1 is for one-furnace operation in a two-furnace northern inland plant. The force report is presented exactly as it is kept by the company with one minor exception. All plants do not use the same terminology in their force reports, and it is not unusual to find identical groups or occupations called by different names. In order to facilitate comparison between the various force reports and to make them more easily understood, explanatory terms have been inserted in parentheses at various points. For example, this plant uses the term "trestle" to cover what is ordinarily known as "stocking"; some plants use the term "material delivery" to cover the same operation. By using a uniform word "stocking" in all such cases, the essential similarity of the operation in different plants is emphasized. Some plants, for instance, have an occupation called "trestlemen," which applies only to those who work on top of the trestle and does not include men or machines engaged in delivering materials. However, in force report No. 1 the term "trestlemen" includes both those engaged in the delivery of ore from the stock piles and those dumping materials into the bins.

In the first place, the men in the crew are divided into two general groups: Direct blast furnace labor and indirect blast furnace labor. The former includes all men employed permanently and regularly around the stack itself; the latter includes all the auxiliary labor which is necessary to the operation of the plant.

The first process in the operation of a blast furnace is the unloading of the materials—ore, scrap, coke, and limestone—in the yard. But this is ordinarily done by the unloading or yard gangs and is considered as indirect labor. In the most modern plants this unloading would usually be done by means of a car dumper in an inland plant or by a Hulett unloader in a lakeside plant. The materials as thus delivered must then be removed either to the bins for immediate use or to the stockpiles for storage until needed. Smaller plants will usually perform these operations by means of locomotive cranes and the yard railway; this particular plant uses an ore bridge to take care of the ore. This machine can perform both operations at once—it removes the ore from the dump to the stockpiles and can at the same time keep the bins supplied. The saving of labor which this makes possible is apparent. The coke, however, is delivered on the trestle in railroad cars, and the four unloaders listed in the force report are responsible for unloading these cars into the coke bins. These men also look after the ore and limestone bins in so far as these need attention.

The next step in the process takes place underneath the bins. By means of a lever the operator of the larry car opens the bins from below and allows the ore, coke, or stone to fall into the car, which is a small, electrically driven dump car and is usually equipped with a weighing device. The larryman runs the loaded car over to the skip, where he dumps the load into the skip bucket, in which it is carried to the top of the stack and dropped in. The man who operates the skip is known as a skip operator, skip engineer, or hoisting engineer. The larrymen, larrymen's helpers, and skipmen are usually termed the charging labor.

In the cast house are included all the men engaged in operating both the stack itself, the stoves, and the gas washer. These men take care of the blowing, the water-cooilng system, the slag removal, the casting, the clean-up, etc.

The blowing engineers and oilers have charge of the blowing engines which furnish the blast for the stack. In some plants these men are classed with the power-house crew, in others (as in this one) with the blast furnace direct labor. The dry blast is very rare in the merchant industry to-day and the dry-blast operators will not be found in any other force report.

The pig-machine crew consists of the men who cast the hot metal. This requires four men to a shift—a foreman, a craneman who pours the hot metal from the ladle into the molds of the machine, a trough man who manages the water-cooling system at the top of the machine and loosens the pigs so that they will drop out into the car below, and a lime mixer who fixes the lime bath through which the molds pass on their way back to the ladle.

In this plant there are a number of full-time mechanical men attached to the blast furnace proper. These include a millwright, a motor inspector, and two molders. In other plants these men might be listed with the mechanical gang and not with the furnace crew.

Since this is a 2-furnace plant the indirect labor is exceptionally large for 1-furnace operation. The boilers, yard railway, and mechanical crew carry approximately as many men as they would for two furnaces; it is only in the cranes, general labor, and track labor that any great saving in men can be obtained while one furnace is down. A 1-furnace plant would not require nearly as much overhead labor as is listed here.

The departments and occupations are mostly self-explanatory, and there is no necessity for going into details. The plant is on an 8-hour basis.

FORCE REPORT No. 1.—*Number of men normally employed in a northern, inland, two stack blast-furnace plant, during one-furnace operation in 1927, by labor groups and occupations*

Labor group and occupation	Number of men employed
BLAST FURNACE DIRECT LABOR	
Trestles (stocking):	
Ore bridge operators	1
Trestle foreman	1
Unloaders	4
Stock house (charging):	
Skip engineers	3
Larry car operators	3
Cast house:	
Blowers	3
Keepers	3
Keepers, first helpers	3
Cinder snappers	3
Stove men	3
Stove cleaners	3
Scrap men	3
Clay men	1
Barmen	1
Gas cleaner and flue-dust men	1
Stove foremen	1
Water tenders	1
Blowing engines and dry blast:	
Blowing engineers	3
Blowing oilers	3
Dry blast engineers	3
Dry blast oilers	3
Pig machine:	
Foremen	3
Cranemen	3
Line mixers	3
Trough men	3
Mechanical: Millwrights	1
Electrical: Motor inspectors	1
Foundry:	
Molders	1
Molders, helpers	1
Slag: Dump men	1
Supervisory: Superintendents	1
BLAST FURNACE INDIRECT LABOR	
Water department: Pumpmen	3
Steam department:	
Foremen	1
Water tenders	3
Firemen	3
Ash wheelers	2
Boiler washers and helpers	2
BLAST FURNACE INDIRECT LABOR—con.	
Electric light and power:	
Foremen	1
Electricians	1
Electricians' helpers	1
Engineers	3
Oilers	3
Yard switching:	
Weighmaster	1
Locomotive engineers	3
Locomotive firemen	3
Locomotive brakemen	6
Locomotive cranes:	
Locomotive brakemen	2
Locomotive crane firemen	2
Mechanical shop:	
Master mechanics and assistants	2
Machinist	1
Pipe fitter	1
Blacksmiths	2
Blacksmiths' helpers	2
Carpenters	4
Riggers	1
Riggers' helpers	1
Painters	2
Boiler makers	1
Masons	2
Masons' helpers	1
Handymen	6
Machinists' helpers	4
Autotrucks and auto department:	
Stablemen	1
Teamsters	1
Cart drivers	1
Chemical laboratory:	
Chemists and assistants	2
Sampler	1
General labor:	
General foremen	1
Foreman	1
Assistant foremen	1
Laborers	10
Track labor:	
Foremen	1
Laborers	6

Force report No. 2 is for a single-furnace inland northern plant. This furnace is very efficiently operated and the crew represents practically a minimum for plants of this type. Some of the labor saving is due to a very scientific arrangement of plant equipment; the rest is due to continuous efforts to cut down the crew, abolish jobs, and expand the duties of each position. The smallness of the crew is especially apparent in certain labor groups. For example, all delivery of materials to the bins is done by means of the ore bridge; there is no trestle or high line. Thus, two men take care of all this operation. The pig machine is run with 7 men instead of the usual 12; the boilers are tended by only 5 men instead of the normal 10 to 15; the mechanical crew is cut to the barest minimum with which it would be possible to operate; the single locomotive crane does such switching as may be necessary around the plant; there is no plant railway.

The success of this plant at saving labor is quite remarkable, but it must be emphasized once more that every blast-furnace plant has its own little peculiarities which distinguish it from every other. Some of the labor saving which has been accomplished at this plant was made possible by the extremely convenient arrangement of plant layout; therefore, it would not be possible for some other plants, even at best, to equal the labor performance of this one. The force report, however, is interesting in that it does show what is actually being done in a blast-furnace plant toward reducing the labor force to the very minimum. Except as indicated to the contrary the plant is on an 8-hour basis.

FORCE REPORT NO. 2.—*Number of men normally employed in a northern, inland, one stack blast-furnace plant in 1927, by labor groups and occupations*

Labor group and occupation	Number of men employed	Labor group and occupation	Number of men employed
Ore bridge:		Mechanical:	
Operators	1	General mechanics	1
Foremen (10 hours)	1	Mechanics	2
Stock house:		Millwrights	3
Larrymen	3	Blacksmiths	1
Larry helpers	3	Blacksmith helpers	1
Skip operators	3	Machinists	1
Cast house:		Chief engineers	1
Blowers	3	Master mechanics	1
Keepers	3	Electrical:	
Keepers' helpers	3	Electricians	3
Water tenders	3	Electrician helpers	1
Cast-house labor (10 hours)	5	Locomotive cranes:	
Pig machine:		Locomotive cranemen	1
Foremen	3	Locomotive firemen (8½ hours)	1
Helpers	3	Miscellaneous:	
Cranemen	1	Laboratory	3
Slag pit:		Filter house	1
Shovel men (10 hours)	2	Chief chemists	1
Car droppers (10 hours)	2	Storeroom men	1
Boilers:		General labor	12
Water tenders	3		
Firemen (10 hours)	2		
Blowing engines:			
Engineers	3		
Oilers	3		

Force report No. 3 shows the situation in a plant before and after the installation of a coke plant. It makes clear the extent of the saving in labor which is possible under the joint operation of a coke plant with a blast furnace. The report for 1925 shows the composition of the force as it was before the coke plant was built; the report for 1927 shows the reorganization necessitated by the operation of the coke plant. The report for the latter year lists the full number of men in each labor group, but the percentages in the next column indicate the amount of each group which is charged against the blast furnace. Therefore, while most of the indirect labor groups have increased in number, only a part of the group is now chargeable against the blast furnace. Thus the saving in labor under joint operation, as has already been stated, is largely in the indirect labor groups, while the furnace crew remains practically unchanged, as would be expected.

The substitution of the ore bridge and the transfer-car man for the trestlemen is, of course, entirely independent of the coke plant installation; it just happened that this change in method was made at about the same time. The apparent change in the laboratory crew is mostly a matter of reclassification. While three samplers and three castmen were added to the laboratory force after the coke plant started operation, at the same time in the salary group the assistant chemists were reduced from three to one. Considering that at present only 50 per cent of the laboratory labor is charged against the blast furnace, the net change in this group amounted to an increase of only one-half a man per day. The plant is on an 8-hour basis except in one occupation.

Force Report No. 3.—*Number of men normally employed in a northern, inland, one stack blast-furnace plant, before and after the installation of a coke plant, by labor groups and occupations with the percentage of labor time chargeable to the blast-furnace department under joint operation with the coke plant in 1927*

Labor group and occupation	Number of men employed: In 1925 *before* installation of coke plant	Number of men employed: In 1927 *after* installation of coke plant	Per cent of labor time chargeable to blast furnace department in 1927
Ore bridge			100
Bridge operators		2	
Trestle			100
Trestlemen	6		
Transfer carmen		1	
Stack house			100
Hoist engineers	3	3	
Operators, scale car	3	3	
Laborers, scrap pit	3	3	
Cast house			100
Keepers	3	3	
Keepers, first helpers	3	3	
Keepers, second helpers	3	3	
Claymen	1	1	
Laborers, cast house (10 hours)	2	1	
Pig machine			100
Repair foremen	1	1	
Operators	3	3	
Operator helpers	9	9	
Stoves			100
Stove tenders	3	3	
Engine house			100
Engineers, blowing engines	3	3	
Oilers, blowing engines	3	3	
Chief engineers	1	1	
Pump house men		1	
Boiler house			60
Water tenders	3	3	
Firemen	3	3	
Ash wheelers		2	
Boiler cleaners	1	3	
Mechanical			57
Repair foremen	1	1	
Repairmen	6	3	
Repair helpers	2	7	
Machinists	1	2	
Blacksmiths	1	1	
Blacksmith helpers	1	1	
Carpenters		3	
Carpenter helpers	1		
Electrical			35
Electricians	1	1	
Electricians' helpers	2	1	
Pipe department			57
Pipe fitters	1	2	
Pipe fitters' helpers		1	
Locomotive cranes			88
Engineers	5	4	
Firemen	5	4	
Conductors		4	
Locomotives (switching)			80
Engineers	3	3	
Firemen	3	3	
Conductors	3	3	

FORCE REPORT NO. 3.—*Number of men normally employed in a northern, inland, one stack blast-furnace plant, before and after the installation of a coke plant, by labor groups and occupations with the percentage of labor time chargeable to the blast-furnace department under joint operation with the coke plant in 1927*—Con.

Labor group and occupation	Number of men employed: In 1925 *before* installation of coke plant	Number of men employed: In 1927 *after* installation of coke plant	Per cent of labor time chargeable to blast furnace department in 1927
Locomotives (switching)—Continued.			
Brakemen	3	3	
Yardmaster	1	1	
Assistant yardmaster		1	
Yard labor			50
Foreman	1		
Cleaning yard		2	
Laborers	26	19	
Iron yard laborers	2	2	
Janitor		1	
Storeroom		1	
Track labor			50
Foreman	1	1	
Laborers	5	7	
Laboratory			50
Assistant chemist	1	1	
Laboratory—Continued.			
Samplers		3	
Cast men		3	
Salaries			50
Superintendents	1	1	
Burden clerks	1		
Blowers	3	3	
Chief chemists	1	1	
Assistant chemists	3	1	
Master mechanics	1	1	
Assistant master mechanics		1	
Chief electricians		1	
Labor foremen	1	1	
Mechanical engineers		1	
Storeroom	1	1	
Timekeepers	1	1	

Force report No. 4 presents a sharp contrast to those previously discussed. This is a southern two-furnace plant mechanically filled and sand cast, although a pig breaker is used. Like a number of other merchant furnace plants it still retains the two-shift, 12-hour day. This plant is quite typical of southern plants, but it should not be directly compared with the northern plants previously discussed which are working the 8-hour day. On all continuous operations the 8-hour plants would use three men for every two men employed at this plant; therefore the number of men shown on the latter force report must be increased to allow for this difference before any direct comparisons are made.

In fact, it is difficult to compare northern and southern plants with reference to the labor force because of different conditions of operation—for example, the handling of materials.

The advantage of the pig machine over the pig breaker as a labor-saving device is shown in comparing the pig machine crew in No. 1 with the iron yard crew (excluding the locomotive cranes) in No. 4. Of course, this saving in labor does not tell the whole story. The pig machine is a very costly piece of machinery to install and the upkeep is high, while the pig breaker is a simple hammer, requiring only a wooden scaffold as auxiliary equipment. Because of the differences in wages in the two sections, the southern plants find it more profiitable to use the pig breaker and hire more labor, while the northern plants find it more economical to cut the labor cost by installing the pig machine.

FORCE REPORT No. 4.—*Number of men normally employed in a southern two stack blast-furnace plant during one and two furnace operations in 1927, by labor groups and occupations*

Labor group and occupation	One-furnace operation	Two-furnace operation
Stock house (stocking and charging):		
Stock dumpers	2	2
Stock dumpers' helpers	1	2
Manganese pitmen	1	2
Scrappers	2	4
Tunnel car men	2	4
Scale car men	2	4
Skipmen	2	4
Cast house:		
Foundry men	2	2
Keepers	2	4
Fallmen (cinder-snappers)	2	4
Scrappers	4	8
Hand sand cutters	2	4
Sand cutters	6	12
Fifth helpers	2	4
Claymen	2	4
Open sand molders	1	1
Stove tenders	2	4
Stove repairmen	1	1
Stove repairmen helpers	1	2
Blowing engines:		
Chief engineer (10 hours)	1	1
Chief engineer's helpers (10 hours)	1	1
Blowing engineers	2	2
Oilers	2	4
Boilers:		
Foremen (10 hours)	1	1
Assistant foremen (10 hours)	1	1
Firemen	2	2
Tube blowers (10 hours)	2	2
Water tenders	2	2
Ashmen (10 hours)	1	2
Pumpmen	2	2
Iron yard:		
Locomotive crane engineers	[1] 2	[1] 2
Locomotive crane firemen	[1] 2	[1] 2
Breakers on platform	1	2
Breakers' helpers	2	4
Hookers	1	2
Cranemen (overhead)	3	5
Switchmen	1	2
Hostlers	1	1
Iron-yard helpers	1	1
Loaders	10	20
Mechanical:		
Machinists (10 hours)	3	3
Machinists' apprentices	1	1
Machinists, repairmen	[2] 3	[2] 3
Machinists helpers	[3] 5	[3] 5
Blacksmiths	1	1
Blacksmiths' helpers	2	2
Pipe fitters	1	1
Carpenter foremen	1	1
Carpenters	3	3
Mechanical—Continued.		
Carpenters' helpers	1	1
Boilermaker foremen	1	1
Boilermakers	1	1
Boilermakers' helpers	2	2
Boilermakers' apprentices	1	1
Welders	1	1
Electricians	1	1
Electricans' assistant	1	1
Electrical power:		
Operators	2	2
Operators' helpers	1	1
Repairmen (10 hours)	1	1
Masonry:		
Brick mason foremen	1	1
Brick masons (8 hours)	2	2
Brick masons' helpers (10 hours)	5	5
Switching and stock delivery:		
Locomotive engineers	2	2
Locomotive firemen	2	2
Switchmen	3	3
Locomotive crane engineers (10 hours)	1	2
Locomotive crane firemen (10 hours)	1	2
Cinder yard:		
Locomotive engineers	1	2
Locomotive firemen	1	2
Pot dumpers	2	2
Pot and car oilers (10 hours)	1	1
Cinder dump:		
Dry car cleaner (10 hours)	1	1
Run cutters	[4] 4	[3] 3
Floating and track gang:		
Labor foremen	2	2
Track foremen	1	1
Trackmen	10	10
Common laborers	16	16
General:		
Watchmen	2	2
Stablemen (10 hours)	1	1
Supply men (10 hours)	1	1
Supply men's helpers	1	1
Cartmen	4	4
Salaries:		
Superintendents	1	1
Master mechanics	1	1
Iron yard foremen	1	1
Chemists	2	2
Sample boys	1	1
Weighmasters	1	1
Timekeepers	2	2
Supply clerks	1	1
Total	178	224

[1] 1 on 10 hours per day. [2] 2 on 10 hours per day. [3] 1 on 12 hours per day. [4] 2 on 12 hours per day.

Force report No. 5 is drawn up to show the effect of the 8-hour day on the blast furnace labor force. This is a northern inland plant with single-furnace operation. One column shows the number of men under the old 10 and 12 hour day in 1923; the next column shows the way the crew was reorganized at the time the change was made; then the third column shows the way the organization was eventually developed after four years of experience. A comparison of the force from period to period is complicated somewhat by the improvements that were introduced in the meantime. The bins were rebuilt and the lage crew of ore fillers eliminated. The method of handling slag at the stack was improved upon and the cinder ladle men were cut off, though this saving was partly counteracted by the addition of 2 men at the cinder dump. Thus when considering the effect of the 8-hour day the crew of 1927 is not on a comparable basis with that of 1923. However the introduction of the 8-hour day brought the problem of labor economy more directly to the attention of the management and probably led indirectly to a large number of the improvements which were made.

FORCE REPORT NO. 5.—*Number of men normally employed in a northern, inland, one stack-blast furnace plant during 2 and 3 shift operations in 1923 and 1927, by labor groups and occupations*

Labor group and occupation	Two-shift operation in 1923	Three-shift operation in 1923	Three-shift operation in 1927
Stocking furnace bins:			
Trestlemen	14	14	11
Steam shovel cranemen and helpers	5	4	4
Stock house:			
Ore fillers	18	24	-------
Scale car operators and helpers	6	6	6
Skip operators	2	3	3
Cast house:			
Blowers	2	3	3
Keepers	2	3	3
Keepers' helpers	6	6	6
Stove tenders	2	3	3
Clay men	1	1	1
Scrappers	3	3	-------
Furnace water tenders	2	3	-------
Filter operator and helper	2	2	1
Cinder ladle men	4	6	-------
Pig machine:			
Pig machine operators	2	3	3
Helpers	10	12	9
Blowing engines:			
Blowing engineers	2	3	3
Oilers	2	3	3
Steam:			
Water tenders	2	3	3
Firemen	2	3	3
Boiler washers	3	3	2
Slag disposal:			
Cinder pit labor	2	3	3
Cinder dump labor	-------	-------	2
Mechanical:			
Master mechanics and assistants	2	2	1
Electricians and helpers	2	2	2

Labor group and occupation	Two-shift operation in 1923	Three-shift operation in 1923	Three-shift operation in 1927
Mechanical—Continued.			
Machinists and helpers	2	2	1
Blacksmiths	3	3	2
Pipefitters	-------	-------	1
Riggers and repairers	9	9	5
Carpenters	3	3	2
Molders and helpers	2	2	-------
Switching:			
Locomotive engineers	1	1	1
Locomotive firemen	1	1	1
Locomotive switchmen	2	2	2
Hostlers	1	1	1
Track labor:			
Track boss	1	1	1
Track labor	6	7	3
Iron yard:			
Foremen and weighmasters	1	1	1
Locomotive cranemen and helpers	-------	-------	2
Laborers	4	3	1
Miscellaneous:			
General laborers	1	2	3
Unloading and stocking material	-------	5	3
Carters	4	6	-------
Cinder crush labor	-------	-------	2
Miscellaneous labor	4	1	-------
Management and general supervisory:			
Office	3	3	3
Chief engineers	1	1	1
Superintendents	1	1	1
General foremen	-------	-------	1
Labor foremen	1	1	-------
Laboratory	3	3	3
Watchmen	2	3	3

Force report No. 6 is but a classification of the labor crew into groups. However, it is shown in sufficient detail to bring out the changes which took place between 1923 and 1926. The one important change was the installation of a skip hoist, which resulted in the elimination of 10 men on the trestle and 45 men in the stock house. There was also a pronounced cut in the cast house and stove crews, but this was independent of the other. The plant in both years was on a 2-shift, 12-hour basis except as noted. This is a one-furnace plant located in Pennsylvania.

Force Report No. 6.—*Number of men normally employed in an eastern Pennsylvania one stack-blast furnace before and after the installation of mechanical filling equipment, by labor groups*

Labor group	Operation in 1926 after the installation of skip	Operation in 1923 before the installation of skip	Labor group	Operation in 1926 after the installation of skip	Operation in 1923 before the installation of skip
Trestle	4	14	General yard (10 hours)	25	26
Stock house	8	53	Iron yard (10 hours)	1	2
Cast house	13	21	Track repair (10 hours)	8	3
Blowers	4	4	Mechanical	22	18
Pig machine	10	11	Miscellaneous	3	3
Boiler room	6	9			
Stove tenders and cleaners	4	11	Total	108	175

Force report No. 7 brings out the comparison between the labor force under a 2-shift, 12-hour system and that under a 3-shift, 8-hour system in a typical northern plant. This shows the situation in 1923 at the time the change was made. It does not show the ultimate organization of the crew under the 3-shift system.

Force Report No. 7.—*Comparison of the labor force under 2-shift operation with the force used under 3-shift operation, 1923, plant 16*

Labor group	Two shifts	Three shifts	Labor group	Two shifts	Three shifts
Blowing room	6	6	Mason	1	1
Boilers	9	9	Mechanics	8	8
Blacksmith shop	2	2	Moulder	1	1
Casting house	15	19	Patrolmen	3	3
Casting machine	14	16	Power house	2	3
Carpenters	3	2	Steam shovel	3	3
Electricians	2	2	Stock house	10	15
Gas washers and pumps	2	3	Stock unloading to bins	12	12
Janitor	1	1	Stove tenders	2	3
Laborers	6	6	Truck driver	1	1
Labor foremen	2	1	Track gang	6	6
Locomotive cranes	10	10	Thaw house	2	2
Locomotive engine	15	15			
Machinist	1	1	Total	139	151

APPENDIX 4.—RELATIVE EFFICIENCY OF A BLAST FURNACE IN PRODUCING DIFFERENT GRADES OF PIG IRON

A. FOUNDRY VERSUS BASIC

The unit used in measuring blast-furnace output for the purposes of this study is the gross ton of pig iron. In the calculations it has been assumed that these tons, as measures of output for productivity purposes, are for the same article. However, even in successive casts at the same blast furnace there are minor differences in grade and quality, and these differences have some slight influence on the amount of pig iron that the furnace can turn out. Of course, it is well known that the ferro-alloys are in an altogether different class from the standard grades of pig iron as far as productivity is concerned. A blast furnace working on ferro-alloys will not ordinarily turn out much more than half as much metal as it would if working on standard basic iron; that is the reason ferro-alloy plants have been excluded from this study.

However, even within the different grades of standard pig iron there are minor differences in output efficiency. The following table shows the comparative efficiency of a blast furnace as between foundry and basic pig iron, which are the two most important grades in the merchant industry. The table shows the daily output of the stack for each grade of iron and for two subclasses within each grade. It is, of course, impossible to maintain identical operating conditions throughout the year, so it is possible that some of the variations in daily output are due to outside factors and not to the grade of pig iron. Nevertheless, the marked difference between daily output of basic iron and that of foundry iron is noticeable. In 1926 the output per stack-day of the furnace when working on basic iron exceeded the daily output when working on foundry iron by 8.5 per cent, in 1927 basic exceeded foundry by 6.7 per cent.

The effect of this on the productivity averages is evident. If this furnace worked altogether on basic iron instead of about equally on both, its output per man-hour being increased from 7 to 8 per cent for every ton of basic substituted for a ton of foundry, the productivity average for the year would be nearly 4 per cent higher than it was. However, the reverse would more frequently be the case. Not many merchant furnaces work exclusively on basic iron, but it is not unusual to find some of them working practically altogether on foundry. It is apparent that such a blast furnace has a somewhat depressed productivity average when it is compared with another furnace which produces a large proportion of basic iron. When a furnace changes frequently from one grade of iron to another, its daily performance suffers still more as a result of irregular operating requirements.

Output per stack-day of different grades of pig iron in a blast furnace

Name	Characteristics	Output per stack-day	
		1927	1926
		Gross tons	*Gross tons*
Foundry	Over 1.75 per cent silicon	372	352
High phosphorus	Over 0.6 per cent phosphorus	378	348
Low phosphorus	Under 0.6 per cent phosphorus	366	356
Basic	Under 1.75 per cent silicon	397	382
Standard	Under 1.50 per cent managanese	400	387
High manganese	Over 1.50 per cent manganese	396	378

B. FOUNDRY VERSUS BASIC AND MALLEABLE

A further illustration on this point is shown in the next table which shows the relative output per stack-day of a particular blast furnace for foundry iron as contrasted with malleable and basic. The two latter grades are very close together in output efficiency, so the daily output figures might be assumed to stand for either of them. The data cover complete operations for this plant for the period 1921–1926.

In the year 1926 the daily output of foundry iron slightly exceeded that of basic, but this was due to the materials in the charge and may be disregarded as not occurring under similar operating conditions. However, in the five years 1921–1925, the daily output of basic iron exceeded that of foundry iron every year, the excess varying from a low of 8.2 per cent in 1923 to 18.5 per cent in 1924. The unweighted average for the five years is slightly less than 13 per cent. This is practically twice as great a discrepancy as existed in the blast furnace previously mentioned; thus it emphasizes still more the loss in productivity of a furnace working on foundry iron instead of basic.

Year	Average daily product		Percentage by which the daily output of malleable and basic exceeds that of foundry iron
	Foundry	Malleable and basic	
	Gross tons	*Gross tons*	
1926	433	432	[1] 0.2
1925	369	411	11.4
1924	336.6	398.9	18.5
1923	328.5	355.3	8.2
1922	313	358	14.4
1921	300	336	12.0

[1] Negative percentage—malleable and basic less than foundry.

C. FOUNDRY VERSUS FERROMANGANESE

The last table shows the relative efficiency of a blast furnace on ferromanganese as compared with foundry iron. One column shows the average daily output when on foundry iron while another shows the output of ferromanganese in the same years and the same furnace. The average daily output of the furnace increased each year and this increase showed itself in both foundry and ferromanganese production. In the last column is shown the percentage which the daily output on ferromanganese is of the daily output on foundry iron. It is probable that the variations from year to year are due to the presence of other factors which can not be taken into account. The variations, however, do not obscure the essential point, which is that the production of a furnace on ferromanganese is only about 50 per cent of its production on foundry iron.

Year	Average daily product		Percentage, (b) of (a)
	Foundry (a)	Ferromanganese (b)	
	Gross tons	*Gross tons*	
1919	219.6	117.8	53.6
1918	204.3	94.8	46.4
1917	187.2	89.7	47.9

APPENDIX 5.—STATISTICS OF MERCHANT BLAST FURNACES IN RELATION TO THE ENTIRE BLAST-FURNACE INDUSTRY

In order to show the position of the merchant furnaces in relation to the blast-furnace industry as a whole, and to bring out the proportion of the merchant industry covered by the present study, a classification of all active blast furnaces is presented in the table below. This table is based upon data published in the 1916, 1920, and 1926 Iron and Steel Directories[1] and upon the records of the bureau. In constructing the table the plants have been classified according to the definitions set forth in the foreword to this study. (See p. III.

All charcoal blast furnaces and all ferro-alloy stacks have been excluded from the tabulation, in so far as it has been possible to do so. In case a plant produced both pig iron and ferro-alloys, it was classed as a ferro-alloy plant if the proportion of ferro-alloy production to the total tonnage was known to be large. In the case of steel works plants it was impossible to exclude ferro-alloy stacks, because the directories do not contain sufficient information upon which to base the exclusion of some stacks out of a large battery. Therefore, in large steel plants all active stacks are included in the figures.

The data in the table are for the active plants and stacks only, although to be classed as active it was necessary only that a plant or stack should have been active at some time during the period, not active continuously. Here again, in the case of steel plants it is impossible to be certain of absolute accuracy on this point, because the directories do not specify which stacks out of a large number in the plant were idle throughout the period.

The count, as given in the table, is substantially accurate, although the classification of some plants in the early periods is somewhat uncertain. However, the number of such plants and stacks is not large enough to affect the data to any extent.

Total number of active blast furnaces in the United States, by kind, and the number of active merchant blast furnaces covered in this study, 1912 to 1926

Period or year	All active blast furnaces in the United States		All active steel works blast furnaces		All active merchant blast furnaces		Active merchant blast furnaces covered in study	
	Number of plants	Number of stacks	Number of plants	Number of stacks	Number of plants	Number of stacks	Number of plants	Number of stacks
1926	(a)	(a)	(a)	(a)	52	84	[b] 48	[b] 77
1921–1925	145	350	58	226	87	124	68	93
1917–1920	176	389	65	235	111	154	67	96
1912–1914	167	358	53	194	114	164	36	56

[a] No data. [b] Excluding one ferro-alloy plant.

[1] Iron and Steel Works Directory of the United States and Canada. By American Iron and Steel Institute. Eighteenth, nineteenth, and twentieth editions—1916, 1920, and 1926.

The table brings out very clearly the decline of the merchant industry in competition with steel works blast furnaces. In the early period 1912–1914 the merchant plants numbered more than twice as many as the steel plants, although the latter excelled in number of stacks, 194 to 164. By the next period 1917–1920 the merchant plants had declined slightly in number, but the steel works blast furnaces increased both in plants and stacks. In 1921–1925 the steel plants receded somewhat from the peak, suffering a loss of 7 plants and 9 stacks, but the merchant plants declined more than 20 per cent, and their total stacks declined about the same amount. The steel plants had nearly twice as many stacks active during this period as the merchant plants had. However, it must not be assumed that there has been a corresponding decrease in production in either merchant or steel works furnaces as the decline in number of plants is partly counterbalanced by the increase in size of the stacks. Nor do these figures convey the whole story, for quite a number of merchant stacks are included in the table as active because they ran for part of a year in 1923, while as a matter of fact they have not operated since and will not do so. The shrinkage in the merchant furnace industry is best shown by the figures for 1926, when there were less than half the number of merchant plants active that there were in the period 1912–1914. As a matter of fact, the decline in strictly merchant plants has been even greater than shown in the table, since the figures include a few independently operated steel company plants, which, according to the definition commonly accepted in the industry, are not classed as merchant. Some allowance must also be made for the fact that the data for 1926 cover only one year as against three years in 1912–1914.

A comparison of the merchant industry as a whole with the plants included in the bureau averages shows to what extent the data in this study cover the whole merchant industry. In 1926 only four active plants, containing seven stacks, are not shown in the averages for that year; these constitute less than 10 per cent of the industry, either in number of stacks or in output. In 1921–1925 the bureau's representation is better than appears at first sight, for a fairly large number of the plants and stacks listed for the industry in this period were active only a few months in 1923; their contribution to the total merchant furnace production during the period was negligible. The most important plants missing from the bureau averages during these years are the same four which did not furnish data for 1926. For the period 1917–1920 the bureau has data for somewhat less than two-thirds of the industry, while in 1912–1914 the averages cover almost exactly one-third, computed either in plants or stacks. Thus, even in the earliest period, the representation is fairly large. In relation to amount of pig iron produced the proportion of the industry represented in the bureau data would be still larger; but no data on production are available along the lines of this classification of plants.

APPENDIX 6.—METHODS OF COMPUTING MAN-HOURS

The part of this study which required the greatest expenditure of time was the computation of the man-hours. This particular subject raised some difficult problems, especially in the field work. These difficulties centered around two main points: (1) The definition of a blast furnace plant, and (2) the compilation of the man-hours from available data.

In theory, the definition of a merchant blast furnace is simple enough, but when the definition is applied to the problem of obtaining man-hours all fine theoretical distinctions have to be subordinated to the practical necessities of the situation. The guiding principle in all this work was so to define the blast-furnace plant that the man-hour data for all plants would cover uniform operations, even though this involved the adjustment of the man-hours for some plants.

The best example of this first point is the sintering plant which is an integral part of many blast furnace plants. In one sense sintering is an important process in blast furnace operation; most large modern plants include a sintering machine in their equipment. But the sintering plant is not an absolutely essential part of furnace operation; it can and does operate independently of the blast furnace, and it does not exist in many of the smaller, older plants. Therefore, the decision was made to exclude the sintering machine from the definition of a merchant blast furnace, which meant eliminating all sintering labor from the man-hours.

A second illustration is that of ore crushers or roasters. These machines treat or rework the ore so as to improve it for smelting in the blast furnace. Yet, because the treatment of ore is really a part of mining and not smelting, these too had to be excluded from the definition.

Still another illustration is that of a slag disposal or cement plant. Ten or 15 years ago most blast furnaces dumped their slag in the most convenient place and left it. Recently, however, slag has come to be a valuable by-product of pig iron manufacture, and at the present time there are very few blast-furnace plants which do not sell or remanufacture their slag. Sometimes the slag is contracted for by an outside company, which takes charge of it as soon as it is dumped. In other cases, however, the blast furnace company builds its own slag-crushing plant and does its own manufacturing. In these plants it was sometimes necessary to take out the slag-preparation man-hours from the total man-hours for the plant.

Finally, there is another class of cases which concern deficiencies in particular plants. At one blast-furnace plant there was no yard railway, the switching being done by the railroad company which delivered the ore and other materials. No switching labor appears in the total man-hours for the plant, and yet this is an essential operation which is actually being performed in this plant. In the lakeside plants, the dock labor is usually included with the blast-furnace labor, but there are some lakeside plants at which the dock unloading is done by a separate terminal company. In all such cases the principle followed has been that of taking the man-hours for the plant just as they are, all exceptional situations or arrangements being noted. Such plants show a slightly higher productivity than they would if all the essential man-hours were included in the data, and to that extent some allowance must be made in comparing them with other plants in the industry.

The second major problem arose in connection with the actual compilation of the man-hours from the plant records. There is almost no uniformity among the plants in the industry in their records of man-hours, but in a general way the plants can be classified into the following groups:

1. A very few plants keep a complete record of all man-hours, classifying and summarizing these man-hours annually. The classification into labor groups will, of course, be on the basis which is most satisfactory for the lay-out of the plant, and this may not coincide with a classification which would be used in another plant; but where the basis of classification is process and overhead, these man-hours are very useful.

2. A somewhat larger group of plants keep man-hours for the direct labor, but have no distribution of the indirect or overhead labor. In the case of an isolated merchant furnace this makes no difference for all indirect labor is chargeable to blast-furnace operation, but where there is integrated operation between a blast furnace and some auxiliary process, data on total indirect overhead man-hours are of little value unless some basis for distribution between the two processes can be determined upon.

3. A small number of merchant plants keep a monthly record of man-days of labor by occupations. By using these in connection with the hours worked per day by those in the occupation it is possible to calculate the total man-hours for each occupation by months. In this case also the problem of distributing the overhead labor is a serious one in plants where there are two or more operations to be considered.

4. A type of record much more frequent in the blast-furnace industry than those listed above is that of daily force reports by positions; these are usually kept in a time book, each position being given one line and each day the position was filled being entered up in the appropriate column. If the number of working-days for each position is added up at the end of the pay period—month, half month, or 10 days—it is possible to add up the total working-days on each position, and by combining these as necessary, the man-days and eventually the man-hours for any labor group can be obtained. In case such figures are not found totaled the expenditure of time in making additions would be prohibitive, and the man-days worked on each position must be estimated from a quick survey of the record. Because of the fact that very many blast-furnace jobs must be filled every day, this is very much simpler than it might seem; keepers, blowers, foremen, stovetenders, watertenders, and numerous other positions will be filled by a fixed number of men every day the furnace operates, and no calculation is necessary beyond figuring up the hours per day and multiplying these by the number of days the plant operated in the course of the year. Attention can then be concentrated on the positions with varying employment; these can either be laboriously added up from the time book for the month, or an average or typical daily employment can be determined upon; the latter can be handled as in the case of the more stable positions indicated above. The resulting total annual man-hours, as calculated by this method, will contain a certain amount of error, but the running of an occasional monthly test count of hours will serve to check. Such tests showed but slight variations.

APPENDIX 7.—DEFINITIONS

Blast furnace.[1]—The blast furnace, in which is conducted the manufacture of pig iron, is merely a cylindrical steel shell lined throughout with fire brick. This shell varies in height from 40 to 100 feet or even higher, and in each furnace has varying diameters from top to bottom, the lines of the furnace being thus adjusted to the various changes going on within it. The furnace consists of three primary sections—the hearth or lower part, the bosh just above the hearth, and the inwall or upper section. The hearth varies in inside diameter anywhere from 10 to 22 feet, the bosh usually from 12 to 24 feet at the widest part, and the top of the inwall from about 9 to 18 feet. The walls of the hearth near the bottom of the furnace are pierced with openings through which the so-called tuyeres supply a strong blast of heated air to unite with the carbon of the fuel. The volume of the blast varies from about 25,000 to 40,000 cubic feet of air per minute and is usually heated to from 1,100° to 1,400° F.

Into the furnace top is charged at frequent intervals the ore, the fuel (coke, bituminous coal, etc.), and the flux (limestone, dolomite, etc.), which together make up the "burden" or furnace charge.

The ore furnishes the iron for which the furnace is operated. The fuel in combustion gives off gases which serve to reduce the iron to a metallic form and also supplies the heat necessary for the reactions which occur within the furnace and to melt the resultant products. The flux serves to unite with various compounds which would otherwise be infusible at furnace temperatures, and so not only removes in a fluid state the ash of the fuel, but the earthy materials and impurities occurring in the ore. It also serves in such combination as the means of controlling the amounts of certain elements desirable in the iron, but desirable only within limited percentages.

As the charge slowly works its way downward, approaching the zone of highest temperature at or slightly above the tuyeres, the various reactions become more and more complete and, finally, fusion of the resultant products occurs, the molten material collecting in the hearth of the furnace, which serves as a reservoir. The molten iron being of greater specific gravity than the impurities, sinks to the bottom while the impurities of the ore and ash, together with the flux, combine to form a slag which floats on the surface of the iron. The two can then be easily tapped off separately through openings located at proper levels.

The gaseous products rising through the descending column of ore, flux, and fuel, pass off through openings at the top and being combustible, are led through the downcomers to the hot blast stoves and to the boilers where they are burned.

The tuyeres are small openings in the lower part of the furnace through which hot air under heavy pressure is blown into the furnace.

[1] Description taken mainly from A Study of the Blast Furnace, by Harbison-Walker Refractories Co. of Pittsburgh, Pa

In addition to the furnace proper, the blast-furnace plant also includes auxiliary equipment essential for furnace operation, such as blowing and pumping engines, hot-blast stoves, stocking and charging equipment, casting machines, yard railroad, boiler house, etc. Also a single plant may consist of one blast furnace, or a "battery" of a number of furnaces operated together. A few plants, which were built a number of years ago, have two stacks operated alternately, a practice not common in the industry at the present time.

The hot-blast stoves are cylindrical in form, up to 100 feet or more in height, and consist of a steel or iron shell lined with fire brick which forms a number of flues or passages. They are regenerative in principle, gas being introduced and burned at the bottom. Air is then forced through the stove at the top, is heated by the hot brick, and blown from there into the furnace through the tuyeres. The larger furnaces ordinarily have four stoves each.

Gross tons of pig iron.—Production of blast-furnace metal is measured in gross tons (2,240 pounds), without reference to differences in grade of pig iron produced. All furnaces producing ferro-alloys have been generally excluded but in some instances, where only a comparatively small amount of ferro-alloy has been manufactured in connection with the manufacture of pig iron, the figures have been used where the labor time could not be separated for each product. Tonnage of product is measured *net;* that is, excluding "runner and ladle scrap" produced at the furnace, since consideration is given to *usable* product, rather than the total metal cast.

Man-hours.—A man-hour is an hour's work by one man. Total man-hours is the sum of the hours worked by all of the employees. The man-hours used in obtaining labor productivity include the total labor time required for the production of pig iron without reference to the kind or quality of labor. For example, 8 hours of a foreman's time and 48 hours of a laborer's time aggregate 56 man-hours, to be combined with the labor time of other workers contributing in production regardless of skill, efficiency, or compensation. All direct and indirect labor essential for blast-furnace operation is used in compiling man-hour totals for productivity measurement, exclusive of strictly clerical and office help, concerning which see page IV.

Stack-day.—The calendar days of operation of one furnace, without reference to labor time. In a plant of more than one furnace the stack-days of operation are the sum of the days operated by each separate furnace. The term calendar day as here used means a day of 24 hours.

Output per stack-day.—Average production per furnace per calendar day of operation. Changes from year to year reflect the changes in materials and operating practice in the smelting process or in the size of the stack due to rebuilding or alteration.

Sand-cast iron.—Blast-furnace metal cast in sand molds on the furnace floor and broken up either by hand or machine and when cool removed to cars by hand labor.

Machine-cast iron.—Blast-furnace metal cast from a ladle into steel or cast-iron molds run on an endless chain parallel to each other with edges overlapping. As the ladle is tipped, the travel of the chain brings into position a continuous train of empty molds to be filled. The chain carries the full molds through a trough of water, thus cooling the iron so that it may be dumped at the turn into cars, ready to be shipped. Thus casting machines eliminate the hand labor involved in sand casting and loading for shipment.

Molten metal.—Technically molten metal means the liquid pig iron as drawn from the furnace. However, in this bulletin, when metal is spoken of as "molten" it refers to that metal which is conveyed directly, without cooling, to a foundry or to a steel or other refining furnace. In most merchant furnaces this covers only a small part of the product; usually the metal is cast cold into pigs either in sand beds or a pig machine.

Ore.—Iron ore is measured in gross tons, no distinction being made as between quality or preparation for the purposes of this study. Purchased flue dust is included in the ore totals. Produced flue dust, however, whether sintered or unsintered, usually recharged at the furnace, has been excluded from consideration, since it has already been weighed in when originally charged as ore. Flue dust, blown to the top of the furnace, is lost at many plants. Where recovered and recharged it represents an improvement in the total efficiency of operation, largely reflected in a higher yield. However, in measuring furnace performance for productivity purposes the same charge should obviously not be duplicated.

Ore equivalent.—All iron-bearing materials other than ore have been included under this heading. This includes cinder, scale, scrap, etc., but excludes "remelt" or runner and ladle scrap which is excluded both as product and as charge. These materials are treated apart from ores because of their high iron content. This furnace scrap is pig iron which remains in the runners and ladles and has to be chipped out. It is unfair to charge the furnace with materials which have already been weighed in. This scrap is not *additional* raw materials when recharged, but is rather a recovery of otherwise waste material during the process of smelting.

Coke.—Coke is commonly measured in net tons, whereas gross tons are used for ores, ore equivalents, and limestone. Metallurgical coke may be bee-hive or by-product, no distinction being made in this study. Figures for consumption have been compiled for "natural" coke, i. e., coke before drying.

Flux.—Flux used in blast furnaces is usually limestone, but sometimes lime in the form of oyster shells, dolomite, or some combination of these ingredients is used. It is impossible to obtain a cheap and high grade limestone in all localities which usually accounts for the other fluxes. Small amounts of sand or gravel have sometimes been added as a fluxing agent.

Sinter.—This word is commonly applied to flue dust (discussed under iron ores) which is charged into the furnace. The flue dust collects at the top of the stack and is composed of fine particles of ore which are blown up through the column of material by the strong pressure of the blast at the bottom. These ore particles have been partially refined and are very high in iron content. However, such material can not be recharged in the form of dust and must be put through a process of agglomeration (usually sintering) to form the finely divided particles into porous lumps suitable for handling. This sintered flue dust must not be conflused with sintered ore. Ore sintering is explained under treatment of ores.

Treatment of ores.—Iron ores are treated in various ways before being charged into the furnace. The usual forms of treatment practiced are: Drying, roasting, washing, jigging, magnetic separation, briquetting, and nodulizing or sintering. These processes are resorted to in order to remove excess moisture, to remove waste materials (clay, rock, and sand), to reduce the percentage of sulphur in high sulphur ores, to form finely divided material into lumps suitable for charging, etc. Many of the above processes are carried on at the plant, the most common one being the sintering process. In sintering fine ore is mixed with fine coal or coke breeze dust and ignited. By the aid of a forced draught the material is burned until it sinters (combines) into a slab. The slabs are then broken into sizes suitable for handling. Also the high temperature resulting from the forced draught drives off the hydroscopic moisture, the sulphur and the water.

However, all the ore treatment processes have been excluded from this study, except in a few instances where the man-hours of labor in ore treatment could not be separated from the total plant labor.