TABLE XXXIX.—Furnace Yield (Hubertushütte).

Average for the Year.		Percentage Yield. Added Ore included.			Percentage Yield. Added Ore not included.	
		Metal.	Slag.	Loss.	Sound Ingots.	Waste.
1905, . . .	With 50 to 55 per cent. molten pig,					
1906, . . .						
1907, . . .		85·7	13·2	1·1	94 to 96 (according to quality of scrap iron).	3·0
1908, . . .						
1909 (6 months),						
Charge all molten pig, .		85·0	13·8	1·2	101·85	3·15

Table xxxix. shows difference in yield when using 50 per cent. scrap and all pig-iron.

TABLE XL.—Consumption of Material (Weight per cent. of Sound Ingots), (Hubertushütte).

Average for the Year.	Iron Ore.	Quicklime.	Coal.	Calcined Dolomite.	Sintered Magnesite.	Ingot Moulds. Cost per Ton of Ingots.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	s.
1905, . .	13·0	4·8	35·6			1·65
1906, . .	14·8	3·3	31·8			1·57
1907, . .	15·9	4·0	25·0	4 to 6	0·1	1·52
1908, . .	11·7	3·6	18·7			1·59
1909 (6 months),	11·6	4·7	17·0			1·62

The low coal consumption shown in Table xl., after 1906, is due to use of coke-oven gas, and the furnaces have been heated with this since that date.

TABLE XLI.—Chemical Changes in Charge No. 3,033 (Julienhütte).

Sample taken at o'clock.	Analysis of Metal, per cent.					Analysis of Slag, per cent.								Charges and Adjuncts.	Remarks.
	C.	P.	Mn	Si.	S	FeO.	MnO.	Al_2O_3.	CaO.	MgO.	P_2O_5.	S.	SiO_2.		
Mixer Iron	3·610	0·410	2·10	1·21	0·050	...	...	...	...	...	...	...	...	7,210 kg. Krivoi-Rog ore, 1,000 kg. lime.	
1.10	...	...	...	...	...	41·30	10·56	2·40	14·86	7·14	3·50	0·061	20·20	32,100 kg. pig and 8,170 kg. turnings.	Charge frothing.
1.40	...	...	...	...	...	42·04	10·15	1·40	15·40	7·05	3·85	0·066	20·05		
2.0	...	...	...	...	...	44·75	9·04	2·15	15·29	6·34	3·73	0·060	18·50		
2.45	0·730	0·066	0·06	Traces	0·037	25·38	9·11	3·40	23·89	9·03	4·03	0·068	24·60		
3.25	0·635	0·048	0·10	,,	0·029	16·23	9·19	4·50	32·06	8·41	3·50	0·057	25·70	370 kg. lime.	All melted.
3.40	0·497	0·052	0·13	,,	0·030	13·65	8·70	4·08	34·47	7·80	3·57	0·075	26·98	490 ,, ,, 255 kg. ore.	Charge begins to boil.
3.55	0·386	0·042	0·15	,,	0·037	13·51	7·67	3·74	36·89	7·87	3·57	0·068	26·70	560 ,, ,, 340 ,, ,,	Charge boils freely.
4.10	0·272	0·032	0·14	,,	0·038	14·73	7·50	5·06	35·98	7·80	3·71	0·066	24·80	210 ,, ,,	
4.20	0·211	0·036	0·17	,,	0·035	14·19	6·87	4·80	39·08	7·51	3·37	0·068	23·70	170 ,, ore.	
4.35	0·142	0·035	0·17	,,	0·030	13·37	7·36	3·95	39·97	7·76	3·50	0·078	23·90	110 ,, lime.	
4.45	0·104	0·032	0·19	,,	0·027	13·24	6·87	4·22	39·69	7·99	3·37	0·075	23·90	120 ,, ,,	
5.0	0·088	0·029	0·19	,,	0·030	13·37	6·25	4·28	42·97	7·44	3·21	0·068	21·86	165 ,, Ferro-Manganese.	Charge quiet.
5.10	0·113	0·034	0·45	,,	0·030	12·69	7·60	4·26	43·89	6·90	3·24	0·068	20·85		Furnace tapped.
Sample of finished steel.	0·105	0·036	0·43	,,	0·035	...	...	...	...	...	...	...	...		

Charge introduced, . . . 11.20 o'clock.
Pig-iron run in, . . . 12.30 ,,
Tapped, ... 5.10 ,,

Yield, . . . 39,490 kg. sound ingots = 98·06 per cent.
970 ,, casting ingots = 2·41 ,,
Total yield, . 40·460 ,, 100·47 ,,

Table xli. shows chemical changes taking place during the working of charge of medium Silicon iron from the mixer. At this works, the mixer is simply used to store the metal, remove about 30 per cent. of the Sulphur, and desiliconise to a small extent.

TABLE XLII.—CHEMICAL CHANGES IN CHARGE No. 5738 (JURIEVKA WORKS).

Sample taken at o'clock.	Analysis of Metal, per cent. C.	P.	Mn.	Si.	S.	Analysis of Slag, per cent. FeO.	MnO.	Al_2O_3.	CaO.	MgO.	P_2O_5.	S.	SiO_2.	Charge and Adjuncts.	Remarks.
7.15	4·20	0·15	2·50	1·10	0·06	...	...	...	...	...	...	...	...	6,314 kg. ore and 2,132 kg. limestone.	Charging commenced.
7.40	4·44	0·08	2·28	0·88	0·03	...	...	...	...	...	...	...	...	} molten pig, 28,520 kg.	Ladle I.
8.0	4·28	0·08	2·39	0·84	0·03	...	...	...	...	...	...	...	...		,, II.
8.30	2·04	0·03	0·11	Trcs.	0·02	33·28	17·03	5·61	20·50	2·59	1·15	0·38	19·52	......	Charge froths strongly.
9.0	...	0·03	0·17	,,	0·01	24·89	16·24	10·00	23·00	3·09	1·31	0·33	21·52	......	Charge gradually settles.
9.30	...	0·02	0·19	,,	0·02	20·07	16·34	9·09	27·60	3·53	1·21	0·27	22·44	492 kg. ore.	Charge quiet.
10.0	0·95	0·02	0·21	,,	0·02	20·87	15·32	5·86	31·35	3·81	1·15	0·49	21·52	328 ,,	
10.20	...	...	...	...	...	...	...	...	...	...	...	...	...	246 ,,	
10.30	0·55	0·03	0·25	,,	0·03	17·88	15·26	4·80	33·41	5·98	1·01	0·38	21·68	197 ,,	Charge froths slightly.
10.50	...	...	...	...	...	...	...	...	...	...	...	...	...	Two shovels of sand.	Charge quiet.
														262 kg. Ferro-Manganese (80 per cent.)	Charge throws up bubbles.
11.0	0·23	0·02	0·28	,,	0·02	14·62	13·58	5·69	36·50	7·49	0·92	0·27	21·50	49 kg. Ferro-Manganese at 11.20 o'clock.	Charge boils quietly.
11.30	0·08	0·04	0·58	,,	0·04	10·76	15·05	6·27	37·52	8·43	0·73	0·33	20·80	......	Furnace tapped.

Yield: Sound ingots 28,011 kg. = 102·2 per cent.; Casting waste 508 kg. = 1·1 per cent.; Slag 4,084 kg.

Table xlii. shows the chemical changes during the working of low Phosphoric metal direct from the blast furnace at the Donetz-Jurievka Works in Russia. The blast-furnace metal gives an average analysis of Carbon, 4·2; Silicon, 1·1; Manganese, 2·5; Phosphorus, 0·15; and Sulphur, 0·06; and is so regular that although two mixers have been installed they are not required.

TABLE XLIII.—TECHNICAL EFFICIENCY OF THE 30 TO 35-TON FURNACES (JURIEVKA WORKS).

Average for the Year.	No. of Charges per Furnace per Day.	Daily Output per Furnace.	Monthly Output.	Weight per Charge.	Annual Output of Ingots.
		Tons.	Tons.	Tons.	Tons.
1905, ...	4·0	100·2	11,220	25·1	134,200
1906, ...	3·9	108·3	11,310	27·7	135,600
1907, ...	3·7	109·8	11,230	27·7	134,350
1908, ...	3·8	114·0	12,810	30·0	153,610
1909 (6 months), . .	4·2	129·0	16,550	30·7	...

TABLE XLIV.—CONSUMPTION OF MATERIALS (JURIEVKA WORKS). (WEIGHTS PER CENT. OF SOUND INGOTS.)

Average for the Year.	Iron Ore.	Limestone.	Coal.	Calcined Dolomite.	Sintered Magnesite.	Ingot Moulds. Cost per Ton of Ingots.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	s.
1905, . .	22·8	7·8	23·4	4·5	0·16	2·1
1906, . .	20·4	8·2	22·5	4·4	0·15	1·7
1907, . .	21·0	8·3	24·8	4·3	0·15	1·8
1908, . .	21·8	8·1	25·4	3·9	0·22	1·9
1909 (6 months),	22·8	8 0	22·4	3·4	0·15	1·8

TABLE XLV.—YIELD FROM FURNACES (JURIEVKA WORKS).

Average for the Year.	Percentage Yield (Total Charge, including Ore).		Percentage Yield (added Ore not included).		
	Metal.	Slag.	Sound Ingots.	Casting Waste.	Total Yield of Metal.
1905, ...	85·52	5·07*	101·40	4·98	106·33
1906, ...	86·26	5·96*	101·28	3·78	105·07
1907, ...	85·93	13·63	101·33	3·46	104·79
1908, ...	84·86	13·08	102·20	3·60	105·80
1909 (6 months), . .	85·80	12·40	103·00	4·20	107·20

Tables xliii., xliv., and xlv. give particulars as to output, materials used, and yield for five years, 1905-1909, at the Donetz-Jurievka Works, Russia.

* Data estimated, slag having been thrown away.

TABLE XLVI.—YIELD FROM COMBINED PROCESS (WITKOWITZ).

Average for Years.	Yield in per Cent.				
	Added Ore Included.			Added Ore not Included.	
	Metal.	Loss.	Open-hearth Slag.	Sound Ingots.	Pouring Waste.
1904-5 . .	87·14	12·86	10·09	90·73	4·09
1905-6 . .	87·07	12·93	12·17	90·81	3·23
1906-7 . .	86·52	13·48	12·59	89·42	3·28
1907-8 . .	87·00	13·00	11·46	89·43	3·97
1908-9 . .	87·12	12·88	10·39	89·25	2·11

TABLE XLVII.—TECHNICAL EFFICIENCY OF FURNACES (WITKOWITZ).

Average for Years.	No. of Daily Charges per Furnace.	Daily Output per Furnace.	Monthly Output per Furnace.	Weight of Charge.	Annual Output of Ingots.
		Tons.	Tons.	Tons.	Tons.
1904-5 . .	6·7	135·7	3,528·2	20·1	127,857·1
1905-6 . .	6·7	136·2	3,541·2	20·1	127,093·8
1906-7 . .	5·8	117·7	3,201·4	20·2	134,560·1
1907-8 . .	5·8	114·8	3,099·6	19·8	150,650·6
1908-9 . .	6·0	121·4	3,277·8	19·9	157,558·1

TABLE XLVIII.—CONSUMPTION OF MATERIALS IN COMBINED PROCESS (WITKOWITZ).

Average for Years.	Weight in per cent. of Sound Ingots.					Ingot Moulds.
	Iron Ore.	Lime.	Coal.	Dolomite (Calcd.)	Magnesite (Sint.)	
						Kg.
1904-5, . .	4·0	5·9	14·7	3·64	0·20	1·30
1905-6, . .	4·7	6·3	14·1	2·51	0·20	1·23
1906-7, . .	3·7	7·2	15·0	2·34	0·24	1·34
1907-8, . .	3·1	7·4	14·3	3·10	0·28	1·43
1908-9, . .	2·7	7·8	10·5	2·67	0·31	1·31

Tables xlvi., xlvii., and xlviii. show the yield, consumption of material, and output from the Duplex process at Witkowitz.

The metal, which contains about 0·4 per cent. of Phosphorus, is blown in acid Bessemer converter to eliminate the greater part of the Carbon, Silicon, and Manganese, and then this refined metal is converted into finished steel in a basic open-hearth furnace.

The refined metal, after Bessemerising, has the following composition:—Silicon 0·04 to 0·06, Manganese 0·25 to 0·35, Carbon 0·10 to 0·20, and Phosphorus 0·30 to 0·50 per cent.

The Talbot Process.

TABLE XLIX.—CHEMICAL CHANGES IN CHARGE B, CARGO FLEET, 16TH NOV., 1909.

Time o'clock.	Analysis of the Metal, per cent.					Analysis of the Slags, per cent.			Charges and Adjuncts.	Remarks.
	C.	P.	Mn.	Si.	S.	SiO_2	FeO.	MnO.		
2.25	0·08	0·038	0·17	...	0·048	...	...	...	......	About 120 tons metal in furnace.
2.45	...	...	...	...	...	11·70	14·01	6·32	......	Furnace walls repaired, 12 tons of slag drawn off.
3.5	...	...	...	...	...	...	...	...	9,140 kg. Gellivara ore, 3,450 kg. lime.	
3.15	3·30	1·650	0·70	1·13	0·061	...	...	...	22,350 kg. molten pig.	
4.40	0·05	0·013	Trace	...	0·050	10·40	22·37	4·09	... ...	
4.45	...	...	...	...	...	...	...	...	2,030 kg. purple ore, 2,130 kg. lime.	
5.5	3·30	1·22	...	1·17	0·059	...	...	...	20,320 kg. molten pig.	
6.15	3·30	1·22	...	1·17	0·059	...	...	...	15,240 ,, ,,	
6.50	...	...	...	...	...	...	...	...	865 kg. lime.	
7.0	0·55	0·018	...	0·039	0·083	11·90	13·24	7·64	......	
7.10	...	...	...	...	...	...	...	...	865 kg. lime.	
7.20	0·45	0·150	...	...	0·050	...	...	...	......	
7.30	...	...	...	...	...	...	...	...	1,020 kg. rolling mill scale.	
8.0	...	...	...	...	...	...	...	...	1,320 kg. purple ore.	
8.5	0·26	0·030	...	...	...	...	...	...	......	
8.30	...	...	...	...	...	...	...	...	1,520 kg. Gellivara ore, 430 kg. lime.	
9.0	...	...	...	...	...	...	...	...	Duration of charge between tappings, 6 hrs. 35 min.	About 55 tons of steel drawn off in ladle with 430 kg. Ferro-Manganese (80 per cent.), 51 kg. Ferro-Silicon (50 per cent.), and Anthracite.
9.10	0·10	0·019	...	3·047	0·033	10·80	14·14	6·32	Composition of finished steel: 0·55 per cent. **C**, 0·68 per cent. **Mn**, 0·026 per cent. **P**, 0·041 per cent. **S**.	

Table xlix. shows the chemical changes during the working of the charges by the Talbot process.

The Talbot Process.

TABLE L.—CHEMICAL CHANGES IN CHARGE C, CARGO FLEET, 16TH NOV., 1909.

Time o'clock.	Analysis of the Metals, per cent.					Analysis of the Slag, per cent.			Charges and Adjuncts.	Remarks.
	C.	P.	Mn.	Si.	S.	SiO_2.	FeO.	MnO.		
11.50	0·16	0·046	0·019	...	0·048	...	...	...	......	About 120 tons metal in furnance.
12.0	...	...	...	...	...	9·20	15·15	5·58	......	Furnace walls repaired, 8 tons of slag drawn off.
12.20	...	...	...	...	...	...	...	...	4,570 kg. Gellivara ore, 2,130 kg. lime.	
12.30	3·65	1·660	0·77	1·39	0·044	...	...	...	22,350 kg. molten pig.	
12.55	0·40	0·058	Trace	...	0·037	9·00	20·57	4·83	......	
1.0	...	...	...	...	...	...	...	...	4,570 kg. Gellivara ore, 2,130 kg. lime.	
1.10	...	1·560	...	0·93	0·067	...	...	...	22,350 kg. molten pig.	
1.30	...	1·600	...	0·65	0·086	...	...	...	8,130 ,, ,,	
2.20	0·65	0·088	Trace	...	0·048	11·20	14·77	2·60	......	
2.25	...	...	...	...	...	...	...	...	1,020 kg. purple ore, 1,270 kg. lime.	
2.30	...	...	...	...	...	...	...	...	1,020 kg. Gellivara ore, 860 kg. lime.	
2.40	0·50	0·080	...	...	...	...	...	...	......	
2.45	...	...	...	...	...	...	...	...	860 kg. lime.	
3.15	0·39	0·040	...	...	...	...	...	...	......	
3.40	0·28	...	...	...	...	...	...	...	......	
3.55	0·22	...	...	...	...	...	...	...	......	
4.0	...	...	...	...	...	...	...	...	860 kg. lime.	
4.20	0·21	0·011	...	0·036	0·032	13·20	13·24	6·32	Duration of charge between tappings, 4 hrs. 30 min. Composition of finished steel: 0·45 per cent. C, 0·68 per cent. Mn, 0·033 per cent. P, 0·040 per cent. S.	About 54 tons of steel drawn off in ladle with 430 kg. Ferro-Manganese (80 per cent.), 51 kg. Ferro-Silicon (50 per cent.), and Anthracite.

Table l. shows the chemical changes during the working of the charges by the Talbot process.

TABLE LI.—WEEKLY RECORD OF A TALBOT FURNACE (175-TON FURNACE, CARGO FLEET).

Date.	Charge.	Molten Pig.					Scrap.	Iron Ore.	Rolling-Mill Scale.	Lime.	Dross.	Ferro-Manganese.	Ferro-Silicon.	Yield of Sound Ingots.	Composition of Finished Product.				Uses of the Iron.
		Weight.	Composition.												C.	S.	P.	Mn.	
			Si.	S.	Mn.	P.													
1909.	No.	Kg.					Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.					
Sept. 5	2,276	152,400	1·32	0·113	0·65	1·58	..	26,416	3,556	27,940	16,916	356	76	57,963	0·155	0·054	0·028	0·570	
,, 5	2,277	76,200					..	17,272	2,337	14,732	2,184	533	76	54,966	0·515	0·055	0·029	0 700	Rails.
,, 6	2,278	55,880					..	14,224	1,168	9,144	2,946	508	76	58,217	0·590	0·063	0·044	0·700	,,
,, 6	2,279	..	1·15	0·122	0·63	1·60	..	..	..	..	..	508	76	59,030	0·580	0·062	0·042	0·655	,,
,, 6	2,280	79,248					30,480	17,272	1,168	14,732	6,604	457	76	57,404	0·160	0·055	0·032	0·700	Construction work.
,, 7	2,281	50,800					10,160	13,716	2,337	8,128	2,946	381	76	54,610	0·185	0·058	0·030	0·660	,,
,, 7	2,282	..	1·09	0·107	0·69	1·83	..	..	..	..	..	381	76	54,610	0·180	0·058	0·032	0·686	,,
,, 7	2,283	76,200					32,512	14,224	3,556	14,732	5,893	457	76	58,217	0·370	0·058	0·029	0·733	Special steel.
,, 8	2,284	..	..	..	..	..	..	..	..	..	..	356	76	58,217	0·170	0·059	0·028	0·630	Construction work
,, 8	2,285	71,120					40,640	14,224	2,337	16,256	6,604	457	254	57,099	0·590	0·053	0·031	0·666	Rails.
,, 8	2,286	..	1·11	0·122	0·67	1·69	..	..	..	..	..	406	51	56,490	0·180	0·053	0·030	0·600	Construction work.
,, 8	2,287	76,200					35,560	2,032	1,168	11,648	7,620	356	76	57,404	0·196	0·058	0·041	0·656	,,
,, 9	2,288	..	..	..	..	..	..	..	..	..	..	356	76	58,979	0·180	0·058	0 040	0·600	,,
,, 9	2,289	83,360	0·96	0·111	0·69	1·63	30,480	17,272	2,337	15,748	3,658	381	51	55,626	0·190	0 056	0·030	0·670	,,
,, 9	2,290	55,880					..	17 272	2,337	12,700	2,184	457	76	58,217	0·590	0·054	0·026	0·733	Rails.
,, 10	2,291	60,960					..	14,224	1,168	11,176	5,080	483	51	56,033	0·590	0·052	0·023	0·750	,,
,, 10	2,292	..					..	..	..	..	..	483	51	56,033	0·570	0·051	0·023	0·790	,,
,, 10	2,293	86,360	1·13	0·101	0·67	1·61	25,400	17,272	1,676	15,748	9,950	483	76	58,217	0·590	0·060	0·029	0·725	,,
,, 10	2,294	..					..	..	..	..	..	432	76	60,808	0·180	0·060	0·028	0·620	Construction work.
,, 10	2,295	111,760					..	23,368	1,981	16,256	1,473	483	51	57,201	0·540	0·059	0·050	0·830	Rails.
,, 11	2,296	..	..	..	..	..	..	..	..	..	..	381	102	54,610	0·175	0·058	0·050	0·790	Construction work.
,, 11	2,297	15,240	1·06	0·104	0·69	..	..	..	..	..	..	381	102	53,289	0·160	0·053	0·030	0·525	,,
	22 Charges.	1,044,448	Time worked in the week 155 hours 15 minutes.				205,232	208,788	27,127	188,976	73,660	9,474	1,768	1,253,744	..	..	..	..	

Total, . . . 1,044,448 kg. molten pig
205,232 ,, scrap.
1,249,680 ,, metal charge.

208,788 kg. iron ore.
27,127 ,, rolling-mill scale.
73,660 ,, purple ore.
309,575 ,, added ore = 24 per cent. of the total weight of ingots producad.

22,352 kg. dolomite consumption = 1·78 per cent. of the yield of ingots.
188,976 ,, lime consumption = 15 00 per cent.
Total yield, . . . 1,253,744 ,, sound ingots + 17,780 kg. casting waste (= 100·3 per cent. of sound ingots = 101·7 per cent. total yield).

Table li. gives a summary of materials used, yield, &c., under normal conditions of working Talbot process.

TABLE LII.—WEEKLY SUMMARY OF STEEL OUTPUT (TALBOT FURNACE AT AN ENGLISH WORKS).

Metals.	Five Ordinary Open-hearth Furnaces.		Two Talbot Furnaces.			
			I. (100-ton).		II. (150-ton).	
	Kg.	Kg/t.	Kg.	Kg/t.	Kg.	Kg/t.
Pig iron, . . .	876,300	602	659,892	868	688,949	842
Scrap, . . .	550,672	379	...	...	108,407	133
Ferro-Manganese, . .	10,363	7	5,588	8	5,994	7
Hematite, . . .	25,400	17	16,154	21	14,224	17
Cold pig, . . .	48,869	34	...	...	10,160	12
Spiegeleisen, . .	8,585	6	7,010	10	12,294	15
Ferro-Silicon, . .	...	...	...	...	...	...
Total, . .	1,520,190	1,045	688,644	907	840,028	1,026
Sound ingots, . .	1,454,404	...	760,152	...	817,816	...
Slag, ...	...	...	247,244	325	247,243	302
Scrap waste, . .	...	...	5,436	...	4,674	...
Rolling-mill scale, .	91,643	63	47,904	63	47,904	59
Hammer scale, . .	10,109	7	...	...	...	...
Gellivara ore, . .	106,578	73	164,795	217	175,869	215
Total, . .	208,330	143	212,699	280	223,774	274
Limestone, . . .	224,739	157	...	..	...	...
Lime, ...	55,067	38	118,618	156	135,382	166
Yield, in per cent. of the metal charge,	95·68	...	* I. 110·4 = 111·2 with scrap.		† II. 97·36 = 97·95 with scrap.	
Coal Consumption, .	42·7 per cent.		25·9 per cent.			

Table lii. gives a comparative summary of materials used, yield, &c., of five ordinary open-hearth furnaces and two Talbot furnaces.

* This yield is above the average. † This yield is below the average.

TABLE LIII.—SUMMARY OF THE WORKING OF TALBOT CHARGES.

I.—Charges with Large Addition of Scrap.

Material.	Three Furnaces.		Three Furnaces.		Three Furnaces.		Three Furnaces.	
	Kg.	Per cent.	Kg.	Per cent.	Kg.	Per cent.	Kg.	Per cent.
Molten pig, . .	1,467,766	44·8	2,080,768	66·6	2,021,434	63·5	2,090,268	66·3
Cold pig, . .	96,520	2·9	73,152	2·3	20,320	0·6	93,472	3·0
Scrap, . . .	1,673,352	51·2	940,816	30·1	1,110,488	34·9	937,768	29·6
Ferro-Manganese,	26,949	0·82	23,076	0·73	23,965	0·77	25,070	0·78
Ferro-Silicon, .	4,800	0·14	4,356	0·13	3,873	0·12	3,023	0·09
Added ore, . .	239,776	7·2	467,360	14·6	488,696	15·0	567,944	17·6
Lime, . . .	379,984	11·4	482,600	15·1	498,856	15·3	495,808	15·3
Dolomite, . .	48,768	1·5	97,536	3·0	66,040	2·0	92,456	2·8
Sound ingots, .	3,267,456	100·0	3,161,792	101·2	3,203,448	100·7	3,168,904	100·6
Scrap, . . .	53,848	1·5	26,416	0·9	54,864	1·7	62,992	2·0
Yield, . . .	...	101·5	...	102·1	...	102·4	...	102·6

II.—Charges with Medium Addition of Scrap.

Molten pig, . .	2,648,052	81·3	2,556,256	74·8	2,470,912	76·7	2,550,160	72·2
Cold pig, . .	11,176	0·3	26,416	0·7	13,208	0·4	99,568	2·8
Scrap, . . .	562,864	17·3	797,306	23·3	701,192	21·7	849,071	24·0
Ferro-Manganese,	29,290	0·9	29,337	0·86	29,388	0·91	30,176	0·86
Ferro-Silicon, .	3,962	0·12	4,445	0·13	6,020	0·19	4,674	0·13
Added ore, . .	854,456	25·8	745,744	21·4	787,400	24·0	712,216	19·9
Lime, . . .	582,168	17·6	618,744	17·8	558,800	17·0	483,616	13·5
Dolomite, . .	57,912	1·7	62,992	1·8	89,408	2·7	69,088	1·9
Sound ingots, .	3,264,408	100·3	3,438,144	100·7	3,213,608	99·8	3,539,744	100·2
Scrap, . . .	38,608	1·1	33,528	1·0	61,976	1·9	35,560	1·0
Yield, . . .	...	101·4	...	101·7	...	101·7	...	101·2

III.—Charges with Very Small Addition of Scrap.

Material.	Two Furnaces.		Two Furnaces.		Two Furnaces.	
	Kg.	Per cent.	Kg.	Per cent.	Kg.	Per cent.
Molten pig, ...	2,134,616	97·0	2,154,396	97·1	1,969,372	91·9
Cold pig, ...	10,160	0·5	10,160	0·4	22,352	1·0
Scrap, ...	31,496	1·4	39,210	1·3	128,016	6·0
Ferro-Manganese, ...	19,304	0·87	20,076	0·94	19,558	0·93
Ferro-Silicon, ...	4,064	0·18	3,962	0·18	3,962	0·18
Added ore, ...	561,848	25·0	618,744	27·8	522,224	24·5
Lime, ...	392,176	17·4	371,856	16·7	352,552	16·5
Dolomite, ...	48,768	2·1	57,912	2·6	76,200	3·6
Sound ingots, ...	2,214,880	100·7	2,186,432	98·5	2,092,960	97·6
Scrap, ...	30,480	1·3	35,560	1·6	34,544	1·6
Yield, ...	...	102·0	...	100·1	...	99·2

Analyses of Pig-Irons suitable for Manufacture of Steel by the Bessemer and Open Hearth Processes.

Acid Processes.

Bessemer.

	Typical Analysis.	
Combined Carbon, . . .	0·40	3·60
Graphite, ...	3·20	
Silicon, ...	2·25	
Sulphur, ...	0·05	
Phosphorus, ...	0·05	
Manganese, ...	0·50	
Arsenic, ...	0·03	

The Carbon will vary from 3·2 to 4·0 per cent. Silicon should not be less than 2·0, nor exceed 2·5 per cent. for Bessemer work in this country, although 3·0 per cent. Silicon pig-iron is sometimes used. In America and Sweden pig-iron containing 1·00 per cent. is frequently employed. The Phosphorus, Sulphur, and Arsenic should be as low as possible, but should never exceed 0·06 per cent. in each case. Manganese should not exceed 1·00 per cent.

Open Hearth or Siemens.

	Typical Analysis.	
Combined Carbon, . . .	0·40	3·60
Graphite, ...	3·20	
Silicon, ...	2·00	
Sulphur, ...	0·04	
Phosphorus, ...	0·04	
Manganese, ...	0·60	
Arsenic, ...	0·03	

The Carbon will vary from 3·2 to 4·0 per cent. Silicon should not exceed 2·50, but may be as low as 1·00 per cent., and large quantities of Swedish pig-iron with this percentage of Silicon are used in Siemens furnaces in this country. Manganese should not exceed 1·00 per cent. Phosphorus, Sulphur, and Arsenic should be as low as possible, the lower the better, but should not exceed 0·05 per cent. in each case.

Basic Processes.

Bessemer.

	Typical Analysis.	
Combined Carbon, . . .	3·40	3·60
Graphite, ...	0·20	
Silicon, ...	1·00 or less	
Sulphur, ...	0·05	
Phosphorus, ...	3·00	
Manganese, ...	2·00	
Arsenic, ...	0·03	

Pig-iron much higher than 1 per cent. Silicon can be used, and frequently is, but it is desirable to keep this as low as possible. The Phosphorus may be as low as 2·5 or as high as 3·5 per cent., but 3·0 per cent. gives better results. Sulphur and Arsenic the lower the better, and in no case exceeding 0·06 per cent.

Open Hearth or Siemens.

	Typical Analysis.	
Combined Carbon, . . .	3·40	3·60
Graphite, ...	0·20	
Silicon, ...	1·00 or less	
Sulphur, ...	0·05	
Phosphorus, ...	2·00 or less	
Manganese, ...	2·00	
Arsenic, ...	0·03	

Pig-iron higher than 1 per cent. Silicon can be used, but it is desirable to keep this as low as possible. For rapid work and production of high-class material the lower the Phosphorus the better, although large quantities of steel are made from pig-iron with 3·00 per cent. or over of Phosphorus. The best all-round results, however, for general work are obtained with 1·75 to 2·00 per cent. Manganese is by no means necessary, but it is difficult to get basic pig low in Sulphur without high Manganese; provided Sulphur is low, 1·00 Manganese or even less is sufficient.

Typical Analyses of Steels from Bessemer and Open Hearth Processes.

Acid.

Bessemer.			Open Hearth or Siemens.		
	Soft Steel.	Rail Steel.		Soft Steel.	Medium and Hard Steel.
Combined Carbon, .	0·10 to ·15	0·32 to ·55	Combined Carbon, .	0·12 to ·20	0·20 to 1·50
Silicon, . .	0·02 ,, ·06	0·04 ,, ·08	Silicon, . .	0·04 ,, ·08	0·04 ,, ·35
Sulphur, . .	0·03 ,, ·08	0·05 ,, ·08	Sulphur, . .	0·02 ,, ·06	0·02 ,, ·06
Phosphorus,	0·04 ,, ·08	0·06 ,, ·08	Phosphorus,	0·02 ,, ·06	0·02 ,, ·06
Manganese, .	0·40 ,, ·80	0·60 ,, 1·00	Manganese, .	0·40 ,, ·60	0·40 ,, 1·00
Arsenic, . .	0·02 ,, ·06	0·02 ,, ·08	Arsenic, . .	0·02 ,, ·06	0·02 ,, ·06

Some special steels made from selected pig-iron will be as low as ·03 per cent. in Phosphorus and Sulphur.

Basic.

Bessemer.			Open Hearth or Siemens.		
	Soft Steel.	Rail Steel.		Soft Steel.	Rail Steel.
Combined Carbon, .	0·08 to ·15	0·32 to ·55	Combined Carbon, .	0·10 to ·18	0·45 to ·70
Silicon, . .	trace.	trace ,, ·02	Silicon, . .	trace.	traces ,, ·35
Sulphur, . .	0·03 to ·08	0·05 ,, ·08	Sulphur, . .	0·02 to ·06	0·04 ,, ·06
Phosphorus,	0·04 ,, ·08	0·06 ,, ·08	Phosphorus,	0·03 ,, ·06	0·04 ,, ·06
Manganese, .	0·40 ,, ·80	0·60 ,, 1·00	Manganese, .	0·40 ,, ·80	0·60 ,, ·90
Arsenic, . .	0·02 ,, ·06	0·02 ,, ·60	Arsenic, . .	0·01 ,, ·06	0·01 ,, ·06

The above are simply typical analyses taken from average steels, and it is not unusual to find the impurities exceed the higher limits given, and, on the other hand, for exceptional purposes steel is made with less than the minimum impurities given above.

Exceptionally pure material containing little more than traces of Phosphorus is made in the basic Siemens by using special Hematite pig-iron low in Silicon and Sulphur.

Analyses of Refractory Materials used for Bessemer Converters and Siemens Furnaces.

Acid or Silicious Materials.

Materials Suitable for Lining Converters.

Ganister.				Silica Bricks.				
	1.	2.	3.		1.	2.	3.	Made from Ganister. 4.
Silica, . .	92·05	94·60	95·20	Silica, . .	96·32	94·80	96·70	94·01
Alumina, .	2·70	1·40	0·59	Alumina, .	1·36	1·40	1·60	2·76
Oxide of iron,	1·85	0·90	0·74	Ferric Oxide,	1·20	1·10	0·65	0·55
Lime, . .	0·60	0·48	0·40	Ferrous Oxide,	nil	nil	nil	nil
Magnesia, .	0·20	0·16	0·16	Lime, . .	1·20	1·90	0·61	2·36
Alkalies, .	0·20	0·14	0·18	Magnesia, .	...	...	...	0·12
Water, .	2·00	2·60	2·70	Titanic Oxide,	...	0·60	...	...
				Alkalies, .	0·21	0·19	0·20	0·18
	99·60	100·28	99·97		100·29	99·99	99·76	99·98

When Silica bricks are used they are frequently jointed with fine ganister, or finely-ground Silica stone, similar in composition to any of the bricks given above.

Materials for Siemens Furnaces.—For the walls, ports, and roofs of Siemens furnaces any of the Silica bricks given above would be suitable as far as the analysis is concerned, all being sufficiently infusible, and they would be set in finely-ground Silica cement containing about 95 per cent. of Silica.

Other questions, however, than those of infusibility, such as contraction and expansion, are very important in determining the selection of a brick for any particular purpose. Thus, although the walls and roof of a Siemens furnace would be built of bricks of similar composition, the texture or fineness of structure of brick selected is often different, coarse-grained bricks being found to give the best results for roofs subject to considerable variation in temperature, and the consequent alternate contraction and expansion. One of the best known bricks used for furnace roofs is the Dinas brick made from the Dinas rock in South Wales. The rock is generally mixed with about 1 per cent. of lime to act as a binding material when made into bricks, which are usually coarse-grained, the rock being only coarsely ground before moulding. The following is a typical analysis:—

Silica, ...	96·80
Alumina, ... ,	0·92
Ferric Oxide, ...	0·50
Lime, ...	1·20
Alkalies, ...	0·20
	99·62

The Alkalies in all kinds of Silica bricks should be as low as possible, preferably not exceeding 0·5 per cent.

For the regenerators Stourbridge or similar fire-bricks are employed.

Basic Materials.

Dolomite.			Calcined Dolomite.			Magnesite.		Chrome Ore.	
	1.	2.		1.	2.				
Silica, .	1·10	0·90	Silica, .	3·66	2·50	Silica, .	0·92	Silica, .	2·25
Oxide of Iron and Alumina,	1·64	1·30	Oxide of Iron and Alumina,	4·80	3·99	Oxide of Iron and Alumina,	4·40	Ferrous Oxide,	35·82
								Alumina,	3·01
Lime, .	33·20	31·00	Lime, .	55·50	57·32	Lime, .	1·82	Lime, .	4·20
Magnesia,	19·60	20·60	Magnesia,	34·83	34·75	Magnesia,	42·70	Magnesia,	2·60
Carbonic Acid, .	44·30	46·34	Loss on ignition,	1·06	1·00	Carbonic Acid, .	50·01	Chromic Oxide,	51·54
	99·84	100·14		99·85	99·56		99·85		99·42

CHAPTER IX.

THE PRODUCTION OF STEEL CASTINGS.

The production of steel castings is so essentially one of those arts which can be acquired only by long experience, and involves a knowledge of so many little details which are of the greatest importance, that it is impossible to do more than give a very general description and draw attention to some of the more important points which are necessary to success.

In addition to preparing metal of the right composition and casting at the right temperature, two all-important points, the composition of the mould, the method of moulding, disposition of the feeding heads, and means of overcoming excessive local strains in contraction, have all to be anticipated and met to secure a satisfactory result. When it is remembered that many of these points vary with different castings according to their weight, strength required, their complexity or the reverse, it will be seen how impossible it is to lay down any very definite rules, and that each case must be left largely to the judgment of the individual responsible.

Steel Employed.—Castings are made from open hearth furnaces, both acid and basic, but generally the former, and from small tipping converters like the Robert, Walrand, and others, or from crucibles, and excellent results can be obtained with all these processes; the electric furnace is also being used with very good results. For the general purposes of a steel foundry when castings of varying sizes are required, a small open hearth furnace is found to give the best results for all-round work, as greater control over both the composition and casting temperature can be exercised. The essential thing in all steel castings is to obtain solid castings free from blowholes, and for this purpose it is most important to get a "dead melt"—that is to say, to finish with a good, thick, clean, non-oxidising slag. If the finishing slag contains much free Oxide the metal will be over-oxidised, with the result that the casting will be spongy. The slag must at the same time be fluid, so that it does not get entangled with the metal, and carried into the casting, and so cause serious defects, and a little ground Fluorspar added to the metal in the ladle is found to give good results in clearing the metal. The temperature of casting is a most important matter, and will vary to some extent