

Iron and Steel

By James C. O. Harris ¹



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NATIONAL pig iron and steel output was below expectations in 1960, but was greater than in 1958 and 1959, and the sixth highest in history. The United States remained for the 71st consecutive year as the world leader in steel manufacture. Its production, representing more than one-fourth of world output, surpassed that of U.S.S.R., which ranked second as producer, by 30 million tons.

Domestic production of pig iron totaled 66.5 million tons, a 10-percent increase over 1959. Steel output by ingot producers was 99.3 million tons, up 6 percent. Steel castings made by noningot producers (1.2 million tons) dropped 13 percent, and shipments of gray and malleable-iron castings (12.4 million tons) decreased 6 percent.

During the first quarter of 1960, record tonnage of steel was produced, and customers replenished stocks that had been depleted by the 1959 steel strike. Then as demand for steel decreased, customers slowed their buying. Lower inventories at yearend placed the steel industry in a good position to increase operations during the first half of 1961.

Advances in technology included increased unit output of blast furnaces through improved preparation of raw materials, the use of natural gas, and higher hot-blast temperatures. Output of open hearth furnaces increased through the greater use of oxygen. Techniques included the addition of oxygen through furnace-roof lances and the use of oxygen-fuel lances to speed the melting of scrap and refinery of pig iron. A new record of about 3.3 million tons of steel was produced in oxygen converters. Rapid progress was made in improving steels to meet growing demands for strength and lightness, corrosion resistance, and formability. The use of vinyl-coated steel increased.

Shipments of steel-mill products, including exports, totaled 71.1 million tons, compared with 69.4 million in 1959 and 59.9 million in 1958. All major consuming industries bought more steel except appliances, utensils, cutlery, and agriculture. Construction and maintenance showed the largest increase. The automotive industry continued to be the leading consumer, receiving 14.6 million tons or 21 percent of domestic shipments.

¹ Commodity specialist, Division of Minerals.

Imports of major iron and steel products totaled 3.5 million short tons and made 1960 the second highest year, compared with the 1959 peak of 4.6 million tons. Exports totaled 3.3 million and exceeded the 1959 low of 2 million tons.

No change in the price of steel had occurred in 2 years. Lower priced foreign steels, however, continued to penetrate domestic markets, although to a lesser degree than in 1959. According to the American Iron and Steel Institute (A.I.S.I.), the 1960 payroll of steel ingot producers set a new record, estimated at more than \$3.9 billion, compared with a record of \$3.8 billion in 1957. Data also showed that the number of wage and salaried employees declined less than 8 percent from 1957, contrasted with a 15-percent decrease in steel production.

Weekly hours per employee in the steel industry in 1960 averaged 37.8, compared with 39.3 in 1959. The average number of employees was 460,000 compared with 417,000 in 1959, and the average hourly wage was \$3.06 compared with \$3.08 in 1959. The 12th wage increase since World War II for steelworkers went into effect December 1, 1960.

TABLE 1.—Salient iron and steel statistics

(Thousand short tons)

	1951-55 (average)	1956	1957	1958	1959	1960
United States:						
Pig iron:						
Production.....	68,247	75,030	78,404	57,155	60,210	66,501
Shipments.....	68,146	75,110	76,887	56,918	61,245	65,612
Imports for consumption.....	522	327	225	210	¹ 700	331
Exports.....	17	269	882	103	10	112
Steel:						
Production of ingots and castings (all grades):						
Carbon.....	93,577	104,888	103,803	78,591	84,539	90,864
Stainless.....	1,000	1,256	1,047	896	1,131	1,004
All other alloy.....	8,488	9,072	7,865	5,768	7,776	7,414
Total.....	103,065	115,216	112,715	85,255	93,446	99,282
Capacity, annual Jan. 1.....	116,105	128,363	133,459	140,743	147,634	148,571
Percent of capacity.....	88.8	89.8	84.5	60.6	63.3	66.8
Index (1951-55=100).....	100.0	111.8	109.4	62.7	90.7	96.3
Imports of major iron and steel products ²	1,441	1,479	1,295	1,820	¹ 4,615	3,544
Exports of major iron and steel products.....	3,738	4,749	5,917	3,225	¹ 1,973	3,298
Total shipments of steel mill products.....	74,991	83,251	79,895	59,914	69,377	71,149
World: Production:						
Pig iron ³	181,000	¹ 221,900	233,200	216,700	¹ 247,000	285,000
Steel ingots and castings.....	253,700	312,650	¹ 322,550	¹ 298,700	¹ 336,400	381,200

¹ Revised figure.

² Data not comparable for all years.

³ Includes ferroalloys.

PRODUCTION AND SHIPMENTS OF PIG IRON

U.S. production of pig iron, exclusive of ferroalloys, was 10 percent greater than 1959 but 3 percent below the 1951-55 average. Blast furnaces operated at above 95-percent capacity during the first quarter with a record monthly production of 7.8 million tons in January. The

operating rate for the year was 69.7 percent of capacity. Pig iron production increased in 12 of the 17 States included in table 2. Pennsylvania, Ohio, Indiana, and Illinois led in production and supplied 25, 17, 13, and 8 percent, respectively, of the pig iron, compared with 25, 19, 11 and 9 percent in 1959.

Blast furnaces produced 28.8 million short tons of blast-furnace slag, or 867 pounds per ton of pig iron, compared with 895 pounds (revised) in 1959; 4.8 million tons of flue dust was recovered, or 145 pounds per ton of pig iron, compared with 166 pounds in 1959.

The number of blast furnaces in the United States decreased from 263 to 260; one furnace was dismantled at Martin's Ferry, Ohio, and another, at Duquesne, Pa.; the Everett furnace in Massachusetts was abandoned. Blast furnace capacity at the beginning of 1960 was 96.5 million tons. Blast furnace capacity as of January 1, 1961, was not collected by A.I.S.I. (See Production and Shipments of Steel). Despite the dismantling of the 3 blast furnaces, capacity increased during the year because of technological developments. United States Steel Corp. was constructing a large, modern blast furnace at Duquesne, Pa., which would include all recent technological advances.

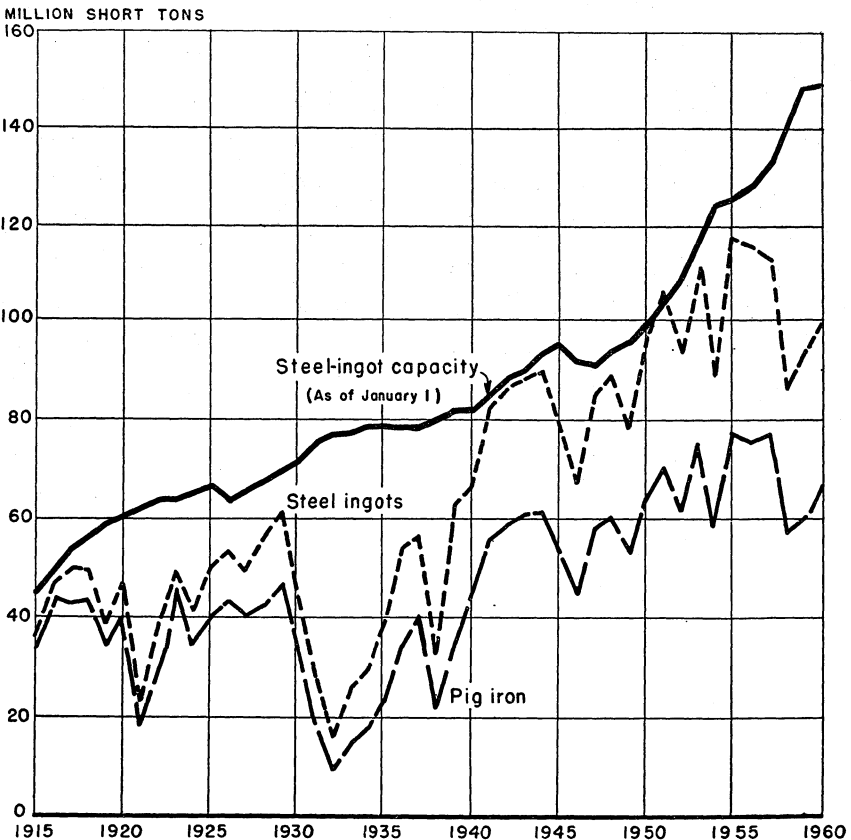


FIGURE 1.—Trends in production of pig iron and steel ingots and steel-iron capacity in the United States, 1915-60.

Shipments of pig iron (including on-site transfers) were 7 percent above 1959. As over 90 percent of all pig iron made in the United States was used in the molten state for making steel ingots, castings, and iron castings, the values of pig iron shown in tables 2 and 4 are largely estimated and may differ from prices published in trade journals or other sources.

Metalliferous Materials Used.—The production of pig iron, excluding coke and fluxes, required 109.4 million tons of iron ore, manganiferous ores, and agglomerates; 3.9 million tons of scrap, compared with 3.3 million tons (revised) in 1959; 62,855 tons of flue dust; and 6.9 million tons of miscellaneous materials, compared with 6.5 million tons (revised) in 1959. The total of the foregoing is equivalent to 1.809 tons of material per ton of pig iron produced. The scrap charge consisted of 2,819,806 tons of home and purchased scrap, 863,111 tons of slag scrap, and 208,742 tons of offgrade pig iron. Consumption of miscellaneous materials included 3.5 million tons of mill cinder and scale, 3.3 million tons of open hearth and Bessemer slag, 60,053 tons of other metalliferous materials, and 196,936 tons of nonmetalliferous materials. Net totals shown in table 6 were computed by deducting 4.8 million tons of flue dust recovered and 708,132 tons of scrap produced at blast furnaces.

The agglomerate charge consisted of 45,407,953 tons of sinter, including 11,187,627 tons of self-flux sinter; 9,004,332 tons of pellets; 48,589 tons of nodules; 44,436 tons of briquets; and 2,519,921 tons of unclassified agglomerates; 1,536,849 tons came from foreign sources. Canada, Venezuela, Chile, and Peru were the leading suppliers of foreign iron and manganiferous ores used in blast furnaces. In addition to the foregoing, 16.3 million tons of foreign iron ore were used in agglomerate plants, and most of this was used in blast furnaces. According to AISI, 4.4 billion cubic feet of oxygen was used at blast-

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

(Thousand short tons and thousand dollars)

State	Produced		Shipped from furnaces			
	1959	1960	1959		1960	
	Quantity		Quantity	Value	Quantity	Value
Alabama.....	3, 658	3, 545	3, 634	\$206, 449	3, 545	\$200, 366
Illinois.....	5, 268	5, 307	5, 327	320, 243	5, 247	316, 382
Indiana.....	6, 630	8, 404	6, 636	390, 329	8, 424	496, 750
Ohio.....	11, 564	11, 788	11, 859	705, 553	11, 561	688, 038
Pennsylvania.....	15, 133	16, 539	15, 593	933, 035	16, 199	973, 815
California.....	3, 067	3, 735	3, 120	188, 703	3, 700	221, 002
Colorado.....						
Utah.....						
Kentucky.....						
Tennessee.....	1, 463	1, 670	1, 446	79, 213	1, 619	93, 718
Texas.....	5, 719	6, 318	5, 755	348, 224	6, 338	395, 955
Maryland.....						
West Virginia.....						
Michigan.....						
Minnesota.....	4, 049	4, 985	4, 109	232, 302	4, 921	265, 094
New York.....	3, 659	4, 210	3, 766	229, 875	4, 058	254, 608
Massachusetts.....						
Total.....	60, 210	66, 501	61, 245	3, 633, 926	65, 612	3, 905, 728

furnace plants, compared with 4.5 billion in 1959. According to data collected by the Bureau of Mines, 11 blast-furnace plants also consumed 3.9 billion cubic feet of natural gas and 282.4 million cubic feet of coke-oven gas by injection through tuyeres.

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	1959	1960 ¹	Source	1959	1960 ¹
Brazil.....	59,399	30,692	Venezuela.....	4,861,766	5,160,601
Canada.....	5,438,401	5,645,373	Other Countries.....	63,476	234,113
Chile.....	1,405,884	1,273,570	Total.....	12,961,569	14,233,215
Peru.....	1,132,643	1,858,866			

¹ Excludes 16,269,354 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	1959			1960		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry.....	1,854	\$111,438	\$60.10	1,526	\$91,739	\$60.11
Basic.....	52,735	3,118,433	59.13	57,806	3,433,263	59.42
Bessemer.....	3,137	186,950	59.60	3,230	193,456	59.90
Low-phosphorus.....	395	24,872	62.98	338	20,997	62.17
Malleable.....	2,828	174,812	61.82	2,427	149,426	61.57
All other (not ferroalloys).....	296	17,421	58.84	285	10,847	59.11
Total.....	61,245	3,633,926	59.33	65,612	3,905,728	59.53

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

State	Jan. 1, 1960			Jan. 1, 1961		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama.....	16	6	22	11	11	22
California.....	2	2	4	3	1	4
Colorado.....	4	—	4	2	2	4
Illinois.....	21	1	22	0	13	22
Indiana.....	21	2	23	11	12	23
Kentucky.....	2	1	3	1	2	3
Maryland.....	9	1	10	4	6	10
Massachusetts.....	—	1	1	—	—	—
Michigan.....	8	1	9	5	4	9
Minnesota.....	2	1	3	1	2	3
New York.....	15	2	17	8	9	17
Ohio.....	46	6	52	18	33	51
Pennsylvania.....	70	6	76	32	43	75
Tennessee.....	1	2	3	1	2	3
Texas.....	2	—	2	1	1	2
Utah.....	5	—	5	3	2	5
Virginia.....	1	1	2	1	1	2
West Virginia.....	4	1	5	3	2	5
Total.....	229	34	263	114	146	260

Source: American Iron and Steel Institute.
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Kentucky-----	436,333	386,032	1,696,204	2,479,299	143,022	219,990	2,842,311	1,248,495	436,366	1,670,360	1.484	.086	.132	1.702	.747	.261
Tennessee-----																
Texas-----																
Maryland-----																
West Virginia-----																
Michigan-----	(4)	(4)	6,243,870	9,485,416	181,864	722,064	10,389,344	4,400,559	1,066,593	6,317,683	1.501	.029	.114	1.644	.697	.169
Minnesota-----	(4)	(4)	4,647,801	8,183,625	186,625	245,901	8,616,151	3,698,981	1,367,341	4,985,388	1.587	.037	.049	1.728	.742	.274
New York-----	2,098,026	305,496	4,549,065	6,650,608	231,640	228,404	7,110,652	3,274,181	1,312,346	4,209,993	1.580	.055	.054	1.689	.778	.312
Massachusetts-----																
Total-----	31,143,941	14,233,215	57,025,231	104,700,770	3,183,527	6,877,937	114,762,234	49,874,978 ⁶	15,932,818	66,501,222	1.674	.048	.103	1.726	.750	.240

¹ Net ores and agglomerates=ores+agglomerates+flue dust used-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 11,846,103 tons of limestone and 4,314,394 tons of dolomite, ex-

cluding 1,975,121 tons of limestone and 1,197,652 tons of dolomite used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

⁶ The corresponding figures for 1960 (⁵) 11,500,714 tons of limestone, 4,431,252 tons of dolomite, 3,389,992 tons of limestone and 1,243,203 tons of dolomite—quantities used at mines are unknown.

PRODUCTION AND SHIPMENTS OF STEEL

Domestic steel production in 1960 was 99.3 million short tons or 66.8 percent of capacity with an AISI index of 101.9 (1957-59=100). The corresponding figures for 1959 were 93.4, 63.3, and 96.2, respectively. In the first half of the year production was high with a total of 60.8 million tons, equivalent to 82.0 percent of capacity. A record tonnage of 12.0 million tons was made in January. However, demand for steel lessened during the last half of the year, and only 38.5 million tons was produced. Steel casting production by independent foundries, not included in the production data, totaled 1,184,459 short tons, compared with 1,366,328 tons in 1959.

Of the total tonnage of steel produced, 87 percent was made in open hearth furnaces, 8.4 percent in electric furnaces, 3.4 percent in oxygen converters, and 1.2 percent in Bessemer converters. Corresponding figures for 1959 were 87.4, 9.1, 2.0, and 1.5, respectively. Pennsylvania led in steel production, and Ohio, Indiana, and Illinois ranked second, third, and fourth, supplying 24, 17, 14, and 8 percent, respectively, compared with 25, 19, 12, and 9 percent in 1959.

The AISI announced in December that it would stop issuing weekly and monthly figures of steel operating rate as a percent of capacity, starting in 1961. Also, yearend steelmaking capacity figures were not published. The primary reason given for discontinuing these figures was that rapid technological developments had made it possible to greatly increase output of existing facilities. It had been demonstrated that the output of a blast furnace could be increased considerably by using natural gas, high hot-blast temperatures, and improved charge. Similarly, steel furnace output could be increased by using more hot metal, by using oxygen, and by installing all-basic roofs, which permit faster firing rates.

At the beginning of 1960, the steel industry budgeted about \$1.6 billion for capital expenditures and considerable progress was made in modernizing and adding new equipment. However when business slowed down, some projects were postponed, and a few were canceled. Expansions include conversion of open hearths to use oxygen roof lances, new oxygen converters, consumable electrode vacuum-arc furnaces, vacuum degassing, vacuum deoxidation units, open hearth enlargements with all-basic roofs, and new rolling mills and revamping of old mills. New electric furnaces were built in El Paso, Tex., and Etiwanda, Calif.

Shipments of steel products (table 10) increased 1.8 million tons. Although shipments in most categories increased, those to the oil and gas industry for construction and drilling and to distributors who service this industry decreased 1.0 million tons. Shipments for export increased 1.1 million tons.

Alloy Steel.²—Domestic alloy-steel production was 8,417,762 short tons—8,355,655 tons of ingots and 62,107 tons of castings—a decline of 5.5 percent from 1959. Alloy steel supplied 8.5 percent of the steel output, compared with 9.5 percent in 1959.

Stainless-steel ingot production (12.7 percent of the total alloy-steel output) was 1,000,683 tons, 11.3 percent below 1959 but 12.1 percent above 1958. The production of austenitic stainless steel AISI 300 (nickel-bearing) and 200 series (manganese-nickel-bearing), representing 64.4 percent of stainless-steel production, was 10.0 percent below 1959; output of ferritic and martensitic, straight chromium types, AISI 400 series, decreased 13.8 percent. Production of AISI 200 series (26,804 tons) decreased 4.8 percent. The output of type 501, 502, and other high-chromium, heat-resisting steels, included in the stainless-steel-production figure, decreased 8 percent.

Output of carbon-steel ingots and castings was 90.9 million short tons, compared with 84.5 million tons in 1959.

Production of all grades of alloy-steel ingots, other than stainless, decreased 4.8 percent. Production of chromium steels (1.2 million short tons) decreased 19 percent; nickel-chromium-molybdenum steels (1.2 million tons) decreased 10 percent; and high-strength steels (940,000 tons) increased 21 percent. Chromium-molybdenum steel output (840,000 tons) was virtually the same as the preceding year.

The percentages of alloy steel produced in the basic open hearth, acid open hearth, and electric furnaces were 61, 1, and 38 percent, respectively, compared with 58, 1, and 41 percent in 1959.

Metalliferous and Other Materials Used in Steelmaking.—Pig iron and scrap consumed in steelmaking furnaces totaled 111.2 million short tons; the percentage of each was 54 and 46, respectively, compared with 52 and 48 percent in 1959. Consumption of foreign iron ore reached a record high of 6.3 million short tons. The principal sources of iron ore were Chile, Brazil, Liberia, Peru, and Venezuela. According to AISI, other materials used in steelmaking, excluding independent foundries, included 5.4 million tons of limestone, 1.4 million tons of lime, 209,609 tons of fluorspar, and 463,303 tons of other fluxes. Oxygen consumption at steel plants, exclusive of blast furnaces, reached a record 43.9 billion cubic feet, used as follows: Steelmaking, 29.2 billion cubic feet; conditioning, 9.8 billion; scrap preparation, 1.5 billion; other burning and welding, 1.3 billion; and all other, 2.1 billion cubic feet.

²The 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. It also includes 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 and 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).

TABLE 7.—Steel capacity, production, and percentage of operations in the United States¹

(Thousand short tons)

Year	Annual capacity, Jan. 1	Production						
		Open hearth		Bes-semer	Oxygen converter	Electric ²	Total	Percent of capacity
		Basic	Acid					
1951-55 (average)-----	116, 105	91, 837	598	3, 628	(³)	7, 003	103, 065	88. 8
1956-----	128, 363	102, 168	673	3, 228	506	8, 641	115, 216	89. 8
1957-----	133, 459	101, 028	630	2, 475	612	7, 971	112, 715	84. 5
1958-----	140, 743	75, 502	378	1, 396	1, 323	6, 656	85, 255	60. 6
1959-----	147, 634	81, 225	444	1, 380	1, 864	8, 533	93, 446	63. 3
1960-----	148, 571	85, 964	404	1, 189	3, 346	8, 379	99, 282	66. 8

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 a very small quantity of crucible steel.³ Data not available.

Source: American Iron and Steel Institute.

TABLE 8.—Production of steel by States and processes¹

(Thousand short tons)

Year and State	Open hearth	Bessemer	Basic oxygen process	Electric	Total
1955-----	105, 359	3, 320	307	8, 050	117, 036
1956-----	102, 841	3, 228	506	8, 641	115, 216
1957-----	101, 658	2, 475	611	7, 971	112, 715
1958-----	75, 880	1, 396	1, 323	6, 656	85, 255
1959-----	81, 669	1, 380	1, 864	8, 533	93, 446
New York-----	5, 011	-----	-----	114	5, 125
Pennsylvania-----	21, 157	(²)	(²)	* 1, 507	23, 781
Rhode Island, Connecticut, New Jersey, Delaware, and Maryland-----	7, 020	-----	-----	143	7, 163
Virginia, West Virginia, Georgia, and Florida-----	(²)	-----	-----	(²)	3, 202
Kentucky-----	(²)	-----	-----	(²)	1, 398
Alabama, Tennessee, and Mississippi-----	(²)	-----	-----	(²)	3, 572
Ohio-----	14, 693	(²)	-----	(²)	17, 225
Indiana-----	(²)	-----	-----	(²)	13, 836
Illinois-----	6, 501	-----	(²)	(²)	8, 229
Michigan-----	(²)	-----	(²)	482	6, 534
Minnesota, Missouri, Oklahoma, and Texas-----	2, 144	-----	-----	889	3, 034
Arizona, Colorado, Utah, Washington, and Oregon-----	(²)	-----	-----	(²)	3, 543
California-----	1, 539	-----	(²)	(²)	2, 639
Total 1960-----	86, 368	1, 189	3, 346	8, 379	99, 282

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 Figure withheld to avoid disclosing individual company confidential data.³ Includes production of crucible steel.

Source: American Iron and Steel Institute.

TABLE 9.—Steel electrically manufactured in the United States¹

(Thousand short tons)

Year	Ingots	Castings	Total ²	Year	Ingots	Castings	Total ²
1951-55 (average)---	6, 932	71	7, 003	1958-----	7, 929	51	7, 980
1956-----	9, 090	57	9, 147	1959-----	8, 477	56	8, 533
1957-----	8, 514	68	8, 582	1960-----	8, 313	66	8, 379

¹ Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 7.² Includes a very small quantity of crucible steel, and for 1955-58, oxygen converter steel.

Source: American Iron and Steel Institute.

TABLE 10.—Shipments of steel products by market classifications, all grades including carbon, alloy, and stainless

(Thousand short tons)

Market classification	1959		1960	
	Shipments	Percent of total	Shipments	Percent of total
Steel for converting and processing ¹	3,133	4.5	2,928	4.1
Forgings.....	957	1.4	841	1.2
Bolts, nuts, rivets, and screws.....	1,071	1.6	1,072	1.5
Warehouses and distributors:				
Oil and gas industry.....	1,890	2.7	1,125	1.6
All other.....	11,159	16.1	11,355	15.9
Total.....	13,049	18.8	12,480	17.5
Construction, including maintenance:				
Rail transportation.....	40	.1	51	.1
Oil and gas.....	2,262	3.3	2,166	3.0
All other.....	6,212	8.9	7,447	10.5
Total.....	8,514	12.3	9,664	13.6
Contractors' products.....	3,573	5.2	3,602	5.1
Automotive:				
Passenger cars, trucks, parts, etc.....	13,792	19.9	14,194	19.9
Forgings.....	422	.6	416	.6
Total.....	14,214	20.5	14,610	20.5
Rail transportation:				
Railroad rails, trackwork, and equipment.....	763	1.1	723	1.0
Freight cars, passenger cars, and locomotives.....	1,572	2.3	1,763	2.5
Street railways and rapid-transit systems.....	22	—	39	—
Total.....	2,357	3.4	2,525	3.5
Shipbuilding and marine equipment.....	642	.9	622	.9
Aircraft.....	71	.1	78	.1
Oil and gas drilling.....	541	.8	404	.6
Mining, quarrying, and lumbering.....	235	.3	288	.4
Agriculture:				
Agricultural machinery.....	964	1.4	765	1.1
All other agricultural.....	301	.4	238	.3
Total.....	1,265	1.8	1,003	1.4
Machinery, industrial equipment, and tools.....	4,158	6.0	3,958	5.6
Electrical machinery and equipment.....	2,052	3.0	2,078	2.9
Appliances, utensils, and cutlery.....	1,829	2.6	1,760	2.5
Other domestic and commercial equipment.....	1,833	2.6	1,959	2.8
Containers:				
Cans and closures.....	5,010	7.2	4,976	7.0
Barrels, drums, and shipping pails.....	773	1.1	842	1.2
All other containers.....	535	.7	611	.8
Total.....	6,318	9.1	6,429	9.0
Ordnance and other military.....	127	.2	165	.2
Shipments of nonreporting companies.....	2,029	2.9	2,120	3.0
Total domestic.....	67,968	98.0	68,586	96.4
Export (companies reporting to AISI only).....	1,409	2.0	2,563	3.6
Total shipments.....	69,377	100.0	71,149	100.0

¹ Net total after deducting shipments to reporting companies for conversion or resale.

Source: American Iron and Steel Institute.

TABLE 11.—Alloy-steel ingots and castings manufactured in the United States, by processes¹

(Thousand short tons)

Process	1951-55 (average)	1956	1957	1958	1959	1960
Open hearth:						
Basic.....	6,651	6,289	5,746	² 3,926	5,144	5,109
Acid.....	192	201	170	² 85	89	89
Electric ³	3,245	3,838	2,996	2,653	3,674	3,220
Total.....	9,488	10,328	8,912	6,664	8,907	8,418

¹ Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. See table 7.² Revised figure.³ Includes a very small quantity of crucible steel, and for 1955-58, oxygen converter steel.

Source: American Iron and Steel Institute.

CONSUMPTION OF PIG IRON

Although all States used some pig iron, 86 percent of the States canvassed (table 14) was consumed in steelmaking centers in the East, North Central, Middle Atlantic, and South Atlantic States. Pennsylvania (the leading consumer) used 24 percent of the total; Ohio, 17 percent; and Indiana, 13 percent; corresponding figures for 1959 were 25, 19, and 12 percent respectively.

TABLE 12.—Metalliferous materials consumed in steel furnaces in the United States

(Thousand short tons)

Year	Iron ore		Sinter ¹	Pig iron	Ferro-alloys ²	Iron and steel scrap
	Domestic	Foreign				
1951-55 (average).....	3,487	3,272	1,605	60,139	1,494	55,248
1956.....	3,398	4,741	1,517	66,438	1,630	62,276
1957.....	2,837	5,592	³ 1,934	68,768	1,530	56,765
1958.....	2,092	4,742	⁴ 1,261	51,299	1,115	43,024
1959.....	1,690	5,238	⁵ 961	54,699	1,380	49,794
1960.....	1,570	6,251	⁶ 931	60,092	1,395	51,140

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, ferro-silicon, and ferrochromium alloys.³ Includes other agglomerates (nodules, pellets, etc.) and 106,602 tons of foreign origin.⁴ Includes 601,509 tons of sinter, 238,040 tons of pellets, 281,390 tons of nodules, and 139,824 tons of other agglomerates. (325,268 tons of foreign origin.)⁵ Includes 271,736 tons of sinter, 215,109 tons of pellets, 255,448 tons of nodules, 32,039 tons of briquets, and 87,017 tons of other agglomerates. (314,507 tons of foreign origin.)⁶ Includes 121,946 tons of sinter, 49,422 tons of pellets, 314,958 tons of nodules, 35,025 tons of briquets, and 409,863 tons of other agglomerates. (403,705 tons of foreign origin.)

TABLE 13.—Consumption of pig iron in the United States, by type of furnace

(Thousand short tons)

Type of furnace or equipment	1959		1960	
	Quantity	Percent of total	Quantity	Percent of total
Open hearth.....	51,250	83.0	55,270	83.0
Bessemer.....	1,483	2.4	1,303	2.0
Oxygen converter.....	1,574	2.6	2,937	4.4
Electric.....	1,391	.6	1,372	.5
Cupola.....	4,412	7.1	3,822	5.7
Air.....	251	.4	210	.3
Direct castings.....	2,411	3.9	2,712	4.1
Total.....	61,773	100.0	66,626	100.0

¹ Includes a small quantity of pig iron consumed in crucible furnaces.**TABLE 14.—Consumption of pig iron in the United States, by districts and States**

(Short tons)

District and State	1959	1960	District and State	1959	1960
New England:			South Atlantic—Con.		
Connecticut.....	34,047	33,756	North Carolina.....	24,732	26,417
Maine.....	4,195	4,929	South Carolina.....	17,846	17,986
New Hampshire.....	77,114	73,313	Virginia.....	2,449,489	2,129,461
Massachusetts.....	45,792	48,380	West Virginia.....		
Rhode Island.....	8,329	7,345	Total.....	6,060,159	6,578,984
Vermont.....					
Total.....	169,477	167,723	East South Central:		
Middle Atlantic:			Alabama.....	3,125,492	3,144,319
New Jersey.....	149,673	147,537	Kentucky.....		
New York.....	2,988,093	3,382,392	Mississippi.....	771,705	905,603
Pennsylvania.....	15,489,188	16,295,129	Tennessee.....		
Total.....	18,626,954	19,825,058	Total.....	3,897,197	4,049,922
East North Central:			West South Central:		
Illinois.....	5,141,524	5,244,885	Arkansas.....		
Indiana.....	7,296,402	8,883,812	Louisiana.....	7,222	8,183
Michigan.....	4,138,861	5,034,654	Oklahoma.....		
Ohio.....	11,574,983	11,503,557	Texas.....	768,110	723,894
Wisconsin.....	255,452	195,801	Total.....	775,332	732,077
Total.....	28,407,222	30,862,709	Mountain:		
West North Central:			Arizona.....	142	88
Iowa.....	93,718	69,287	Nevada, Colorado,		
Kansas.....	5,251	5,332	Idaho, Montana,	1,847,229	2,202,759
Nebraska.....			and Utah.....		
Minnesota.....	432,814	431,151	Total.....	1,847,441	2,202,847
Missouri.....	73,518	44,649	Pacific Coast:		
Total.....	605,301	550,419	California.....	1,379,104	1,649,991
South Atlantic:			Oregon.....	5,004	3,327
Delaware.....			Washington.....		8,279
Maryland.....	3,554,242	4,392,072	Total.....	1,384,108	1,656,597
Florida.....			Total United States.....	61,773,191	66,626,336
Georgia.....	13,850	13,048			

PRICES

Pig iron and steel prices remained virtually constant during 1960. The weighted average annual price of pig iron, as published by Iron Age, was \$59.28 per short ton. The Iron Age composite price of finished steel for 1960 was 6.196 cents per pound, the same as in 1959.

TABLE 15.—Average value of pig iron at blast furnaces in the United States, by States
(Per short ton)

State	1951-55 (average)	1956	1957	1958	1959	1960
Alabama.....	\$46.14	\$50.23	\$53.94	\$55.14	\$56.81	\$56.52
California.....	51.15	50.67	57.44	57.53	60.47	59.73
Colorado.....						
Utah.....						
Illinois.....	49.16	54.52	58.04	61.32	60.12	60.30
Indiana.....	49.07	53.09	58.33	58.41	58.82	58.90
New York.....	50.02	54.54	63.09	64.48	61.01	62.54
Ohio.....	48.24	52.42	55.88	57.93	59.50	57.79
Pennsylvania.....	49.74	55.01	59.25	62.45	59.84	60.12
Other States ¹	49.24	54.19	60.37	60.53	58.38	58.06
Average.....	49.09	53.58	58.43	59.60	59.33	59.53

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

TABLE 16.—Average prices of chief grades of pig iron¹

(Per short ton)

Month	Foundry pig iron at Birmingham furnaces	Foundry pig iron at Valley furnaces	Bessemer pig iron at Valley furnaces	Basic pig iron at Valley furnaces
	1959-60	1959-60	1959-60	1959-60
January-December.....	\$55.80	\$59.38	\$59.82	\$58.93

¹ Prices did not change during 1959 and 1960.

Source: Metal Statistics.

TABLE 17.—Free-on-board value of steel-mill products in the United States, in cents per pound

Product	1959			
	Carbon	Alloy	Stainless	Average
Ingot.....	4.432	9.135	27.629	5.688
Semifinished shapes and forms.....	5.912	10.410	40.388	6.724
Plates.....	6.333	12.606	61.850	7.114
Sheets and strips.....	7.146	14.341	46.678	8.261
Tin-mill products.....	9.176	-----	-----	9.176
Structural shapes and piling.....	6.406	8.079	-----	6.424
Bars.....	7.752	13.836	63.526	9.406
Rails and railway-track material.....	7.779	-----	-----	7.779
Pipes and tubes.....	10.766	19.642	163.464	12.118
Wire and wire products.....	12.870	37.497	82.895	13.549
Other rolled and drawn products.....	9.460	43.810	69.493	8.432
Average total steel.....	7.894	14.223	54.387	8.857

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.

Source: Computed from figures supplied by the U.S. Department of Commerce, Bureau of the Census.

FOREIGN TRADE *

Lower priced foreign steels continued to penetrate domestic markets, although to a lesser degree than in 1959.

Imports.—Imports for the year were the second highest on record, totaling 3.5 million short tons, compared with 4.6 million tons in 1959, the previous record year. The European Coal and Steel Community and Japan were the leading suppliers of foreign steel to the United States with 2.2 and 0.6 million short tons, respectively. Imported steel furnished 52.8 percent of the domestic barbed wire market, 43.1 percent of nails and staples, 27.3 percent of wire rods, 21.3 percent woven wire fence, and 19 percent of concrete reinforcement bars. Imports of pig iron were 330,847 tons, compared with 699,593 tons in 1959.

Exports.—Exports of iron and steel products totaled 3.3 million short tons, compared with 2 million in 1959. Exports of pig iron were 111,773 tons, compared with 10,444 tons in 1959.

TABLE 18.—U.S. imports for consumption of pig iron, by countries
(Short tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America: Canada.....	255, 623	303, 121	221, 166	182, 128	437, 095	281, 593
South America:						
Brazil.....	6, 787	19, 621		2		
Chile.....	11, 964					
Total.....	18, 751	19, 621		2		
Europe:						
Austria.....	18, 740					
Belgium-Luxembourg.....	3, 930					4, 408
Finland.....	34				10, 253	
France.....	7, 533					
Germany ¹	76, 568		34	13, 933	² 71, 805	386
Netherlands.....	27, 909	112		1, 125	³ 4, 427	1, 575
Norway.....	5, 624	339		334	168	
Portugal.....					4, 395	
Spain.....	15, 728			7, 867	78, 499	21, 551
Sweden.....	21, 244	1, 852	3, 135	1, 615	1, 071	1, 445
U.S.S.R.....					1, 550	1, 298
Other Europe.....	816				51	
Total.....	178, 126	2, 303	3, 169	24, 874	⁴ 172, 219	30, 663
Asia:						
India.....	13, 101	336			56	6, 742
Japan.....					10, 674	
Turkey.....	7, 442					
Total.....	20, 543	336			10, 730	6, 742
Africa:						
Rhodesia and Nyasaland, Federation of ⁴	1, 758				4, 863	392
Union of South Africa.....	5, 430	128			70, 519	7, 543
Total.....	7, 188	128			75, 382	7, 935
Oceania: Australia.....	41, 932	1, 191	1, 052	2, 739	4, 167	3, 914
Grand total: Short tons.....	522, 163	326, 700	225, 387	209, 743	⁵ 699, 593	330, 847
Value.....	\$24, 572, 596	\$17, 842, 357	\$13, 527, 813	\$12, 026, 015	⁵ \$35, 493, 259	\$18, 351, 333

¹ Effective 1952 classified as West Germany.

² Includes 110 tons from East Germany.

³ Revised figure.

⁴ Classified as Southern Rhodesia through June 30, 1954; 1,562 short tons January through June 1954.

Source: Bureau of the Census.

* Figures on imports and exports compiled by Mae B. Price and Elsie D. Jackson, Division of Foreign Activities, Bureau of Mines, from records of the U.S. Department of Commerce, Bureau of the Census.

TABLE 19.—U.S. imports for consumption of major iron and steel products

Products	1959		1960	
	Short tons	Value	Short tons	Value
Iron products:				
Bar iron, iron slabs, blooms, or other forms.....	81	\$30,222	73	\$21,942
Pipes and fittings:				
Cast-iron pipe and fittings.....	16,330	1,842,424	18,390	2,112,097
Malleable cast-iron pipe fittings.....	6,461	2,490,604	7,518	2,917,896
Castings and forgings.....	17,334	3,600,240	15,202	3,617,809
Total.....	40,206	7,963,490	41,183	8,669,744
Steel products:				
Steel bars:				
Concrete reinforcement bars.....	851,950	68,697,236	515,522	47,353,942
Solid and hollow, n.e.s.....	215,536	22,714,724	133,511	19,168,100
Hollow and hollow drill steel.....	1,697	578,891	1,848	651,189
Wire rods, nail rods, and flat rods up to 6 inches in width.....	¹ 448,628	¹ 45,218,485	408,201	46,763,683
Boiler and other plate iron and steel, n.e.s.....	¹ 382,314	¹ 40,389,675	301,885	34,970,619
Steelingots, blooms, and slabs; billets, solid and hollow.....	91,771	9,025,204	67,762	8,780,659
Die blocks or blanks, shafting, etc.....	1,263	361,395	2,195	652,737
Circular saw plates.....	41	51,670	51	52,437
Sheets of iron or steel, common or black and boiler or other plate iron or steel.....	¹ 179,167	¹ 27,965,171	274,335	42,508,732
Sheets and plates and steel, n.s.p.f.....	26,083	3,232,925	12,977	3,194,914
Tinplate, terneplate, and taggers' tin.....	66,989	12,949,433	19,726	3,846,437
Structural iron and steel.....	¹ 871,483	¹ 90,480,482	607,161	73,445,439
Rails for railways.....	8,194	735,878	7,831	656,430
Rail braces, bars, fishplates, or splice bars and tie plates.....	650	61,201	875	109,936
Steel pipes and tubes.....	553,139	87,982,850	480,044	77,641,974
Wire:				
Barbed.....	78,287	10,251,360	52,964	7,849,830
Round wire, n.e.s.....	¹ 236,505	¹ 37,237,324	206,564	35,764,109
Telegraph, telephone, etc., except copper, covered with cotton jute, etc.....	2,875	1,082,778	3,013	783,701
Flat wire and iron and steel strips.....	80,579	16,267,399	63,389	15,657,325
Rope and strand.....	41,855	¹ 14,258,835	35,974	11,981,995
Galvanized fencing wire and wire fencing.....	79,040	11,373,461	51,881	7,920,155
Iron and steel used in card clothing.....	(²)	533,817	(²)	518,122
Hoop and band iron and steel, for baling.....	29,094	3,933,149	22,592	3,086,315
Hoop, band and strips, or scroll iron or steel, n.s.p.f.....	10,828	1,759,375	15,003	2,821,964
Nails.....	315,102	48,822,612	239,577	39,041,521
Steel castings and forgings.....	1,675	287,790	3,945	679,156
Total.....	4,574,745	556,253,120	3,528,826	485,901,421
Advanced manufactures:				
Bolts, nuts, and rivets.....	53,869	15,772,886	48,303	15,460,819
Chains and parts.....	6,998	4,465,750	9,022	5,111,540
Hardware, builders'.....		831,742		1,712,324
Hinges and hinge blanks.....		1,721,929		1,845,399
Screws (wholly or chiefly of iron or steel).....		¹ 2,017,786		2,033,059
Tools.....		¹ 17,120,055		18,555,594
Other.....		289,586		546,200
Total.....		¹ 42,219,734		45,267,935
Grand total.....		¹ 606,436,344		539,839,100

¹ Revised figure.² Weight not recorded.

Source: Bureau of the Census.

TABLE 20.—U.S. exports of major iron and steel products

Products	1959		1960	
	Short tons	Value	Short tons	Value
Semimanufactures:				
Steel ingots, blooms, billets, slabs, and sheet bars.....	14,719 ¹	\$2,261,733	74,524	\$7,664,271
Iron and steel bars and rods:				
Carbon-steel bars, hot-rolled, and iron bars.....	39,399	7,091,515	43,832	8,223,429
Concrete reinforcement bars.....	13,775	2,057,893	15,467	2,235,889
Other steel bars.....	13,917	5,551,294	25,542	9,710,031
Wire rods.....	4,189	464,651	10,238	1,326,981
Iron and steel plates, sheets, skelp, and strips:				
Plates, including boiler plate, not fabricated.....	65,585	13,649,810	91,434	20,473,441
Skelp iron and steel.....	15,742	1,915,143	44,370	5,338,650
Iron and steel sheets, galvanized.....	140,615	18,851,511	46,341	9,957,398
Steel sheets, black, ungalvanized.....	437,028	91,478,276	1,324,388	248,310,646
Strip, hoop, band, and scroll iron and steel:				
Cold-rolled.....	17,778	8,592,523	40,447	19,262,047
Hot-rolled.....	21,892	6,674,977	27,685	8,355,908
Tinplate and terneplate.....	368,355	62,954,269	565,536	101,356,117
Tinplate circles, cobbles, strip, and scroll shear butts.....	16,892	1,774,146	22,949	2,679,757
Total.....	1,069,886	1213,317,741	2,332,753	444,894,565
Manufactures—steel-mill products:				
Structural iron and steel:				
Water, oil, gas, and other storage tanks (unlined), complete and knockdown material.....	30,206	11,745,510	18,367	7,576,258
Structural shapes:				
Not fabricated.....	225,958	29,594,976	334,292	39,473,511
Fabricated.....	57,704	18,426,091	76,068	18,977,810
Plates, sheets, fabricated, punched, or shaped.....	30,372	6,949,496	9,505	3,110,125
Metal lath.....	1,362	501,742	1,176	450,996
Frames, sashes, and sheet piling.....	14,918	2,832,062	11,615	2,398,121
Railway-track material:				
Rails for railways.....	161,318	17,373,146	108,768	14,290,683
Rail joints, splice bars, fishplates, and tie plates.....	20,429	3,958,268	24,100	5,088,184
Switches, frogs, and crossings.....	1,665	806,435	3,132	1,507,246
Railroad spikes.....	1,006	231,196	941	224,524
Railroad bolts, nuts, washers, and nutlocks.....	416	227,215	571	348,467
Tubular products:				
Boiler tubes.....	6,298	3,932,547	9,783	6,355,181
Casing and line pipe.....	161,117	47,565,393	96,064	31,584,691
Seamless black and galvanized pipe and tubes, except casing, line and boiler, and other pipes and tubes.....	19,048	6,354,533	22,502	6,544,562
Welded black pipe.....	35,583	7,891,539	12,247	3,760,584
Welded galvanized pipe.....	2,396	690,057	3,606	1,136,258
Malleable-iron screwed pipe fittings.....	1,317	1,391,406	933	1,183,782
Cast-iron pressure pipe and fittings.....	15,485	2,920,187	16,075	3,334,748
Cast-iron soil pipe and fittings.....	11,439	2,252,625	6,892	1,599,636
Iron and steel pipe, fittings, and tubing, n.e.c.....	145,570	134,068,754	54,095	39,262,046
Wire and manufactures:				
Barbed wire.....	625	119,078	565	115,227
Galvanized wire.....	5,311	1,507,682	6,463	1,538,762
Iron and steel wire, uncoated.....	12,925	4,563,915	13,950	5,039,494
Spring wire.....	1,921	1,100,147	1,656	942,005
Wire rope and strand.....	10,217	6,212,575	9,400	5,175,155
Woven-wire screen cloth.....	1,301	1,630,450	1,349	1,604,638
All other.....	19,038	10,510,034	16,676	10,197,772
Nails and bolts, iron and steel, n.e.c.:				
Wire nails, staples, and spikes.....	3,060	2,736,449	4,675	3,352,351
Bolts, screws, nuts, rivets, and washers, n.e.c.....	14,475	15,290,146	13,329	16,109,025
Tacks.....	1,034	666,763	644	446,048
Castings and forgings: Iron and steel, including car wheels, tires, and axles.....	189,734	125,260,743	85,450	26,175,386
Total.....	1,903,248	1,259,311,160	964,889	258,903,266

See footnotes at end of table.

TABLE 20.—U.S. exports of major iron and steel products—Continued

Products	1959		1960	
	Short tons	Value	Short tons	Value
Advanced manufactures:				
Buildings (prefabricated and knockdown).....		15,111,272		7,244,540
Chains and parts.....	9,800	10,757,618	8,432	10,100,501
Construction material.....	6,065	4,661,866	6,650	4,962,240
Hardware and parts.....		23,624,560		22,199,037
House-heating boilers and radiators.....		9,135,741		7,696,062
Oil burners and parts.....		8,915,323		8,162,330
Plumbing fixtures and fittings.....		4,879,980		3,206,255
Tools.....		49,613,574		53,865,508
Utensils and parts (cooking, kitchen, and hospital).....	958	3,218,988	990	3,449,296
Other.....		35,837,151		36,800,258
Total.....		1165,756,073		157,686,027
Grand total.....		1638,384,974		861,483,858

¹ Revised figure.² Includes wire cloth as follows—1959: \$1,103,761 (5,037,493 square feet); 1960: \$1,152,568 (5,339,940 square feet).

Source: Bureau of the Census.

WORLD REVIEW

World production of pig iron, including ferroalloys, and steel reached a new peak with a 15-percent increase in pig iron and a 13-percent increase in steel. The United States led, and the European Coal and Steel Community and the U.S.S.R. ranked second and third in both pig-iron and steel output. The United States produced 24 percent of the pig iron and 26 percent of the steel, compared with 25 and 28 percent, respectively, in 1959 and 27 percent and 29 percent in 1958.

The Economic Commission for Latin America estimated production of rolled steel products by 1965 would be as follows:

Country:	Short tons per year
Argentina	2,600,000
Brazil	3,800,000
Colombia	300,000
Chile	560,000
Mexico	1,800,000
Peru	120,000
Venezuela	440,000
All other South American countries.....	240,000
Total	9,860,000

Another projection indicated that steel production in Latin America would be 20.6 million tons by 1975.⁴

⁴ Iron and Steel Engineer, vol. 38, No. 1, January 1961, p. 139.

TABLE 21.—World production of pig iron (including ferroalloys), by countries^{1 2}
(Thousand short tons)

Country ¹	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada.....	2,714	3,808	3,923	3,172	4,318	4,857
Mexico.....	309	455	473	547	617	733
United States.....	70,416	77,670	80,920	58,867	62,135	68,620
Total.....	73,439	81,933	85,316	62,586	67,070	74,210
South America:						
Argentina.....	36	32	37	32	39	198
Brazil.....	1,032	1,291	1,400	1,513	1,651	* 1,650
Chile.....	299	406	421	336	320	320
Colombia.....	* 104	128	158	164	138	* 140
Total.....	1,471	1,857	2,016	2,045	2,148	2,308
Europe:						
Austria.....	1,412	1,915	2,161	2,004	2,025	2,460
Belgium.....	5,266	6,350	6,160	6,084	6,575	7,222
Bulgaria.....	* 9	11	60	100	195	220
Czechoslovakia.....	2,847	3,618	3,928	4,160	4,679	5,172
Denmark.....	44	62	65	49	64	76
Finland.....	105	114	142	111	106	116
France.....	10,479	12,831	13,310	13,380	13,950	15,591
Germany:						
East.....	1,084	1,735	1,840	1,957	2,090	2,196
West.....	14,158	19,375	20,236	18,363	20,275	28,372
Saar.....	2,795	3,341	3,490	3,420	3,540	
Hungary.....	789	847	923	1,213	1,236	1,389
Italy.....	1,501	2,198	2,432	2,389	2,416	3,113
Luxembourg.....	3,272	3,655	3,713	3,621	3,795	4,173
Netherlands.....	648	730	773	1,011	1,259	1,485
Norway.....	309	498	624	577	672	788
Poland.....	2,556	3,865	4,059	4,259	4,822	5,030
Portugal.....				43	40	43
Rumania.....	477	643	756	812	933	1,118
Spain.....	925	1,100	1,030	1,479	1,889	2,132
Sweden.....	1,174	1,555	1,701	1,559	1,658	1,672
Switzerland.....	44	45	50	* 40	* 50	* 60
U.S.S.R. ³	30,350	39,410	40,830	43,650	47,370	51,590
United Kingdom.....	12,534	14,750	15,997	14,532	14,092	17,660
Yugoslavia.....	381	713	812	860	995	1,123
Total ⁴	93,159	119,361	125,092	125,673	134,726	152,801
Asia:						
China.....	2,640	5,265	6,060	* 10,470	* 22,600	30,300
India.....	2,086	2,194	2,141	2,352	3,427	4,608
Japan.....	4,771	6,905	7,864	8,510	10,908	13,604
Korea, North.....	33	205	300	350	* 765	* 1,100
Taiwan (Formosa).....	8	20	22	19	36	26
Thailand.....	4	4	4	6	8	7
Turkey.....	215	244	239	254	260	272
Total ⁴	9,757	14,837	16,630	21,961	38,004	49,917
Africa:						
Rhodesia and Nyasaland, Federation of:						
Southern Rhodesia.....	44	66	88	94	* 80	* 175
Union of South Africa.....	1,247	1,495	1,574	1,744	1,992	2,204
United Arab Republic, (Egypt region).....	(*)	* 4	* 13	* 45	130	* 140
Total.....	1,291	1,565	1,675	1,883	2,202	2,519
Oceania: Australia.....	1,875	2,324	2,474	2,553	2,804	3,226
World total (estimate).....	181,000	221,900	233,200	216,700	247,000	285,000

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 because of rounding where estimated figures are included in the detail.

³ Estimate.

⁴ Average for 1954-55.

⁵ Average for 1952-55.

⁶ U.S.S.R. in Asia included with U.S.S.R. in Europe.

⁷ Based on figures from Chinese sources. 1958 does not include approximately 4,000,000 tons produced 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.

⁸ Data not available; no estimate included in the total.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

TABLE 22.—World production of steel ingots and castings by countries ¹

(Thousand short tons)

Country	1951-55 (average)	1956	1957	1958	1959	1960
North America:						
Canada.....	3,824	5,301	5,068	4,359	5,901	5,790
Mexico.....	640	969	1,136	1,144	1,442	1,713
United States ²	103,065	115,216	112,715	85,255	93,446	99,282
Total.....	107,529	121,486	118,919	90,758	100,789	106,785
South America:						
Argentina.....	184	340	400	269	236	305
Brazil.....	1,177	1,640	1,523	1,672	1,801	2,200
Chile.....	297	420	428	384	457	465
Colombia.....	21	99	126	133	120	173
Total.....	1,679	2,499	2,477	2,458	2,614	3,145
Europe:						
Austria.....	1,443	2,291	2,766	2,638	2,769	3,487
Belgium.....	5,616	7,035	6,917	6,626	7,096	7,925
Bulgaria.....	96	143	175	233	254	277
Czechoslovakia.....	4,840	5,381	5,695	6,074	6,764	7,460
Denmark.....	218	265	289	281	322	351
Finland.....	171	217	230	207	262	285
France.....	11,837	14,727	15,398	16,111	16,776	19,047
Germany:						
East.....	2,302	3,020	3,191	3,354	3,535	3,678
West.....	18,409	25,561	27,014	25,116	28,464	37,589
Saar.....	3,104	3,719	3,791	3,814	3,983	4,140
Greece.....	50	83	80	125	99	2,078
Hungary.....	1,634	1,560	1,516	1,793	1,939	2,478
Ireland ⁴	25	33	28	31	44	44
Italy.....	4,343	6,512	7,481	6,913	7,454	9,071
Luxembourg.....	3,261	3,810	3,850	3,725	4,038	4,502
Netherlands.....	886	1,157	1,306	1,585	1,841	2,141
Norway.....	130	320	388	409	470	527
Poland.....	3,956	5,527	5,847	6,242	6,790	7,585
Rumania.....	762	859	952	1,030	1,564	1,991
Spain.....	1,163	1,365	1,526	1,734	1,995	2,137
Sweden.....	1,961	2,644	2,737	2,653	3,132	3,548
Switzerland ⁶	171	188	247	256	270	275
U.S.S.R. ⁷	42,037	53,680	56,412	60,539	66,085	71,981
United Kingdom.....	19,706	23,137	24,303	21,914	22,609	27,198
Yugoslavia.....	619	978	1,156	1,233	1,432	1,590
Total ¹	128,320	164,212	173,293	174,636	189,987	214,927
Asia:						
China.....	2,006	4,922	5,897	8,820	14,720	20,340
India.....	1,787	1,947	1,920	2,030	2,726	3,613
Israel.....				29	26	45
Japan.....	8,446	12,242	13,856	13,358	18,330	24,403
Korea:						
North ⁴	55	210	310	400	500	610
Republic of.....	3	13	19	22	42	55
Philippines.....			63	73	70	70
Taiwan (Formosa).....	31	87	98	118	175	174
Thailand.....	4	4	6	6	7	8
Turkey.....	182	213	194	176	236	293
Total ¹	12,514	19,638	22,363	25,032	36,832	49,611
Africa:						
Rhodesia and Nyasaland, Federation of.....						
Southern Rhodesia.....	39	64	72	79	88	88
Union of South Africa.....	1,412	1,769	1,915	2,019	2,090	2,328
United Arab Republic (Egypt Region) ⁸	43	120	110	190	190	190
Total.....	1,494	1,953	2,097	2,288	2,368	2,606
Oceania:						
Australia.....	2,135	2,844	3,377	3,509	3,788	4,122
World total (estimate).....	253,700	312,650	322,550	298,700	336,400	381,200

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 castings.

⁴ Estimate.

⁵ Average for 1953-55.

⁶ Including secondary.

⁷ U.S.S.R. in Asia included with U.S.S.R. in Europe.

⁸ Includes 1957 production when plant came into operation.

Compiled by Pearl J. Thompson, Division of Foreign Activities.

NORTH AMERICA

Canada.—Despite a decline each quarter after the high steel production of the first quarter in Canada during 1960, steel production exceeded midyear expectations of steel executives and was the largest in history.

Extensive expansions in the Canadian steel industry were underway. Algoma Steel Corp., Ltd., was constructing a \$15 million universal mill to include new continuous reheating furnaces for its rail, structural, and merchant mills. This mill was expected to be completed early in 1961 and was to produce wide flange beams up to maximum size of 24 inches. Algoma also was building a 6-stand-wide strip mill, as an extension to its bloom and plate mill, at an estimated cost of \$30 million. The mill was scheduled for completion in 1963 and was to produce hot-rolled sheets and light plates to a maximum width of 96 inches.

Steel Company of Canada (STELCO) reported that its new open hearth furnace would be in operation during the first quarter of 1961, increasing its steelmaking capacity to approximately 3.1 million tons a year. STELCO was arranging for a supply of 200 tons of oxygen per day to be used in its open hearth furnaces and for other metallurgical applications and was planning to inject natural gas in one of its blast furnaces.

During the year, the Big Inch Pipe Corp. started operating a continuous pipe mill at Calgary, Alberta. This mill fabricated pipe in sizes from 18 to 36 inches outside diameter with a wall thickness of $\frac{3}{16}$ to $\frac{5}{8}$ inches.

In addition to experimental work on using natural gas in the blast furnace, Canadian steel companies were investigating the use of fuel oil as a partial replacement for coke in the blast furnace. Experiments were carried out by the steel companies and Imperial Oil Limited, utilizing bunker C fuel oil. The fuel oil was injected into the furnace through a series of special nozzles in blowpipes, through which hot air was blasted into the furnace.

Algoma Steel announced the development of a new steel with improved weldability and a 20 percent higher yield strength than ordinary structural steel.

The statement on page 592 of the 1959 Minerals Yearbook, referring to the production of titanium slag by Crucible Steel, was incorrect. Quebec Iron Titanium Corp. at Sorel was the only producer of titanium slag operating in Quebec Province.⁵

Mexico.—Hojalata y Lamina, one of the largest steel producers in Mexico, was engaged in a major expansion program, which included erecting a new steel plant in Mexico City. It used the HyL direct-iron process. In this process, reform natural gas is used to convert iron ore to sponge iron. The sponge iron is then hot-charged to open-top electric furnaces for refining steel.⁶

⁵ U.S. Embassy, Toronto, Canada, State Department Dispatch No. 66, Mar. 8, 1961.
U.S. Embassy, Toronto, Canada, State Department Dispatch No. 110, June 29, 1960.
Iron and Steel Engineer, vol. 38, No. 1, January 1961, p. 138.

⁶ Skillings' Mining Review, vol. 49, No. 22, Aug. 27, 1960, p. 10.

SOUTH AMERICA

Argentina.—The first blast furnace of the State-controlled St. Nicholas steel plant started operating in 1960, and production of steel was scheduled to begin in 1961.⁷ This steel plant had a pier 2,225 feet long on the Parana River, two unloaders with a combined hourly capacity of 880 short tons, and capacity to store 1,500,000 tons of ore and 330,000 tons of coal. The blast furnace, installed by Arthur McKee of Cleveland, Ohio, had a hearth diameter of 28 feet and a daily capacity of 1,650 short tons of pig iron. The plant had coke ovens of German design and included 89 ovens. The coke plant will produce 1,600 tons of coke per day, of which 1,375 tons will go to the blast furnace. The coke plant installation includes a byproduct plant. Steelmaking facilities are composed of four 250-ton stationary open-hearth furnaces fired with coke oven and fuel oil or tar. The furnaces were designed by the U.S. firm, Loftus Engineering Corp., and are being built by Didier-Werke, A.G., of Germany. The blooming and slabbing mill is serviced by six batteries of soaking pits with an annual capacity of 1 million tons. Other mills include a continuous billet mill and structural mill and a continuous plate and sheet mill capable of hot-rolling 150,000 tons of heavy plate, 150,000 tons of sheet, and 335,000 tons of coils for cold reduction. The capacity of the cold reduction mill will be 315,000 tons a year, of which 170,000 tons will go for making tin plate. The tin mill will be equipped with hot-dipped tin pots and an electrolytic tinning line with an annual capacity of 110,000 tons. Steelmaking facilities are scheduled to start operating by the middle of 1961, and the plate and sheet mill will be in operation by the early part of 1962.⁸

The Governor of the Province of Buenos Aires announced early in 1960 that a plate and sheet rolling mill at Gary, Ind., had been purchased and would be transferred to a suitable site in the Province. The initial investment was reportedly \$23 million.⁹

Brazil.—Supplementing the information given in the 1959 chapter, Iron and Steel preprint, pages 23 and 24, ACOS Villares S/A of São Paulo signed a license agreement with the Ohio Steel Foundry Co., Lima, Ohio, for manufacturing cast and forged steel and iron rolls for the Brazilian steel industry. The company was to make high-alloy steel, high-alloy stainless and heat-resistant steel and the higher alloy grades of construction steel, as well as carbon and alloy heavy castings and forgings.¹⁰

Companhia Siderurgica Paulista (COSIPA) was constructing a plant at Piacaguera to make steel by the Linz-Donawitz (L-D) oxygen steelmaking process.¹¹

Peru.—Expansion plans announced by the Peruvian Santa Corp. called for doubling the steel ingot capacity of the Chimbote steel mill to 120,000 tons per year and tripling the capacity of the complementary hydroelectric powerplant in the Canondelpato to 150,000 kilowatts. The expansion was closely related to the installation of

⁷ Mining Journal (London), vol. 255, No. 6524, Sept. 2, 1960, p. 262.

⁸ Metal Bulletin (London), No. 4527, Sept. 9, 1960, p. 25.

⁹ Foreign Trade (Ottawa), vol. 113, No. 11, May 21, 1960, p. 31.

¹⁰ Foreign Trade (Ottawa), vol. 113, No. 3, Feb. 11, 1961, p. 24.

¹¹ Skillings Mining Review, vol. 48, No. 3, Apr. 16, 1960, p. 16.

beneficiation facilities at St. Nicholas Bay by the Marcona Mining Co.¹²

Venezuela.—The Government's Matanzas stainless pipe mill near the Caroni River has been importing steel for producing seamless pipe. Planned pipe production for 1960 was 45,000 tons; 1961, 130,000 tons; 1962, 160,000 tons; and 1963, 280,000 tons.¹³

EUROPE

The European Coal and Steel Community.—The Community had its best year in 1960, and prices remained remarkably steady. Despite a rise, French prices were still the lowest in the Community. The scrap gap amounted to about 2 million tons, but at no time was there any noticeable tightness in the market. New orders for rolled products and deliveries by plants totaled 57.7 million and 58.5 million short tons, respectively, compared with 55.7 million and 50.7 million tons in 1959. Exports of iron and steel products in 1960, the second highest on record, totaled 9.1 million tons, compared with 12.0 million tons in 1958, the previous peak year.

Community pig iron (including ferroalloys) production and crude steel production both reached new highs in 1960, totaling 59.6 million short tons and 80.2 million tons, respectively. The corresponding figures for 1959 were 51.4 million and 69.6 million tons. The average operating rate of the 409 blast furnace was 95 percent of capacity. New peaks in steel output were reached in all countries with the highest rate of increase 21.5 percent in Italy; the average rate of increase for the community was 15.3 percent. The Community share of world steel was 20 percent, compared with 20.7 percent in 1959. Average steel-furnace operating rate for the year was 98.1 percent of capacity with 104.1 percent for Luxemburg and 100.3 percent for France.

The percentages of total steel made by the several processes during 1960 were as follows: Basic Bessemer, 49.5; acid Bessemer, 0.3; open hearth, 37.8; electric, 10.3; and other (including L-D Rotor and Kaldo), 2.1. Corresponding figures for 1959 were 51.0, 0.3, 37.1, 10, and 1.6, respectively. The production of "new steel" by oxygen processes was increasing rapidly. In 1960, it represented 1.8 million tons or 2.1 percent of total production, compared with 1.6 percent of the total in 1959.

The quantity of pig iron produced per ton of steel capacity declined from 1,560 pounds to 1,478 pounds from 1955-59 and rose to 1,488 pounds in 1960 as a result of the investment policy adopted in 1955.

Scrap imports for 1960 increased to 1.9 million tons, compared with the low of 1.19 million tons in 1959. The decrease in foreign market demand for scrap resulted in a lower scrap price. The Community stock scrap pile increased to 13.8 million tons in 1960.

Construction projects declared for iron and steel plants in 1960 were valued at \$1.8 billion, compared with \$495 million in 1959. A breakdown of the 1960 investments was as follows: Coke plants, \$41

¹² Mining World, vol. 2, No. 7, June 1960, p. 74.

¹³ Foreign Trade (Ottawa), vol. 115, No. 1, Jan. 14, 1961, p. 14.

million; burden preparation, \$132 million; blast furnaces, \$149 million; steel furnaces, \$357 million (\$287 million, L-D and similar processes); rolling mills, \$930 million; and power generation and miscellaneous, \$193 million.¹⁴

Austria.—Austrian steel production in 1960 surpassed 3.5 million short tons for the first time. Per capita consumption of steel based on ingot production in Austria is now higher than that of the U.S.S.R. Production and shipments of steel both rose 20 percent over 1959 output. Of the total steel produced, 1.8 million tons was made at Linz and 1 million tons was made at Donawitz. Plans called for expanding annual steel output by another 550,000 tons at Linz. Virtually all of the steel in Austria is made in oxygen converters or by the Linz-Donawitz process.¹⁵

U.S.S.R.—In 1960 the U.S.S.R. reportedly blew in the largest blast furnace in the world at the Krivoi Rog Steel Works in the Ukraine. It was claimed that natural gas and superheated oxygen-enriched blast would be used to obtain high efficiencies. Previous reports on the 32-foot-hearth-diameter furnace called for a daily output of 5,000 tons of pig iron. The U.S.S.R. planned to build four more such furnaces. The largest blast furnace in the United States is that of National Steel Corps., Ecorse, Mich. with a hearth diameter of 30.25 feet.¹⁶

Soviet engineers were planning a new 6-furnace open hearth plant with an annual capacity of 3.5 million tons. Each of the large furnaces was to have a heat capacity of 900 to 1,000 short tons and be able to make 700,000 to 825,000 tons of steel annually. Output per man hour was expected to be increased at least 25 percent as compared with 550-ton furnaces.¹⁷

The 7-year plan of economic development for 1959 to 1965 for the Soviet Union called for increasing steel production to 95 million or 100 million tons by 1965, a growth rate of 7.5 percent per year. Blast furnace capacity will be increased by 26 million to 33 million tons; steelmaking capacity, by 31 million to 40 million tons; and rolling-mill capacity, by 25 million to 32 million tons. During 1960, new large blast furnaces, 10 open hearth furnaces, 3 electric furnaces, 6 rolling mills, and 8 coke oven batteries were commissioned. By 1963 two large blast furnaces, seven large open hearth furnaces, two converters, shops, and five rolling mills were to be built in the Dondas or Stalino economic area. These blast furnaces will utilize oxygen-enriched blast at temperatures exceeding 1,800° F., and half of the furnaces will use natural gas. In the Dniepropetropsk area, all blast furnaces will be put on natural gas injections. Some have oxygen-enriched blast and high top pressures up to 22 p.s.i., which is considerably higher than that used in the United States.

Large metallurgical plants were planned for the Ukraine and in the Urals with plants to be built east of the Urals in Siberia and Kazakhstan. In the Kazakhstan area, the Karaganda plant was put in operation, and the West Siberian Iron and Steel Works was under construction. Metallurgical plants were planned at Kustanai and

¹⁴ European Coal and Steel Community, Ninth General Report on the Activities of the Community: January 31, 1961, pp. 153, 158, 223, 428-432. (In French.)

¹⁵ Iron and Coal Trade Review (London), vol. 182, No. 4829, Feb. 3, 1961, p. 260.

¹⁶ General Metals, vol. 13, No. 3, March 1961, p. 185.

¹⁷ General Metals, vol. 12, No. 12, December 1960, p. 900.

Transbaikal, near the ore deposits of Kazakhstan. The Soviets also were planning to expand existing plants. For example, at the Magnitogorski Iron and Steel Works rolled steel capacity was to be increased to 9.3 million tons by 1965. In general, steel plants in the U.S.S.R. are designed to specialize in a minimum number of products. For example, wire products will be made at one plant; another will emphasize pipe; and another will produce flat rolled products.¹⁸

United Kingdom.—The United Kingdom planned to increase its steel-making capacity by 30 percent by 1965, or 33 million net tons per year. Outlay for 1960 was reported at about \$370 million, and substantially more was to be spent in 1961. The program called for adding two wide strip mills and expanding the capacity of one of the three operating mills. Meanwhile, an appreciable quantity of wide sheet was being imported from the United States. Four new blast furnaces were blown in during 1960. These included a 31-foot-hearth-diameter unit by the Steel Company of Wales, Limited, and a 25-foot-hearth-diameter furnace at South Durham Iron and Steel Company, Limited. A new 45-inch slab mill was installed at Appleby-Frodingham, Scunthorpe. Stewart and Lloyds started its 40- and 32-inch mills, and Patent Shaft Steel Works, Limited, began a 96-inch four-high plate mill. Richard Thomas and Baldwins, Limited, England, ordered a slab mill, a fourstand tandem cold mill, and a temper pass mill from the United States.¹⁹ England's first steelmaking oxygen converter (the L-D process) started operating on a full three-shift basis during the year at the Ebbw Vale Works of Richard Thomas and Baldwins. The vessel was a 30-ton-capacity unit and had provision for injecting powdered lime through the oxygen lance.²⁰ The Ford Motor Company, Limited, exclusively owned by the parent United States firm, awarded a contract to the Davy-Ashmore group—Ashmore, Benson, Pease and Company, Limited to construct a 20-foot-diameter-hearth blast furnace at Dagehnham (Essex). The furnace was scheduled to go into production in the summer of 1962. This would be the 50th blast furnace constructed by Ashmore-Benson-Pease in 30 years.²¹

Yugoslavia.—The Yugoslavia iron and steel industry was reportedly composed of self-managed, socialized enterprises, which included nine steel works coordinated by the Government and the Yugoslav Association of Iron and Steel Works. Government control was exercised through legislation and the basic investment policy, as well as through party, trade unions, and local-government organizations.

Since 1956, gross investments in the Yugoslav iron and steel industry averaged about \$12 million per annum. In March 1960, a loan of \$8.5 million from the development and loan fund was completed for the expansion of the Sizak Iron and Steel Works, and in August 1960, \$6.3 million was made available to the steel industry to buy hard coal, coke, and scrap.

Yugoslav iron and steel production in 1960 was 13 percent greater than in 1959, and the industry set a target of 3.4 million short tons by 1972. The increased production was attributed to improved pro-

¹⁸ Iron and Steel Engineer, vol. 38, No. 1, January 1961, p. 141.

¹⁹ Work cited in footnote 18, p. 139.

²⁰ Journal of Metals, vol. 12, No. 9, September 1960, p. 663.

²¹ Iron and Coal Trade Review, London, vol. 182, No. 4827, Jan. 20, 1961, p. 160.

duction methods and modernization and expansion of the Niksic, Ilisjas, Store, Zenica, and Jesenica plants.²²

ASIA

China.—Despite heavy losses incurred by the metallurgical industries because of natural disasters during 1960, China met its steel-production target of 20.2 million short tons. August floods caused destructive damage to plants producing steel ingots, pig iron, and coal. Electrical power production and transport had to be temporarily suspended.²³

After several revisions, China's targets for steel production through 1972 were established as follows: 1962, 27-29 million short tons (including 10 million tons produced in small plants; 1967, 31.5 million short tons (small plant production not given); 1972, 44 million short tons.²⁴

A brief summary of China's steelmaking centers sponsored by the U.S.S.R. was as follows:

Anshan—Capacity 6.5 million short tons; uses 600-ton open-hearth furnaces tapping into 3 ladles simultaneously, using a trifurcated spout. This mill produced a well-balanced group of steel products including rails, structurals, sheets, seamless pipe, plates, and almost all other multiple purpose steels. U.S.S.R.-designed blast furnaces at this plant were using a 100 percent sinter charge.

Wuhan—Capacity 3.3 million short tons; furnaces are similar to those at Anshan. Size of furnaces compares with those at the Fontana, Calif., plant of Kaiser Steel Co. Products of this plant are equal to those at Anshan. Blast furnaces are similar to those at Anshan.

Paotow—Capacity 3.3 million short tons; this plant is similar to Wuhan and is not near fabricating plants.

Chi-Chi-Ha-Erh—Capacity 550,000 short tons; specializes in high-quality steel suitable for aircraft and computers. This plant also produces high-strength steel in the range of 110,000 pounds per square inch.

A summary of plants expanded with Soviet and European satellite assistance was as follows:

Tayeh—Capacity 1.4 million short tons; uses open hearth and electric furnaces and is being expanded with East European aid. Capable of producing products similar to those at Wuhan.

Tai-Yuan—Capacity 2.2 million short tons; open hearth and electric furnaces. East German blooming mills and Russian rolling mills have been added recently.

Ma-An-Shan—Capacity 1.1 million short tons; 21 converters and 2 electric furnaces.

Chungking—Capacity 1.7 million short tons; open hearth furnaces capable of producing 330 tons per melt. Czechoslovakian rolling mills and new converters have been added since 1959.

²² U.S. Embassy, Belgrade, Yugoslavia, State Department Dispatch No. 705, May 4, 1961.

²³ Far East Iron and Steel Trade Reports, No. 73, February 1961, p. 16.

²⁴ The British Steelmaker, July 1960, p. 259.

Shih-Chinang-Shan—Capacity 1.4 million short tons; open hearth furnaces of about 220 tons capacity. A pipe mill of U.S.S.R.-design has been installed, which reportedly will supply the petroleum industry.

Huhan—Capacity 1.3 million short tons; open hearth furnaces of about 220 tons capacity. This plant will be fully integrated by 1965.

Existing partially integrated plants were as follows:

Dairen—Capacity 110,000 short tons; 55-ton electric furnaces and rolling mill.

Shenyang—Capacity 330,000 short tons; open hearth and electric furnaces. Center of heavy machinery industry where such items as rolling mills, hydraulic forging presses, and turbines are produced.

Fushun—Capacity 770,000 short tons; electric furnaces and rolling mills.

Penchi—Capacity 110,000 short tons; 55-ton electric furnace.

Integrated plants now being built by the Chinese were:

Chiu-Chuan—Capacity 1.6 million short tons; open hearth furnaces about the size of those at Chungking.

Hsi-Chang—Capacity 2.2 million short tons.

Lung-Yen—Capacity 1.7 million short tons.

Shao-Kuan—Capacity 1.7 million short tons.

The sum of the capacities of the foregoing listed steel plants was 29.8 million short tons. However, steel experts in the United States believe that China could produce 39 million short tons of steel by 1965, and experts in England set the figure at 28.5 million tons. Accurate information on the Chinese steel industry was difficult to obtain. Historically, steel produced in China was considered inferior to that produced in other countries.²⁵

India.—In India steel demand far exceeded steelmaking capacity, and plans were underway to make India not only self-sufficient, but a steel-exporting country. The target for India's steelmaking capacity in 1961 was 6.6 million short tons with an increase to 11.2 million tons by 1966. A breakdown of steel capacity by plants projected to 1966 was as follows: Bhilai—2,750,000 tons; Durgapur—1,800,000 tons; Rourkela—2,000,000 tons; Bokaro—1,100,000 tons, a new plant; Tata Iron and Steel Company—2,200,000 tons; Burnpur—1,100,000 tons; Mysore—100,000 tons; and miscellaneous places—200,000 tons.

Construction of the Durgapur plant was scheduled for completion by July 1961. Two blast furnaces operated during 1960. Other units remaining to be built at the Durgapur plant were a third coke oven battery, a third blast furnace, four open hearth furnaces, a 24-inch medium section mill, a continuous merchant mill, a foundry, and a wheel and axle plant. At Rourkela, three blast furnaces, four 90-ton open hearths, and three 45-ton oxygen converters were operating in the spring of 1960. This plant will have a steelmaking capacity of 1,100,000 tons. Rourkela was operating a new wide strip mill, consisting of two 4-high roughing stands and six 4-high finishing stands. This mill could produce strip $\frac{1}{16}$ to $\frac{3}{8}$ of an inch thick with a maximum width of 62 inches. Strip leaves the final finishing stands at 2,400 feet per minute. At Tata Iron and Steel Company, Ltd., Jamshedpur, a new lightsection continuous mill was put into operation.

²⁵ American Metal Market, vol. 67, No. 108, June 7, 1960, pp. 1-2.

This mill consisted of four stands with horizontal rolls and an edger, a finishing train consisting of 2 stands with horizontal rolls and 2 stands with vertical rolls, and a single-stand rack-type rolling bed with automated facilities. Rounds, squares, flats, angles, tees, and channels from 3 by 3, 4 by 4, and 4 by 5 inch billets could be made.²⁶

Japan.—The Japanese steel industry made a striking increase in output during 1960. Pig iron, crude steel, and ordinary hot-rolled steel advanced 26 percent, 33 percent, and 33 percent, respectively. Special steels increased 41 percent. To meet the high demand for pig iron, nearly 1 million tons was imported.

At the beginning of 1960, Japan had 29 blast furnaces in operation with a monthly production capacity of 885,000 short tons. Four new blast furnaces were built: In April, a 1,650 ton-per-day furnace at the Chiba Works of Kawasaki Steel and a 330-ton furnace by Osaka Steel; in October, a 1,650-ton furnace at the Hirohata Works of Fuji Steel and a 1,650-ton furnace at the Tobata Works of Yawata Steel. These 4 furnaces increased the annual pig-iron capacity of Japan to 12.7 million short tons, a 20-percent increase.

To meet the expected additional increase in pig iron requirements, the Ministry of International Trade and Industry authorized the construction of six additional blast furnaces: A 1,800 ton-per-day furnace at Muroran, Fuji; a 2,200-ton furnace at Tobata, Yawata; a 1,100-ton furnace at Nadahama, Kobe; a 1,650-ton furnace at Mizue Works; a 1,650-ton furnace at Chiba Works; and a 1,650-ton furnace at the Kure Works of Nisshin Steel.

Crude steel production for 1960 was 24.4 million short tons, 1.33 times the 1959 level. Percentage production by type of furnace was 67.9 by open hearth, 11.9 by converter, and 20.2 by electric furnace. The corresponding figures for 1959 were 74.0, 71.3, and 18.7.

TABLE 23.—Production of crude steel during 1960

(Thousand metric tons)

Type of furnace and steel	Total	Index (1959=100)
Open hearth furnace.....	15,045	122.2
Converter.....	2,629	218.1
Electric furnace.....	4,469	143.6
Total.....	22,143	133.2
Ordinary steel.....	19,937	132.3
Special steel.....	2,206	141.4

New steelmaking furnaces added during 1960 were one 165-ton open hearth at Kawasaki Steel Corporation's Chiba Works, two 110-ton open hearth furnaces at Otani Steel Works, Ltd., and two 75-ton open hearth furnaces at Nakayama Steel Works, Ltd., Nagoya Works. Seven new converters were added at various locations. The type was not given, but it was assumed they all were the L-D type. Among the large size electric furnaces put into operation was a 65-ton furnace at the Kobe Steel Works, Ltd.

²⁶ Iron and Steel Engineer, vol. 38, No. 1, January 1961, p. 141.

There was a marked increase in the output of most steel products during the year. Leading products included wide strips, plates, small bars, hoops, ordinary wire rods, sheet, medium plate, medium sections, large sections, and tube rounds.

For steel pipe, electric-resistance-welded tube registered a notable advance. The output of special hot-rolled steel totaled 1.3 million tons, a 41-percent increase over 1959. Estimated output of stainless steel for the year was 200,000 tons, compared with 110,000 tons in 1959.

Imports of steel mill products for the year were 275,000 short tons; exports were 2.8 million tons. A considerable part of the imports was old rails and tinplate.

Bars, plates, cold-rolled sheet, wire rods, and galvanized sheet were the important export items, and the principal buyers were the United States, India, Australia, the Philippines, and Thailand.

According to the long-range expansion programs of the six major steel producers in Japan, steel production in 1965 would be 38.6 million short tons. These six producers planned to produce 89.2 percent of the expected total production, compared with 66.6 percent in 1960 (table 24). The companies planned to double pig iron production by building 19 new blast furnaces.

In steel expansion many new oxygen steelmaking converters were to be built, and some of the existing open hearth furnaces were to be replaced with oxygen converters. Many steel products have been produced by one or two companies. The expansion plan calls for a greater number of producers of these products, which include silicon sheet, large structural sections, tin plate, and strip.²⁷

TABLE 24.—Production expansion program of six big steel makers

	1960		1965		Equipment investment 1961-65 (thousands)
	Crude steel output (thousand metric tons)	Percent of national total	Crude steel output (thousand metric tons)	Percent of national total	
Yawata Iron and Steel Co., Ltd.....	5,130	22.0	9,080	25.9	\$89,100
Fuji Iron and Steel Co., Ltd.....	3,640	15.6	7,600	21.7	74,670
Nippon Kokan Kabushiki Kaisha.....	2,350	10.1	4,690	13.4	47,100
Kawasaki Steel Corp.....	2,060	8.8	4,360	12.4	37,140
Sumitomo Metal Industries, Ltd.....	1,350	5.8	3,340	9.5	27,350
Kobe Steel Works, Ltd.....	1,010	4.3	2,220	6.3	42,250
Total.....	15,540	66.6	31,290	89.2	317,610

Source: Far East Iron and Steel Trade Reports.

North Korea.—U.S.S.R. engineers were working on plans for expanding the Kim Chak Iron and Steel Works at Chong-din in North Korea to make it one of the largest and most up-to-date steel plants on the Asian continent. In 1960 the plants consisted of two batteries of coke ovens and two blast furnaces. Four new coke oven batteries and two modern blast furnaces identical in size to the latest installed

²⁷ Far East Iron and Steel Trade Reports, No. 73, February 1961, pp. 3-9.

in the U.S.S.R. were to be added. Also included was a new converter shop, utilizing 100-ton capacity converters of Soviet design.²⁸

Pakistan.—The Pakistan Government announced its decision for establishing a steel mill in Karachi. A report outlining the feasibility of such a venture was submitted to the British consultants, John Miles and Partners, who contacted firms in the United Kingdom, United States, Canada, and Japan. Koppers Co., Inc., Pittsburgh, submitted its feasibility report on a 250,000-ton plant for Karachi, and a Japanese team of experts completed its report for a 100,000-ton plant at Chittagong-East Pakistan.²⁹

Philippines.—After an economic and technical study by a West German firm, Santa Ines Steel Company, planned to build a new steel plant in the Philippines with a daily steelmaking capacity of 220,000 tons, based on Santa Ines ore deposits. Plans called for the refining of pig iron to steel by the L-D process. Semifinished products, ingot molds, and gray iron casting were suggested as possible products.³⁰

Turkey.—The following supplements the information given in the 1959 Minerals Yearbook on the new integrated steel plant to be built at Ereğli on the Black Sea coast. The Development and Loan Fund agreed to loan \$129.6 million to finance half the cost of this plant. This was reportedly the largest single U.S. Government loan ever made for an overseas industrial project. A byproduct coke plant, a blast furnace, basic oxygen converter, rolling mills, and power and steam plants were to be built. Output was expected to be 470,000 tons a year initially and later to be expanded to 1.2 million tons.³¹

AFRICA

Rhodesia and Nyasaland, Federation of.—A \$24 million expansion program was underway at the Redcliff Works of the Rhodesian Iron and Steel Company, which will boost annual steel output to 150,000 tons. Equipment at the new plant included a 500-ton-a-day blast furnace, a 200-ton-a-day open hearth furnace, coke oven, cogging mills and soaking pits, reheating furnaces, and a black and galvanized sheet mill. The blast furnace, fourteenth in Africa, will increase pig iron output in Rhodesia to 750 tons a day. The additional open hearth doubles steel capacity to 400 tons a day.³²

United Arab Republic (Egypt Region).—The Egyptian Iron and Steel plant erected by the West German firm, Demag, at Helwan, that began producing in June 1958 had operated at less than 50 percent of capacity and was reportedly operating at a loss. The mill was equipped with two blast furnaces, each designed for a daily output of 400 tons of molten pig. Blast furnace coke was imported from West Germany and China. Through 1960, only one blast furnace had been used. Three basic Bessemer converters were used for steelmaking. The rolling mills had an annual capacity of about 20,000 tons

²⁸ Iron and Coal Trades Review, London, England, vol. 80, No. 47 AD 1, March 4, 1960, p. 543.

²⁹ Mining Magazine (London), vol. 104, No. 3, March 1961, p. 166.

Iron Age, vol. 186, No. 11, Sept. 15, 1960, p. 13.

³⁰ Mining World, vol. 13, No. 8, July 1960, p. 73.

³¹ Mining World, vol. 23, No. 3, March 1961, p. 75.

³² Steel, vol. 148, No. 4, January 23, 1961, p. 31.

of billets, rail sections, heavy and medium plate, and some sheet. In 1960 output of billets was less than 300 tons per day, part of which was sent to other smaller mills in Egypt. The cost of producing pig iron at this plant was reportedly double the cost of imported material.

Most of the operating difficulties were attributed to variable iron ore composition. Other problems included lack of adequate rail transportation and an inexperienced labor force. Two International Cooperation Administration iron and steel experts were studying the company's technical operating problems.

The Soviet-Egyptian economic assistance agreement contained the following projects relevant to the iron and steel plant: (1) Coke cehmical plant in Helwan, including shop for coal preparation, one battery of 45 coke oven, and a coke-oven-byproduct plant; (2) Projecting work and delivery of equipment for a strip mill with an annual capacity of 70,000 tons of sheets on a two-shift-per-day basis; (3) Projecting work and delivery of equipment for strip and cold-rolling sheet mill for producing 25,000 tons of sheet for tinning.³³

OCEANIA

Australia.—Australian production of pig iron, crude steel, and shipments of steel mill products reached new records in 1960. Despite the large increase in productive capacity, demand of the rapidly expanding Australian economy continued to exceed production in many fields. The main shortages occurred in structural steel. However, Australia was on its way toward balancing its steel production and needs. Current outlay calls for doubling output. Australia might become a net exporter of steel by the midsixties. Some evidence of growing self-sufficiency in Australia was shown by the drop in U.S. exports of iron and steel products from 59,000 short tons in 1955 to less than 6,500 tons in 1959. Some of the long-term projects were announced for the expanding Australian steel industry: (1) Installation of four Linz-Donawitz oxygen-type steelmaking converters, which could increase steel ingot capacity by as much as 95 percent; (2) installation of important new rolling mills at New Castle and Whyalla; (3) establishment of a \$90 million integrated steel industry at Kwinana, Western Australia; (4) construction of an iron ore treatment plant at Iron Knob, in Southern Australia, about 200 miles northwest of Adelaide; and (5) construction of a spun-cast-iron pipe mill with an annual capacity of 90,000 short tons in the Sidney area. This last mill, which was to cost over \$4.5 million, would produce pipe 4 to 20 inches in diameter. A similar plant was planned for the Melbourne area at a later date.³⁴

New Zealand.—New Zealand planned to produce a substantial part of its needs for reinforcing bars, angles, rounds, flats, and squares by the end of 1961 through constructing a \$10.1 million merchant bar mill at Auckland. The mill was to be totally financed by New Zealand and United Kingdom firms.³⁵

³³ Mineral Trade Notes, vol. 50, No. 3, pp. 23-24, March 1960.

³⁴ Foreign Commerce Weekly, vol. 65, No. 12, March 20, 1961, p. 40.

Steel Magazine, vol. 147, No. 14, Oct. 3, 1960, p. 49.

Mining and Chemical Engineering Review, Melbourne, Australia, vol. 52, No. 9, June 15, 1960, p. 10.

³⁵ Iron and Coal Trade Review, London, England, vol. 180, No. 4755, Jan. 22, 1960, p. 206.

TECHNOLOGY

The Bureau of Mines, U.S. Department of the Interior, published several reports on its blast furnace research program. In one study, natural gas was used to replace 30 percent of the coke charge, and output was increased 25 percent in the Bureau's experimental blast furnace.³⁶ In another experiment with this furnace, raw (unfired) iron ore pellets were successfully smelted with no significant change in coke consumption and only moderate increase in dust losses.³⁷ A third test showed that part of the coke charge can be replaced by injecting anthracite directly into the smelting zone. Hot blast temperature should be increased to compensate for chilling effect of cold anthracite; use of finer anthracite will permit reduction in carbon-to-iron ratio and, therefore result in a higher production rate.³⁸

Another experiment included enrichment of the blast with steam, natural gas, and oxygen. Results showed that natural gas with oxygen increased output and reduced coke requirement and that varying the moisture content of the blast was an effective tool for controlling the operation of the furnace.³⁹

Fuel oil was atomized into the natural gas stream as it passed through the tuyeres of a blast furnace in one experiment. Fuel oil supplements the natural gas, which can only be added in limited amounts.⁴⁰

Results of tests on the use of natural gas in the blast furnace of Lone Star Steel, Lone Star, Texas, in 1960 were promising. With a 3-percent injection of natural gas, production increased 30 percent and coke consumption decreased 20 percent. Hot blast temperature was increased 25 percent. During the tests, savings of 17 percent in fuel cost and 15 percent in operating cost were realized.⁴¹

Tests at Pittsburgh Coke and Chemical Company at Pittsburgh, Pa., showed that merchant pig iron could be made with undesulfurized coke oven gas, containing hydrogen sulphide by injection in the tuyeres of a blast furnace. The injection resulted in increased metal output and decreased coke consumption.⁴²

In Germany the efficiency of the blast furnace was increased by adding oxygen and carbon dioxide to the blast; in trial smelting in a 0.6-meter-diameter furnace, the blast was enriched to 16.6 percent carbon dioxide and 45.0 percent oxygen, resulting in a 40-percent increase in efficiency.⁴³

In the Low Shaft Blast Furnace at Liege, Belgium, the thermal aspects and shaft efficiency of indirect reduction were established with or without fuel oil and gas injection with or without top pressure.

³⁶ Melcher, N. B., Morris, J. P., Ostrowski, E. J., and Woolf, P. L., Use of Natural Gas in an Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5621, 1960, 15 pp.

³⁷ Melcher, N. B., and Royer, M. B., Smelting Unfired Iron Ore Pellets in an Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5640, 1960, 9 pp.

³⁸ Ostrowski, E. J., Royer, M. B., and Ropelewski, L. J., Injecting Solid Fuels Into Smelting Zone of an Experimental Blast Furnace: Bureau of Mines Rept. of Investigations 5648, 1960, 14 pp.

³⁹ Blast Furnace Coke Oven and Raw Materials Proceedings, A.I.M.E., 1960, vol. 19, pp. 279-300.

⁴⁰ Iron and Steel Engineer, vol. 38, No. 1, January 1961, p. 147.

⁴¹ Blast Furnace and Steel Plant, vol. 49, No. 4, April 1961, pp. 317-323.

⁴² Journal of Metals, vol. 13, No. 1, January 1961, pp. 49-50.

⁴³ Stahl und Eisen, vol. 81, No. 3, Feb. 2, 1961, pp. 149-154.

The effect of varying the quantity of carbon monoxide and hydrogen on indirect reduction also was established.⁴⁴

A method for continuous refining of molten pig iron in a blast furnace runner by injecting pure oxygen through a porous bottom plate was described. In the experiment, silicon was reduced; iron losses due to oxidation were low; and brown smoke did not occur.⁴⁵

The use of electronic computers for predicting effects of oxygen, moisture, and fuel additions in blast furnace operations evoked considerable interest. Essential elements of methods developed were described, and results of computed predictions for several iron blast furnaces were compared with actual results.⁴⁶

Radioactive tracers were used to determine the movement of the blast furnace charge under normal working conditions. The results of 193 experiments carried out in 1956-57 at the Azovstal works in U.S.S.R. were described.⁴⁷

At the Colorado Fuel and Iron Corporation, Pueblo, Colo., radioactive cobalt (Co) was used to show brick wear in areas of extreme erosion. Radioactive cobalt needles were mixed with castable refractories, placed in the furnace wall, and monitored outside with Geiger counters. A sudden drop in radiation indicates wear. Cobalt 60 is a satisfactory isotope since its half life of 5.3 years corresponds to a normal furnace-lining life.⁴⁸

In Rumania and Bulgaria lead-bearing iron ores were successfully smelted in a blast furnace. It was demonstrated that lead can be recovered without disturbing the working and operating conditions of the furnace and without producing dangerous concentrations of lead oxide in air when tapping metal.⁴⁹

All the recent advances in blast furnace technology will be considered in an ultramodern blast furnace with a 28-foot hearth diameter to be built by U.S. Steel at its Duquesne Works, Pittsburgh, Pa. The furnace was scheduled for completion in 2 years and was expected to produce about 850,000 tons of molten iron annually. Technological advances to be incorporated in the plant include blast furnace stoves that will deliver increased hot-blast temperature up to 2,000° F., refractories-lined bustle pipe, high hot-pressure up to 30 pounds per square inch, automatic probing of the stock column, and advanced instrumentation. A modern turboblower and a new raw materials trestle will be constructed. U.S. Steel also was constructing a small experimental blast furnace, similar to the Bureau of Mines Experimental furnace, at Universal, Pa.⁵⁰

The Armco Steel No. 3 blast furnace at Middletown, Ohio, produced a record tonnage of 2,804 tons of pig iron a day for a period of 1 month during 1960. Its output for the entire year totaled 884,407 tons, an average of 2,500 tons per day. This high output was realized through the use of sized material in the furnace and through the use of large quantities of pellets.⁵¹

⁴⁴ Journal of Metals, vol. 13, No. 1, January 1961, pp. 41-44.

⁴⁵ P. Leroy, R. Simon, Revue de Metallurgie, vol. 57, No. 1, January 1960, pp. 21-43.

⁴⁶ A. L. Hodge, Blast Furnace and Steel Plant, vol. 48, No. 7, July 1960, pp. 665-675, 689.

⁴⁷ Stal, vol. 19, No. 8, August 1959, pp. 571-576, 676, 683.

⁴⁸ Steel, vol. 147, No. 4, July 25, 1960, pp. 126, 128.

⁴⁹ Stal, vol. 20, No. 7, July 1960, p. 473-475.

⁵⁰ U.S. Steel Corporation—Annual Report 1960; Iron Age, vol. 186, No. 5, August 4, 1960, p. 81.

⁵¹ Armco Steel Corporation, 60th Annual Report for the Year Ended, December 31, 1960.

In steelmaking, developments continued to revolve around some phase of oxygen use. One dramatic example was by Ford Motor Company, Dearborn, Mich., where steelmaking time was reduced more than 50 percent by using oxygen. Production rates of 70 tons per hour on a 200-ton furnace and 105 tons per hour on a 400-ton furnace were reported. These production rates compare favorably with rates achieved in oxygen converters. In the operation, rapid charging of the furnace is stressed, and lime is sandwiched in with scrap during charging. Maximum end-firing goes on during charging at the rate of 14 gallons of oil enriched with 5,000 cubic feet of oxygen per minute in the 200-ton furnace. Additional heat is also supplied from lances, lowered about a foot through the roof, furnishing 30,000 cubic feet of natural gas mixed with 48,000 cubic feet of oxygen per hour, a heat input from both sources of about 190 million B.t.u. per hour.

After charging, which takes 23 minutes, the roof lances are lowered to about 2 feet above the scrap, and as the scrap melts down, the lances are lowered still farther. About one-half hour after charging, 11 minutes are required to add molten pig iron. The natural gas is then shut off, and oxygen at the rate of 48,000 cubic feet per hour is surface-blown onto the melt through lances lowered to 4 inches above the bath. Thirty minutes after the hot metal addition, end-firing virtually ceases. About two tons of iron ore are added during the refining period. Total charge-to-tap time runs about 2 hours and 50 minutes. Fuel and oxygen requirements per ton run 1,368,000 B.t.u. and 1,575 cubic feet, respectively. Ford is continuing its research in this field, employing many new techniques.⁵²

An interesting variation in open-hearth design was a 250-ton furnace without a front wall built in U.S.S.R. The steel framework is all-welded construction, and instead of a front wall with a number of water-cooled door frames and doors, seven water-cooled free-hanging doors cover the 5-foot-9-inch-by-40-foot-long opening. A furnace so designed can be charged faster and more uniformly, and the worry of hitting the door frames with charging boxes is eliminated. One reported drawback is higher heat losses from cooling water.

Open-hearth furnaces of 660-ton capacity were under construction in the U.S.S.R. in 1960, and plans for 880-ton units, which could be increased to 1,000 tons, were being designed.⁵³

Wheeling Steel at Steubenville, Ohio, used steam-oxygen blowing in the Bessemer converter process. In the process a mixture of 50 percent steam and 50 percent oxygen preheated to 300° F. was blown through the bottom tuyeres of the converter in place of air. The nitrogen content of the steel made by this method was 0.0018 percent, compared with the normal range of 0.002 to 0.005 percent for low-carbon open-hearth steel. Hydrogen content averaged 0.3 to 0.4 parts per million—about the same as air-blown Bessemer or open-hearth steel. The heat cycle time, from charge to finish tap, was reduced from 12 to 9 minutes, and the blowing time was decreased from 9 to 7 minutes. Metallic yield was increased by 0.5 to 1 percent.⁵⁴

⁵² Iron Age, vol. 186, No. 16, Oct. 20, 1960, pp. 158-160.

⁵³ Madsen, I. E., Developments in the Iron and Steel Industry During 1960: Iron and Steel Eng., vol. 88, No. 1, January 1961, p. 152.

⁵⁴ Steel, vol. 147, No. 8, August 22, 1960, pp. 82, 85.

The feasibility of using Krupp-Renn processed iron and sponge iron instead of iron and steel scrap as cooling agents was demonstrated in an experimental L-D 3-ton oxygen-blown converter in Germany.⁵⁵

The British Oxygen Research and Development firm in England introduced argon experimentally through hollow electrodes in an electric furnace. Qualitative and quantitative results showed that the argon had a stabilizing effect on the arc, decreased melting time 22 percent and decreased electrical consumption 13 percent in a 1-cwt. manually operated electric-arc furnace.⁵⁶

Considerable work was done at the Indian Institute of Metals on the use of rare-earth compounds in steels. The possibility of using rare-earth compounds for desulfurization was demonstrated. Limited quantities of oxides and fluorides of rare-earth metals and LanCerAmp alloy tended to reduce the size of inclusions and distribute them more uniformly; excessive rare earth caused inclusions to appear again; rare-earth oxides and LanCerAmp appear to refine grain size of low-alloy steel, while rare-earth fluorides result in grain coarsening.⁵⁷

In evaluating high-strength steels for rocket motor casings, small size pressure bottles were used. Steels evaluated included: AISI, H-11, AMS 6434, and PH 15-7 Molybdenum alloy steel. When there was proper control of optimum tempering range, effects of weld mismatch, porosity, improper weld repairs, ground flush welds, and ovality, consistent burst strengths could be expected for vessels heat-treated in range of 240,000 to 260,000 p.s.i. tensile strength.⁵⁸

The use of vinyl-clad steel increased during the year. Ford Motor Company was the first automobile company to use the laminating technique, called the Marvibond process and developed in 1953 by Naugatuck Chemical Co. Ford used vinyl-clad steel extensively in the interior of the 1959 Thunderbird and was considering its use in other models.⁵⁹

Armco Steel Corporation, Sheffield Division, Kansas City, Mo., was using molten cupola metal to increase open-hearth output. The metal was made in cupolas with 108-inch shell diameters of the continuous casting type from which hot metal runs into a 150-ton holding ladle. Metal from the cupola contains about 3 percent carbon, 0.20 percent phosphorus, and 0.13 percent sulfur. The metal is desulfurized by introducing sodium carbonate into the hot metal as it is poured from the holding ladle. The normal charge for the cupola is 40 percent cast iron and pig iron and 60 percent steel scrap. In addition, coke and limestone are charged. About 300 pounds of coke and 50 pounds of limestone per ton of iron is required.⁶⁰

The Bureau of Mines continued its research program on the use of uranium in steel. Studies were directed toward establishing the hardenability factor of uranium and in developing safety measures in its use. Ingots weighing 300 pounds were successfully air-melted by the Bureau, but a 1,000-pound ingot failed during forging at a commercial laboratory.

⁵⁵ Technische Mitteilungen Krupp, vol. 18, No. 1, August 1960, pp. 1-8.

⁵⁶ Iron and Coal Trade Review, vol. 180, No. 4778, Feb. 12, 1960, pp. 353-358.

⁵⁷ Indian Institute Metals, Transactions: Vol. 13, September 1960, pp. 265-276.

⁵⁸ Aerospace Engineering, vol. 19, No. 12, December 1960, pp. 30-36.

⁵⁹ American Metal Market, vol. 66, No. 141, July 21, 1959, p. 8.

⁶⁰ Iron and Steel Engineer, vol. 37, No. 2, February 1960, p. 93.

The Canadian Department of Mines and Technical Surveys had been conducting research on using depleted uranium as an alloying agent in steel at an annual cost of about \$250,000. In tests conducted in Canada, uranium was successfully added to a 500-pound heat by wrapping the material in aluminum foil to avoid high oxidation losses. Recoveries in the range of 75 to 85 percent for 0.4 percent carbon steels and 55 to 60 percent for 0.10 percent carbon steel were realized. Uranium is an excellent deoxidizer, and steel can be fully killed with this element.

The experiment showed that 0.7 percent uranium in steel increases hardenability. It was also determined that uranium improved the corrosion resistance of steel in tests, utilizing a 5 percent hydrochloric acid solution. In fatigue studies, the endurance limit of a 0.4 percent carbon steel was found to increase from 29,000 p.s.i. to 36,000 p.s.i. by adding 0.02 percent uranium and to 40,000 p.s.i. with 0.20 percent. Creep studies at elevated temperatures of AISI 1010 and AISI 1040 steels showed that uranium increased the time to rupture at a given temperature and stress. This feature might be of interest to steel consumers for high temperature application such as steam piping and for nuts and bolts used in high temperature surroundings.⁶¹

Since World War II, large tonnages of depleted uranium have become available as the result of Atomic Energy Commission activities.

The British Iron and Steel Research Association (BISRA) had a number of interesting programs on iron and steel, and expenditures for the year 1959 were nearly \$2.3 million. In blast furnace chemistry, BISRA used a special apparatus with a stationary charge in controlled environment to simulate actual blast furnace conditions. In this apparatus, full-sized blast furnace materials are subject to the conditions experienced by a normal charge during its passage down the blast furnace stack. The materials remain stationary, and gas of controlled composition and temperature is circulated through them in a closed system.

Using this apparatus in experiments on sintering, the strongest sinter is produced when the quantity of air slightly exceeds that needed for gaseous combustion and the waste gas flow is just sufficient to draw gasses from the bed. The practicability of injecting pulverized coal and oxygen, with or without iron ore fines, in the blast furnace hearth was examined.

In new ironmaking techniques, BISRA continued its steady progress in developing the flame smelting process. Problems connected with constant rates of feed of powdered coal and ore to the high temperature reactor were solved, and the reliability of the unit was improved so that molten metal and slag could be made at will.

In steelmaking, a survey of the use of gaseous oxygen in open hearth furnaces showed that the greatest use of oxygen was in combustion of the fuel for melting or refining the charge. The use of oxygen shortens steelmaking time and reduces cost. In oxygen-converter steelmaking research, extensive trials were made at the Vale and the Daubessy laboratories using the flame-brightness method for determining the end point of the refining period. In ingot practice,

⁶¹ Department of Mines and Technical Surveys, *Uranium in Steel*: Ottawa, Canada, January 30, 1961, 9 pp.

experiments were carried out, comparing the yield obtained by chemical capping to that obtained with rimmed steel ingots.

At the Sheffield laboratories, valuable operating data were developed on the design of continuous casting equipment. Of particular interest was a pneumatic spring-mounted mold system that was designed to give good surface quality and high casting speeds. In this system the mold is mounted on springs to take care of friction as the metal passes through the vertically mounted mold. As the friction increases, the mold is pulled downward against the springs, and then at a predetermined moment the pneumatic cylinders are automatically actuated to give the mold a downward impulse. At the bottom of the stroke, an upward impulse aids the springs in returning the mold to its topmost position.

In research conducted at the Centre National de Recherches metalurgiques, Charleroi, Belgium, in cooperation with BISRA, 4-inch-square ingots of killed steel were cast at speeds of 9 feet per minute. Also considerable progress was made in continuous casting of rimmed steel in 8-inch squares in the BISRA spring-mounted metal. Research was conducted on improving forging equipment, automatic forging, cold-rolling, tinning, plastic-coated steel, and lacquered strip.

An optical instrument was developed for continuously gaging bar in four planes on an experimental rolling mill.

Considerable progress was made in manufacturing high-speed steel rounds and shapes by extrusion of cast material.

At the Sheffield laboratories, a pilot plant fluidized bed was used for rapidly and uniformly cooling 10-cwt. ingot molds in 46 minutes, compared with 380 minutes by normal, natural cooling methods. Provisional patents were filed for a double fluidized-bed recuperator in which strip is fed through the fluidized-bed system without loss of the granular material.

In experiments on the vacuum-degassing of steel with pressures about 0.01 mm. of mercury, the Roots-type blower was successfully used in an experimental plant. However steam ejectors, which are used in the United States, were believed to be the best solution for larger plants.

In electrical sheets the effect of impurities on the magnetic properties were studied. It was determined that sulfur had a marked effect on magnetic properties: both hysteresis loss and coercive force vary linearly with sulfur content. Manganese in quantities up to 0.2 percent was found to modify the effect of sulfur by altering the form and dispersion of the precipitated sulphide phase. Automatic magnetic testing equipment, which enables rapid measurements of the fundamental properties and thus facilitates studies on electrical sheet, was installed.

Alloy steel studies included internal friction techniques to study grain boundary properties. A report on these studies states: "The spectrum of relaxation peaks forming the damping/temperature curve contains a peak which is associated with the movement of grain boundaries and it has been shown that there are differences in the damping curves of temper-embrittled and non-embrittlement of high purity iron-nitrogen alloys."

The research association has been granted some 37 patents in the United Kingdom with 111 applications pending. Income from royalties on patents in 1959 was \$44,960.⁶²

Research, financed by the High Authority of the European Coal and Steel Community, in progress in 1960 was as follows: Prospecting for iron and manganese ores in certain African countries, utilization of liquid and gaseous hydrocarbons in blast furnaces, direct reduction of iron ore, study of flames, improvement and utilization of blast-furnace gas, and dedusting of reddish-brown fumes produced by converting molten pig iron by means of oxygen.

Research on using liquid fuel in the blast furnace resulted in a 20-percent decline in coke consumption and a 15-percent increase in productivity. Each 80 to 90 kilograms of fuel used per ton of pig iron required a 100° C. increase in hot-blast temperature. The use of oxygen (24 percent of the blast) resulted in a 30-percent decrease in coke consumption and up to a 55-percent increase in output. Improvements were also realized by using residual gas, containing 60 percent methane and coke oven gas. Studies on the combustion of unpurified blast-furnace gas were begun, and work on flames continued satisfactorily. Considerable progress was made in producing a high-quality direct iron product in a rotary kiln for steel-furnace use. Ring formations in the kiln and desulfurization of the iron product were overcome. Dedusting of reddish-brown fumes was technically feasible, but the cost of recovering the vapor and heat to make the process economical was not realized in the apparatus used.⁶³

⁶² Iron and Coal Trades Review, vol. 181, No. 4812, Oct. 7, 1960, pp. 787-791.

⁶³ European Coal and Steel Community, Ninth General Report on the Activities of the Community: Jan. 31, 1961, pp. 240-246.