Iron and Steel

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Contents

A RECORD steel ingot production in 1964 of 127 million tons was led by a phenomenal increase of 80 percent in steel made in basic oxygen converters. Pig iron production increased 19 percent, and shipments of steel products increased 12 percent. During the first 6 months the gain over that of 1963, though modest, seemed based solidly on demand, but talk of inventory buildup raised third quarter production nearly 7 million tons over that of the same quarter in 1963. Record fourth quarter production was caused by purchasing for expanded inventory which resulted from rumors that there would be a steel strike.

The steel industry received notice that a request for negotiations for a new labor contract would be formally tendered January 1, 1965.

TABLE 1.—Salient iron and steel statistics

(Thousand short tons)

	1955-59 (average)	1960	1961	1962	1963	1964
United States:						
Pig iron:						
Production	69,530	66,501	64,853	65,638	71,840	85,458
Shipments	69,492	65,612	65,307	65,727	72,211	85,693
Imports for consumption	349	331	377	500	645	736
Exports	260	112	416	154	70	176
Steel: [1]						
Production of ingots and castings (all grades):						
Carbon	95,640	90,862	89,338	89,160	98,714	114,442
Stainless	1,110	1,004	1,137	1,085	1,204	1,443
All other alloy	7,984	7,416	7,539	8,083	9,343	11,191
Total	104,734	99,282	98,014	98,328	109,261	127,076
Index (1955-59=100)	100.0	94.8	93.6	93.9	104.3	121.3
Total shipments of steel mill products	75,431	71,149	66,126	70,552	75,555	84,945
Imports of major iron and steel products [2] [3]	2,056	3,570	3,308	4,297	5,637	6,628
Exports of major iron and steel products	4,061	3,247	2,221	2,266	2,670	3,911
World production:						
Pig iron [4]	226,283	285,355	282,540	292,542	310,121	350,092
Steel ingots and castings	313,590	381,590	386,900	396,300	425,470	480,780

[1] American Iron and Steel Institute.
[2] Data not comparable for all years.
[3] Bureau of the Census.
[4] Includes ferroalloys.

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The steel industry paid $4,376 million in wages and salaries in 1964. The net billing value of products shipped was $16,200 million compared with $14,500 million in 1963.

Trends and Developments.—The $1,600 million capital investment by the steel industry was primarily for plant modernization to increase productivity and reduce cost. The emphasis in spending was for new basic oxygen converters, for rebuilding blast furnaces to increase productivity, and for continuous casting machines, with the automatic controls that these accelerated steelmaking methods demand.

PRODUCTION AND SHIPMENTS OF PIG IRON

A new record-high pig iron production in 1964 increased 19 percent over that of 1963. The average production of pig iron per blast furnace day was 1,443 short tons, according to the American Iron and Steel Institute (AISI). Pennsylvania, Ohio, and Indiana produced over half the pig iron.

One blast furnace was dismantled and four were abandoned, leaving a total of five fewer at the end of the year. However, 44 more blast furnaces were in operation at the end of 1964 than in 1963.

Metalliferous Materials Consumed in Blast Furnaces.—The record steel ingot production resulted in record amounts of materials being consumed in blast furnaces, but the significant increases were in domestic iron ore, agglomerates, and scrap. The average of 108 pounds of scrap per ton of pig iron produced was the highest for the last 10 years. The combined net charge of metalliferous materials per ton of pig iron produced decreased 42 pounds per ton. The amount of flux consumed per ton of pig iron increased 14 pounds, reversing a 10-year trend. This was a result of the acceleration of ironmaking in the blast furnace.

There was 5.1 million tons of foreign agglomerates used in blast furnaces in 1964, which was four times the quantity used in 1963. Blast furnace charge included 41.1 million tons of sinter, 13.8 million tons of self-fluxing sinter, 24.6 million tons of pellets, and 1.6 million tons of unclassified agglomerates. The use of only 10,000 tons of nodules, none self-fluxing, was reported.

TABLE 2.—Pig iron produced and shipped in the United States, by States

(Thousand short tons and thousand dollars)

State	Produced		Shipped from furnaces			
	1963	1964	1963		1964	
	Quantity		Quantity	Value	Quantity	Value
Alabama	3,908	4,321	3,899	$217,020	4,353	$234,346
Illinois	4,476	5,671	4,541	261,186	5,579	322,098
Indiana	9,957	11,511	10,050	564,355	11,483	658,162
Ohio	12,734	15,163	12,772	737,990	15,355	925,078
Pennsylvania	17,290	20,986	17,338	1,028,796	21,005	1,207,869
California, Colorado, Utah	4,044	4,726	4,062	204,378	4,739	276,743
Kentucky, Maryland, Tennessee, Texas, West Virginia	8,707	10,582	8,720	557,866	10,641	636,785
Michigan and Minnesota	6,451	7,387	6,523	360,659	7,405	409,657
New York	4,273	5,111	4,306	290,218	5,133	320,568
Total	71,840	85,458	72,211	4,222,468	85,693	4,991,306

Canada, Venezuela, and Chile furnished 87 percent of the foreign iron ore consumed by blast furnaces in the United States.

According to the AISI, blast furnace consumption of oxygen decreased 0.6 billion cubic feet in 1964 to 9.7 billion cubic feet. Blast furnaces consumed 40.5 billion cubic feet of natural gas, 3.4 billion cubic feet of coke-oven gas, and 46.6 million gallons of oil, according to data collected by the Bureau of Mines. There were 13,650 tons of bituminous and anthracite coal used in blast furnaces during 1964.

TABLE 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, by sources of ore

(Short tons)

Source	1963	1964 [1]	Source	1963	1964 [1]
Brazil	48,229	188,745	Venezuela	4,749,444	5,779,531
Canada	5,829,190	4,658,880	Other countries	526,359	1,148,522
Chile	1,220,384	1,169,654			
Peru	191,282	354,326	Total	12,564,888	13,299,658

[1] Excludes 24.5 million tons used in making agglomerates.

TABLE 4.—Pig iron shipped from blast furnaces in the United States, by grades [1]

(Thousand short tons and thousand dollars)

Grade	1963			1964		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	1,657	$92,156	$55.62	1,761	$95,984	$54.51
Basic	65,062	3,803,535	58.46	78,003	4,546,819	58.29
Bessemer	2,821	171,317	60.73	2,789	165,308	59.27
Low-phosphorus	173	10,554	61.01	325	19,436	59.80
Malleable	2,299	135,070	58.75	2,523	146,810	58.19
All other (not ferroalloys)	199	9,836	49.43	292	16,949	58.04
Total	72,211	4,222,468	58.47	85,693	4,991,306	58.25

[1] Includes pig iron transferred directly to steel furnaces at same site.

TABLE 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States, by States

State	Jan. 1, 1964			Jan. 1, 1965		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	11	10	21	16	3	19
California	3	1	4	4		4
Colorado	3	1	4	3	1	4
Illinois	9	13	22	16	6	22
Indiana	21	2	23	21	2	23
Kentucky	2	1	3	2	1	3
Maryland	6	4	10	10		10
Michigan	9		9	9		9
Minnesota	1	1	2	2		2
New York	10	7	17	12	3	15
Ohio	27	22	49	36	13	49
Pennsylvania	37	27	64	50	13	63
Tennessee	1	2	3		3	3
Texas	2		2	2		2
Utah	2	3	5	3	2	5
Virginia		2	2	1	1	2
West Virginia	3	1	4	4		4
Total	147	97	244	191	48	239

Source: American Iron and Steel Institute.

TABLE 6.—Iron ore and other metallic materials, coke and fluxes consumed and pig iron produced in the United States, by States

(Short tons)

Year and State	Metalliferous materials consumed							Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made				Coke and fluxes consumed per ton of pig iron	
	Iron and manganiferous ores		Agglomerates	Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Net total				Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Total	Net coke	Fluxes
	Domestic	Foreign														
1963:																
Alabama	2,872,047	r1,129,847	3,139,514	6,967,701	119,372	113,974	7,201,047	3,240,051	1,055,212	3,907,537	1.783	0.031	0.029	1.843	0.829	0.270
Illinois	3,167,151	(4)	4,249,190	7,222.567	320,492	471,620	8,014,679	3,271.955	819,839	4,476,337	1.614	.072	.105	1.791	.731	.183
Indiana	6,095,289	1,829,021	9,432,431	16,632,897	225,326	1,529,729	18,387,952	6,581,129	1,436,894	9,957,082	1.670	.023	.154	1.847	.661	.144
Ohio	5,119,029	2,007,183	12,226,113	18,558,176	1,074,130	1,472,743	21,105,049	8,852,586	2,926,796	12,733,837	1.458	.084	.116	1.658	.695	.230
Pennsylvania	5,424,093	2,848,667	17,761,693	25,335,965	961,519	2,004,602	28,302,086	11,259,322	2,598,801	17,289,805	1.465	.056	.116	1.637	.651	.150
California, Colorado, Utah	(4)	(4)	4,249,452	6,857,560	139,988	131,051	7,128,599	2,387,376	703,462	4,044,051	1.696	.035	.032	1.763	.590	.174
Kentucky, Tennessee, Texas	1,059,349	353,062	1,751,297	3,119,595	60,720	126,691	3.307,006	1,182,501	475,416	1,759,012	1.773	.035	.072	1.880	.672	.270
Maryland and West Virginia	(4)	(4)	6,732,922	10,433,717	187,988	599,636	11,221,341	4.446,682	676,751	6,947,446	1.502	.027	.086	1.615	.640	.097
Michigan and Minnesota	(4)	(4)	7,663,773	10,032,859	258,528	307,979	10,599,366	4,094,351	1,433,738	6,451,261	1.555	.040	.048	1.643	.635	.222
New York	1,647,015	280,503	4,929,479	6,618,290	116,476	378,603	7,113.369	2,845,734	1,087,396	4,273,375	1.549	.027	.089	1.665	.666	.254
Total	30,938,796	12,564,888	72,135,864	111,779,327	3,464,539	7,136,628	122,380,494	48,161,687	[5]13,214,305	71,839,743	1.556	.048	.099	1.703	.670	.184

1964:																
Alabama	2, 484, 443	1, 548, 083	3. 594, 910	7, 422, 462	111, 397	55, 286	7, 589, 145	3, 649, 460	1, 079, 896	4. 320, 973	1. 718	. 026	. 013	1. 756	. 845	. 250
Illinois	4, 236, 471	(4)	5, 220, 224	9, 022, 912	345, 039	514, 480	9, 882, 431	3, 983, 486	1, 258, 201	5, 671, 009	1. 591	. 061	. 091	1. 743	. 702	. 222
Indiana	6, 555. 950	1, 156 253	11, 523, 887	18, 205, 533	207, 269	1, 488, 275	19, 901, 077	7, 339, 461	1, 638, 002	11, 511, 028	1. 582	. 018	. 129	1. 729	. 638	. 142
Ohio	6, 159, 946	1, 753, 649	14, 673, 231	21, 713, 499	1, 320, 517	1, 704, 666	24, 738, 682	9, 977, 842	3, 654, 148	15, 163, 176	1. 432	. 087	. 112	1. 632	. 658	. 241
Pennsylvania	7, 857, 245	4, 048, 268	19, 781, 888	30, 825, 959	1. 059, 531	2, 423, 251	34, 308, 741	13, 455, 012	3, 585, 231	20. 986, 345	1. 469	. 050	. 115	1. 635	. 641	. 171
California, Colorado, Utah	(4)	(4)	4, 636. 842	8, 009, 805	991, 490	149, 258	9, 150, 553	2, 755, 970	811, 013	4, 726, 261	1. 695	. 210	. 032	1. 936	. 583	. 172
Kentucky, Maryland, Tennessee, Texas, West Virginia	1, 962, 501	3, 897, 716	11, 184, 176	16, 413, 990	278, 158	1, 019, 137	17, 711, 285	6, 796, 458	1, 511, 766	10, 581 928	1. 551	. 026	. 096	1. 674	. 642	. 143
Michigan and Minnesota	(4)	(4)	9, 653, 049	11. 576, 902	183, 691	348, 503	12, 109, 096	4, 573, 939	1, 479, 034	7, 386, 353	1. 567	. 025	. 047	1. 639	. 619	. 200
New York	1, 464, 287	645, 529	5, 897, 949	7, 767, 468	133, 326	464, 018	8, 364, 812	3, 250, 092	1, 334, 387	5, 111, 326	1. 520	. 026	. 091	1. 636	. 636	. 261
Total	36, 218, 021	13, 299, 658	86, 166, 156	130, 958, 530	4, 630, 418	8, 166. 874	143, 755. 822	55, 781, 720	[6] 16, 351, 678	85, 458, 399	1. 532	. 054	. 096	1. 682	. 653	. 191

r Revised.

1 Net ores and agglomerates equal ores plus agglomerates plus flue dust used minus flue dust recovered.

2 Excludes home scrap produced at blast furnaces.

3 Does not include recycled material.

4 Included in total.

5 Fluxes consisted of 9,066,274 tons of limestone and 4,148,031 tons of dolomite, excluding 4,686,330 tons of limestone and 1,913,125 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

6 Fluxes consisted of 10,743,800 tons of limestone and 5,607,878 tons of dolomite, excluding 4,876,636 tons of limestone and 1,820,229 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

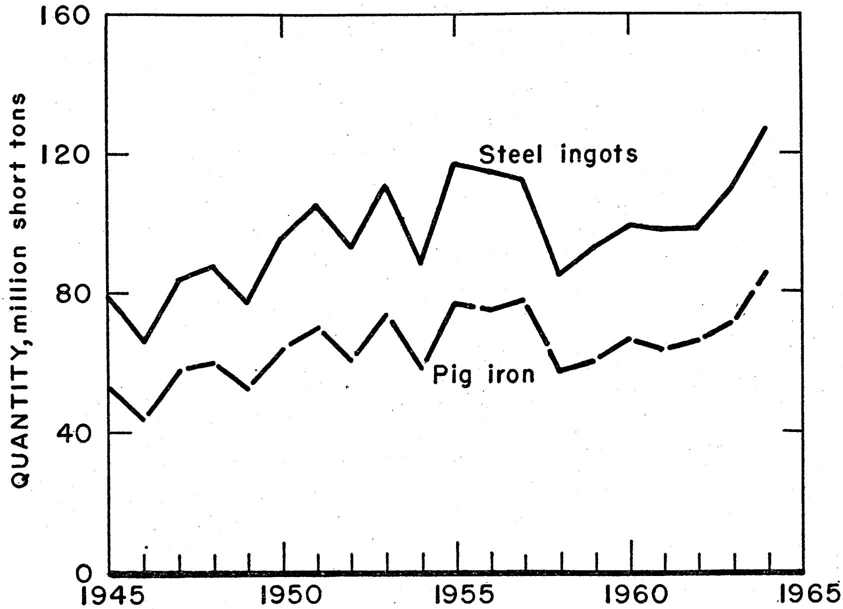

FIGURE 1.—Trends in production of pig iron and steel ingots in the United States.

PRODUCTION AND SHIPMENTS OF STEEL

Record-high production and shipments of steel ingots and steel products were made in 1964. The industry produced 127 million short tons of ingots, 16 percent more than in 1963, and nearly 9 percent better than the previous record of 117 million tons in 1955. Production of steel in basic oxygen converters nearly doubled to furnish 12 percent of the total steel ingot produced. Open-hearth furnace production dropped to 77 percent, electric furnaces produced 10 percent, and Bessemer converters 0.7 percent. Seventy percent of the steel was made in Pennsylvania, Ohio, Indiana, Illinois, and Michigan. These States produced 24 percent, 17 percent, 14 percent, 8 percent, and 7 percent, respectively.

Total shipments of steel products increased over 9 million tons compared with shipments in 1963. The increase was in all market classifications. Three of the largest consuming groups, construction, automotive, and containers, while taking more steel than in 1963, lost small percentages of their share of the market.

Alloy Steel.[2]—The production of 11.2 million tons of alloy steel (in-

[2] The Bureau of Mines uses the American Iron and Steel Institute specifications for alloy steels, which include stainless and any other steel containing one or more of the following elements in the designated percentages: Manganese in excess of 1.65 percent, silicon in excess of 0.60 percent, and copper in excess of 0.60 percent. The specifications also include steel containing the following elements in any quantity specified or known to have been added to obtain a desired alloying effect: Aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, and other alloying elements.

Stainless steel includes all grades of steel that contain 10 percent or more of chromium with or without other alloys or a minimum combined content of 18 percent of chromium with other alloys. Valve or bearing steels, high-temperature alloys, or electrical grades with analyses meeting the definition for stainless steels are included. All tool-steel grades are excluded.

Heat-resisting steel includes all steel containing 4 percent or more but less than 10 percent of chromium (excluding tool-steel grades).

cluding nearly 62,000 tons for castings but excluding all stainless) was 20 percent greater than that in 1963. Stainless production (including 1,772 tons of direct castings) increased 20 percent to 1.4 million tons. Alloy and stainless represented 10 percent of total production.

Austenitic (AISI 200 and 300) stainless steel production increased 24 percent to comprise 70 percent of the total stainless production. Series 400 stainless steels increased 7 percent to a volume of 307,000 tons, 2,000 tons more than that in 1962. Production of AISI type 500 and all other high-chromium heat-resisting steels again declined.

The production of alloy and stainless steel in basic oxygen converters rose to 3 percent of the total. Open-hearth furnaces accounted for 58 percent of this production and electric for 39 percent.

Materials Used in Steelmaking.—Pig iron made up 55 percent of the 143.3 million tons of metallics consumed in steelmaking in 1964. According to AISI, 294,690 tons of fluorspar, 5,746,115 tons of limestone, 2,421,723 tons of lime, and 481,739 tons of other fluxes were used in steelmaking. There was 90.6 billion cubic feet of oxygen used in steelmaking, or 30 percent more than that consumed in 1963. Sixty-four percent of the oxygen was used in the open-hearth and 33 percent in basic oxygen converters.

TABLE 7.—Steel production in the United States, by type of furnace [1]

(Thousand short tons)

Year	Open hearth		Bessemer	Basic oxygen process	Electric [2]	Total
	Basic	Acid				
1955–59 (average)	92,946	536	2,360	[3] 861	8,031	104,734
1960	85,964	404	1,189	3,346	8,379	99,282
1961	84,108	394	881	3,967	8,664	98,014
1962	82,578	379	805	5,553	9,013	98,328
1963	88,437	397	963	8,544	10,920	109,261
1964	97,655	443	858	15,442	12,678	127,076

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. Omits about 2 percent of total steel production.
[2] Includes crucible, oxygen converter steel, 1955.
[3] Data for 4-year period only.

Source: American Iron and Steel Institute.

CONSUMPTION OF PIG IRON

Domestic consumption of pig iron increased 19 percent in 1964. The East North Central and Middle Atlantic States consumed over 76 percent of the total production.

TABLE 8.—Metalliferous materials consumed in steel furnaces in the United States

(Thousand short tons)

Year	Iron ore		Agglomerates [1]	Pig iron	Ferro-alloys [2]	Iron and steel scrap
	Domestic	Foreign				
1955-59 (average)	2,674	4,986	1,485	61,832	1,455	54,727
1960	1,570	6,251	931	60,092	1,395	51,140
1961	1,913	5,277	855	59,418	1,367	49,455
1962	1,875	4,768	[3] 644	60,561	1,408	49,606
1963	1,783	3,995	[4] 885	66,188	1,557	56,506
1964	2,114	4,816	[5] 1,379	78,925	1,819	64,348

[1] Includes consumption of pig iron and scrap by ingot producers and iron and steel foundries.
[2] Includes ferromanganese, spiegeleisen, silicomanganese, manganese briquets, manganese metal, ferrosilicon, ferrochromium alloys, and ferromolybdenum.
[3] Includes 20,039 tons of sinter, 342,466 tons of pellets, 276,632 tons of nodules, 702 tons of briquets, 3,661 tons of other agglomerates. (532,031 tons of foreign origin.) 1959-62 see Iron and Steel chapter, Minerals Yearbook, v. I, p. 695.
[4] Includes 71,116 tons of sinter, 487,886 tons of pellets, 300,411 tons of nodules, and 25,189 tons of other agglomerates. (875,573 tons of foreign origin.)
[5] Includes 725,575 tons of sinter, 346,390 tons of pellets, 292,938 tons of nodules, and 13,768 tons of other agglomerates. (620,917 tons of foreign origin.)

TABLE 9.—Consumption of pig iron in the United States, by type of furnace

Type of furnace or equipment	1963		1964	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Open hearth	57,291	78.8	65,206	75.5
Bessemer	1,603	2.2	949	1.1
Oxygen converter	7,082	9.8	12,446	14.4
Electric [1]	212	.3	325	.4
Cupola	3,597	4.9	3,704	4.3
Air	178	.2	170	.2
Direct castings	2,726	3.8	3,582	4.1
Total	72,689	100.0	86,382	100.0

[1] Includes a small quantity of pig iron consumed in crucible furnaces.

TABLE 10.—Consumption of pig iron in the United States, by districts and States

(Short tons)

District and State	1963	1964	District and State	1963	1964
New England:			South Atlantic—Con.		
Connecticut	30,802	32,833	North Carolina	30,213	33,246
Maine and New Hampshire	1,741	1,999	South Carolina	17,949	16,683
Massachusetts	49,025	57,586	Virginia and West Virginia	2,229,954	2,375,911
Rhode Island	42,660	42,408	Total	7,135,217	8,131,073
Vermont	6,020	6,178	East South Central:		
Total	130,248	141,004	Alabama	3,427,531	3,737,824
Middle Atlantic:			Kentucky, Mississippi, Tennessee	963,950	1,495,872
New Jersey	113,289	112,089	Total	4,391,481	5,233,696
New York	3,837,813	4,606,010	West South Central:		
Pennsylvania	17,460,390	21,373,302	Arkansas, Louisiana, Oklahoma	7,990	12,144
Total	21,411,492	26,091,401	Texas	942,427	1,332,816
East North Central:			Total	950,417	1,344,960
Illinois	4,837,935	5,858,222	Rocky Mountain:		
Indiana	9,863,042	11,367,746	Arizona and Nevada	92	
Michigan	6,531,984	7,462,185	Colorado, Idaho, Montana, Utah	2,230,501	2,510,068
Ohio	12,556,922	15,092,990	Total	2,230,593	2,510,068
Wisconsin	173,669	192,249	Pacific Coast:		
Total	33,963,552	39,973,392	California and Hawaii	1,891,049	2,250,640
West North Central:			Oregon and Washington	16,417	46,884
Iowa	74,685	88,128	Total	1,907,466	2,297,524
Kansas and Nebraska	5,850	5,854	Grand total	72,688,740	86,381,699
Minnesota	454,249	524,912			
Missouri	33,490	39,687			
Total	568,274	658,581			
South Atlantic:					
Delaware and Maryland	4,844,795	5,691,698			
Florida and Georgia	12,306	13,535			

PRICES

The average composite price of pig iron remained at $63.11 per long ton throughout 1964, and the average composite price for steel remained at 6.368 cents per pound throughout the year.[3]

TABLE 11.—Average value of pig iron at blast furnaces in the United States, by States

(Per short ton)

State	1955–59 (average)	1960	1961	1962	1963	1964
Alabama	$52.45	$56.52	$56.62	$57.46	$55.66	$53.83
California, Colorado, Utah	55.80	59.73	50.50	51.59	50.31	58.40
Illinois	56.57	60.30	60.42	59.10	57.52	57.74
Indiana	55.73	58.90	58.96	57.34	56.15	57.32
New York	58.37	62.54	60.05	59.13	67.40	62.45
Ohio	54.52	57.79	60.78	59.89	57.78	60.24
Pennsylvania	56.80	60.12	59.48	58.93	59.34	57.50
Other States [1]	56.82	58.06	57.44	57.66	60.26	57.99
Average	56.01	59.53	58.51	58.15	58.47	58.25

[1] Comprises Kentucky, Maryland, Michigan, Minnesota, Tennessee, Texas, West Virginia, Massachusetts, and Virginia.

[3] Iron Age. V. 195, No. 1, Jan. 7, 1965, pp. 187–191.

TABLE 12.—Average prices of chief grades of pig iron

(Short tons)

Month	Foundry pig iron at Birmingham furnaces, 1964	Foundry pig iron at Cleveland furnaces, 1964	Bessemer pig iron at Valley furnaces, 1964	Basic pig iron at Valley furnaces, 1964
January-December	53.13	56.70	57.14	56.25

Source: Metal Statistics.

TABLE 13.—Free-on-board value of steel mill products in the United States, in 1963[1]

(Cents per pound)

Product	Carbon	Alloy	Stainless	Average
Ingots	3.559	9.681	27.973	7.059
Semifinished shapes and forms	5.662	10.007	39.366	6.444
Plates	6.563	10.239	[2] 58.724	7.722
Sheets and strips	7.091	14.539	45.130	7.934
Tin mill products	9.183			9.183
Structural shapes and piling	6.366	9.181		6.457
Bars	7.408	13.120	67.557	8.797
Rails and railway-track material	8.311			8.311
Pipes and tubes	10.275	16.988	144.230	11.462
Wire and wire products	12.604	36.491	83.310	13.697
Other rolled and drawn products	(3)	35.035	72.190	39.586
Average total steel	7.640	13.157	53.755	8.495

[1] This table represents the weighted average value based on the quantity of each type of steel shipped; therefore, it reflects shifts in the distribution of the 3 classes of steel.
[2] Includes unknown quantity of hot-rolled bars.
[3] Included with rails and railway-track material.

Source: Computed from figures supplied by the Bureau of the Census.

FOREIGN TRADE

The value of iron and steel mill products exported from the United States exceeded the value of imports by nearly 19 percent.

Imports in 1964 of iron and steel products were 6.6 million tons compared with imports of 5.6 million tons in 1963. The total quantity of iron and steel products exported was 4 million tons in 1964 and 2.7 million tons in 1963. The European Coal and Steel Community supplied 42 percent of the imports, Japan, 33 percent, and Canada, 15 percent.

TABLE 14.—U.S. imports for consumption of pig iron, by countries

(Short tons)

Country	1955-59 (average)	1960	1961	1962	1963	1964
North America: Canada	280,850	281,593	349,403	386,296	387,449	395,202
South America: Brazil	3,925	----	----	----	----	67,895
Eruope:						
Belgium-Luxembourg	----	4,408	----	----	----	----
Finland	2,051	----	----	681	12,123	73,004
Germany:						
East	22	----	----	----	----	57,182
West	17,132	386	719	56,341	87,435	51,412
Netherlands	1,379	1,575	----	----	----	----
Norway	213	----	----	3,584	3,319	101
Portugal	879	----	----	----	----	1,051
Spain	17,873	21,551	19,113	42,416	45,161	11,683
Sweden	2,028	1,445	1,201	1,416	10,146	9,969
U.S.S.R	310	1,298	396	----	----	----
United Kingdom	10	----	----	94	8	----
Total	41,897	30,663	21,429	104,532	158,192	204,402
Asia:						
India	2,322	6,742	----	----	----	----
Japan	2,135	----	----	----	----	----
Total	4,457	6,742	----	----	----	----
Africa:						
Rhodesia and Malawi	1,021	392	----	----	----	----
South Africa, Republic of	14,414	7,543	4,096	5,030	76,696	68,620
Total	15,435	7,935	4,096	5,030	76,696	68,620
Oceania: Australia	2,432	3,914	2,252	4,216	22,997	352
Grand total: Short tons	348,996	330,847	377,180	500,074	645,334	736,471
Value	$18,690,611	$18,351,333	$20,511,391	$24,684,220	$28,936,920	$31,591,381

Source: Bureau of the Census.

TABLE 15.—U.S. imports for consumption of major iron and steel products

Products	1963 Short tons	1963 Value	1964 Short tons	1964 Value
Iron products:				
Bar iron, iron slabs, blooms, or other forms	265	$87,906	248	$71,221
Pipes and fittings:				
Cast-iron pipe and fittings	r 38,651	r 4,320,028	34,655	3,859,069
Malleable cast-iron pipe fittings	3,936	1,534,890	2,884	1,124,632
Castings and forgings	r 14,188	r 4,389,287	8,268	6,187,207
Total	r 57,040	r 10,332,111	46,055	11,242,129
Steel products:				
Steel bars:				
Concrete reinforcement bars	545,203	39,254,792	411,997	32,132,687
Solid and hollow, n.e.s.	r 217,645	r 25,600,691	367,869	40,485,012
Hollow and hollow drill steel	r 3,078	r 1,319,541	4,757	1,988,406
Wire rods, nail rods, and flat rods up to 6 inches in width	r 801,353	r 76,986,562	952,767	88,455,563
Steel ingots, blooms, and slabs; billets, solid and hollow	260,355	24,831,885	344,760	36,526,720
Circular saw plates	[1] 146	70,639	(1)	819,951
Sheets and plates and steel, n.s.p.f.	r 1,024,013	r 124,344,206	1,596,137	211,732,366
Tinplate, terneplate, and taggers' tin	82,941	14,197,413	80,693	13,754,201
Structural iron and steel	933,075	89,203,358	1,062,864	101,000,875
Rails for railways	r 10,123	636,452	10,843	1,044,333
Rail braces, bars, fishplates, or splice bars and tie plates	638	67,260	828	85,717
Steel pipes and tubes	r 743,515	r 106,333,167	787,111	114,464,632
Wire:				
Barbed	90,029	11,522,607	72,433	9,191,390
Round wire, n.e.s.	r 285,780	r 50,517,341	377,979	65,529,795
Telegraph, telephone, etc., except copper, covered with cotton jute, etc.	1,751	1,012,236	577	448,245
Flat wire and iron and steel strips	r 79,344	r 16,735,879	14,238	5,962,758
Rope and strand	r 47,641	r 13,688,654	52,129	15,319,067
Galvanized fencing wire and wire fencing	r 73,096	r 9,735,282	42,790	6,003,340
Iron and steel used in card clothing	(2)	r 372,362	(2)	160,559
Hoop and band iron and steel, for baling	27,707	3,701,291	30,479	4,019,129
Hoop, band and strips, or scroll iron or steel, n.s.p.f.	r 27,664	r 8,173,376	44,119	16,257,407
Nails	r 308,867	r 41,678,183	310,437	44,643,750
Steel castings and forgings	r 16,483	r 5,042,574	16,038	4,075,042
Total	r 5,580,447	r 665,025,751	6,581,845	814,100,945
Advanced manufactures:				
Bolts, nuts, and rivets	r 68,551	r 19,650,311	74,624	22,744,338
Chains and parts	9,243	6,200,689	12,408	8,179,704
Hinges and hinge blanks	----	2,014,423	----	2,353,359
Screws (wholly or chiefly of iron or steel)	----	r 3,853,173	----	9,306,665
Tools	----	r 13,216,052	----	31,995,104
Other	----	r 851,316	----	1,139,019
Total	----	45,785,964	----	75,718,189
Grand Total	----	721,143,826	----	901,061,263

r Revised.
[1] Data are January–August; effective Sept. 1, 1963, saws were reported in number, September–December, 127,250 ($181,280), 1964, 190,840.
[2] Weight not recorded.

Source: Bureau of the Census.

TABLE 16.—U.S. exports of major iron and steel products

Products	1963		1964	
	Short tons	Value	Short tons	Value
Semimanufactures:				
Steel ingots, blooms, billets, slabs, and sheet bars	r 304,481	$24,665,086	856,445	$65,383,757
Iron and steel bars, and rods:				
Carbon-steel bars, hot-rolled, and iron bars	47,269	9,105,344	71,119	12,114,341
Concrete reinforcement bars	46,009	6,016,137	60,580	7,828,539
Other steel bars	24,901	12,352,386	42,831	17,221,341
Wire rods	24,033	4,145,703	33,939	5,717,371
Iron and steel plates, sheets, skelp, and strips:				
Plates, including boilerplate, not fabricated	139,483	26,389,591	176,613	35,199,150
Skelp iron and steel	2,482	234,626	29,574	3,283,888
Iron and steel sheets, galvanized	r 114,448	r 23,135,017	169,006	34,361,158
Steel sheets, black, ungalvanized	457,610	r 114,075,360	704,288	146,503,570
Strip, hoop, band, and scroll iron and steel:				
Cold-rolled	37,732	17,625,323	54,807	25,631,435
Hot-rolled	51,297	11,260,004	68,050	12,944,542
Tinplate and terneplate	342,363	51,059,805	351,642	52,709,046
Tinplate circles, cobbles, strip, and scroll shear butts	23,355	2,489,110	27,542	3,136,681
Total	r 1,615,463	r 302,553,492	2,646,436	422,034,819
Manufactures-steel mill products:				
Structural iron and steel:				
Water, gas, and other storage tanks (unlined), complete and knockdown material	21,031	9,759,863	15,023	7,527,697
Structural shapes:				
Not fabricated	r 153,143	r 22,548,595	236,115	36,840,374
Fabricated	r 170,836	r 37,479,578	89,914	32,551,537
Plates and sheets, fabricated, punched, or shaped	r 16,571	r 5,733,393	11,815	3,727,697
Metal lath	1,163	477,968	1,016	407,126
Frames, sashes, and sheet piling	8,235	1,953,252	14,387	2,730,908
Railway-track material:				
Rails for railways	44,045	5,970,153	45,536	5,859,758
Rail joints, splice bars, fishplates, and tieplates	45,323	9,183,035	10,079	2,639,019
Switches, frogs, and crossings	3,867	1,582,820	1,578	1,057,159
Railroad spikes	3,436	1,071,737	756	191,720
Railroad bolts, nuts, washers, and nut locks	6,023	1,429,887	727	401,671
Tubular products:				
Boiler tubes	11,840	8,066,150	13,865	8,792,275
Casing and line pipe	122,520	34,501,999	125,486	34,766,192
Seamless black and galvanized pipe and tubes, except casing, line and boiler, and other pipes and tubes	42,553	12,074,972	358,708	129,353,673
Welded black pipe	7,357	2,069,338	13,800	3,745,308
Welded galvanized pipe	12,017	2,610,468	15,029	3,450,149
Malleable-iron screwed pipe fittings	1,279	1,308,765	1,471	1,384,949
Cast-iron pressure pipe and fittings	119,397	15,450,543	32,153	5,764,250
Cast-iron soil pipe and fittings	7,246	1,803,201	6,623	1,607,468
Iron and steel pipe, fittings, and tubing, n.e.c	58,743	46,352,732	67,333	49,962,115
Wire and manufactures:				
Barbed wire	23,178	4,294,517	592	144,400
Galvanized wire	22,492	6,025,095	20,290	8,364,891
Iron and steel wire, uncoated	21,477	6,956,824	24,573	10,095,935
Spring wire	1,418	915,333	1,760	1,000,337
Wire rope and strand	9,227	5,042,761	10,549	6,306,286
Woven-wire screen cloth	1,540	[1] 2,138,642	1,701	[1] 2,629,550
All other	17,160	10,798,742	18,455	12,150,240
Nails and bolts, iron and steel, n.e.c.:				
Wire nails, staples, and spikes	4,348	3,587,563	4,482	4,518,324
Bolts, screws, nuts, rivets, and washers, n.e.c	19,580	22,465,248	21,636	26,589,950
Tacks	671	455,958	736	483,018
Castings and forgings: Iron and steel including car wheels, tires, and axles	76,766	25,533,033	98,239	35,504,895
Total	r 1,054,482	r 309,642,165	1,264,427	440,548,878

See footnotes at end of table.

TABLE 16.—U.S. exports of major iron and steel products—Continued

Products	1963		1964	
	Short tons	Value	Short tons	Value
Advanced manufactures:				
Building (prefabricated and knockdown)		r $6,608,289		$7,668,546
Chains and parts	8,189	11,201,215	13,732	13,454,945
Construction material	8,099	5,888,865	12,461	7,288,026
Hardware and parts		24,422,387		27,354,061
House-heating boilers, and radiators		6,197,711		7,259,766
Oil burners and parts		9,712,142		10,296,030
Plumbing fixtures and fittings		4,987,304		6,076,797
Tools		39,725,808		66,788,075
Utensils and parts (cooking, kitchen, and hospital)		3,298,068		2,989,943
Other		53,391,629		57,202,018
Total		r 165,433,418		206,378,207
Grand total		r 777,629,075		1,068,961,904

r Revised.
[1] Includes wire cloth as follows 1963, $1,638,819 (3,404,155 square feet); 1964, $2,035,676 (3,707,046 square feet).

Source: Bureau of the Census.

WORLD REVIEW

The United States led world production of pig iron (including ferroalloys) to a new high with an increase of 14 million tons. The increase in world steel production was led by the United States, which had an increase of nearly 18 million ingot tons. Japan again had the largest percentage increase in production with 29 percent more ingot steel produced in 1964.

TABLE 17.—World production of pig iron (including ferroalloys) by countries [1] [2]

(Thousand short tons)

Country [1]	1955–59 (average)	1960	1961	1962	1963	1964 [p]
North America:						
Canada	3,725	4,436	5,064	5,427	6,059	6,707
Mexico	493	756	864	912	947	1,068
United States	71,771	68,620	66,717	67,636	73,853	87,922
Total	75,989	73,812	72,645	73,975	80,859	95,697
South America:						
Argentina	35	198	437	438	467	649
Brazil	1,439	1,965	2,050	2,337	2,778	2,484
Chile	353	293	314	440	480	482
Colombia	147	204	208	164	224	243
Venezuela	---------	---------	6	136	333	357
Total	1,974	2,660	3,015	3,515	4,282	4,215
Europe:						
Austria	1,954	2,467	2,500	2,339	2,326	2,434
Belgium	6,223	7,223	7,104	7,439	7,622	9,327
Bulgaria	75	212	227	246	292	1,026
Czechoslovakia	3,934	5,225	5,529	5,767	5,847	6,361
Denmark	60	80	73	76	76	77
Finland	122	151	168	377	413	653
France	13,129	15,921	16,372	15,716	16,010	17,728
Germany:						
East	1,857	2,199	2,239	2,287	2,370	2,491
West	22,677	28,372	28,033	26,732	25,253	29,963
Hungary	1,034	1,390	1,455	1,543	1,544	1,647
Italy	2,269	3,113	3,528	4,054	4,264	3,996
Luxembourg	3,637	4,173	4,226	3,965	3,954	4,620
Netherlands	902	1,485	1,606	1,732	1,884	2,147
Norway	556	794	834	798	821	976
Poland	4,087	5,030	5,258	5,854	5,947	6,220
Portugal	[3] 30	45	134	248	265	297
Rumania	754	1,118	1,211	1,666	1,881	2,121
Spain	1,321	2,124	2,340	2,374	2,187	2,045
Sweden	1,570	1,799	2,094	2,164	2,220	2,434
Switzerland	49	[e] 60	[e] 60	[e] 60	49	35
U.S.S.R. [4]	41,596	51,541	56,100	60,919	64,697	68,784
United Kingdom	14,667	17,655	16,517	15,335	16,342	19,347
Yugoslavia	794	1,123	1,161	1,216	1,168	1,186
Total [4]	123,297	153,300	158,769	162,907	167,432	185,915
Asia:						
China	[5] 9,679	30,300	[e] 16,500	[e] 16,500	[e] 18,700	[e] 19,800
India	2,466	4,705	5,621	6,522	7,431	7,432
Japan	8,034	13,604	18,059	20,325	22,525	27,017
Korea:						
North	354	959	1,047	1,365	1,305	[e] 1,510
South	6	15	10	2	6	1
Taiwan	23	26	58	69	60	68
Thailand	4	7	6	6	7	6
Turkey [6]	244	272	260	323	434	[e] 440
Total [4]	20,810	49,888	41,561	45,112	50,468	56,274
Africa:						
Rhodesia (formerly Southern)	78	95	243	266	276	287
South Africa, Republic of	1,648	2,197	2,566	2,663	2,691	3,181
United Arab Republic (Egypt)	39	163	192	225	---------	---------
Total	1,765	2,455	3,001	3,154	2,967	3,468
Oceania: Australia [7]	2,448	3,240	3,549	3,879	4,113	4,523
World total [e]	226,283	285,355	282,540	292,542	310,121	350,092

[e] Estimate.
[p] Preliminary.
[1] Pig iron is also produced in Republic of the Congo, but quantity produced is believed insufficient to affect estimate of world total.
[2] This table incorporates some revisions. Data do not add to totals shown due to rounding where estimated figures are included in the detail.
[3] Average annual production 1958–59.
[4] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[5] Based on figures from Chinese sources. 1958 does not include approximately 4,000,000 tons of substandard grade iron produced at small plants. 1959 production probably includes pig iron obtained from reworking the low-grade product of 1958 and an unreported quantity (probably relatively small) of substandard iron from small plants most of which were shut down early in the year.
[6] Includes foundry iron.
[7] Includes scrap.

TABLE 18.—World production of steel ingots and castings by countries [1]

(Thousand short tons)

Country	1955–59 (average)	1960	1961	1962	1963	1964 [p]
North America:						
Canada	5,033	5,809	6,488	7,173	8,190	9,131
Mexico	1,117	1,657	1,882	1,896	2,237	2,564
United States [2]	104,734	99,282	98,014	98,328	109,261	127,076
Total	110,884	106,748	106,384	107,397	119,688	138,771
South America:						
Argentina	297	305	486	725	1,006	1,394
Brazil	1,644	2,531	2,756	[e] 2,870	3,123	3,340
Chile	401	465	400	546	539	600
Colombia [3]	112	190	212	173	245	[e] 240
Peru	[4] 40	66	83	79	80	83
Venezuela	[e] [4] 55	52	83	248	401	485
Total	2,549	3,609	4,020	4,641	5,394	6,142
Europe:						
Austria	2,495	3,487	3,418	3,274	3,249	3,521
Belgium	6,835	7,923	7,728	8,115	8,298	9,624
Bulgaria	177	279	375	466	508	522
Czechoslovakia	5,769	7,460	7,764	8,421	8,375	9,234
Denmark	283	349	356	405	396	445
Finland	220	280	305	336	346	391
France	15,304	18,907	19,211	18,857	19,214	21,804
Germany:						
East	3,174	3,678	3,796	3,993	3,997	4,246
West	29,701	37,589	36,881	35,895	34,830	41,159
Greece	93	[e] 140	[e] 150	[e] 170	230	[e] 240
Hungary	1,721	2,078	2,263	2,572	2,617	2,606
Ireland	33	44	31	21	22	22
Italy	6,862	9,071	10,283	10,755	11,196	10,795
Luxembourg	3,795	4,502	4,534	4,420	4,445	5,025
Netherlands	1,394	2,141	2,173	2,301	2,582	2,924
Norway	355	540	550	538	599	678
Poland	5,857	7,585	7,974	8,470	8,823	9,449
Rumania	1,051	1,991	2,344	2,702	2,981	3,350
Spain	1,609	2,115	2,579	2,547	2,747	3,017
Sweden	2,706	3,547	3,926	3,982	4,299	4,894
Switzerland [3]	235	303	327	351	342	380
U.S.S.R. [5]	57,328	71,973	77,994	84,113	88,403	93,691
United Kingdom	22,826	27,222	24,737	22,950	25,222	28,918
Yugoslavia	1,138	1,590	1,689	1,758	1,750	1,849
Total [5]	170,961	214,794	221,388	227,412	235,471	258,784
Asia:						
China	[6] 7,500	[6] 20,340	10,500	11,000	13,000	[e] 15,000
India	2,107	3,622	4,502	5,676	6,582	6,649
Israel	[e] [7] 20	45	68	88	74	[e] 74
Japan	13,631	24,403	31,160	30,364	34,724	43,871
Korea:						
North	313	707	855	1,157	1,127	1,157
South	22	55	73	163	176	154
Taiwan	109	220	218	201	303	331
Thailand	6	8	9	8	[e] 8	[e] 8
Turkey	205	330	356	323	400	492
Total [5]	23,913	49,730	47,741	48,980	56,394	67,736
Africa:						
Rhodesia (formerly Southern)	65	95	101	88	55	[e] 55
South Africa, Republic of	1,907	2,328	2,738	2,903	3,124	3,414
United Arab Republic (Egypt)	108	152	174	209	217	[e] 275
Total	2,080	2,575	3,013	3,200	3,396	3,744
Oceania: Australia	3,200	4,137	4,351	4,667	5,126	5,603
World total [e]	313,590	381,590	386,900	396,300	425,470	480,780

[e] Estimate.
[p] Preliminary.
[1] This table incorporates some revisions. Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
[2] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingots.
[3] Including secondary.
[4] Average annual production 1958–59.
[5] U.S.S.R. in Asia included with U.S.S.R. in Europe.
[6] Claimed figures for 1959 and 1960 appear to be exaggerated by a fifth or more.
[7] Average annual production 1957–59.

NORTH AMERICA

Canada.—The Steel Co. of Canada, Ltd. (Stelco), ordered a six-strand curved mold continuous casting machine capable of casting 350,000 tons per year. Stelco's first continuous casting unit was a vertical machine. Stelco was to build the first hydrochloric acid pickle line in Canada at its Hilton works. The new line will be able to pickle steel 74 inches wide, with maximum speed of 800 feet per minute.

The four largest Canadian producers of basic steel, Algoma Steel Corp., Ltd., Dominion Foundries & Steel, Ltd., Dominion Steel & Coal Corp., Ltd., and Stelco were all increasing the pattern of vertical integration from iron ore to finished product.

Imperial Oil, Ltd., planned to spend about $7 million in construction of an experimental research plant to develop a process to reduce iron ore by using petroleum products. The research plant will be at the company refinery site at Dartmouth, Nova Scotia.

Dominion Bridge Co., Ltd., planned a new electric melting shop and continuous casting machine in a major modernization of its facilities in Selkirk, Manitoba.

An integrated steel mill estimated to cost $225 million was planned to be built either at Becancour, about halfway between Montreal and Quebec, or at Contrecoeur, about 30 miles east of Montreal. Either site will have the advantage of being a seaport on the St. Lawrence River. New Brunswick announced plans for a $64 million steel mill in the northeastern part of that province.

A new integrated steel producer will be the first in Western Canada, when Consolidated Mining & Smelting Co. of Canada, Ltd. (Cominco), starts to make steel using pig iron that it produces at Kimberley, British Columbia.

SOUTH AMERICA

Argentina.—A new integrated steel plant, Altos Hornos Zapla, planned and built by DEMAG A.G. of West Germany, was commissioned in October. The plant is at Palpalá in the vicinity of an iron ore deposit in the Sierra de Zapla and will use local charcoal in the blast furnace. Production capacity was 131,000 tons of ingot steel annually.

A fully automatic rolling mill with an annual production capacity of 240,000 tons was opened at Avellaneda, near Buenos Aires.

Brazil.—Brazilian and Mexican interests were cooperating in the erection of a plant projected by Usina Siderurgia da Bahia S.A. (USIBA). The Governor of Bahia announced that the plant will employ the reduction process developed by Hojalata y Lámina S.A. of Mexico, which produces sponge iron.[4]

Chile.—Compañia de Acero del Pacifico S.A. (CAP) completed financing for its second blast furnace at Concepcion. The furnace will have a 20-foot, 9-inch hearth diameter, and will be equipped for supplemental oil injection through the tuyères. Secondary development will provide for oxygen enrichment of the hot blast and high top-

[4] Blast Furnace & Steel Plant. V. 52, No. 5, May 1964, pp. 438–439.

pressure. CAP also uses oxygen injection through lances in the open-hearth roof.[5]

EUROPE

Austria.—Vereinigte Österreichische Eisen U. Stahlwerke, (VOEST) has developed a converter vessel transfer car for Linz Donawitz (LD) oxygen steelmaking plants. This car enables the practically continuous operation of a one-furnace LD converter plant by the use of two interchangeable furnace shells, since workers can be relining one vessel while the other is in operation.

Czechoslovakia.—A new system of central control, the first of its kind in Czechoslovakia, enables the dispatcher to follow and control, on three panels, the operation of all the casting cranes in the preparation and transfer of the casting equipment. The system is equipped with automatic temperature recorders, two-way radio, and telecommunications equipment.

VOEST announced the signing of a contract for three oxygen process (LD) steel converters for installation in a new steel complex at Kosice, Czechoslovakia. Each LD unit is to be 120 tons rated capacity.

European Coal and Steel Community (ECSC).—Steel ingot production of 91 million short tons was 13 percent greater in 1964 than in 1963 for ECSC. All Community countries except Italy showed gains.

ECSC exports to Great Britain were expected to drop about 75 percent because of the British Labor Government's import duty surcharge of 28 percent.

A unique feature of the new Chertal works of the S.A. Métallurgique d'Ésperance-Longdoz (Longdoz) was the transportation of hot metal 14 miles from the Seraing plant by torpedo-type ladle cars on the Belgium National Railway. A total car weight of 330 tons is necessary to carry 165 tons of hot metal at 1,300° C with a loss in hot metal temperature of only about 5° per hour. The Chertal works utilized two symmetrical oxygen converters of 150-ton capacity, capable of producing steel either by LD or LDAC techniques. The high phosphorus hot metal received required the furnaces to be used as LDAC powdered lime units.[6]

The LDAC oxygen steelmaking process introduced into Belgium in 1963 was expected to account for about 36 percent of the country's steelmaking capacity by 1967. The powdered lime in the LDAC process enabled users to refine the high phosphorus hot metal which comes from European ores.

Syndicat Siderurgique Maritime S.A. (SIDEMAR) started erection of a large steel mill complex at Zelzate on the Ghent-Terneuzen canal. The first plant to be erected was a cold rolling mill, later units will include two blast furnaces each with a productive capacity of 3,000 tons of pig iron per day, and two LD-Arbed converters of 200 metric tons each.

Steel ingot production in France set a record during 1964. Total production was up nearly 13 percent, but production by the oxygen

[5] Iron and Steel Engineer. V. 42, No. 1, January 1965, pp. 144, 147.
[6] Journal of Metals. Belgium and Its New Steelmaking Facilities. V. 16, No. 1, January 1964, pp. 37–41.

processes increased by over 65 percent, representing 11 percent of total production.

The Research Institute of the French Steel Industry (IRSID) has systematically studied the application of its powder-blowing technique to steelmaking for the last 10 years. The study of its application to electric furnace steelmaking has led to the development of precise and rapid methods of dephosphorization, desulfurization, and a recarburization and dissolution of steelmaking additives. These methods have now been introduced to about 15 electric-furnace steel works in France and other European countries, where they are applied mainly for recarburization or dephosphorization.[7]

The shift to oxygen steelmaking has been reflected in West Germany for August Thyssen-Hütte A.G. has announced the installation of two 180-ton capacity basic oxygen steelmaking furnaces.

The merger of August Thyssen-Hütte A.G. with Phoenix-Rheinrohr A.G. will form the largest steel combine in Europe with a combined capacity of over 8 million tons.

Mannesmann A.G. of Dusseldorf acquired an interest in Concast, Inc., of New York. Mannesmann A.G. installed a new rolling mill for heavy plate of 300,000 tons capacity, to replace three old mills with a joint annual capacity of 200,000 tons. The new mill requires 443 men for operation as compared with 684 men for the 3 old mills.

Italsider was completing a new integrated steelworks at the port of Taranto in southern Italy. Major steelmaking units for this plant are two 330-ton LD basic oxygen converters to be controlled by a CAE–510 digital computer of French manufacture. In the opposite end of the country, Italsider has been rebuilding its plant at Trieste. The old port of Servola has been completely replaced, and modern ore handling equipment installed at the new location. After the new blast furnace is fired and the current furnace modernized, output of pig iron will be about 176,000 net tons annually.

Italy has been importing plate and hot coils from Czechoslovakia and the U.S.S.R.

The Netherlands was also planning to increase steel production capacity. The Koninklijke Nederlandsche Hoogovens en Staalfabrieken N.V. (Hoogovens), the only fully integrated Netherlands concern for producing steel, was rapidly expanding its oxygen steelmaking, with three 100-ton LD converters replacing two 60-ton converters installed in 1958. The LD steelmaking is controlled with an analog computer. The other two steel producing concerns in the Netherlands, Koninklijke Demka Staalfabrieken, N.V., and the N.V. Nederlandsche Kabelfabrieken were not fully integrated and are principally concerned with expanding and modernizing their mill capacities.

Hungary.—A new organization to coordinate steel production for Hungary, Czechoslovakia, and Poland was established with headquarters in Budapest. The organization—Intermetall—will be the first Council for Mutual Economic Aid (COMECON) body with power to put its resolutions into effect, without endorsement by superior

[7] Journal of Metals. Powder Blowing Techniques for Electric Steelmaking. V. 16, No. 11, November 1964, pp. 885–890.

authorities in the member country concerned. Bulgaria and East Germany have already shown some interest in joining.

Hungarian researchers investigating the cause of brittleness in titanium-bearing steel apparently have confirmed the fact that nitrogen tied up by the titanium causes the brittleness.

Poland.—The first steel from a new open-hearth furnace was reported in July at the Zawiercie Steel Works. Construction of this furnace represented the first step in the rebuilding of the 90-year-old Zawiercie foundry, whose eventual output will be 800,000 tons of steel.

It was also planned to construct six more large foundries, each of which will be in a particular metalworking area. COMECON plans to increase Polish and Czech steelmaking capacity by 10 percent per year for the next 5 years.

Poland exported more than 900,000 tons of steel in 1964, securing orders for high-grade steel products from India, West Germany, and Switzerland, among others. Use of a computer to direct rolling mill operations at the Babedy Steelworks is reported to have reduced scrap by almost half.

The amount of research conducted in the COMECON countries to reduce the use of nickel and molybdenum indicates shortages of these metals.

Spain.—In common with steel producers all over the world, the steelmaking companies in Spain were expanding, modernizing, and merging. Altos Hornos de Vizcaya S.A. (AHV) has tendered 25 percent of its capital stock to United States Steel Corp. in exchange for technical and economic assistance. United States Steel will also give technical and vocational training for a period of 10 years. AHV put two LD basic oxygen converters into operation.

The Sociedad Union de Siderurgicas Asturianas (UNINSA) contracted with Kaiser Engineers for a two-phase study. The first phase will be to assess present facilities of the UNINSA group, the second phase to plan an entirely new integrated steel complex on the Asturian coast in the north. Armco Steel has a technical assistance and vocational program in cooperation with Empresa Nacional Siderurgica Española S.A. (ENSIDESA) at Aviles, on the Bay of Biscay. Koppers Co. built the second blast furnace for ENSIDESA at Aviles and was building a third.

Insufficient domestic production caused Spain to suspend import duties on bars, ingots, blocks, blooms, and slabs. Suspension was to remain in effect until December 2, 1964.

Sweden.—A rotating furnace for producing pig iron directly from iron ore has been developed by Stora Kopparbergs Bergslag a.-b. of Sweden. The new process permits a high degree of silicon and phosphorus refinement, the use of pulverized ore without sintering or pelletizing, cheaper fuels, and cheaper coke. Since the rotating cylindrical furnace used is very similar to that used in the Kaldo steelmaking process this may lead to a more successful direct reduction process for making steel.[8]

Sandvik Steelworks Co., Ltd., furnished up to 80 percent of the steel for Swiss watchmakers. A recent innovation was the use of

[8] Mining Magazine (London). V. 110, No. 7, July 1964, pp. 51, 53.

stainless steel for the watch spring, which is said to last up to 10 times as long as the older type of carbon steel spring. The Motala Works claims a world record for producing a 1,200-meter-long continuous steel casting in 4 hours. The casting unit was constructed by E. A. Olsson, of Zurich, Switzerland.

Switzerland.—E. A. Olsson, the Swiss firm that holds the patent on a continuous casting machine such as that installed at Motala, has filed a patent for a technique that protects the surface of continuously cast steel from decarburization. The Olsson patent recommends that powders be suspended in the cooling water. As these powders come into contact with the hot metal surface, they sinter and form a protective coating.[9]

U.S.S.R.—Oxygen steelmaking was not increasing as rapidly in the Soviet Union as in other countries. Open-hearth steelmaking amounted to about 84.3 percent in 1964. Trouble was reported in the Soviet Union with badly sorted scrap metal contaminated with nonferrous metals and alloy waste, combined with low-quality pig iron with up to 40 percent having a sulfur content in excess of the maximum. If the planned rate of 20 million short tons of oxygen steel per year by the end of 1965 is realized, it will mean doubling the output of oxygen converter steel in 1965. The changeover to oxygen converters undoubtedly has been slowed because the actual cost of making steel in the open hearth is about 8 percent less than that for oxygen converter steel. This is due in large measure to the fact that a ton of hot metal costs from 1.7 to 2 times more than a ton of steel scrap.

Although oxygen steelmaking was not increasing rapidly, continuous casting was beginning to be used. There were 14 continuous casting installations in 10 different steel plants in U.S.S.R. Soviet steelmakers are using continuous casting for nearly all grades of carbon steel and many types of alloy steel. Billets run from 5 to 12 inches square, and slabs as large as 8 by 55 inches. The Soviet researchers are working to produce stainless steel with low nickel content by which they hope to save the country 1,000 tons per year of nickel at present rates of production.

Soviet planners expect the Yenisei River Basin to become the industrial heart of the Soviet Union in the next 20 years.

United Kingdom.—Six separate functions of a hot strip mill at the Spencer works of Richard Thomas and Baldwins, Ltd., are controlled by means of an online computer. The digital computer controls slab tracking, mill facing, mill setup and width control, temperature control, and production and engineering logging. Use of this computer allows the final product to be dimensionally accurate to plus or minus 0.002 inch.

A vacuum-degassing plant coupled with induction stirring can treat 110 tons of steel at a time at the Samuel Fox & Co. Ltd., Stocksbridge works, near Sheffield. Carbon-chromium bearing steels are being handled in this unit. The unit reaches a vacuum level of less than 100 microns in 10 minutes and holds this level for a further 10 minutes to complete the degassing with a temperature loss of 35° to 40° C. only. The induction stirring action speeds up the process by constantly renewing the surface.

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[9] Journal of Metals. V. 16, No. 8, August 1964, pp. 617, 618.

Three out of the four oxygen steelmaking processes were operating in the Scunthorpe region of England. Appleby-Frodingham Steel Co. used the Ajax process, Richard Thomas and Baldwins' Redburn works used the Rotor process, and Lysaght's Scunthorpe Works recently commissioned two LDAC units with the result that oxygen steel capacity at Scunthorpe was about 2.5 million tons per year.

The use of oxygen in the steelmaking revolution is represented in the United Kingdom by the fact that there was 96 cubic feet of oxygen used per ingot ton produced in 1958, while the corresponding figure for 1963 was 620 cubic feet.

Two companies have gone onstream with the Kaldo process of basic oxygen steelmaking. The Park Gate Iron & Steel Co., Ltd., installed the Kaldo furnaces as part of the company's $90 million development.

Shelton Iron & Steel, Ltd., combined two 55-ton Kaldo furnaces with its continuous casting facilities. The continuous casting machines consist of three three-strand units and one large two-strand unit which casts blooms up to 24 by 17 inches. Charges in the Kaldo unit consist of about 35 percent scrap.

Steel, Peech & Tozer have opened up new research laboratories costing about $3 million devoted to quality control and process development.[10]

Richard Thomas & Baldwins has patented an infrared analytical apparatus which gives a detailed analysis of the carbon content of steel in about 3 minutes. A water treatment plant that reduces the suspended solids in the mill effluent from approximately 300 parts per million to not more than 3 parts per million without the addition of chemicals has been installed at Appleby-Frodingham Steel works at Scunthorpe.

The British Iron & Steel Research Association (BISRA) completed the second set of facilities at the association's Battersea laboratories. The new addition provides space for a heavy plant laboratory, drawing office, and other facilities. Decision to construct an entirely new ironmaking research and pilot-plant laboratory on the northeast coast near Middlesborough was announced. This facility, expected to be completed early in 1966, will make it possible to concentrate, in one place, all research on ironmaking and materials handling.

A complete computer system to direct all operations of the mill from the reheat furnace to the downcoiler has been ordered by the Steel Co. of Wales, Ltd. (Stelco), for its Abbey Works in Port Talbot, Wales. The 80-inch hot strip mill at the Abbey Works, the widest in Europe, has a 3 million-ingot-ton annual capacity. It consists of five reheat furnaces; a five-stand horizontal roughing mill; three edging stands; a six-stand continuous finishing mill, and three downcoilers.

A relatively low-cost mechanical/magnetic system of automatic gage control for a wide hot-strip mill has been developed at the Ebbw Vale works of Richard Thomas & Baldwins. Signals from an X-ray gage at the exit end of the mill are used to control the screw-down settings on the mill stands. The equipment gives more uniform gage than is

[10] Metallurgia (Manchester, England). New Research Laboratories at Steel, Peech & Tozer. V. 69, No. 416, June 1964, pp. 296–300.

possible without automatic control. Variations rarely exceed 0.002 inches even in silicon steels.

Investigations at the British Iron & Steel Research Association (BISRA) have developed a mechanism that gives accurate quick acting automatic position control of the press tool in forging operations. Work on integrating the manipulator with the press tool inspired the Parks forge unit, which allows basic forging operations to be carried out automatically.

The strike against Stelco which lasted 6 weeks ended in February.

A stainless steel is to be used, because of its nonmagnetic properties, for concrete reinforcement in the construction of a new physical laboratory for investigation of electromagnetic phenomena.

ASIA

India.—The Rourkela steelworks of Hindustan Steel, Ltd., was being increased from 1 million tons to 1.8 million tons of annual capacity by new mill equipment ordered from DEMAG A.G. of West Germany.

Blast furnace No. 4 was being built at the Durgapur, West Bengal, steelworks to complete second stage construction. Great Britain and Japan have offered India financial assistance to start work on the third stage, which would double the annual productive capacity to 3 million ingot tons. Agreement to build an additional blast furnace at Bhilai Steel plant has been reached by the U.S.S.R. and the Government of India. The new furnace, with annual productive capacity of about 700,000 tons of pig iron, will be in addition to the three blast furnaces currently operating at Bhilai.

VOEST of Austria was to supply three LD furnaces to Rourkela with an annual capacity of 750,000 tons. Fried. Krupp Industriebau was to install two 60-ton open hearth vessels for the total capacity of 250,000 tons.

A new Indian company, established to manufacture alloy steels, has negotiated a loan of over $3 million from the International Finance Corp. The company Mahindra Ugine Steel Co., Ltd., was a partnership of Société d'Électro-Chimie, d'Électro-Métallurgie, et des Aciéries Electriques d'Ugine (Ugine) and of Mahindra, Ltd., of Bombay. The new plant, about 65 miles from Bombay, at Khopoli, will have the capacity of 18,000 tons of finished alloy steel products and cost about $14 million. The Government of India announced that the U.S.S.R. had agreed to finance construction of the first section of the Bokaro steel plant which will have a 1.5-million ton annual capacity. The Government has allowed two private sector steel companies, Tata Iron & Steel Co., Ltd., and Indian Iron & Steel Co., Ltd., to expand existing capacity from 2 million and 1 million tons per year to 3 million and 2 million tons per year, respectively, during the Fourth Plan.

Japan.—Total Japanese steel production was up about 20 percent over that of 1963, but its oxygen converter production was up 29 percent over that of 1963.

Japan produced more basic oxygen steel than any country and was the only country in which the converter steel production was higher than open-hearth production. Of the 80 LD plants in operation at the end of 1964, 19 were in Japan. The Hikari works of Yawata Iron & Steel Co., Ltd., have been continuously casting wide slabs since 1960. The works have continuously cast slabs as wide as 49 inches by 4 inches thick.

Japan, the leader in oxygen steel, started to expand its continuous casting. Japanese steelmakers have concast systems at the Sumitomo Metal Industries, Ltd., Osaka Special Steel Works, and Yawata's Hikari Stainless Steel Works. There is a Mannesmann unit at the Nippon Koshuha Steel Co., Ltd., Hachinoe Works, and one Hitachi unit operating along experimental lines. Many smaller companies have announced plans for continuous casting, most of them preferring the new compact Swiss concast system, which is only about 30 percent as high as the vertical systems.

Twin 70-ton Kaldo converters formed the basis for a steel works ordered by Sanyo Special Steel Co., Ltd., to be built by Krupp of West Germany. Annual capacity was estimated at 300,000 tons of high-quality steel. Nippon Kokan K.K. started construction of a new integrated steel-works which would include six blast furnaces and three converter shops, with an annual capacity of 6 million tons. A new blooming and rolling mill capable of handling steel up to 170 inches in width was ordered for the Wakayama Works of Sumitomo Metal Industries, Ltd., of Tokyo, for approximately $3 billion.

Tokai Iron & Steel Co., Ltd., became an integrated producer during 1964, blowing in a blast furnace with a capacity of 3,850 tons per day as well as two 135-ton oxygen converters. Iron from the new blast furnace which is not used directly as hot metal will be granulated instead of pigged. The plant is on 1,600 acres of reclaimed land.

AFRICA

Ghana.—Ghana had a new steelworks with an annual capacity of 30,000 tons of finished products. Construction at a cost of over $5 million was handled by a British manufacturer.

South Africa, Republic of.—Stainless steel production by direct smelting of Transvaal ores was announced by Rand Mines, Ltd. Stainless steel ingots will be shipped to Eastern Stainless Steel Corp. of the United States, where they will be rolled. Finished products will then be returned to South Africa.

OCEANIA

Australia.—As construction for the $90 million steelmaking works at Whyalla on the Spencer Gulf of South Australia was being completed, Broken Hill Pty. Co., Ltd. (BHP), announced a program expansion in Western Australia at Kwinana to cost nearly $90 million. Steel at Whyalla will be made in 100-ton basic oxygen converters.

A new process to provide a galvanized matt finish to sheet steel should more than double the life of a motor-car body. This new corrosion resistant steel was produced by John Lysaght (Australia), Ltd.

BHP has had to recruit steel workers in Great Britain.

TECHNOLOGY

Approximately $1,500 million was spent in 1964 by iron and steel companies for capital improvements. This brings the cumulative totals since World War II to over $18,000 million. Need for this investment results from the advances in steelmaking technology, and most of this expenditure is to improve range and quality of products and efficiency of operations rather than to expand capacity.

Continuous casting, starting from its first commercial production early in 1963, was in operation or in the plans of 15 different steelworks. A double-strand unit, which will cast slabs from 8 to 25½ inches to 5⅛ by 50½ inches, is being installed in the Midland Works of Crucible Steel Co., Pittsburgh, Pa. The Wisconsin Steel Works of International Harvester Co., south Chicago, Ill., will have a 120-ton-per-hour vertical continuous casting machine that will produce eight strands of 5- and 6-inch square billets. National Steel Corp. has ordered a four-strand continuous casting machine for its Weirton, W. Va., works. This machine will manufacture over 1 million tons of heavy slabs per year, ranging from 7 to 9 inches in thickness, and from 30 to 40 inches in width. A two-strand continuous casting machine, producing slabs up to 12 inches thick by 80 inches wide, has been ordered in a modernization program for the Phoenix Steel Corp. Operations at the Dunkirk, N.Y., continuous casting plant of the Roblin Steel Co. started on January 29. Production should be about 120,000 tons per year. Soule Steel Co. of California installed a continuous casting machine having two-strands producing 5-inch-square billets. This machine is of the curved-mold type.

United States Steel has reported that it will construct a large-scale continuous casting unit at its Gary Steel works.

A new low-head continuous casting unit producing 6-strand 4-inch-square billets is to be installed in Stelco's Hilton Works at Hamilton, Ontario. The unit will be in Stelco's No. 2 open-hearth shop and will produce 350,000 tons of billets annually.

Western Gear Corp. has signed a long-term agreement with the Swiss firm of E. A. Olsson, A.G., to manufacture and sell continuous casting machinery in the United States, Mexico, and Canada.

The molten metal level in the mold of a continuous casting machine generally is controlled by varying the rate of withdrawal of the cast billet from the mold. However, a more uniform billet results from uniform withdrawal speeds. Also, varying the rate of withdrawal necessitates varying the amount of cooling water applied. As these problems are compounded by multiple strand units, it becomes evident that systems are going to have to be devised to control the level in the mold and perhaps in the tundish by other means.[11]

Tensile and fatigue tests, both longitudinal and transverse, together with tests of inclusion occurrence, show that continuously cast steel

[11] Iron Age. Continuous Casting Takes Cues From "Strategic" Controls. V. 194, No. 6, Aug. 6, 1964, pp. 62–63.
Iron and Steel Engineer. Metal Level Is Controlled Automatically in Continuous Casting Machine. V. 41, No. 10, October 1964, p. 168.
Steel. Controls Metal Level in Continuous Casting. V. 155, No. 8, Aug. 24, 1964, pp. 87–88.

is equivalent to ingot cast steel. Center shrinkage cavities are closed completely by hot reductions of 4 to 1 or greater.[12]

A single-strand machine designed to cast a slab 9.8 inches thick by 63 inches wide is in production at the Dillinger Hüttenwerke, in West Germany.[13]

BISRA has announced that it has cast in a continuous casting machine short lengths of dog-bone shaped blanks which have been successfully rolled to wide-flange beams by Algoma Steel Corp., Ltd.

Controlled pressure pouring by forcing molten metal with compressed air up through a refractory tube into a graphite mold cavity filled with an inert gas is a technique that is growing more slowly than oxygen steelmaking or continuous casting. However, pressure poured slabs of both carbon and stainless steel composition are being evaluated by several companies.[14]

Vacuum Degassing.—Lukens Steel Co. has installed a 150-ton Dortmund-Hörder (D-H) vacuum degassing unit. It is to be operated in conjunction with the company's two existing 100-ton electric furnaces and will take care of a third new 145-ton furnace scheduled for start up in 1965.

Bethlehem Steel Corp. announced the installation of a 300-ton vacuum degassing unit at its Lackawanna plant.

Republic Steel Corp. announced installation of a vacuum degassing unit capable of handling 150-ton ladles of steel in its South Chicago plant. The degassing installation of Jones & Laughlin Steel Corp. is built so that it works on a ladle placed on a transfer car. Also alloying elements can be added under vacuum to the ladle during the degassing treatment cycle.

The three main techniques of degassing are—stream, ladle, and incremental degassing. In stream degassing the ladle is positioned over an evacuated chamber containing another ladle or ingot mold. When the nozzle is opened steel sprays into the evacuated chamber and gases are given off by the steel as it falls. In ladle degassing, as the name implies, the ladle is placed in the evacuated chamber and usually given extra stirring to be sure of complete degassing, which occurs only at the surface. What is spoken of an incremental degassing is exemplified by the D-H and R-H processes. In the D-H process either the chamber or the ladle moves up and down and small quantities of steel are degassed each time, which then fall back into the ladle. In the R-H process some steel moves up into the evacuated chamber through one leg and then out through a different leg as more untreated steel moves up, giving a continuous flow.[15] In one method of ladle de-

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[12] Wulpi, Donald J. A Consumer Looks at Continuously Cast Steel. Metal Prog., v. 86, No. 6, December 1964, pp. 72–77.

[13] Blast Furnace & Steel Plant. V. 52, No. 12, December 1964, p. 1175.

[14] Carlson, E. A., II. Description of the Controlled Pressure Pouring Plant at Eastern Stainless Steel Corp. Blast Furnace & Steel Plant, v. 52, No. 12, December 1964, pp. 1134–1136.

Fitch, T. S. Description of the Controlled Pressure Pouring Plant of Washington Steel Corp. Blast Furnace & Steel Plant, v. 52, No. 12, December 1964, pp. 1132–1134.

Fitch, T. S., and L. H. Wilson. The Controlled Pressure Pouring Process for Producing Slabs and Certain Cast Products. Iron and Steel Eng., v. 41, No. 12, December, 1964, pp. 69–85.

Mandich, L. I. Alloy Plates From Pressure Poured Slabs Vacuum Degassed and Non-Vacuum Degassed Electric Furnace Steel. Blast Furnace & Steel Plant, v. 52, No. 12, December 1964, pp. 1131–1132.

Woodburn, J., G. R. Lohman, and R. J. Nylen. Pressure Pouring Steel Slabs. J. Metals., v. 16, No. 12, December 1964, pp. 967–971.

[15] Weymueller, Carl, R. Vacuum Degassing: Key to Better Steels. Metal. Prog., v. 86, No. 3, September 1964, pp. 74–80.

TABLE 19.—Companies using vacuum degassing

Company	Type	Company	Type
Forging:		Specialty Steels—Continued	
Bethlehem Steel Corp.: Bethlehem, Pa.	Stream.	Copperweld Steel Co.:	
Cameron Iron Works Inc.: Houston, Tex.	Ladle (Finkl).	Warren, Ohio	D-H ladle.
Erie Forge & Steel Corp.: Erie, Pa.	Stream.	Warren, Ohio	D-H ladle.[1]
A. Finkl & Sons Co.: Chicago, Ill.	Ladle (Finkl).	Crucible Steel Co. of America: Midland, Pa.	D-H ladle.
Isaacson Iron Works: Seattle, Wash.	Stream.	Jones & Laughlin Steel Corp.: Detroit, Mich.	Do.
Mesta Machine Co.: Pittsburgh, Pa.	Do.	Republic Steel Corp.: Canton, Ohio.	Ladle—Induction stirred.
Midvale-Heppenstall Co.:		Sharon Steel Corp.: Sharon, Pa.	Stream.
Philadelphia, Pa.	Do.	The Timken Roller Bearing Co.:	
Philadelphia, Pa.	Stream—tap.	Canton, Ohio	D-H ladle.
National Forge Co.: Irvine, Pa.	D-H ladle.	Canton, Ohio	Do.
Ohio Steel Foundry Co.: Lima, Ohio.	Stream.	United States Steel Corp.:	
Standard Steel Works Div.:		Homestead, Pa.	Stream.
Baldwin-Lima-Hamilton Corp., Burnham, Pa.	Do.	Duquesne, Pa.	Do.
United States Steel Corp.: Duquesne, Pa.	Do.	Universal-Cyclops Steel Corp.: Bridgeville, Pa.	Do.
Specialty steels:		General:	
Allegheny Ludlum Steel Corp., Pittsburgh, Pa.	Pilot.	Bethlehem Steel Corp.:	
Armco Steel Corp.:		Lackawanna, N.Y.	D-H ladle.
Torrance, Calif.	Stream.	Bethlehem, Pa.	Stream.
Butler, Pa.		Bethlehem, Pa.	R-H ladle.
The Babcock & Wilcox Co.: Beaver Falls, Pa.	Stokes ladle.	Jones & Laughlin Steel Corp.: Pittsburgh, Pa.	D-H ladle.
Bethlehem Steel Corp.: Bethlehem, Pa.	Stream.	Lukens Steel Co.: Coatesville, Pa.	D-H ladle.[1]
The Carpenter Steel Co.: Bridgeport, Conn.	D-H ladle.	National Steel Corp.:	
		Weirton, W. Va.	D-H ladle.
		Weirton, W. Va.	(1).
		Republic Steel Corp.: Chicago, Ill.	Ladle.
		United States Steel Corp.:	
		Gary, Ind.	(1).
		Chicago, Ill.	Stream.

[1] Vacuum degassing units to be used with continuous casting.

gassing the ladle is mounted on a car at the melt shop and is moved through the vacuum chamber on a track, with 90 to 100 ton heats degassed in from 15 to 30 minutes at vacuums approaching 50 microns.[16]

Basic Oxygen Converters.—Production of steel in basic oxygen converters rose from 8.5 million tons in 1963 to 15.4 million tons in 1964. With planned additional capacity of 5 million, 8 million, and 6 million tons in 1964, 1965, and 1966, respectively, the production of steel in basic oxygen converters will continue to increase rapidly. The trend is not only toward more oxygen converter steels but toward larger oxygen converters. Vessels of 60- and 75-ton capacity were installed in the late 1950's. In the 1960's most of the furnaces range from 220 to 300 tons.

Bethlehem Steel put two 250-ton capacity converters into operation at the Lackawanna, N.Y., works, and each was producing 275 tons after about 1 month of operation. The 2 converters replaced an open hearth shop with 14 furnaces. The unit is highly automated; a General Electric 412 core-drum process computer is used. It is designed to calculate the charge, the alloy addition, and any corrective action after analysis. It should control the lance position, the oxygen flow

[16] Iron & Steel Engineer. Car-Type Vacuum Degassing Unit Goes On-Line. V. 41, No. 10, October 1964, p. 170.

and any additions to the converter other than hot metal and scrap. These furnaces have a height-to-diameter ratio of 1½ to 1.[17]

The Wisconsin Steel works of International Harvester Co. has completed a "start up" period of basic oxygen steelmaking. The oxygen shop contains two 120-ton-per-hour capacity furnaces. These 2 furnaces, capable of producing more than 1 million tons of ingots annually, will replace 11 open hearth furnaces. It is planned to add additional modernization facilities including continuous casting and vacuum degassing.

The oxygen steel plant at the Duquesne Works of the United States Steel Corp. consists of two 150-ton converters. These furnaces were being tested during the first part of 1964. They are now producing mostly silicon steels.[18]

The oxygen steelmaking furnaces to be built at the Republic Steel Corp.'s Cleveland district steel plant are 220-ton converters. Republic is also installing two 150-ton furnaces at its Warren, Ohio, plant, and two 150-ton furnaces at its Gadsden, Ala., plant. The converters at the Cleveland plant will eventually replace the No. 1 open-hearth shop. Three of the six open hearths in the No. 2 shop are using roof lances to furnish oxygen.

The Henry J. Kaiser Co., together with Brassert Oxygen Technik, A.G. (BOT) and VOEST, in a suit against the McLouth Steel Corp., is claiming that McLouth is infringing on patents for the Suess process with its oxygen steelmaking. Theodore Suess was a German steel expert who developed this process while working for VOEST.

Wheeling Steel Corp. has ordered an advanced control system for its oxygen steelmaking plant in Mingo Junction, Ohio.[19]

Charging a 70-ton electric arc furnace with hot metal from a 70-ton LD furnace is the complete switch being utilized by Société des Aciéries de Pompey in France. Duplexing takes care of the intermediate carbon and alloy grades in the company's steelmaking program.

United States Steel Corp. has made 80 different kinds of steel in its oxygen vessels at the Duquesne works.[20]

The Bureau of Mines continues to probe for the causes of fuming in the basic oxygen converters and to seek methods of reducing or containing these fumes.

In one of the first reported overhauls of a converter vessel the Colorado Fuel and Iron Corp. saved a good furnace bottom and stopped the harmful warping of a trunnion ring. First, a bottom which did not need repair was removed from a vessel at the trunnion ring and a newly fabricated top put in its place; then the furnace was reversed, the old top cut out and the bottom which had been removed from the other side put in place of the wornout top. This saved a complete rebuilding and, in fact, reversed the position of the trunnion ring 180° so that a deflection which was putting the ring out of position is now bringing it back into good horizontal position.[21]

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[17] Steel. Planning Smooths Startup of BOF's. V. 155, No. 21, Nov. 23, 1964, pp. 108, 110.

[18] Blast Furnace & Steel Plant. OSM Shop Is Important Addition in Duquesne Works Expansion. V. 52. No. 8. August 1964, pp. 719–721.

[19] Blast Furnace & Steel Plant. V. 52, No. 8. August 1964, p. 734.

[20] American Metal Market. V. 71. No. 97, May 19, 1964, p. 4.

[21] Iron and Steel Engineer. Operation Bottoms Up. V. 41, No. 4, April 1964, pp. 152–154.

End-point carbon control is determined by the use of two different methods of effluent gas analysis. One method is to test for percentage of oxygen in the waste gases in the hood draft above the mouth of the oxygen furnace; another method is the calculation of the end point based upon infrared analysis of the amount of waste CO_2 gas. The latter is similar to studies conducted by IRSID in France.[22]

A pyrometric detector tube containing a platinum-rhodium-18 thermocouple has been developed for continuous temperature measurement in the bath of LD and LDAC furnaces. Numerous tests in vessels ranging from one-fourth to 80 tons have demonstrated that this device accurately measures bath temperature when positioned properly with regard to bath height. This continuous temperature measurement not only makes it possible to take suitable corrective action during the blowing of heat, but it gives a valuable permanent record of the course of every melt. It also offers many possibilities for the eventual automatic control of the basic oxygen process.[23]

Another good discussion of the thermal balance in an oxygen converter and the problems of accuracy in determining the CO to CO_2 ratio is discussed in a paper on the LD plant of Hoogovens.[24]

Over 200 billion cubic feet of oxygen were consumed in 1964. The rapidly increasing use of oxygen by steelmakers is responsible for much of this phenomenal growth, since the industry consumes over 60 percent of the total oxygen output.

A measure of the huge growth in the amount of oxygen used in steelmaking can be gained from the knowledge that United States Steel Corp. has awarded a contract to provide 1,260 tons of high-purity oxygen and 520 tons of high-purity nitrogen per day at their Gary, Ind., works.

A third "Kaldo" oxygen furnace will be added by Sharon Steel Corp. to nearly double its present capacity of 1 million tons of steel ingot per year. Sharon is operating the only two Kaldo steelmaking units presently installed in the United States. After initial difficulties with refractories, Sharon now is averaging 120 heats per furnace lining and using a 50–50 ratio of scrap and hot metal. Further installations in the modernization program are a second vacuum degassing unit and a pressure pouring installation.

Electric Furnaces.—Over 60 percent of the output of electric furnaces in 1964 consisted of carbon steels. Electric furnaces are thus being shifted from the traditional use for high-alloy specialty steels. From 1950 to 1960 the increase in electric steel output was slow and uneven, but since 1960 the increase has been steadier and more rapid. The advent of the much more spectacular basic oxygen converter may well be a decisive factor in the complete acceptance of the electric furnace. The reduced scrap consumption of the basic oxygen converter has highlighted the need for better prepared scrap and the availability of a larger supply. An oversupply of scrap helps to maintain a firm

[22] Iron and Steel Engineer. Continuous Determination of Bath Carbon in the Basic Oxygen Process. V. 41, No. 10, October 1964, pp. 67–71.
Journal of Metals. Effluent Gas Analysis for End-Point Carbon Control. V. 16, No. 9, September 1964, pp. 715–717.

[23] Journal of Metals. Continuous Temperature Measurement for Basic Oxygen Steelmaking. V. 16, No. 6, June 1964, pp. 483, 484.

[24] Steel Times (London). Assessment of the Limitations of Computer Control of the LD Process. V. 190, No. 5035, Jan. 15, 1965, pp. 82–87.

TABLE 20.—Chemical and physical characteristics of converter linings

	Working lining: tempered tar-bonded dolomite	Permanent lining: burnt tar-impregnated dolomite
Chemical analysis:		
MgO percent	35	35
CaO do	56	56
Fe_2O_3 do	.3	.8
SiO_2 do	.9	.9
Al_2O_3 do	.3	.8
Ignition loss (tar) do	6.5	6.5
Bulk density kg./cu. cm	2.8	2.8
Porosity volume-percent	11	15
Cold crushing strength at 20° C kg./sq. cm	180	450
Refractoriness under load at 2 kg./sq. cm:		
t_A °C	1,720	1,760
t_E °C	>1,800	>1,800
Thermal conductivity, kcal/mm °C:		
At 500° C	2.8	2.8
At 800° C	2.6	2.6
At 1,000° C	2.3	2.3
Storability:		
Winter days	35	100
Summer do	20	60

price structure and gives the electric furnace a cost advantage. The electric furnace shares with the oxygen converter the advantage of extreme flexibility of operation and apparently surpasses it in regard to reduced capital cost.

Estimates as to the optimum size for the electric furnace still vary considerably, although the average size is gradually increasing. The rated output of most electric furnaces in the United States is under 200 tons, but there are several furnaces in Japan and Europe rated over a 200-ton capacity. The advent of the basic oxygen converter also forced a realistic assessment of furnace capabilities. Careful programing of the charging, adapting operation to the electrical characteristics, and even installation of fume collection systems, are factors that have increased production.[25]

Lukens Steel Co. has put an IBM Operator Guide Control System into operation with its two 100-ton electric furnaces, operated in connection with a 150-ton vacuum degassing facility. In England BISRA has developed an automatic input control for use on electric arc furnaces.[26]

Latrobe Steel Co. has installed a 30-ton vacuum induction furnace in connection with its 30-ton electric furnaces. The induction furnace is charged with hot metal which permits stream degassing as the furnace is being charged, then induction heating and magnetic stirring continues under a higher vacuum. Bulk additions of alloys may be added and ingots cast, still within the vacuum. Heats are generally finished at a vacuum of about 5 microns.[27]

Carpenter Steel Co. has added a vacuum induction furnace at its Carpenter works in Reading, Pa. This unit is capable of 7.5 to 10 tons per heat with ingots being cast in vacuum.

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[25] Journal of Metals. Arc Furnace Steel Production, Kansas City Works—Armco Steel Corp. V. 16, No. 12, December 1964, pp. 1005–1012.
[26] Metcalf, A. Automatic Power Input Control for Arc Furnaces. Steel Times (London). V. 188, No. 4982, Jan. 10, 1964, pp. 50–52.
[27] Blast Furnace & Steel Plant. New Vacuum Melt Shop Unveiled. V. 52, No. 8, August 1964, pp. 716–718.

Introduction of oxygen lancing into the open hearth has reduced the time for completion of heats of steel and at the same time intensified the need for more rapid and more accurate determinations of carbon in the heat. More accurate and faster sampling of the steel and development of methods of indirectly analyzing the amount of carbon by the ratio of oxygen and carbon dioxide in the effluent gas have been attempted.[28]

As operating times in the open hearth are shortened, the need and advantage of automatic over manual combustion control becomes apparent. Comparison of the performance of furnaces with and without controllers in one shop indicated that the introduction of automatic combustion control resulted in a 6-percent decrease in the fuel consumption, a 33-percent decrease in basic brick consumption, and a nearly 5-percent increase in production rate.[29]

The Bureau of Mines continued research using mathematical techniques to work out the reactions involved with changing variables in blast furnace operation.

Nuclear measuring techniques are being developed to aid the operation of the blast furnace. The use of the continuous immersion thermocouple to aid temperature control in the blast furnace has been reported.[30]

A technique to get more representative samples of the hot metal coming from the blast furnace, which in turn would give the open-hearth operator a much more accurate picture of the silicon analysis, has been developed. Dip sampling of the pugh ladle is more representative than runner sampling and is good for both basic and merchant iron with a high degree of accuracy in either case. It is practical for everyday use. Pins from these dip samples can be analyzed spectrographically in much shorter time than by chemical analysis.[31]

"Caroline," a high-pressure, high-temperature experimental blast furnace operated by the Bureau of Mines at Bruceton, Pa., was blown in during April 1964. Operation of Caroline is supported by the appropriations of the Bureau of Mines and by Blast Furnace Research, Inc., a nonprofit organization representing 22 ironmaking companies in the United States and Canada.

Research continued by Bureau of Mines on the extent to which highly reduced iron pellets may be used as feed in steelmaking furnaces.

Automation, or automatic control, of various parts of the steelmaking process traditionally has centered on the rolling mill. As computers begin to be designed into the entire steelmaking operation, it has been difficult to design instrumentation rugged enough for monitoring at steelmaking temperatures to furnish data precise enough to take advantage of the computer's speed. However, it is now possible to have a certain amount of automatic control from the charging of the

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[28] Journal of Metals. Rapid Carbon Determination for Open-Hearth Control. V. 16, No. 2, February 1964, pp. 165–169.

[29] Iron and Steel Engineer. Combustion Control in the Open Hearth. V. 41, No. 6, June 1964, pp. 109–115.

[30] Blast Furnace & Steel Plant. Nuclear Applications in Coke Plant and Blast Furnace Operations. V. 52, No. 7, July 1964, pp. 611–620.
Iron and Steel Engineer. Continuous Immersion Thermocouple Aids Blast Furnace Control. V. 41, No. 7, July 1964, pp. 179–186.

[31] Smith, Phillip H. An Improved Technique for Sampling Blast Furnace Hot Metal. Blast Furnace & Steel Plant, v. 52, No. 9, September 1964, pp. 825–833, 880.

blast furnace, through basic oxygen converter steelmaking with the steel continuously cast and automatically rolled.[32]

National Steel Corp. plans the first completely new steelmaking facility in this country to take advantage of basic oxygen furnaces, vacuum degassing, and continuous casting. This new unit will be at the company's Weirton Steel division.

A new steelmaking facility called the dual-hearth, or tandem hearth furnace, has been announced both here and South Africa. The furnace is essentially two identical interconnected hearths in which cold scrap in one hearth acts as a regenerator taking maximum advantage of the sensible heat of the waste gases being generated by the steelmaking in the other hearth. Efficiency of the heat transfer is greater. Because of alternating overlappinng functions the furnace does not lose heat, but stays alive.[33] The unlimited flexibility of the hot metal to scrap ratio up to 100-percent cold scrap charge reduces raw material expense.

Refractories.—Newer, better refractories are being developed to withstand the increased heat and pressure resulting from the introduction of oxygen. Basic materials are principally alumina and magnesia. Better chemistry, better material processing, and higher component purity have combined to raise the temperature threshold and provide special characteristics such as resistance to reduction in dry hydrogen atmospheres.[34]

Rolling mills are increasing in size, speed, and accuracy. Sharon Steel Corp. installed a 60-inch Sendzimir mill with a 3,500-hp. main drive. The mill operates at 2,000 feet per minute with a threading pass of 900 feet per minute.[35]

Width gages that work on a shadow technique and thickness gages that employ either X-ray or isotope exciting are only now being introduced in the United States, although there are several in use in Europe.[36]

High-velocity compacting of iron powders gives near theoretical densities for the resulting parts. If this is preceded by sintering, the part has higher strength and ductility than with ordinary compacting.[37]

Electroplating a steel slab 4 to 6 inches thick with a thick coating of nickel and then hot rolling the sandwich gives a pore-free nickel cladding which can be fabricated by everyday metalworking processes. A 6-inch steel core clad with an 0.060-inch layer of nickel is rolled to a ½-inch core with an 0.005-inch nickel skin. Another big advantage is that costs are said to be cut 50 percent.[38]

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[32] Iron Age. Automation: A Tough Taskmaster Bears Down on Instrumentation. V. 194, No. 5, July 30, 1964, pp. 60–62.

[33] Holz, Peter. Tandem Furnace Is Innovation in South African—Iscor-Steel Co. Blast Furnace & Steel Plant, v. 52, No. 4, April 1964, pp. 322–323, 349.

Mathias, W. M. The Dual-Hearth Furnace—The Most Versatile Tool in Modern Steelmaking. Iron and Steel Eng., v. 41, No. 12, December 1964, pp. 93–100.

[34] Birch, R. E. The Future Refractories and Steelmaking. J. Metals, v. 16, No. 6, June 1964, pp. 512–515.

Iron and Steel Engineer. Insulating Firebrick Developed for 2800° F. 100 Percent Dry Hydrogen Service. V. 41, No. 6, June 1964, pp. 183–184.

[35] Beck, A. J. Sharon Steel's 60-inch Sendzimir Mill Has 3,500 HP Main Drive. Iron and Steel Eng., v. 41, No. 12, December 1964, pp. 185–188.

[36] Iron and Steel Engineer. Precision Gaging Strip Width and Thickness. V. 41, No. 12, December 1964, pp. 129–134.

[37] Stein, Eugene M., John R. Van Orsdel, and Peter V. Schneider. High Velocity Compaction of Iron Powder. Metal Prog., v. 85, No. 4, April 1964, pp. 83–87.

[38] Iron Age. Plating Teams Up With Rolling To Clad Nickel Into Steel. V. 193, No. 22, May 28, 1964, pp. 63–65.

Nondestructive testing, and nondestructive testing during operation, is becoming necessary. The combination of an electron microscope and an X-ray microanalyzer coupled with a computerlike device that works off the microanalyzer has reduced rejection of steel tubes some 90 percent, according to the Tube Investment Research Laboratories (TIRL), an English firm. An optical emission spectrometer, combined with a pneumatic tube system for sending samples and returning analyses, can return a typewritten analysis of a melt to the operator in less than 9 minutes, giving a record of 11 major and minor elements. It can detect boron, for instance, down to 0.0005 percent. It may soon be possible to examine the crystalline structure of steel with ultrasonic spectroscopy. With this type of examination, heat treating could be much more meaningful. Electromagnetic, ultrasonic, and X-ray techniques are being improved and combined. The use of the X-ray fluoroscope on welds is being refined. Eddy currents are used to inspect pipe welds in continuous welding mills. An infrared detector can measure the thickness of hot steel plates to an accuracy of 0.002 inch, making the check every 8 inches on steel products going through rolling mills at 70 miles per hour.

The ability to predict the characteristics of compounds or alloys of all 33 metallic elements when mixed in all of their billions of possible combinations may be the outcome of a new theory known as the electron theory of crystal structure. Described as the most important new idea to come out of the materials field in the past decade, the theory was developed by Brewer of the University of California. Researchers should be able to seek new materials in the transition series systematically and comprehensively. In developing his theory Brewer says that he combined Engle's theory (the correlation between electronic configurations and crystal structures of metallic phases) with known information about the sizes of atoms, predictions of their solubility, and the effects of heat on various combinations and ratios of the metals. He has considered temperatures up to the melting points.[39]

[39] Product Engineering. V. 35, No. 15, July 20, 1964, pp. 63–64.