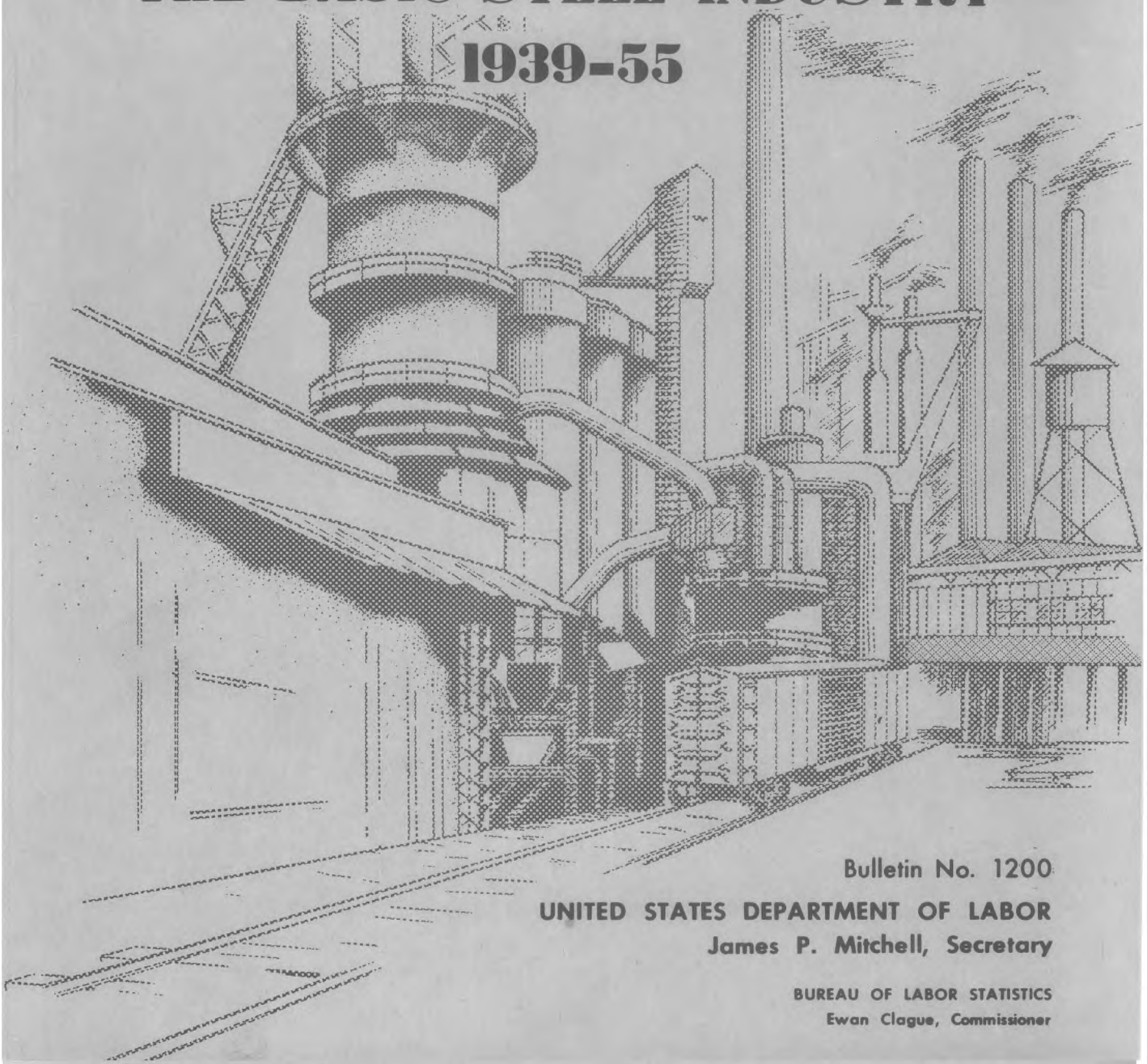
Man-Hours Per Unit of Output

in

THE BASIC STEEL INDUSTRY

1939-55



Bulletin No. 1200

UNITED STATES DEPARTMENT OF LABOR
James P. Mitchell, Secretary

BUREAU OF LABOR STATISTICS
Ewan Clague, Commissioner

This report contains information on trends in productivity in the blast furnaces, steel works and rolling mills industries, 1939-55. This group of industries is commonly referred to as the "basic steel industry." The report was prepared in the Bureau's Division of Productivity and Technological Developments. Allan D. Searle provided general direction to the study and developed the statistical techniques, assisted by Enzo A. Puglisi and Maurice Haven. Others who worked on the report were Harriet S. Taylor, Natalie Strader, and Frances Jernigan.

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MAN-HOURS PER UNIT OF OUTPUT IN THE BASIC STEEL INDUSTRY, 1939-55

Man-hours of production workers per unit of output in blast furnaces, steel works, and rolling mills (this group of industries is commonly referred to as the basic steel industry) decreased at an average annual rate of 2.8 percent between 1947 and 1955. Stated the other way around, the output per man-hour increased at a rate of 2.9 percent per year. 1/ The year-to-year changes were quite irregular during this 8-year period, influenced to some extent by the fluctuations of the business cycle. For example, a rapid expansion of output in 1950 was accompanied by a sharp decrease in unit man-hours. During the cycle 1953-55, there was first a sharp decrease in production in 1954 accompanied by an increase in unit man-hours; in 1955 there was a large increase in production as well as a large decline in unit man-hours. Changes in productivity tended to be more moderate in the other years studied.

The decline in unit man-hours in the steel industry was somewhat less than that of all manufacturing in the postwar period, based on trends from 1947 through 1953, the last year for which data for total manufacturing are now available. Because of a better showing in steel from 1939 to 1947, spanning World War II, the average percent decrease for the years 1939 to 1953 was 2.8 compared with 1.8 for all manufacturing. 2/

All these figures refer to productivity measures based on man-hours of production workers. Inasmuch as employees other than production workers have increased in relative numbers in recent years, the decline in unit man-hours for all employees would be somewhat less than for production workers alone. (See p.16.)

Man-hours per unit of output (and its reciprocal, output per man-hour) measures the relationship between one factor of input--labor time--and production in physical units. This productivity ratio does not measure the specific contribution to output of labor or of capital or of any other factor of production. Changes in the ratio may reflect the joint effect of a large number of separate, though interrelated, influences, such as technological improvements, the rate of operation, the relative contributions to production of plants at various levels of efficiency, the flow of materials and components, as well as

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1/ "Man-hours per unit of output" is the reciprocal of "output per man-hour," which is frequently used to describe productivity trends. An increase in output per man-hour, of course, implies a decrease in man-hours per unit, and vice versa, but the percent changes may not be identical.

2/ Using comparable measures of productivity. See also Trends in Output per Man-Hour and Man-Hours per Unit of Output, Manufacturing, 1939-53, BLS Report 100, December 1955.

the skill and effort of the work force, the efficiency of management, and the status of labor relations. Technological and other factors contributing to the changes which have taken place in the basic steel industry are discussed on p. 10.

Trends in Unit Man-Hours

An earlier measure of productivity in the steel industry--although not strictly comparable with the measure presented here--shows a somewhat larger rate of decline in unit man-hours for the 20 years preceding 1939 than in later years. 3/ From 1919 to 1939, man-hours per unit of output dropped an average of 3.6 percent a year, compared with an annual decrease in all manufacturing of 3.3 percent. (See tables 1 and 4.) Most of the improvement in steel came in the decade 1919-29, when the average annual rate was 5.9 percent. During this decade, all manufacturing also experienced a higher than average annual change (5.0 percent). 4/

Trends from 1939-47

In 1939, when the country was recovering from the depression, steel works were operating at only 65 percent of capacity. The outbreak of war in Europe and the accompanying upsurge in industrial production in the latter half of 1939, resulted in a considerably higher level of capacity utilization. In addition, progress was made during 1939 in the form of further beneficiation or conditioning of raw materials, better control of blast furnaces and steel making units through metallurgical advance and instrumentation, and more extensive use of controlled atmospheres. These advances also contributed to increased output per man-hour, decreases in man-hours per ton, and to improvement in the quality of products.

During the defense and war period from 1940 to 1944, there was a great demand for steel and steel products, with the peak in 1944 when 89.6 million net tons of ingots and steel for castings were produced, 70 percent more than in 1939. Steel works operated at over 95-percent capacity from 1941 through 1944, with virtually no work stoppages.

Productivity estimates are not available for the entire steel industry for the World War II period (1942-46) but there is evidence that unit man-hours

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3/ Productivity and Unit Labor Cost in Selected Manufacturing Industries, 1919-1940, February 1942, U. S. Department of Labor, Bureau of Labor Statistics.

4/ Some of this decrease must be attributed to the shift from low to high value-added-per-man-hour industries. Estimates based on employment per unit of production indicate that the industry shift between the terminal years 1919 and 1929 accounted for nearly 18 percent of the total change in employment per unit. See Solomon Fabricant, Employment in Manufacturing, 1899-1939, New York, National Bureau of Economic Research, 1942 (p. 335).

decreased. Data are available for selected companies which continued to produce only the normal products of the industry or which added only a minimum of purely military products. (See table 2.) Trends of man-hours per unit for these companies--representing over 75 percent of total output--declined significantly during the war period. 5/

The experience of the steel industry differed sharply from that of all manufacturing during World War II and the period immediately thereafter. The industry did not share the large conversion and reconversion problems of many other industries. This fact, plus high demand for steel, provided a favorable setting for the productivity increases which occurred. Other industries--such as aircraft and shipbuilding--experienced large wartime productivity gains because they were able to use techniques adapted to large volumes of more or less standardized output. Some gains of this type could not be maintained after cessation of hostilities brought a reduction in munitions production. In another group of industries--the so-called civilian goods industries operating under adverse conditions such as low volume, low priorities in men and machines, and interruptions to production--wartime productivity dropped.

Between 1939 and 1947, unit man-hours in the steel industry declined at an average annual rate of 2.8 percent, slightly lower than the 3.1-percent rate of the preceding 10 years (table 1). This was quite different from total manufacturing, where the reductions in unit man-hours dropped from a 2.2-percent annual rate (1929-39) to a 0.5-percent rate between 1939 and 1947. During this latter period, production in steel rose 71 percent and production-worker employment in the steel industry increased from an average of 391.2 thousand in 1939 to 479.0 thousand in 1947.

Trends from 1947-55

Man-hours per unit in the steel industry declined at an average annual rate of 2.8 percent from 1947 to 1955. These trends partly reflect continued investment in plant and equipment by the steel industry. For example, expansion after World War II provided for increased blast furnace capacity by enlargement and improvement of existing facilities as well as construction of new furnaces and mills.

Despite the general improvement during the period, some factors tended to retard productivity advance--particularly in the early years following World War II. Utilization of capacity fell off between 1948 and 1949. Scrap was of

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5/ Heavy steel plates made up the greatest proportion of total rolled products in the war years. The effect of the increasing proportion of these items is minimized by weighting plates separately.

mixed types and poor quality. The quality of coking coal and the iron content of many ores continued to decline. 6/ The effects of this quality decline were partially offset by increased coal washing to reduce sulphur ash and slate content, increased beneficiation of iron ore to concentrate iron content and reduce silica content, and greater use of sinter and limestone.

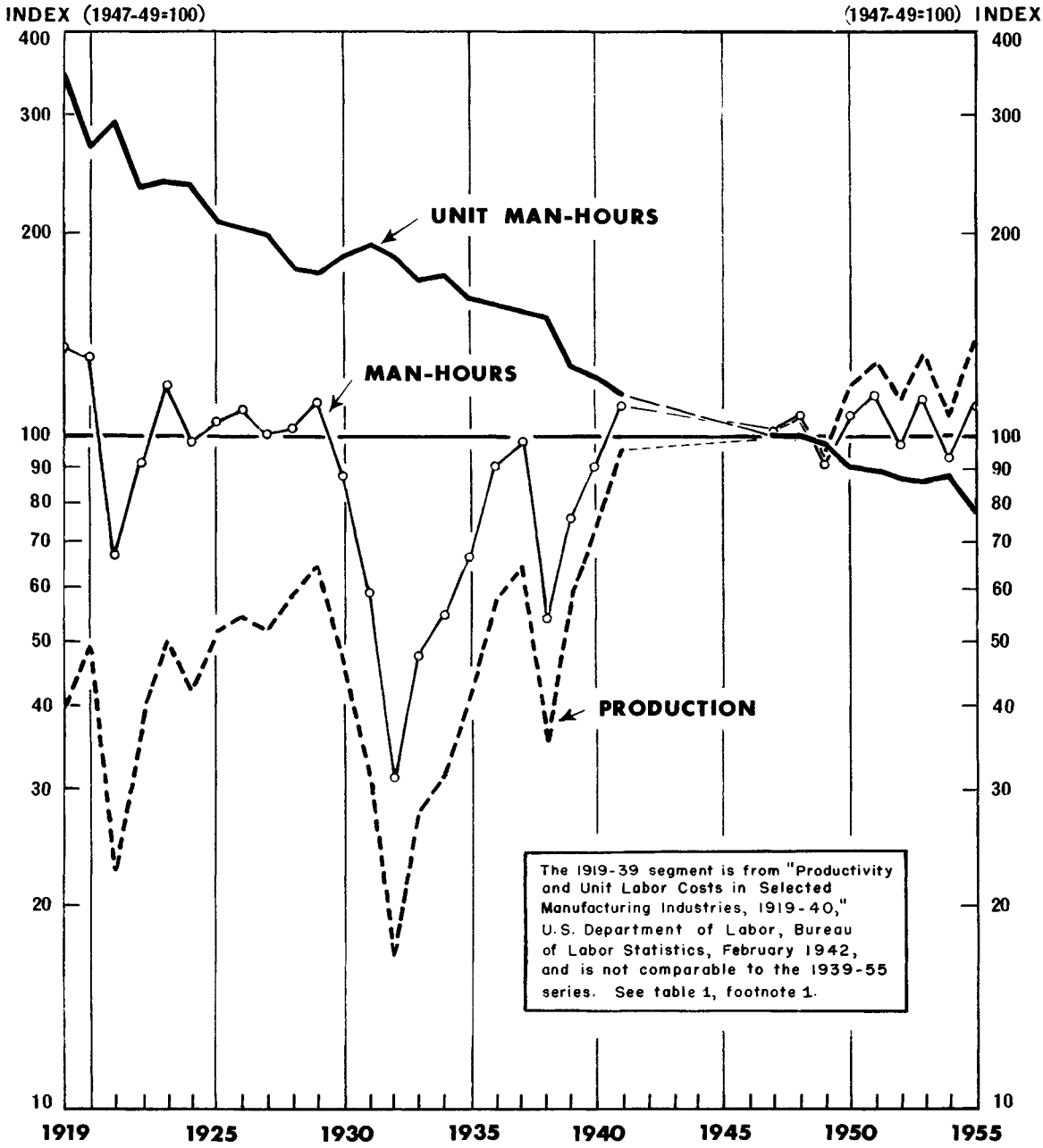
On the whole, trends in the steel industry tended to follow those of all manufacturing from 1947 to 1953, with average annual reductions in unit man-hours of 3.2 percent in steel compared with 3.3 percent for manufacturing. 7/ As in the case of all manufacturing, trends in unit man-hours in the steel industry are influenced not only by long-run improvements in technology, but also by changes in the general level of business activity. Volume fluctuations may affect an industry's ability to make most effective use of productive facilities, and this in turn may influence the trend of unit man-hours. Thus, in 1949, production in the steel industry followed the downward trend of business in general. Increased efficiency of existing facilities and installation of up-to-date furnaces and mills in the postwar years began to show their effect in portions of the year during which the industry was in full operation, but a nationwide steel strike in October 1949 left less than 10 percent of the industry's capacity in operation. These and other factors resulted in only moderate gains in man-hour output and in a less-than-average decline in unit man-hours. On the other hand, the business upturn in 1950 had a generally favorable effect on total manufacturing and unit man-hours declined at a rate almost double that for the period as a whole. Steel shared in the favorable business situation--in 1950, steel works operated at about 97 percent of capacity. The reduction in unit man-hours in this year--as in many other individual manufacturing industries--was large. In steel the decline was over 8 percent. Again, the decline in activity between 1953 and 1954 (and subsequent recovery) resulted, first, in an increase in unit man-hours, and then in a large decline between 1954 and 1955. 8/ In general, however, trends in unit man-hours after 1947 were more moderate and reflect continued progress in improving plant efficiency, modified to some extent by changing production volume. (See further discussion on p. 10.)

6/ See Steel, January 3, 1949 (p. 265); and William T. Hogan, S. J., Productivity in the Blast-Furnace and Open-Hearth Segments of the Steel Industry 1920-1946, Fordham University Press, 1950.

7/ See footnote 2, table 1, for method of calculating average annual trends.

8/ Year-to-year changes may vary widely; therefore, long-run inferences should not be drawn from data covering only a short span of years.

INDEXES OF UNIT MAN-HOURS, PRODUCTION, AND MAN-HOURS IN THE BASIC STEEL INDUSTRY 1919-41 and 1947-55



UNITED STATES DEPARTMENT OF LABOR
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Table 1.--Average annual percent decrease in man-hours per unit of output in the basic steel industry and in all manufacturing, 1919-55 1/

Years	Steel 2/	All Manufacturing 2/
1919-39	3.6	3.3
1919-29	5.9	5.0
1929-39	3.1	2.2
1939-55	2.7	(3/)
1939-53	2.8	1.8
1939-47	2.8	0.5
1947-53	3.2	3.3
1947-55	2.8	(3/)

1/ Data for 1919-39 are not strictly comparable with those for 1939-55. Trends for steel are computed from production data combined with unit value-added weights rather than unit man-hours as in the years following 1939. (See technical note, p. 20.) Trends for total manufacturing 1919-39 are derived from production indexes for the odd-numbered years from Employment in Manufacturing 1899-1939 by Solomon Fabricant. For even numbered years, the Federal Reserve Board index was used for interpolating. Man-hours are based on Census and BLS data. Component industry series are combined with value-added weights. For the later period 1939-55, the total manufacturing index is the current-year-weighted physical output productivity index (component industries combined with man-hour weights) as described in Trends in Output per Man-Hour and Man-Hours per Unit of Output--Manufacturing, 1939-53, BLS Report 100, December 1955.

2/ Computed from the least squares trend of the logarithms of the index numbers of output per man-hour.

3/ Information not available.

Table 2.--Indexes of production, man-hours, and productivity for selected companies in the basic steel industry, 1942-46

(1939=100)

Year	Production 1/	Man-hours 2/	Output per man-hour	Man-hours per unit
1942 (last 6 months) . .	152.1	141.4	107.6	93.0
1943	158.3	149.8	105.7	94.6
1944	164.6	146.9	112.0	89.2
1945	153.0	136.7	111.9	89.3
1946	134.9	116.5	115.8	86.4

1/ 1939 data secured from reports of selected companies to the Bureau of the Census; 1942-46 data secured from reports of these companies to the War Production Board and Civilian Production Administration. The methods used in constructing the indexes for these companies differs from that used in the series for the industry as a whole mainly in that alloy steel is not weighted separately from carbon.

2/ Based on reports made to BLS by the same selected companies for which data were included in the production index.

Table 3.—Indexes of production, employment, man-hours, productivity, and unit labor requirements in the basic steel industry, 1939-55

(1947-49=100)

Year	Weighted production	All employees	Production workers	Man-hours of production workers	Output per —			Unit labor requirements		
					All employees	Production worker	Production worker man-hour	All employees per unit	Production workers per unit	Production worker man-hours per unit
1939 . . .	59.0	80.9	82.9	75.1	72.9	71.2	78.6	137.1	140.5	127.3
1940 . . .	73.3	92.6	94.8	90.0	79.2	77.3	81.4	126.3	129.3	122.8
1941 . . .	95.5	105.8	108.6	110.6	90.3	87.9	86.3	110.8	113.7	115.9
1942 1/ . .	94.9	—	—	—	—	—	—	—	—	—
1943 1/ . .	99.1	—	—	—	—	—	—	—	—	—
1944 1/ . .	100.3	—	—	—	—	—	—	—	—	—
1945 1/ . .	92.4	—	—	—	—	—	—	—	—	—
1946 1/ . .	80.0	—	—	—	—	—	—	—	—	—
1947 . . .	100.7	100.9	101.4	101.5	99.8	99.3	99.2	100.2	100.7	100.8
1948 . . .	106.0	104.8	105.2	106.6	101.1	100.8	99.4	98.9	99.2	100.6
1949 . . .	93.3	94.3	93.4	91.8	98.8	99.9	101.6	101.2	100.1	98.4
1950 . . .	118.4	104.6	104.4	106.9	113.2	113.4	110.8	88.3	88.2	90.3
1951 . . .	128.5	110.2	109.7	115.2	116.6	117.1	111.5	85.8	85.4	89.6
1952 . . .	113.4	97.8	95.3	97.8	116.0	119.0	116.0	86.1	84.0	86.2
1953 . . .	133.4	111.9	109.6	114.0	119.2	121.7	117.0	83.9	82.2	85.5
1954 . . .	107.0	99.5	96.5	93.9	107.5	110.9	114.0	93.0	90.2	87.8
1955 . . .	141.0	108.8	106.7	111.0	129.6	132.1	127.0	77.2	75.7	78.7

1/ Production index for the war years is understated because it includes some of the strictly war products made in these industries during the war. The regularly published BLS employment series, however, covers the special wartime activities carried on in these industries. Owing to the lack of comparability between the production index and the employment index, indexes of labor, output per man-hour and unit labor requirements are not shown.

Table 4.--Indexes of production, employment, man-hours, productivity, and unit labor requirements in the basic steel industry, 1919-39

(1947-49=100)

Year	Weighted production	Production workers	Man-hours	Output per --		Unit labor requirements	
				Production worker	Man-hour	Production workers per unit	Man-hours per unit
1919. .	39.5	83.0	135.0	47.6	29.3	210.1	341.8
1920. .	49.1	85.0	131.6	57.8	37.3	173.1	268.0
1921. .	22.7	50.3	66.7	45.1	34.0	221.6	293.8
1922. .	39.8	64.3	91.6	61.9	43.4	161.6	230.2
1923. .	50.0	84.1	119.0	59.5	42.0	168.2	238.0
1924. .	41.9	78.2	98.2	53.6	42.7	186.6	234.4
1925. .	50.4	79.2	104.0	63.6	48.5	157.1	206.3
1926. .	54.0	81.2	108.3	66.5	49.9	150.4	200.6
1927. .	50.7	77.1	100.4	65.8	50.5	152.1	198.0
1928. .	58.4	77.4	102.4	75.5	57.0	132.5	175.3
1929. .	64.1	83.1	111.8	77.1	57.3	129.6	174.4
1930. .	47.2	72.7	87.1	64.9	54.2	154.0	184.5
1931. .	30.8	55.1	58.6	55.9	52.6	178.9	190.3
1932. .	17.0	46.5	31.0	36.6	54.8	273.5	182.4
1933. .	28.0	57.2	47.5	49.0	58.9	204.3	169.6
1934. .	31.4	69.4	54.1	45.2	58.0	221.0	172.3
1935. .	41.1	74.2	66.0	55.4	62.3	180.5	160.6
1936. .	57.8	86.3	90.1	67.0	64.2	149.3	155.9
1937. .	64.1	99.5	98.2	64.4	65.3	155.2	153.2
1938. .	35.9	73.5	53.9	48.8	66.6	204.7	150.1
1939. .	59.0	82.9	75.1	71.2	78.6	140.5	127.3

Source: Productivity and Unit Labor Cost in Selected Manufacturing Industries 1919-1940, U. S. Department of Labor, Bureau of Labor Statistics, February 1942, linked to the current series in 1939. (See footnote 1, table 1.)

Factors Affecting Productivity Change

As indicated earlier, many factors can affect the rate of productivity--in varying degrees among different industries. Ranking high in importance, although impossible to quantify, is the human factor as expressed in the effort, skill, organization, and application of both management and labor. Adoption of technological improvements is enhanced by a work force which has the capacity and willingness to learn, change, and adapt. Union and management organizations have helped in this direction by developing higher pay scales, pension programs, increased leisure, incentive pay plans, and machinery for resolving grievances. The introduction in 1947 and 1948 of a revised job classification program in steel plants, for example, contributed to better personnel relations and general efficiency through a reduction in the number of grievances and in the amount of time lost from work. Also contributing to the advance in productivity has been the willingness and ability of management to experiment, to invest in new machinery and research, and to seek new markets.

Productivity and Production Volume

Productivity (output per man-hour) 9/ is also often associated with changes in production volume. However, the relationship between these two items is often elusive. In some industries, during some periods of time, production may increase while productivity declines, or vice versa, thus running counter to "normal" expectations. Observation of year-to-year changes, influenced by all the vagaries of business cycle, war, and temporary factors, may lead to conclusions which differ from those derived from observation of long-term trends. For example, as will be seen later, sharp, short-run (year-to-year) changes in level of activity in the steel industry have overshadowed many of the other factors and strongly influenced the change in productivity. Over the years, however, although production volume has fluctuated quite widely, output per man-hour has maintained a persistent upward trend (with a few minor interruptions) reflecting the influence of constant technological improvements. Even where long-term changes in productivity and production volume are highly correlated, cause-and-effect relationships are not necessarily established. It is true that high volume may permit higher utilization of capacity 10/ and more efficient use of facilities, thus resulting in higher productivity. At the same time, increases in productivity may permit the maintenance of a price level which leads to greater demand and, hence, to greater volume of output.

9/ Trends in output per man-hour, the reciprocal of unit man-hours, will be used in the analysis in this section.

10/ During the period studied, there was a significant positive correlation between annual changes in volume and changes in capacity utilization. Thus, for short-run periods, increased volume has generally been accomplished by increased use of existing capacity.

Long-run comparisons. Determination of long-run trends and the relationship between productivity and production in the steel industry is rather difficult because of the extremely wide fluctuations which have occurred in volume of output. The problem can be overcome to some extent by using average annual rates of change which take into account, not only the terminal years, but the intervening years as well, 11/ or by comparing base and terminal years of roughly equal capacity utilization.

Using average trends, somewhat different relationships appear for the prewar and postwar periods. From 1939-55 average annual production increased somewhat more rapidly than productivity (4.0 percent compared with 2.8 percent). This average rate of productivity gain was about the same in the subperiods 1939-47 and 1947-55, but production increased more rapidly in the earlier years (5.5 percent) than in the later years (3.5 percent).

In order to remove, roughly, the influence of cyclical variation on average trends, another set of calculations was made for the postwar period, in which only the peak production years of 1948, 1951, 1953, and 1955 were used. The average annual increase in output per man-hour, using only these selected years, was 3.5 percent, compared with the 2.9 percent average obtained when all the years 1947 to 1955 were included in the calculation. The average annual increase in production was 4.1 percent using the selected years and 3.5 percent using all years. Thus, the average annual rates of change, for both production and output per man-hour, were higher when computed for selected, peak output years, than when all years were included. However, the relationship of average productivity change to average production change was the same, whether all or selected years were used.

During the 20 years 1919-39, the average annual increase in volume of output was very low (0.3 percent) while output per man-hour increased at an average yearly rate of 3.7 percent. However, production fluctuated widely during these two decades so that an average figure is less meaningful for production than for output per man-hour, which maintained a much steadier rate of change. Consequently, comparison of specific years may be more meaningful.

Identical production peaks were reached in 1929 and 1937; yet, between these years, output per man-hour increased by 14 percent. In 1932, production volume was 25 percent below that of the previous low point in 1921; but productivity rose 61 percent from 1921 to 1932. These figures further illustrate the "non-reversability" of productivity gains over the long run despite declines in volume.

Short-run comparisons. The relationship between productivity and volume of production in the steel industry is more apparent when short-run or

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11/ That is, computed from the least squares trend of the logarithms of the index numbers.

year-to-year changes are examined. With occasional exceptions, productivity gains have been very much influenced by recession and recovery in the industry--sharp gains have generally been achieved when volume expanded rapidly and when such expansion followed a previous year's reduction in the employed labor force.

Employment changes, productivity, and production volume. Of the 30 years (since 1919) for which data on annual changes are available, large productivity increases (4 percent or more) occurred in 12 years. (See table 5.) In 10 of these 12 years production increased by more than 10 percent. Output per man-hour declined in 6 years; production declined by 10 percent or more in 4 of these years, and increased 10 percent or more in the other 2. The relationship of changes in output per man-hour to changes in production is placed in sharper focus if employment figures are examined. Of the 12 years registering large increases in output per man-hour, 8 were preceded by a decline in production worker employment during the previous year, and 3 were preceded by an increase in employment. No information is available for the other year.

However, it does not necessarily follow that large increases in volume are accompanied by large increases in output per man-hour. In 16 of the years since 1919 production increased by more than 10 percent, but productivity increases of 4 percent or more occurred in only 10 of these years. Five of the remaining 6 years--in which large production increases occurred but in which productivity increased moderately or declined--were preceded by a year in which production worker employment increased.

Technology 12/

Numerous technological improvements have been developed in the basic steel industry. These, however, have not been introduced at a uniform rate, or uniformly in the various parts of the industry. Moreover, improvements introduced during any specified year may not contribute their full effect until a later period.

Technological improvement in the steel industry has involved raw materials, processing controls, and materials handling. Some of the more important changes are described below.

Blast Furnaces. Greater efficiency has been achieved in the blast furnace industry both by conditioning the coke and iron ore used as raw materials, and by improvements in the blast furnace and its auxiliary equipment. Coal washing has offset the declining quality of coke, and the addition of sintering plants to convert flue dust into large pieces of material suitable for reuse in the furnaces as part of the charge has helped in furnace performance. Beneficiation and sintering of iron ore before it is

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12/ Much of the description of technological improvements was compiled from information furnished to BLS by William T. Hogan, S. J., of Fordham University.

Table 5. Annual percent change in production, number of workers, man-hours, and output per man-hour in the basic steel industry, 1919-55 1/

Year	Weighted production	Production workers	Man-hours of production workers	Output per production worker man-hour
1919. . .	(2/)	(2/)	(2/)	(2/)
1920. . .	+24.3	+ 2.4	- 2.5	+27.3
1921. . .	-53.8	-40.8	-49.3	- 8.8
1922. . .	+75.3	+27.7	+37.3	+27.6
1923. . .	+25.6	+30.9	+29.9	- 3.2
1924. . .	-16.2	- 7.1	-17.5	+ 1.7
1925. . .	+20.3	+ 1.3	+ 5.9	+13.6
1926. . .	+ 7.1	+ 2.6	+ 4.1	+ 2.9
1927. . .	- 6.1	- 5.1	- 7.3	+ 1.2
1928. . .	+15.2	+ 0.4	+ 2.0	+12.9
1929. . .	+ 9.8	+ 7.3	+ 9.2	+ 0.5
1930. . .	-26.4	-12.5	-22.1	- 5.4
1931. . .	-34.7	-24.2	-32.7	- 3.0
1932. . .	-44.8	-15.5	-47.1	+ 4.2
1933. . .	+64.7	+23.0	+53.2	+ 7.5
1934. . .	+12.1	+21.3	+13.9	- 1.5
1935. . .	+30.9	+ 6.8	+22.0	+ 7.4
1936. . .	+40.6	+16.3	+36.5	+ 3.0
1937. . .	+10.9	+15.3	+ 9.0	+ 1.7
1938. . .	-44.0	-26.1	-45.1	+ 2.0
1939. . .	+64.3	+12.8	+39.3	+18.0
1940. . .	+24.2	+14.4	+19.8	+ 3.6
1941. . .	+30.3	+14.6	+22.9	+ 6.0
1942-47 .	(2/)	(2/)	(2/)	(2/)
1948. . .	+ 5.3	+ 3.7	+ 5.0	+ 0.2
1949. . .	-12.0	-11.2	-13.9	+ 2.2
1950. . .	+26.9	+11.8	+16.4	+ 9.1
1951. . .	+ 8.5	+ 5.1	+ 7.8	+ 0.6
1952. . .	-11.8	-13.1	-15.1	+ 4.0
1953. . .	+17.6	+15.0	+16.6	+ 0.9
1954. . .	-19.8	-12.0	-17.6	- 2.6
1955. . .	+31.8	+10.6	+18.2	+11.4

1/ Percent change from preceding year. (See tables 3 and 4.)
2/ Information not available.

used in the blast furnaces results in a richer ore charge and also contributes to lower unit man-hours. To the extent that this work is done in greater amount by workers employed in the steel industry the effect on unit man-hours might be somewhat offset. It is true, generally, that improved quality of production in one industry may contribute to higher productivity in another.

Improvement in blast furnaces has been effected mainly by increasing their size. As a result, larger stoves have been built to preheat the air for the furnace blast. Turbo blowers, capable of delivering up to 120,000 cu. ft. of air per minute have been installed, replacing the reciprocating steam engines, which had less capacity and required more maintenance. In order to handle the increased output, enlarged and improved ladles, particularly the torpedo type, have been put into service to carry the pig iron away from the furnace once it is produced.

Open Hearth Steel. In the steel mills, the average size of the heat in the open hearth furnaces increased from approximately 125 net tons in 1939 to approximately 160 net tons in 1951 and 1952. This was due to the construction of some new open hearth shops capable of producing as high as 225-250 ton heats. In addition, the furnaces in most of the existing shops were enlarged to increase heat sizes.

The use of oxygen in the open hearth segment was another recent development that decreased man-hour requirements in the furnaces, particularly during the years 1947-53, by reducing melting time per ton of steel ingots produced. This development was more prevalent in open hearths making low carbon steel (less than 0.1 percent carbon content), where it reduces carbon content quicker than other methods.

Electric Furnaces. The amount of steel produced in electric furnaces increased from 2 percent of total steel production in 1939 to 6 percent in 1954, although the increase was not steady. The output per dollar investment is higher for electric furnaces than for the open-hearth type. In addition, the recent development of top charging in place of side charging will reduce still further the number of man-hours required to produce steel ingot. The greater efficiency of the electric furnace is illustrated by the fact that an electric furnace 17 feet in diameter can produce 15 tons an hour, whereas a 240-ton open hearth furnace 87 feet long produces 20 to 21 tons of steel an hour, only a third more than the much smaller electric furnace.

Rolling Mills. Important technological advances have been made in rolling mills, and additions to rolling mill capacity have kept pace with increases in ingot capacity.

Since 1930 most primary mills constructed have been larger than before and are powered with electric motors. These larger mills are capable of handling heavier ingots with consequent decreases in man-hours required per ton. The substitution of electric motors for steam engines as a driving force on the mills, a change beginning as early as 1920, has added power to

the rolling mills. The electrically driven mills operate more smoothly, and produce less shock each time the ingot passes through. Operations are smoother because, at low speeds, electrically driven mills can produce enough torque to make a sufficient reduction on the ingot on each pass. Steam engines require higher speeds to develop equal torque.

Primary Mills. An example of technological improvement in primary mills is that of a blooming mill installed during World War II. Before the war the steam-driven 35-inch blooming mill at this location had an annual capacity for rolling 500,000 tons of steel. During the war an electrically driven 44-inch blooming mill was built with a capacity for rolling 1,100,000 tons of steel annually. The 44-inch mill employed the same size crew as the 35-inch mill.

Rod Mills and Bar Mills. Replacement of the looping type mill by the continuous rod mill has promoted greater efficiency. The introduction of a multiple strand continuous rod mill which allows the same crew to account for 2 or 3 times as much production as the old methods, depending on the number of strands, represents a further improvement.

In bar mills increased power has led to much higher speeds and higher production per man-hour.

Strip Mills. A major technological development in the rolling of steel strips took place in the late 1920's. The continuous strip mills replaced to a great extent the earlier hand rolling mills. Today, there are few hand mills in operation. The hand mill is a small unit capable of producing 8 to 10 tons of steel per 8-hour turn, whereas the continuous mill can produce 1,000 tons per 8-hour turn without a proportionate increase in labor involved.

Especially after 1939, the output of continuous mills increased appreciably. Several new continuous hot strip mills, each capable of rolling 2,000,000 tons or more of steel strip annually have been finished since 1939. The additional output from continuous mills has increased man-hour output in this segment of the steel industry. Additional improvements since 1939 include (1) larger slab sizes, (2) increased furnace capacity for heating slabs about to be passed through the mill, (3) better coiling and handling equipment in the finishing operations of the mill, (4) better guides and improved furnace and run-out table construction, and (5) improved slab conditioning. These improvements are reported to have been accomplished without a large addition of manpower and have tended to alleviate bottlenecks.

Cold Reduction Mills. Other important developments include improved cold reduction mills, which have grown in importance since 1940. Newer mills are now capable of speeds in excess of 5,000 feet per minute. The speed of the mills that were in operation before 1940 has also been increased by the installation of new motors and controls. For example, one mill was capable of a maximum speed of 1,500 feet per minute at its installation in 1935, but after the motors, controls, and power were improved in the late 1940's, its speed was increased to 4,500 feet per minute. The same size crew operated the mill before and after the changes, with the result that the same number of men are now turning out much more steel per hour.

Increase of mill speeds did present problems, however. Coils had to be fed in rapid succession and the product removed and passed quickly to the next operation. The economies of continuous operation would be lost if the mill passed a coil through in 2 or 3 minutes and then had to be stopped to put another coil through. The size of coils was therefore increased.

Capacity of cold reduction mills increased from 5 million tons annually in 1939 to 11.5 million tons in 1951-52 as a result not only of mill improvements but also of an increase in the number of such mills installed throughout the country.

Tin Plate. The electrolytic process developed during World War II has gradually replaced the hot dip process of producing tin plate and reduced the man-hours required per ton.

In conclusion, the technological improvements mentioned above, and other power equipment installed in blast furnaces, steel works, and rolling mills, have reduced direct man-hours. However, additional indirect labor required for repairs, maintenance, and inspection of the new equipment, has offset somewhat the savings in direct labor.

Total Employment and Production Worker Employment

The productivity trends described in this report are based on the employment and hours of production and related workers. (See technical note, p. 23.) As in many other industries, production workers have been declining relatively to all workers in recent years. According to BLS statistics, the proportion of production worker employment to total employment in the steel industry remained fairly constant between 1939 and 1947, at 88.0 and 87.9 percent, respectively. However, the proportion dropped to 85.7 percent between 1947 and 1955. 13/ Consequently, the number of employees per unit of output declined less than the number of production workers per unit of output, from 1947 to 1955.

It would be desirable to construct measures of productivity using the hours of all employees in order to study the change in total manpower requirements of an industry, and to compare the results with trends for production workers alone. However, man-hours for nonproduction workers are not generally available. In an effort to obtain some general indications of trend, two

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13/ Source: For 1950-55, BLS Employment and Earnings, Annual Supplement Issue, June 1956; for earlier years, summary sheet for blast furnaces, steel works, and rolling mills, 1932-50, February 1953. Census figures for 1939 and 1947 show proportions of 89.1 and 87.5 percent, respectively. Statistics of the American Iron and Steel Institute (AISI) reveal a greater trend toward employment of other than production workers. These data indicate that "employees receiving wages" comprised 88.1 percent of the work force in 1939, 85.3 percent in 1947, and 83.1 percent in 1955.

experimental measures have been constructed, by combining the man-hours of production workers with the estimated man-hours (employment multiplied by estimated weekly hours) for other employees. In one measure, the weekly hours of other employees were assumed to be the same as for production workers; in the other, a constant 40-hour workweek was assumed for other employees.

The two assumptions about weekly hours yield approximately the same results. Using 1947 as a base (i.e. 1947=100) an index of unit man-hours for production workers would be 127.3 in 1939, compared with 125.3 for all employees assuming a 40-hour week, and 123.9 assuming the same workweek as production workers. In 1955, the unit man-hour index for production workers would be 78.1 compared with 79.6 and 80.0 for all employees depending on concept of hours worked for all employees. 14/

Concepts and Limitations

The measures for the period 1939-55 have been constructed in accordance with the "physical output" concept of productivity measurement. It is possible to conform more closely, statistically, to this concept in constructing measures for this industry than for some other industries for which data are less readily available.

The index of man-hours per unit of production in this report is of the "current weight" form; it compares the actual man-hours of a given (current) year with the man-hours which would have been required in the base-period (average for 1947-49) at base-period productivity rates to produce current year output. Formulas and detailed descriptions of the measures of unit man-hours as well as the underlying production and man-hours series appear in the technical note. It should be noted here, however, that the comparable production index is of the fixed-weight (base year) variety and that the weights consist of man-hours per ton of the various steel products.

In constructing productivity measures, problems are frequently encountered in adequately measuring output or in matching output series with man-hours. Some of the more important of these are described in this section. It should also be noted that the indexes in this report refer to the blast furnace, steel works, and rolling mill industries. Establishments classified in these industries may make products which are usually manufactured in other industries; that is, the products are "primary" to other industries, but "secondary" to the covered industries. Also, products primary to the covered industries, may sometimes be made as secondary products in other industries. (See p. 18.)

14/ AISI man-hour data for all employees and for "employees receiving wages" showed similar differences. The hours of "other" employees are generally scheduled hours reported to the AISI.

Coverage

Some of the products made in the steel mills (SIC 3-digit group 331) are also made in other industries (SIC 3392, Wire Drawing; 3393, Welded and Heavy Riveted Pipe; 3399, Primary Metal Industries, n.e.c.; 3481, Nails and Spikes; and 3489, Wirework, n.e.c.). The production index covers the entire output of these products--both the amounts produced in steel mills and the amounts made in the other industries. The employment series of the BLS covers only the 3-digit SIC group 331, however, and this can result in some noncomparability between output and man-hours indexes.

An attempt was made to evaluate the importance of this by combining the man-hours of these other industries with those of the steel industry and relating the total man-hours to the production index. 15/ Industries SIC 3392 and 3489 were omitted from the combined man-hour total, however, because only 12 and 25 percent, respectively, of the value of their output in 1947 is common to SIC 331.

Appendix table A shows that steel products represent a significant part of the total output of the remaining 3 industries (SIC 3393, 3399, and 3481). A combined man-hour index for steel and these 3 industries differs from steel alone by a maximum of 2.7 percent in 1947 to 1953. The effect on productivity is the same.

Since not all of the output of these industries consists of products made by steel mills, their inclusion in the final index would represent an over-correction. For this reason, another comparison was made. Instead of adding all of the man-hours of these 3 industries to the man-hours for steel, only the estimated man-hours devoted to steel production were included. The man-hours devoted to steel in these industries were estimated by applying the ratio of value of steel output to total value of shipments. For example, 92.5 percent of the man-hours in SIC 3393 were included. The combined index of man-hours on this basis differs from steel alone by a maximum of 2.2 percent in the period 1947 to 1953.

The man-hours of production workers in these three industries accounted for 7 percent of the man-hours in the combination in 1947 and 9 percent in 1953.

Plant Integration

Changes in the scope of an industry's activity can affect productivity measures. When an industry becomes more integrated--that is, undertakes more work in the processing or manufacture of raw materials which it consumes or when it devotes more work to finishing or fabricating products--comparability

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15/ Census man-hours data were used for this test because no BLS data were available.

between production and man-hours may be affected. Ordinarily an increase in the degree of integration in an industry would result in the addition of man-hours without necessarily increasing the amount of production reported. As a result, productivity indexes would be understated, and unit man-hour indexes overstated. Increased specialization, on the other hand, would have an opposite effect.

An increase (or decrease) in the degree of fabrication of end product will increase (or decrease) man-hour requirements without correspondingly affecting the measure of physical production. However, such changes will affect the value of production (or shipments) since additional fabrication obviously leads to a product with higher value. In order to check on the importance of this problem, an index was constructed from estimates of value of shipments (adjusted for price change) of the steel industry, SIC 331, for the period 1947-55. This agrees very closely with the physical output index, indicating that changes in the degree of final processing have had little influence.

Integration may also change with respect to raw materials. For example, in the steel industry, some mills operate coke ovens on the same premises. Man-hours worked in these coke ovens may be reported either separately or in combination with man-hours worked in the production of steel. In the latter case, an increase (or decrease) in the importance of coke production will increase (or decrease) man-hours without a corresponding effect on the measure of physical production of steel. Since the proportion of coke made in the industry varies in proportion to total coke consumed, such reporting might spuriously accelerate or depress the rate of productivity change. However, this appears to be a factor of limited significance, for the following reasons:

(1) Employment in all byproduct ovens (including those which report man-hours separately and those which do not) was only 6.6 percent of that in steel mills in 1947. Since employment in the by-product coke ovens which do not report separately is even a smaller fraction of steel employment, it would have little effect on the total man-hours estimate.

(2) The industry produced 93.6 percent of the total byproduct coke consumed by the industry in 1947, and 97.9 percent in 1954. The proportion tends to vary with changes in steel production. This variation would affect annual changes in productivity, but there is no consistent bias, so the net effect over a period of several years would be small if not zero.

(3) As an additional check a productivity index was prepared for the steel (SIC 331) and byproduct coke (SIC 2932) industries combined, for the period 1939-54. The combined index was lower than the index for steel alone in every year, but the maximum difference in any one year was 1.3 percent. In all but 2 years the difference was less than 1 percent.

Inventory Change

In the steel index, data on shipments rather than production are used for more than half of the index. When statistics on shipments are used to estimate production, comparability between output and man-hours indexes is affected by year-to-year changes in inventory holdings. Opinions of persons familiar with the industry lead to the conclusion that the inventory factor has been unimportant. From statistics on value of shipments and inventories, deflated with appropriate price series, it is estimated that the inventory change could have affected the indexes in the years 1947-53 by less than 1 percent. Because some production data are in fact used in constructing the index, the actual effect would be smaller--probably by not more than 0.5 percent.

Quality Change

The intangibles of quality change cannot be measured. To the extent that quality is increasing, the unit man-hours indexes contain an upward bias. The steel index shares this limitation in varying degrees with all other indexes of production, productivity, and prices.

Technical Note

The Blast Furnaces, Steel Works, and Rolling Mills Industries Group represents the activities of 3 component industries as defined in the 1947 Census of Manufactures and the Standard Industrial Classification: (1) establishments primarily engaged in manufacturing pig iron and blast furnace ferroalloys from iron ore and scrap, (the Blast Furnace Industry SIC 3311) (2) establishments primarily engaged in converting pig iron, scrap iron, and scrap steel into steel and in hot-rolling iron and steel into shapes such as plates, sheets, strips, rods, bars, and tubing, (the Steel Works and Rolling Mills Industry SIC 3312) and (3) establishments primarily engaged in manufacturing ferrous and nonferrous additive alloys by electrometallurgical processes, (the Electrometallurgical Products Industry SIC 3313).

The trends shown are averages for the group as a whole, and do not necessarily represent the trend for any one plant or company.

Man-Hours per Unit, Production Workers, and Total Employees per Unit

The indexes of man-hours per unit, production workers per unit and total employees per unit are obtained by dividing an index of man-hours or employment by a production index. The production index is computed from physical quantities of the various products of the industry combined with fixed unit man-hour weights. The use of unit man-hour weights in the production index removes the effect on the unit man-hour series which would result from changes in the relative volume of production of the various items. Thus, within the limits of the data, the index measures the average change in unit man-hours and output per man-hour for products of the industry. The general formulas used as well as details of construction of the production, man-hours, and employment series are set forth on page 21.

Formulas

The index of man-hours per unit of production used in this report is of the form--

$$\text{Unit man-hours} = \frac{\sum l_t q_t}{\sum l_o q_t}$$

where l = man-hours used to produce one unit of a product
q = number of units (quantity) of a given product
t = current year
o = base year

This index form employs current year quantity weights. The comparison is between actual total man-hours in the current year ($l_t q_t$) and the total man-hours which would have been required to produce the current quantity of goods if base year productivity prevailed ($l_o q_t$).

In practice, the unit man-hour measure is derived by dividing an index of man-hours by an index of production thus:

$$\frac{\sum l_t q_t}{\sum l_o q_t} = \frac{\sum l_t q_t}{\sum l_o q_o} \div \frac{\sum l_o q_t}{\sum l_o q_o}$$

The fixed unit man-hour weights of the base period "l_o" are used to construct the production index.

Production

The annual production index is based on production data for pig iron, ferroalloys, and steel ingots, and net shipments--or net production for sale--of steel mill shapes and forms, all measured in short tons, combined with unit man-hour weights.

Basic Data on Output. Because of changes in product detail, the number of classes was increased from 69 in 1939 through 1943 to 73 in 1944-45, 74 in 1946-48, 76 in 1949, 82 in 1950-54, and 83 in 1955. The index was constructed from data compiled by the American Iron and Steel Institute (AISI), and adjusted in 1939 and 1947 to data from the Census of Manufactures. Except for some unpublished AISI figures on alloys and stainless steel for earlier years, all the data are from the published Annual Reports of the Institute. Table B shows the methods used for estimating some of the detailed shipments figures and compares the 1939 and 1947 AISI data with the data used in the Census adjustments for those years.

Ten items of relatively small volume were introduced after 1943; alloy rails, standard and other; alloy wheels; alloy axles; alloy bars, reinforcing; alloy galvanized sheets; alloy steel piling; stainless wire nails and staples;

stainless structural shapes, heavy; and stainless woven wire fencing. Alloy bars, reinforcing, have not been shown since 1950 and have subsequently been dropped. All of these items contributed a combined total of only 0.04 percent of the total weighted production in 1950 and less than 0.01 percent in 1955. In addition, four items previously included with other items were shown separately. These include carbon sheet, all other coated; carbon sheet, enameling; carbon, electrical sheet and strip; and alloy electrical sheet and strip. For years in which data were not available, production of all new items was considered to be zero. For the four items previously included with other items, the increased detail was used with no adjustment when it became available.

As indicated below, the production index consists of weighted output of pig iron and ingot to which is added the output of finished or semi-finished products weighted with the additional man-hours required to produce the product from ingot. One of these product classes is ingots, blooms, billets, etc., shipped. The quantity of ingot in this figure represents duplication of counting, inasmuch as ingot production is counted at an earlier stage. This duplication was eliminated in 1950 when separate figures became available for ingots shipped. An estimate of the duplication for earlier years was made by applying to the combined figure for ingots, billets, and slabs shipped in earlier years the ratio of ingots to the combined figure in 1950 and 1951. This is a small adjustment, inasmuch as ingots shipped constituted only 1.2 percent of total steel products in 1950.

Weights. The basic data from which the pig iron and carbon steel weights were derived were obtained from an analysis of the experience during 1946-47 of companies considered to be representative of the industry and assumed to be adequate for the purposes of this study.

The basic data for 25 products represent raw materials and steel plant man-hours and gross total man-hours for the production of pig iron and carbon steel.

The weight for pig iron represents the number of man-hours per ton required in blast furnaces. The weight applied to ingot production is the additional man-hours per ton for processing beyond the pig iron stage and represents steel mill requirements, not the total number of man-hours needed for ingot production in earlier processes. For other finished or semi-finished products, the weights used are the additional man-hours required per ton in steel mills to produce the product from ingot.

In order to obtain weights which represent unit man-hour requirements beyond the ingot stage of manufacture, it was necessary to subtract the man-hours spent in ingot production from the gross man-hours required for the end product. A ton of end product requires more than a ton of ingot in its manufacture, however, and it was necessary to determine the yield of end products from ingot and adjust the unit labor requirement figure for ingot by the yield factor for each end product before subtracting.

The yield factors themselves were estimated from the ratio of man-hours required per ton of raw material (iron ore and coal) in ingot manufacture to man-hour requirements for manufacture of each product. Since the man-hours expended on the raw materials which enter into each product are actually expended in the pre-ingot stage of manufacture, the ratios based on man-hour requirements for raw materials actually represent yield ratios. It is believed that the calculated yield factors are in close accord with actual experience of the industry.

From these man-hour weights for carbon steel, additional man-hour requirements for alloy (other than stainless) and for stainless were estimated. These weights for stainless steel and alloy shapes and forms are BLS estimates obtained by applying alloy-carbon and stainless-carbon steel price ratios to the carbon steel weights. The unit labor requirement weight for the ferroalloys was obtained from the 1947 Census of Manufactures.

Employment and Man-Hours

The employment index is based on the series regularly published by BLS, adjusted to levels indicated by the Census of Manufactures in 1939 and 1947. The adjustment method consists in: (1) computing the ratios of the Census to the BLS employment figure for the 2 years 1939 and 1947; (2) interpolating the ratio for noncensus years and (3) multiplying the interpolated ratio by the BLS figure for the given year. The BLS series is based on a sample showing the percent change for identical establishments in overlapping 2-month periods. The index of man-hours is derived from the adjusted BLS employment series and BLS average weekly hours.

The man-hour series cover only production and related workers and exclude salaried officers, superintendents, other supervisory employees, and professional and technical employees. The data used to compute the indexes of man-hours and man-hours per unit include man-hours paid for but not worked--vacations, call-ins, etc. It is not possible to eliminate from the indexes the effect of changes in the proportion which such man-hours bear to total man-hours. 16/

The regularly published BLS employment series covers the special wartime activities carried on in these industries during the war but the production index excludes some of the special war products made by these industries. Owing to this lack of comparability, industrywide indexes of output per man-hour and unit labor requirements are not shown for the years 1942-46.

16/ For practices of the U. S. Steel Corporation with respect to paid vacations, holidays, and other related wage matters, see Wage Chronology, United States Steel Corp. U. S. Department of Labor, Bureau of Labor Statistics, Report 106. This publication indicates a practice in 1939 of a 1-week paid vacation after 5 years' service, and in 1952, 1 week after 1 year, 2 weeks after 5 years, and 3 weeks after 15 years. In 1939, no paid holidays were provided; in 1952, there were 6 paid holidays.

Adjustment to the 1947 Census of Manufactures

The labor data were adjusted to levels shown by the Census of Manufactures for 1939 and 1947. The production data were adjusted to Census levels for 1939 and 1947, using Census data (supplemented by AISI data where necessary). The index is based on data for 81 product classes (including pig iron, ferro-alloys, steel ingots, and steel mill shapes and forms), all measured in short tons, combined with unit man-hour weights. The data for pig iron and ferro-alloys represent production for sale and interplant transfer in 1939 and shipments and interplant transfers in 1947. The figures on ingots and steel for castings are for total production in both 1939 and 1947. The data for steel mill shapes and forms represent production for sale and interplant transfer in 1939 and shipments and interplant transfers in 1947. For shapes and forms, for which receipts of the item (for manufacture into other basic shapes and forms) were of importance, receipts were deducted from the 1947 shipments and transfer figures and the 1939 Census figures were converted to a net basis using AISI ratios of net to total tonnages. For weighting purposes, some combined Census figures were separated on the basis of AISI ratios.

A P P E N D I X

Table A.--Percent of selected steel products made in the basic steel industry and in other industries in 1947

	Total 1/	Value of product class made in industry					
		SIC 331	SIC 3392	SIC 3393	SIC 3399	SIC 3481	SIC 3489
		(Percent)					
A. Product class							
Nails, spikes, brads	100.0	69.3	6.3	(2/)	(2/)	19.3	(2/)
Wire, steel	100.0	67.7	32.0	(2/)	(2/)	(2/)	(2/)
Cold rolled sheet, strip, bars, shapes	100.0	78.5	----	----	21.5	----	----
Pipe and tubes	100.0	3/ 80.3	(2/)	3/ 24.6	(2/)	(2/)	(2/)
		Value of industry shipments accounted for by steel products					
		(Percent)					
B. Product class							
Nails, spikes, brads	----	(2/)	0.8	(4/)	(4/)	78.3	(4/)
Wire, steel	----	(2/)	11.1	(4/)	(4/)	(4/)	5/ 25.4
Cold rolled sheet, strip, bars, shapes	----	(2/)	----	----	63.4	----	----
Pipe and tubes	----	(2/)	(4/)	92.5	(4/)	(4/)	(4/)
Total, selected steel products	----	(2/)	11.9	92.5	63.4	78.3	25.4
Other products	----	(2/)	88.1	7.5	36.6	21.7	74.6
Total	----	100.0	100.0	100.0	100.0	100.0	100.0

1/ Figures may not add to totals because of small amounts made in industries not listed.
2/ Information not available.
3/ Figures add to more than 100 because of duplication in reporting.
4/ Quantity unknown. Included with other products.
5/ This figure is probably considerably overstated. It includes the total amount of wirework n.e.c. made in the industry without regard to material; not merely steel wire. That the true amount is small is evident from the fact that section A above shows that SIC 331 and 3392 account for 99.7 percent of all steel wire.

Source: Census of Manufactures, 1947.

Table B.--Comparison of data from American Iron and Steel Institute and U. S. Bureau of the Census for deriving 1939-47 index of steel production

Type of product	Weights 2/	Quantity (short tons) 1/			
		1939		1947	
		AISI	CENSUS	AISI	CENSUS
Furnace products					
Pig iron 3/	1.00	4/ 34,808,682	5/ 34,711,800	4/ 58,328,912	5/ 58,339,942
Ferroalloy 3/	6/ 17.4	4/ 868,415	7/ 877,649	4/ 1,788,407	7/ 1,877,357
Ingots and steel for casting					
Carbon steel					
Ingots 8/	1.37	49,586,759	9/ 49,569,863	77,465,840	77,244,331
Steel for casting 10/	1.37		170,179		188,613
Alloy steel					
Ingots 8/	2.74	3,032,335	2,950,362	6,908,298	6,737,548
Steel for casting 10/	2.74		11/ 91,096		109,520
Stainless steel					
Ingots 8/	15.77	179,620	180,177	519,933	541,628
Steel for casting 10/	15.77	0	11/ 0		
Semifinished shapes and forms 12/					
Carbon steel					
Blooms, slabs, etc.	0.29	(13/)	(14/)	1,697,175	14/ 1,697,175
Skelp	2.83	226,508	14/ 226,508	160,989	14/ 160,989
Wire rods	1.97	(15/)	(14/)	665,263	14/ 665,263
Alloy steel					
Blooms, slabs, etc	0.49	(13/)	(14/)	277,072	14/ 277,072
Wire rods	3.37	(15/)	(14/)	1,311	14/ 1,311
Stainless steel					
Blooms, slabs, etc	2.51	(13/)	(14/)	6,917	14/ 6,917
Wire rods	16.34	(15/)	(14/)	708	14/ 708

See footnotes at end of table.

Table B.--Comparison of data from American Iron and Steel Institute and U. S. Bureau of the Census for deriving 1939-47 index of steel production--Continued

Type of product	Weights 2/	Quantity (short tons) 1/			
		1939		1947	
		AISI	CENSUS	AISI	CENSUS
Finished shapes and forms					
Carbon steel					
Structural shapes 16/	1.49	(17/)	5/ 3,140,866	12/ 4,368,551	5/ 4,999,997
Steel piling 18/	1.49	171,428		324,224	
Plates 19/	1.14	(20/)	21/ 2,946,628	6,167,837	22/ 5,690,817
Alloy steel					
Structural shapes 16/	2.57	(17/)	(23/)	67,578	23/ 67,578
Plates	1.94	(20/)	(21/)	166,106	24/ 172,315
Stainless steel					
Plates	9.37	(20/)	(25/)	11,273	24/ 16,173
Rails 26/					
Carbon steel					
Standard tee	1.31	1,161,988		2,206,989	2,213,046
Light tee	1.31	125,109	1,316,272	211,825	191,750
All others	1.31				31,646
Alloy steel					
Standard tee	2.26	(27/)	(27/)	157	28/ 157
All others	2.26			75	28/ 75
Rail joints and track spikes					
Carbon steel					
Joints and splices 29/	4.71	132,880	147,465	173,923	217,242
Tie plates 29/	3.80	333,367	369,955	504,779	542,345
Track spikes 30/	4.71	119,719	28/ 119,719	163,746	28/ 163,746

See footnotes at end of table.

Table B.--Comparison of data from American Iron and Steel Institute and U. S. Bureau of the Census for deriving 1939-47 index of steel production--Continued

Type of product	Weights 2/	Quantity (short tons) 1/			
		1939		1947	
		AISI	CENSUS	AISI	CENSUS
Wheels and axles					
Carbon steel					
Wheels 31/	32/ 27.8	150,750	159,484	356,820	415,767
Axles 16/	32/ 26.3	73,970	28/ 73,970	184,461	28/ 184,461
Alloy steel					
Wheels 31/	32/ 47.3	27/ 0	27/ 0	53	28/ 53
Axles 14/	32/ 44.7	27/ 0	27/ 0	558	28/ 558
Bars					
Carbon steel					
Hot rolled 33/	2.83	3,292,876	(34/)	6,242,485	5,602,717
Concrete reinforcing 18/	2.20	1,214,202	1,225,409	1,452,908	1,378,521
Cold finished 18/	2.83	592,514	(35/)	1,426,541	1,361,367
Tool steel 33/	2.83	(36/)	(34/)	24,499	24/ 20,785
Alloy steel					
Hot rolled 37/	4.83	(38/)	(34/)	1,716,187	24/ 1,844,993
Cold finished 18/	4.83	(38/)	(35/)	196,200	235,910
Tool steel 37/	4.83	(36/)	(34/)	62,780	24/ 63,619
Stainless steel					
Hot rolled 33/	23.51	(38/)	(34/)	25,176	24/ 23,723
Cold finished 18/	23.51	(38/)	(35/)	22,762	23,063
Pipe 39/					
Carbon steel					
Standard 33/	7.97	(40/)	41/ 1,746,467	42/ 2,241,396	2,362,549
Oil country goods 43/	5.69	(40/)	41/ 998,734	42/ 1,264,377	1,200,791
Line 43/	5.71	(40/)	41/ 644,677	42/ 1,321,849	1,618,295

See footnotes at end of table.

Table B.--Comparison of data from American Iron and Steel Institute and U. S. Bureau of the Census for deriving 1939-47 index of steel production--Continued

Type of product	Weights 2/	Quantity (short tons) 1/			
		1939		1947	
		AISI	CENSUS	AISI	CENSUS
Alloy steel					
Standard 33/	13.57	(40/)	41/ 263	42/ 725	44/ 725
Oil country goods 43/	9.69	(40/)	41/ 47,357	42/ 153,666	232,232
Line 43/	9.71	(40/)	41/ 116	42/ 362	44/ 362
Stainless steel					
Standard 33/	66.14	(40/)	(28/)	42/ 25	28/ 25
Tubing 33/					
Carbon steel					
Mechanical	8.31	(40/)	41/ 206,648	42/ 632,188	546,362
Pressure	8.31	(40/)	41/ 140,879	42/ 287,358	338,311
Alloy steel					
Mechanical	14.14	(40/)	41/ 58,308	42/ 189,184	181,002
Pressure	14.14	(40/)	41/ 5,826	42/ 18,483	27,260
Stainless steel					
Mechanical	68.91	(40/)	(45/)	42/ 3,028	8,813
Pressure	68.91	(40/)		42/ 5,243	6,701
Wire drawn 16/					
Carbon steel					
Plain	4.46				1,939,015
Galvanized	4.46	(46/)	(47/)	2,553,636	378,415
Other coated	4.46				89,958

See footnotes at end of table.

Table B.--Comparison of data from American Iron and Steel Institute and U. S. Bureau of the Census for deriving 1939-47 index of steel production--Continued

Type of product	Weights 2/	Quantity (short tons) 1/			
		1939		1947	
		AISI	CENSUS	AISI	CENSUS
Alloy steel					
Plain	7.60	(46/)	(47/)	28,436	54,101
Stainless steel					
Plain	37.03	(46/)	(47/)	8,891	11,490
Other wire material 48/					
Carbon steel					
Wire nails, spikes	7.23	678,786	689,443	799,436	807,700
Wire staples	7.23		28,735		34,403
Barbed and twisted wire	10.09	231,021	230,765	256,991	257,781
Woven wire fencing	10.09	273,596	49/ 312,130	407,295	49/ 477,609
Wire bale ties	4.46	59,547	84,783	119,917	159,202
Tin mill products					
Carbon steel					
Black plate 50/	4.20	269,341	51/ 280,483	820,997	24/ 861,625
Tin plate 18/					
Electrolytic	6.37		2,560,721	1,617,659	1,778,623
Hot dipped	6.37	52/ 2,561,451		52/ 2,093,149	1,902,882
Terne plate (short ternes) 18/	6.37		53/ 175,344		99,280
Sheets					
Carbon steel					
Hot rolled	1.46	(54/)	(55/)	7,114,070	22/ 7,188,064
Cold rolled	2.80	(54/)	(56/)	5,185,624	24/ 5,236,410
Galvanized	4.29	1,394,922	57/ 1,619,476	1,609,881	57/ 1,501,535
Long terne	4.29		119,598		148,363

See footnotes at end of table.

Table B.--Comparison of data from American Iron and Steel Institute and U. S. Bureau of the Census for deriving 1939-47 index of steel production--Continued

Type of product	Weights 2/	Quantity (short tons) 1/			
		1939		1947	
		AISI	CENSUS	AISI	CENSUS
Alloy steel					
Hot rolled	2.49	(54/)	(55/)	745,370	24/ 815,888
Cold rolled	4.77	(54/)	(56/)	251,474	58/ 208,737
Stainless steel					
Hot rolled	12.00	(54/)	(25/)	32,358	24/ 43,825
Cold rolled	23.20	(54/)	(56/)	67,480	24/ 66,467
Strip					
Carbon steel					
Hot rolled	1.46	(54/)	(59/)	1,671,079	24/ 1,302,791
Cold rolled	2.80	(54/)	(60/)	1,407,998	24/ 1,363,127
Alloy steel					
Hot rolled	2.49	(54/)	(59/)	67,972	61/ 0
Cold rolled	4.77	(54/)	(60/)	103,719	24/ 94,431
Stainless steel					
Hot rolled	12.00	(54/)	(59/)	1,034	61/ 0
Cold rolled	23.20	(54/)	(60/)	101,288	24/ 104,928
Index of production of basic steel products (1947 = 100)		57.5	58.6	100.0	100.0

See footnotes at end of table.

FOOTNOTES

1/ Figures refer to net shipments or production for sale except as noted. Data are from various editions of the Annual Report of the American Iron and Steel Institute, the Census of Manufactures, and other sources. For specific source references, noted in the stub of the table, see p. 40.

2/ The actual weights are 1947 man-hour requirements per net ton; those for alloy and stainless steel were estimated from the carbon steel weights, using weighted price ratios as estimating factors. (See description on p. 22.) With the exception of the figures for ferroalloys, and wheels and axles (footnotes 6 and 32), the figures in this column are directly proportional to the actual weights used.

3/ Source reference 1 on p. 40. (See footnote 1.)

4/ Figures refer to total production.

5/ Shipments to other companies and interplant transfers.

6/ The ferroalloy weight (man-hours required per net ton produced) is computed from 1947 Census of Manufactures data on man-hours expended and quantities shipped. An electric furnace ferroalloy man-hours figure is estimated from the published figure for man-hours expended in the Electrometallurgical Products Industry, using the ratio of the value of shipments of electric furnace ferroalloys (made in the industry) to the total for the Electrometallurgical Products Industry. A quantity figure is computed in a similar fashion from the published quantity of electric ferroalloys shipped (total less shipments of blast furnace ferroalloys) using the ratio of value of electric furnace alloys made in the industry to the total value made in all industries. The ratio of the resulting estimate of man-hours expended in producing electric furnace ferroalloys to the quantity shipped yields the weight--the man-hours required per net ton of ferroalloys produced in electric furnaces.

7/ 1947 data represent shipments; 1939 data represent production; shipments data are not available.

8/ Source reference 2.

9/ Grade breakdown for 1939 Census figure estimated. See 1945 AISI (pp. 32-33) for source of 1939 production data used in the estimating ratios.

10/ Source reference 3. AISI castings data include only those foundries operated by companies producing steel ingots.

Footnotes --Continued

11/ 1939 figure reported in 1953 AISI, p. 41, for stainless steel ingots and castings combined is the same as that reported for stainless steel ingots in 1945 AISI (p. 33). Hence, it is concluded that (1) no stainless castings were produced in 1939; and (2) the 1939 figure for alloy including stainless reported in 1953 AISI (p. 41) represents alloy castings only.

12/ Source references 4 and 5. Blooms, slabs, etc., are reported in combinations with ingots; the breakdown between products is estimated using 1950 and 1951 AISI data.

13/ 1,305,866 tons of carbon, alloy and stainless blooms, slabs, etc., and ingots were shipped in 1939. Data for alloy and stainless steel grades are unpublished estimates; the figure for carbon steel was obtained by subtracting these estimates from the total.

14/ AISI data were used in the computations because the Census method of computing net shipments has resulted occasionally in a negative net shipments figure.

15/ 550,040 tons of wire rods were shipped in 1939. The details for shipments are unpublished estimates.

16/ Source references 5 and 7.

17/ 2,544,515 tons of structural shapes were shipped in 1939. (See 1948 AISI p. 56.)

18/ Source reference 7.

19/ Plates are shown in 1947 CM as floor plates, and plates other than floor plates. Source references 6 and 8.

20/ 2,793,798 tons of plates were shipped in 1939.

21/ Reported in 1939 CM as total production (including that consumed by the producing plant) of carbon and alloy plates combined (2,968,463 long tons) and of armor plate (31,420 long tons). Shipments are first estimated from total production, and then the grade breakdown of the shipments figure is also estimated. The 1939 data used in the two sets of estimating ratios are derived as follows: total shipments from 1948 AISI (p. 56); the grade breakdown of shipments from unpublished estimates, and total and stainless production from 1940 AISI (pp. 2 and 41). Both numerator and denominator of the estimating ratios exclude stainless plates.

Footnotes--Continued

22/ Shipments less receipts. Source of receipts figure is FTI M22-B-09, table 3 (p. 6).

23/ AISI alloy data are used because 1947 CM reports the production of alloy structural shapes as part of the category other rolled and drawn alloy steel products.

24/ Shipments less receipts. Source of receipts figure is 1947 CM, table 6-E (pp. 540-541).

25/ 1939 CM (p. 188) reports the shipments of stainless steel plates and sheets as a combined figure (25,185 long tons). Census shipments and the product breakdown are estimated simultaneously. Unpublished estimates furnished the 1939 data on shipments of stainless steel plates which are used in the estimating ratio. For data on the production of stainless plates and hot rolled sheets, reported separately, see 1940 AISI (p. 41).

26/ Source references 5 and 6. The product listing of the 1947 CM (p. 543) is used. AISI shows two categories: (1) Standard (over 60 pounds), and (2) all other.

27/ Assumed to be zero. See p. 21 of text.

28/ No Census data are available; therefore, the corresponding AISI data have been used.

29/ Source reference 6. Joint and splice bars, and tie plates (except for 1947 AISI) are reported as a combined figure. The product breakdown is estimated; for the 1939 data used in the estimating ratios, see 1947 AISI (p. 48).

30/ Source reference 4.

31/ Source references 5 and 7. Listed by Census as wheels, rolled, including tires and rims; and by 1949 AISI (p. 54) as wheels (rolled or forged).

32/ The man-hours per net ton of end product used in computing the weights for wheels and axles were estimated from data in the article, Man-Hours of Labor per Unit of Output in Steel Manufacturing by Bernard H. Topkis and H. O. Rogers, Monthly Labor Review, May 1935. The method used was the same as that employed for carbon weights for the current year; see description in the Technical Note.

33/ Source reference 8.

Footnotes--Continued

34/ 1939 CM reports total production of hot rolled steel bars and tool steel bars combined (4,143,231 long tons) under heading steel bars, total. Census net shipments figure estimated from AISI ratio of shipments to total production. AISI total production data from 1943 AISI (p. 8). Grade breakdown is estimated using 1939 alloy data from unpublished estimates.

35/ Breakdown by grade estimated from data supplied by unpublished source.

36/ 45,117 tons of tool steel were shipped in 1939.

37/ Source reference 6.

38/ 702,322 tons of alloy (including stainless) steel bars and 66,384 tons of cold finished bars were shipped in 1939.

39/ 1939 AISI shipments of steel pipe and tubing are reported under 5 classifications: buttweld, lapweld, electric weld, seamless, and conduit. Classification here corresponds to the listing as shown in the 1939 CM.

40/ 3,626,137 tons of carbon steel pipe and tubing (excluding miscellaneous) were produced in 1939. Shipments of all steel pipe (including alloy and stainless) totaled 3,505,582 tons. After subtracting the amounts of alloy and stainless steel pipe and tubing, the remainder was apportioned among the various grades in the same proportions as the production. Data for alloy and stainless steel pipe and tubing were obtained from an unpublished source and the other data from AISI Annual Statistical Reports--1940 (pp. 35-36) and 1948 (p. 56). The proportions of alloy steel and stainless steel pipe and tube in each category were estimated based on their respective shipment proportions in the biennium 1950 and 1951; see AISI Annual Statistical Report--1950 (p. 55) and 1951 (p. 56).

41/ The breakdown between carbon and alloy steels is estimated by using AISI 1939 data by grade. Census reports carbon and alloy shipments of seamless line pipe and oil country goods as a combined figure. These products separated using data from 1940 AISI (p. 36) in the estimating ratio.

42/ Total shipments of pipe and tubing separated into grade using 1947 stainless and alloy data cited in 1949 AISI (p. 56). Estimating ratios applied to obtain desired product classifications derived from 1950 AISI (p. 47).

43/ Source reference 9.

Footnotes--Continued

44/ Census reports one figure for alloy miscellaneous pipes and tubes (including standard and line). Therefore AISI data are used.

45/ Estimated from the combined production figure for stainless steel mechanical and pressure tubing (3115 long tons) reported by 1939 CM (p. 190) by subtracting AISI figure for shipments of stainless steel standard pipe.

46/ 1,354,992 tons of drawn steel wire were shipped in 1939, including alloy and stainless steel.

47/ 1,375,262 tons were shipped in 1939. The distribution among the types of steel has been made on the same basis as the AISI items.

48/ Source reference 10.

49/ The 1947 Census category of fence gates, wire (except chain link) is excluded from 1947 data. The 1939 Census reports total production of fencing and fence gates as one figure and includes the wire fence gates (except chain link) category. The shipments in 1939, excluding this category, are estimated using 1947 Census data in the estimating ratio.

50/ Source reference 11.

51/ Includes output produced and consumed in same plant, reported as 2,970,471 long tons. Shipments estimated from ratio of AISI shipments and AISI production from 1940 AISI (p. 30).

52/ AISI reports hot dipped tin plate and terne plate under the classification tin and terne plate--hot dipped.

53/ Long ternes and terne plate are reported as a combined figure. The product breakdown is estimated using 1939 AISI production data.

54/ The following shipments of sheet and strip wire were made in 1939.

5,087,886 tons hot rolled sheet
2,021,859 tons cold rolled sheet
1,160,513 tons hot rolled strip
676,397 tons cold rolled strip

Data for alloy and stainless sheet and strip were obtained from unpublished estimates.

55/ 9,454,345 long tons or 10,588,866 short tons of hot rolled carbon and alloy (except stainless) steel hot rolled sheets were produced in 1939. Estimated shipments are based on the proportion of production for sale

Footnotes--Continued

to total production shown in the AISI Report, 1940,(pp. 2 and 41). Estimated Census shipments of carbon and alloy sheet are distributed in the same proportion as AISI detail.

56/ 2,767,526 tons of cold rolled sheet were produced in 1939. Estimated shipment by type was based on proportion of total production of cold rolled sheet reported in the AISI report and on data from an unpublished source. See AISI 1945 (p. 59) and AISI 1940 (p. 3).

57/ Figures include galvanized strip.

58/ Figure refers to shipments less receipts and includes electrical and enameling sheets.

59/ Total production reported 1,755,475 tons. Details from unpublished estimates.

60/ Shipments estimated from AISI shipments to production ratio. AISI shipments data in 1948 AISI (p. 56) and AISI production data in 1940 AISI (p. 2).

61/ Shipments less receipts is negative figure, these shipments are assumed to be zero.

APPENDIX, Table B--Continued

Source: For convenience in reference the following table contains all the source references for the data in this table. "AISI" refers to Annual Statistical Report of the American Iron and Steel Institute, "CM" refers to the particular Census of Manufactures, and "FFI" refers to the Facts for Industry series published by the Bureau of the Census.

Ref. No.	1939		1947	
	AISI	CENSUS	AISI	CENSUS
1. . .	1948 AISI (p. 16)	1947 CM (pp. 538-539)	1948 AISI (p. 16)	1947 CM (pp. 538-539)
2. . .	1953 AISI (p. 41)	1939 CM (p. 187)	1953 AISI (p. 41)	1947 CM (p. 541)
3. . .	1953 AISI (p. 41)	1953 AISI (p. 41)	1953 AISI (p. 41)	1953 AISI (p. 41)
4. . .	1948 AISI (p. 56)	1948 AISI (p. 56)	1949 AISI (pp. 54,56)	1949 AISI (p. 54)
5. . .	Unpublished	1947 CM (pp. 540-543)	1949 AISI (p. 56)	1947 CM (pp. 540-543)
6. . .	Unpublished	1939 CM (pp. 187-188)	1949 AISI (p. 56)	1947 CM (pp. 540-543)
7. . .	1948 AISI (p. 56)	1947 CM (pp. 540-543)	1949 AISI (pp. 54,56)	1947 CM (pp. 540-543)
8. . .	1948 AISI (p. 56)	1939 CM (pp. 187-188)	1949 AISI (pp. 54,56)	1947 CM (pp. 540-543)
9. . .	1948 AISI (p. 56)	1939 CM (p. 190)	1949 AISI (pp. 54,56)	1949 FFI M22-BT3
10. . .	1948 AISI (p. 56)	1947 CM (p. 572)	1948 AISI (p. 56)	1947 CM (p. 572)
11. . .	1948 AISI (p. 56)	1939 CM (p. 188)	1949 AISI (pp. 54,56)	1947 CM (p. 547)

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