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Copper matting blast furnace run

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Subject

"Copper Matting Blast Furnace Run,"

BY

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STALL ROASTING AND COPPER MATTING IN BLAST FURNACE.

The thory of the copper blast furnace run having been given us in the class room, we wishing to familiarize ourselves with the practical processes and the difficulties involved, selected it as the basis of an investigation of which the following is a correct report.

The original ore was a high grade copper sulphide from the Ducktown, Tenn. district to which was added some heavy pyritic ore from various quarters. The latter was added to furnish the iron oxide necessary as a flux in the blast furnace and sulphur in sufficient amount to make the ore self roasting wheh charged into a previously heated stall roast.

THE ROAST:

The roast was conducted in the following manner. An old pot furnace was found to hold the entire charge. Around this ashes were packed to a depth of five inches on three sides, the wall of a building occupying the fourth side. This was dried out for two days previous to chargig and then heated to as high a temperature as possible with soft coal. The fire was then drawn and the ore dumped in, the ore having previously been spalled to one inch size and sampled by lump sample method.

Moderately heavy fumes were noticed coming off immediately after charging and they continued to come off for forty hours thereafter when they stopped and the charge was drawn.

The ore was found to be sufficiently roasted and was mixed, sampled and weighed and made ready for the blast furnace run. To make the roasted ore ready for the blast furnace, the fines had to be sifted out and mixed with a small amount of molasses and water and briquetted fand these dried for a week in the boiler room.

The roasted ore was sampled by mixing and quartering until the sample wieghed ten pounds when it was crushed and sampled down to one half pound with a "Jones' Sampler". Samples were all bucked down to pass a 12 120 mesh sieve and analyzed.

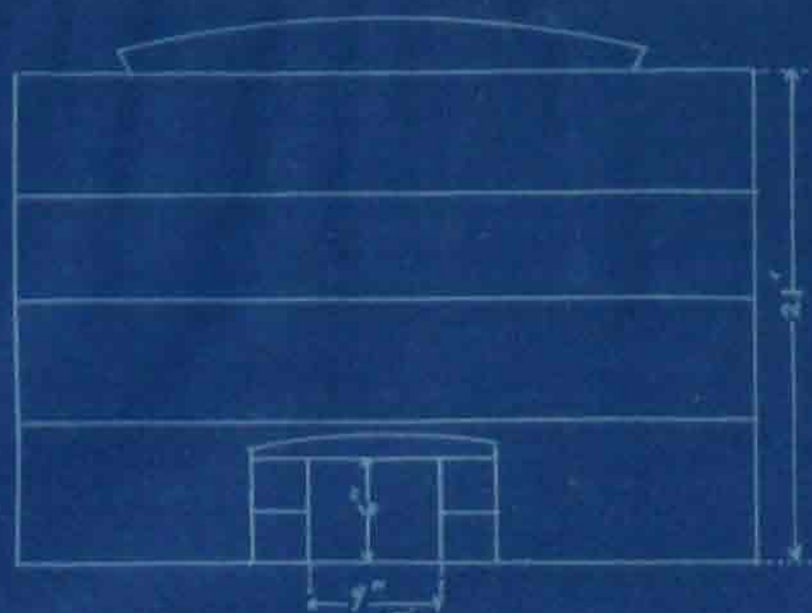
Comments on the roasting:

Ordinary stall roasting is carried on in a slag brick roaster with three sides enclosed and the fourth side open and has the ore and fuel charged together.. In this way it requires ten days to roast a twenty ton charge from 25% sulphure down to 10 % Sulphur.

THE BLAST FURNACE:

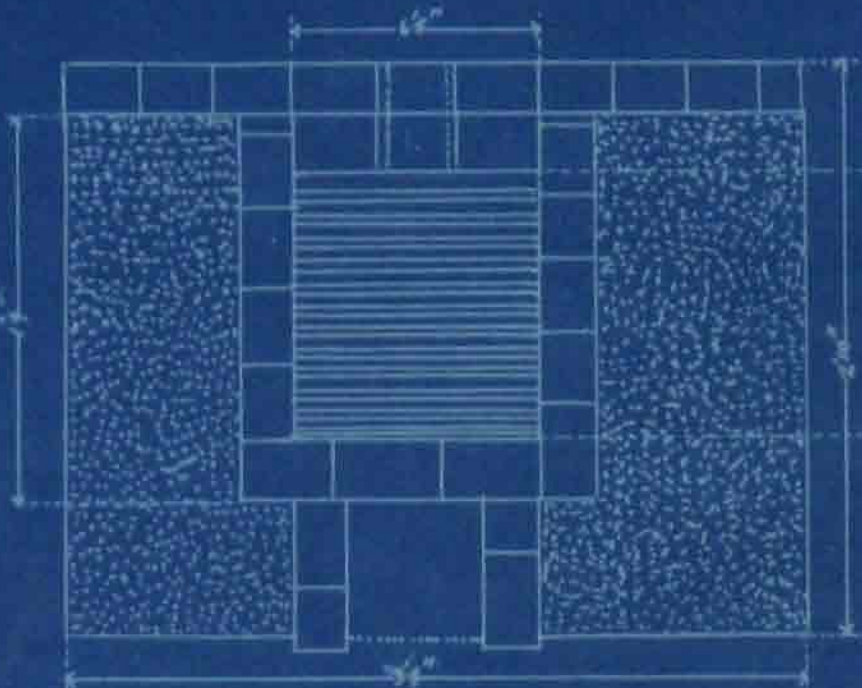
This was one of the small,round,water jacketed type. A false bottom of coke and cement was put in this, thus closing the matte well, metal tap and drain tap, our object being to tap matte and slag together and make separation of the two in an external fore-hearth. Experience had previously shown that the furnace froze when the internal crucible was used. (Figure x is a blue -print showing size and proportions of the blast furnace used.)

The fore-hearth worked well until the matte worked its way through the bottom of the pot, which was due to a high temperature and no clay wash in the bottom to protect it. We substituted the regular slag pot for the fore-hearth after it broke and obtained a very good separation of matte and slag.



elevation.

STALL ROASTING FURNACE.



Plan.

Fore hearth Construction:

This was made of sheet metal one fourth of an inch thick and lined with a layer of brick, a grate having ~~been~~ previously been constructed to give the coke sufficient oxygen. (Fore-hearth shown in figure 1.).

The material in the fore hearth was cooled, broken and re-smelted after the fore-hearth broke.

The analysis of the original ore was as follows;

Copper, Sulphur, Iron, Gold, Silver.-

Slag Calculation.

30 SiO_2 45 FeO 15 CaO

Analysis of roasted ore and fluxes:

	SiO_2	FeO	CaO	Al_2O_3	S	Cu
Roasted ore	17.33	10.17	2.5	35.98	10.82	21.28
Sil. Rock	81.0	6.5	2.7	———	———	———
Limestone	1.4	———	55.2	———	———	———
Iron Ore	———	85.0	———	———	———	———
Slag	24.2	34.5	1.	5.4	7.5	13.8
Coke ash	50.0	38.0	1.5	———	———	———

To adjust the oxides:

Consider 10% of the alumina as acting as an acid. We then have 3.6% (in terms of Al_2O_3) SiO_2 and the remaining 32.38% as FeO.

$\frac{72}{102}$ x 32.38 equals 22.86 FeO

$\frac{50.4}{102}$ x 3.6 equals $\frac{1}{2}$ x 3.6 equals 1.8 SiO_2

Adjusted Oxides.

	SiO_2	FeO	CaO	S	Cu	PbO
Roasted Ore	19.13	33.03	2.5	10.82	21.28	
Sil. Rock	81.0	6.5	2.7	___	___	
Limestone	1.4	___	55.2	___	___	
Iron Ore	___	85.0	___	___	___	
Slag	24.2	38.1	21.5	___	___	13.8
Coke Ash.	50.0	38.0	1.5	___	___	___

Ore weighs 100 pounds.

21.28 Cu will take S as Cu_2S

Cu_2 ; S : : 126.8 : 32 equals 21.28 : x

x equals 5.38 # S to join with 21.28 # Cu in ore

Figure to burn off 30% S

.30 x 10.82 equals 3.246 (Sulphur burned off)

5.38 plus 3.25 equals 8.63

10.82 minus 8.63 equals 2.19 (Sulphur remaining in ore to join with Fe to form FeS)

Fe : S : : 56 : 32 equals x : 2.19

x equals 3.83 # Fe required to form FeS

3.83 x $\frac{9}{7}$ equals 4.92 FeO equivalent to 3.83 Fe.

33.03 minus 4.92 equals 28.11 (FeO left in roasted ore).

	21.28 # Copper
	7.57 # Sulphur
Grade of Copper Matte	3.83 # Iron
	32.68 (total in matte)

XXII. $\frac{21.28}{32.68}$ equals 65.1 % Cu. in matte

To Flux the Ore.

The available FeO in the ore will go to slag the SiO_2 of the ore. (Have 28.11 FeO available.)

SiO_2 : FeO :: 30 : 45 equals 19.13 : x

x equals 28.69, FeO needed to flux SiO_2

28.11 FeO present, hence

28.11 minus 28.69 equals .59 FeO remaining.

This was considered good and no iron ore needed.

SiO_2: CaO :: 30 : 15 equals 19.13 : x.

x equals 9.56 CaO to flux silica

2.5 % CaO present, hence

add 9.56 minus 2.5 equals 7.06 # CaO.

Limestone : CaO :: 100 : 5.5 equals x : 7.06

x equals 13# limestone

To Flux the Ash of the Coke.

Use 19% coke. Coke is 12% ash.

12% of 19 equals 2.28# ash

50% of 2.28 equals 1.14# SiO_2 of ash
38% of 2.28 equals .86# FeO of ash

1.5% of 2.28 equals .034# CaO of ash

To get FeO to flux SiO_2 of ash:

30 : 45 :: 1.14 : x

x equals 1.7 FeO required to flux SiO_2 of ash

Have present .87# FeO

1.7 minus .87 equals .83 FeO to be added in form of iron ore.

100 : 85 :: x : .83

x equals 1.00# iron ore needed to flux 19# coke

30 : 15 :: 1.14 : x

x equals 5.4# CaO required to flux SiO_2 of ash.

Have present .034 CaO in ash

.54 minus .034 equals .506 CaO required as limestone

Limestone : CaO :: 100 : 5.5 equals x : .506

x equals .92# limestone for 19 # coke.

To Make Up Ore Charges:

19# coke containing 2.28# ash.

Fluxes for ash equal 1.00# iron ore
.92# limestone
3.10 total

Make charge thus:

Regular charge is 1/2 ore plus 1/2 slag plus coke ash with fluxes for 19#

100# minus 3.10# equals 97.# (approx.)

$\frac{97}{2}$ equals 48.5# weight of slag
48.5# weight of ore and fluxes

48.5# minus 13# limestone equals 35.5# ore to be added.

Hence regular charge is

35.5# ore
(13# plus .92#) 13.92 # limestone
1.00 # iron ore
48.50 # slag (old)
19.00 # coke

Blowing in charge:

NO. 1 and 2; Coke 60 # (7.2 # ash)
slag 17 #

No. 3 Coke 40 #
SiO_2 5 # (Rock)
Slag 106 #

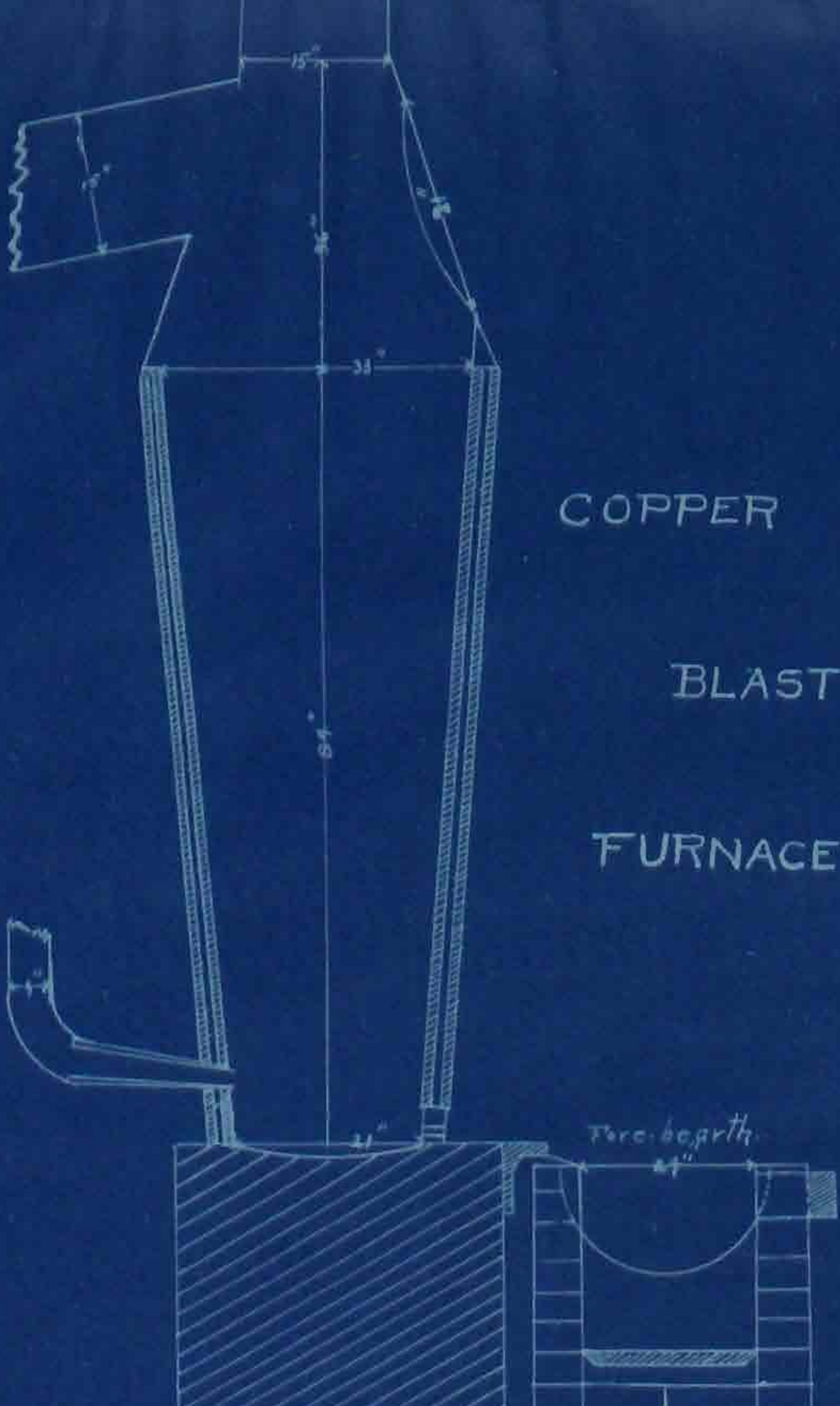
No. 4 Coke 40 #
SiO_2 10 # (Rock)
Slag 212#

No. 5 Ore 17.7 #
Limestone 7.00 #
Iron ore 1.00 #
Slag 48.5 #
Coke 19. #

No. 6 Regular charge

No. 7 Regular charge.

The five following sheets are original data collected during the actual run.of the blast furnace.



COPPER

BLAST

FURNACE.

Fig. 2.

No.1 **Weigher.**

Weigh charge. Record the time when the charge is weighed completely and tend to No. 2.

Charge	Time	Ore wt.	Iron Ore	Slag	Limestone	Coke	Sil. Rock	Name
1	1.45pm	-----	----	17	----	60	-----	Helper
2	1:50	-----	----	17	----	60	- ----	"
3	1:55	-----	----	106	------	40	5	"
4	----	-----	----	212	-----	40	10	"
5	2:10	17.7	1	48.5	7.0	19	-----	F.P.
6	2:25	35.5	1	48.5	14.0	19	----	"
7	2:37	35.5	1	48.5	14.0	19	-----	"
8	2:47	35.5	1	48.5	14.0	19	----	"
9	2:57	35.5	1	48.5	14.0	19	-----	"
10	3:09	35.5	1	48.5	14.0	19	-----	"
11	3:17	35.5	1	48.5	14.0	19	-----	"
12	3:27	35.5	1	48.5	14.0	19	-----	"
13	3:37	17.7	1	48.5	7.0	19	-----	"

(Feed charge 3 in small amounts.)

Last charge in at 4:00 P.M. Knocked out the at 4:30 P.M.

No. 2 **Feeder.**

Help No 1 with his weighing. Feed the furnace putting in coke evenly distributed then a layer of ore charge which has itself been distributed in layers on the feed floor and mixed. Record time when charge is all in. Record distance top of charge is below the bottom of the feed floor door, whether top is hor or cold. Record your observa-tions in following table. Post on No. 3.

No. Charge	Time Ore	Time Coke	Distance feed floor to top of charge.	Top hot or cold	Signature
1		1:45		Cold	Powell
2		1:5 0		Cold	"
3		1:55		Cold	"
4					"
5	2:10	2:10	4' 8"	Cold	"
6	2:25	2:25		Fairly cold	"
7	2:37	2:37		Medium	"
8	2:47	2:47		"	"
9	2:57	2:57		"	Helper
10	3:09	3:09		" hot	"
11	3:17	3:17		" hot	"
12	3:27	3:27			"
13	3:37	3:37			"

No. 3 Tapper.

Hold the bar or strike alternately with No. 4. Make the plug mixture and prepare the plugging bar, plug the furnace. Clean up after eah each tap. Record time of tap and plug. In " notes on slag" put down in the table when slag first begins to come and when metal is first noticed. Also state whether the furnace is running hot or cold and whether the slag is ropy or short. See that the furnace is tapped on time. Record results in table

Time of tap	Time of plug.	Interval	Slag notes and remarks	Names
2:18	2:19		1st Tap	Helper
2:25	2:26		2nd tap	"
2:30	2:30-50"		Very liquid	"
2:36	2:36-45"		"	"
2:41	2:42		"	"
2:55	2:56		"	J.V"S.
3:00	3:01		"	J.V"S.
3:03	3:04		"	"
3:15	3:16		"	"
3:22	3:23		2% coke left out chg.	"
3:27	3:28		Slag liquid	"
3:35	3:36		"	"
3:43	3:44		"	"
3:45	3:46		Matte came out first	"
3:55	3:56			"
4:04	4:05			"
4:12	4:13			"

No.4 Assistant Tapper.

Help number 3 in tapping and plugging the furnace. Try to keep the temperature of the out going water at 180 degrees F or 83 degrees C. Record time, temperature of water, pressure of blast, appearance of tuyeres- bright, dull or black. Post on duties of number 5. Record observations.

Time	Pressure of blast	TemP water (C)	Remarks	Siganture
2:18	2.0	Good		Shanks
2:30	2.0	Good		"
2:36	2.0	Good		"
2:41	2.0	Good		"
2:55	5.0	Too hot		"
3:00	5.0	too hot		"
3:15	5.0	too hot		"
3;22	5.0	Good		"
3:27	5.0	Good		"
3.35	4.5	Good		J"V.S.
3:43	4.5	Good		Shanks
3.50	2.0	Good		"
3:55	2.0	Good		"
4:00	2.0	Good		"
4:12	2.0	Good		"

No. 5 Slagman, etc.

Look after the slag pots, note the appearance of the slag, ropy or short, acid or basic. Take a sample of each tap, keeping the samples separate. The sample should be taken on an iron rod and then dipped into water at once, so that it will be soluble in acids. The first slags are different from those we figured on, so keep them separate. Post on No. 1.

Time	No. Taps	Slag notes and remarks	Signature
2:18	1	Slag thick	Helper
2:25	1	Slag thick	"
2 :30	1	Good	"
2:36	1	Good	"
2:41	1	Good	"
2:55	1	Good	"
3:00	1	Good	"
3:05	1	Very liquid	"
3:15	1	Very liquid	"
3:22	1	Very liquid	"
3:27	1	Good	"
3:35	1	Good	"
3:43	1	Good	"
3:45	1	Good	"
3:55	1	Good	"
4:04	1	Good	"
4:12	1	Good	"

Comments on the Blast Furnace run.

The ore, flux and fuel aere charged as calculated with the exception that the coke was cut down 2% toward the middle of the run, but with no effect on the liquidity of the slag. The slag was thoroughly liquid all through the run with the exception of the first two taps when it was rather cold and stiff.

Powdered coke and charcoal were put on top the slag-pot after each tap, thus keeping the heat in and allowing a good separation of matte and slag.

The height of the ore charge above the tuyeres was four and two thirds feet all through the regular run.

The pressure of blast used was five inches of water during time ore was being charged. In "blowing in" and "blowing out", two inches pressure was used.

The temperature of the water in the jacket was kept at about 80 degrees Centigrade, with fluctuations on either side of a few degreed.

In blowing in and blowing out, an easy smelting material was used with a large amount of coke and no ore was charged. This was necessary as there would be a large mechanical loss if iron ore were charged at first and the furnace would be likely to freeze.

Samples of the slag were taken at each tapping and an analysis gave the following results.

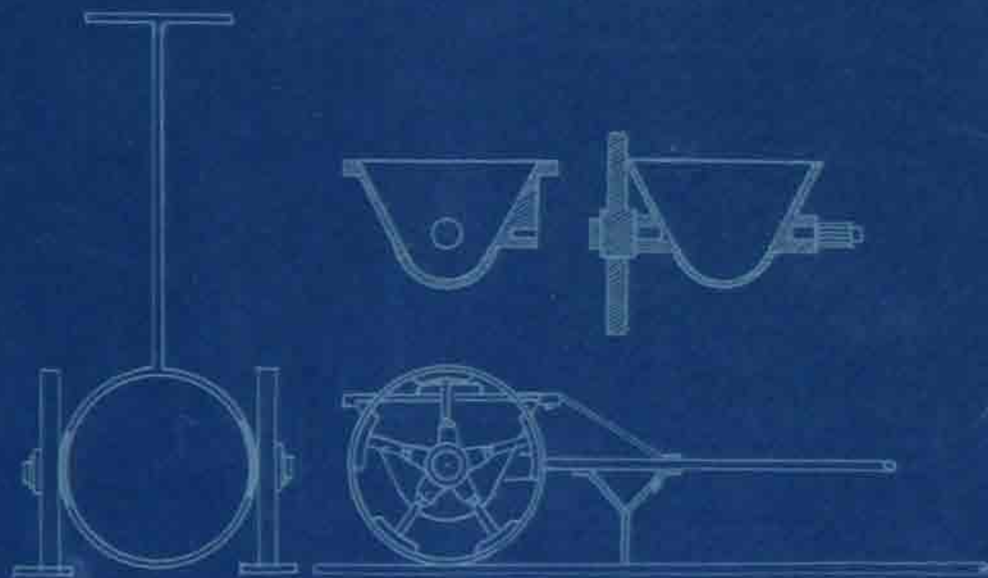


Fig. 3. SLAG POTS.

Scale. 1" = 2'

SiO_2 34.14 %

FeO 39.90 %

CaO 15.90 %

Al_2O_3 4.4 %

Cu 1.4 %

Slag as calculated was

SiO_2 30 %

FeO 45 %

CaO 15 %

(9/10 Al_2O_3 figured as FeO.)

The slag ran too high in copper, but this was probably due to t e rod being dipped too deep into the mixture and entering the matte.

The weight of the copper matte obtained was 50 #.

NO. 1 Weigher.

Weigh charge. Record the time when charge is weighed completly and tend to No. 2.

Charge	Time	Ore WT.	Iron Ore	Slag	Limestone	Coke	Sil.Rock	Name
1	1.45 pm	----	----	17	----	60	----	
2	1.50	----	----	17	----	60	----	
3	1.55	----	----	106	----	40	5	
4	——	----	----	212	-----	40	10	
5	2.10	17.7	1	48.5	7.0	19	----	
6	2:25	35.5	1	48.5	14.0	19	----	
7	2:37	35.5	1	48.5	14.0	19	----	
8	2:47	35.5	1	48.5	14.0	19	----	
9	2:57	35.5	1	48.5	14.0	19	----	
10	3:[illegible]	35.5	1	48.5	14.0	19	----	
11	3:17	35.5	1	48.5	14.0	19	----	
12	3:27	35.5	1	48.5	14.0	19	----	
13	3:37	17.7	1	48.5	7.0	19	----	
14								
15								
16								
17								

(Feed charge (3) in small amounts).

Fed charge [illegible]
Finished [illegible]

No 2-- Feeder

Help No 1 with his weighing. Feed the furnace, putting in coke evenly distributed then a layer of ore charge, which has, itself been distributed in layers on the feed floor and mixed. Record time when charge is all in. Record distance top of charge is below the bottom of the feed floor door, whether top is hot or cold, record your observations in the following table. Post on No 3.

No. of Chge.	Time		Dist of Feed-floor to Top of Chge.	Top Hot or Cold.	Furnace Tight or Loose.	Remarks	Signature
	Ore	Coke					
1.	[illegible]	1.45		Cold			Powell
2.	"	1.50		"			"
3.		1.55		"			"
4.	—	—					"
5.	2.10	2.10	4' 8"	"			"
6.	2:25	2:25		Fairly cold			"
7.	2:37	2:37		Medium			"
8.	2:47	2:47		"			"
9.	2:57	2:57		"			[illegible]
10.	3:09	3:09		M. Hot			"
11.	3:17	3:17		"			"
12.	3:27	3:27					"
13.	3:37	3:[illegible]					"
14.							
15.							
16.							
17.							

No 3 Tapper--

Hold the bar or strike alternately with No 4. Make the plug mixture, and prepare the plugging bar, plug the furnace. Clean up after each tap. Record time of tap and plug. In " notes on slag", put down in the table when slag first begins to come and when metal is first noticed. Also state whether the furnace is running hot or cold and whether the slag is ropy or short. See that the furnace is tapped on time. Record results in table. Post on No 4.

Time of Tap	Time of Plug	Interval	Slag Notes & Remarks	Names
2 18	2 19		1st Tap	[illegible]
2 25	2 26		2nd Tap	
2 30	2 30 50"		Slag very liquid	
2 36	2 38 45"			
2 41	2 42			
2 55	2 56		"	[illegible]
3 00	3 01		"	[illegible]
3 03	3 04		"	[illegible]
3 15	3 16		"	[illegible]
3 22	3 23		2% coke left out of charge	[illegible]
3 27	3 28		Slag liquid	[illegible]
3 35	3 36		"	[illegible]
3 43	3 44		"	[illegible]
3 45	3 46		Metal the same [illegible]	
3 55	3 56			[illegible]
4 04	4 05			
4 12	4 13.			

No. 4, Asst Tapper-

Help No 3 in tapping and plugging the furnace. Try to keep the temperature of the ourgoing water at 180 degrees F. or 83 degrees C. Record time, temperature of water, pressure of blast, appearance of tuyeres-bright, dull or black. Post on duties of No 5. Record observations.

Time	Pressure of blast	Temp. H_2O. C.	Appearance of Tuyeres			Remarks	Signature
2 18	2.0	Good					[illegible]
2 30	2.0	Good					
2 36	2.0	Good					
2 4[illegible]	4.0	Good					
2 55	5.0	[illegible]					
3 00	5.0	Good					
3 15	5.0	[illegible]					
3 22	5.0	Good					
3 27	5.0	Good					
3 35	4.5						JLS
3 43	4.5						
3 50	2.0						
3 55	2.0						
4 00	2.0						
4 15	0.0	"					

No. 5, Slagman, etc.

Look after slag pots, note the appearance of the slag, ropy or short, acid or basic. Take a sample of each tap, keeping the samples separate. The sample should be taken on an iron rod and then dipped into water at once, so that it will be soluble in acids. The first slags are different from those we figured on, so keep them separate. Post on No. 1.

Time	No. Taps	Slag notes & remarks	Signature
2 14	1	Slag thick	Helper
2 25	1	" "	"
2 30	1	Good.	"
2 36	1	"	"
2 [illegible]	1	"	"
2 45	1	"	"
3 00	1	"	
3 05	1	very liquid	
3 15	1	"	
3 22	1	"	
3 27	1	Good.	
3 35	1	"	
3 43	1	"	
3 [illegible]	1	"	
3 [illegible]	1	"	
4 04	1	"	
4 12	1	"	