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Copper matting blast furnace run

John Vivian Stevens

Frank Bowman Powell

John Dozier Shanks

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There is Backlor of Science in Mine Engineering Subject Copper Matting Blast Furnace Run, ВY

J. V. STEVENS, F. B. POWELL AND J. D. SHANKS.

M. S, M., 1906,

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 familiarine 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 one was a high grade copper solphide from the Ducktoon, Tenn. districe to which was added some heavy pyritic one from various quarters. The latter was added to furnish the iron oxide necessary as a flux in the blast furnace and solphur in sufficient amount to make the one self roasting when charged into a previously heated stall roast. THE ROAST:

The reast was conducted in the following manner. An old pet 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 charging and then heated to as high a temperature as possible with soft coal. The fire was then drawn and the one dumped in, the one 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 one was found to be sufficiently roasted and was mixed, sampled and weighed and made ready for the blast furnace run. To make the roasted one 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 reasted 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 10 120 mesh sieve and analyzed.

Comments on the roasting:

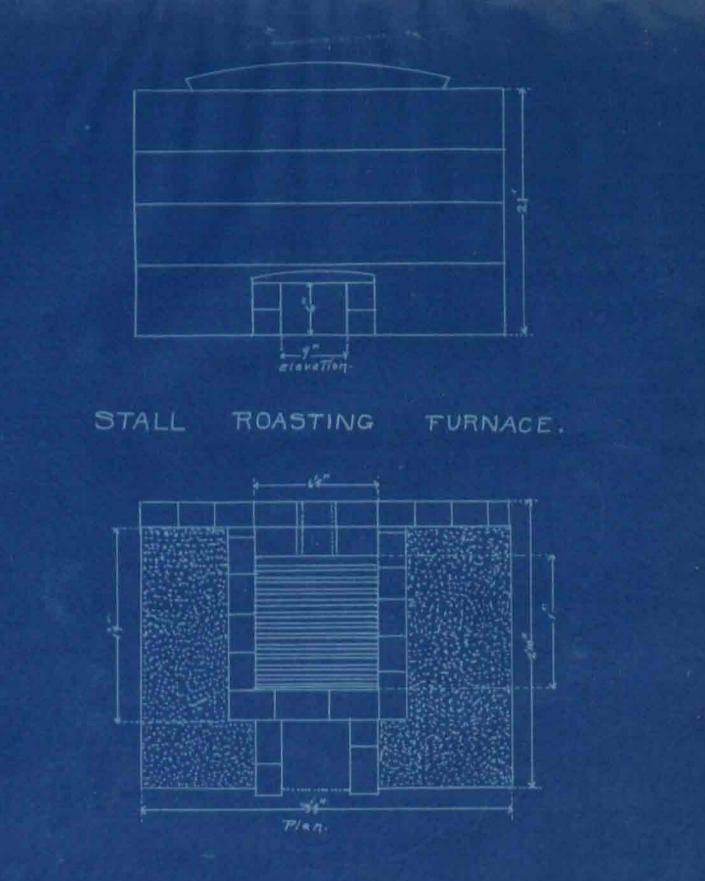
Ordinary stall roasting is carried on in a slag brick roaster with three sides enclosed and the fourth side open and has the ore and fuel charged together.. In this way it requires ten days to roast a twenty ton charge from 25% sulphure down to 10 % Sulphur.

THE BLAST FUENACE:

This was one of the small, round, water jacketed type. A false bottom of coke and dement 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 city 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.

2.



Fore hearth Construction:

This was made os sheet metal offe 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,///SulphureMiron, Gold, Silver.-

Slag Calculation.

		up ou.	10 1.000 m 011			
30 SiO ₂			45 Pe	0		15 Ca0
Analysis	of roaste	d ore and	fluxes:			
	Si02	FeO	CaO	Al203	S	Cu
Reasted ore	17.33	10.17	2.5	35.98	10.82	21.28
Sil.Bock	81.0	6.5,	2.7	1		
Limestone	1.4		55.2	· · · · · · · · · · · · · · · · · · ·		
Iron Ore		85.0		² و		
Slag	24.2	34.5	1.	5.4	7.5	13.8
Coke as h	50.0	38.0	1.5	ניגן ג'ר 'ר' 10 גע געע לי ג'ר 'רי 'רי גע עט ג'ר איזיג 'רי 'רי ג'ר' עט ג'ר איזיג 'רי ג'ר' עט ג'ר ג'ר' גער ג'ר'	•	
	the oxide		as acting	as an acid.	Ve then	have 3.6%
(in terms of						
	38 equals	22.86 FeO				
$\frac{50.4}{102}$ x 3.6	$5 \text{ equals } \frac{1}{2}$	x 3.6 equ	als 1.8 S:	10 ₂		

3.

Adjusted Oxides.

	Si02	₽өО	CaO	S	Cu	РЪО
Roasted Ore	19.13	33.03	2.5	10.82	21.28	
Sil. Rock	81.0	6.5	2.7			
Limestone	1.4	and the second	55.2			
Iron Ore		85.0		Surgerit and a sufficient Stripp of		
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 Cu2S

Cu₂ ; 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 (Supphur burned off)

5.38 plus 3.25 equals 8.63

10.82 minus 8.65 equals 2.19 (Sulphur remaining in one 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 9 equals 4.92 FeO eq uivalent to 3.83 Fe.

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

4.

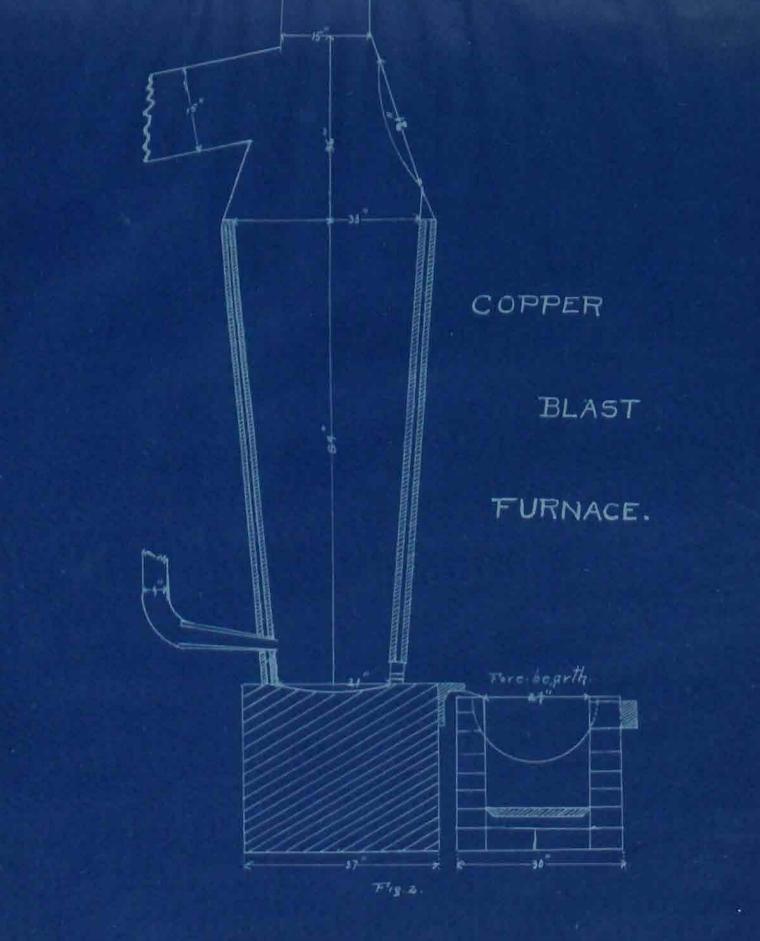
-5-Grade of Copper Matte $\frac{21.28 \ \# \ Copper}{7.57 \ \# \ Sulphur}$ $\frac{3.83 \ \# \ Iron}{32.68}$ (total in matte) 21.28 32.68 equals 65.1 % Cu. in matte X2II. To Flux the Ore. The available FeO in the ore will go to slag the SiO, of the ore. (Have 28.11 FeO available.) SiO₂ : FeO :: 30 : 45 equals 19.13 : x x equals 28.69, FeO needed to flux sio_{\odot} 28.11 FeO present, hence 28.11 minus 28.69 equals .59 FeO remaining. This mas considered good and no iron ore needed. SiO₂: CaO :: 30 : 15 equals 19.13 : x. x equals 9.56 CaO to flox silica 2.5 CaO present, hence add 9.56 minus 2.5 equals 7.06 # CaO. Limestone 1 CaO :: 100 : 5.5 equals x : 7.06 x equals $13\frac{1}{7}$ limestone To Flux the Ash of the Coke. Use 19% coke. Coke is 12% ash. $12^{e^{\prime}}$ of 19 equals 2.28 π ash 50% of 2.28 equals 1.14# $\rm SiO_2$ of ash 38% of 2.28 equals .86# $\rm FeO$ of ash

-6-1.5% of 2.28 equals .034# Ca0 of ash To get Fe0 to flux SiO2 of ash: 30 : 45 :: 1.14 : x x Squals 1.7 FeO required to flux SiO2 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 Ca0 in ash .54 minus .034 equals .506 CaO required as limestom Limestone 1 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 <u>.92# limestone</u> 3.10 total Make charge thus: Regular charge is 1/2 ore plus 1/2 slag plus coke ask with fluxes

for 19#

-7-100# minus 3.10# equals 97.# (approx.) 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: 1 and 2;6oke 60 # 17 # (7.2 # ash) NO. slag 40 **#** 5 # 106 # Coke No. 3 Si0 Slag (Rock) Coke 40 # No. 4 10 # Si02 (Rock) 212# Slag 17.7 # 7.00 # No. 5 Ore Limestone 1.00"# Iron ore 48.5 # 19. # Slag Coke No. 6Regular charge No. 7 Regular charge. The five following sheets are original data collected during the

actual run.of the blast furnace.



No.1 Weigher.

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

Cha	rge '	Time	Ore wt.	Tron Ore	SIAP	Limestone	Coke	Sil.Rock	Name
1		1.45pm	The state of the state of the state of the		17		60		Helper
2		1:50		10 un 14 h.	17		60		"
3		1:55	MB em 141 av 94		106	-	40	5	**
4			and part the same stat		212		40	10	"
5	:	2:10	17.7	l	48.5	7.0	19		F.P.
6		2:25	35.5	l	48.5	14.0	19		"
7		2:37	35.5	l	48.5	14.0	19		11
8		2:47	35.5	l	48.5	14.0	19		"
9		2:57	35.5	l	48.5	14.0	19	800 au 14 au 191	11
10		3:09	35.5	1	48.5	14.0	19		**
11		3:17	35.5	1	48.5	14.0	19	Sall an air an an	**
12		3:27	35.5	l	48.5	14.0	19		"
13		3:37	17.7	1	48.5	7.0	19		Ħ
(Fe	ed ch	arge 3	in small	l amounts.)				
	Last	charge	in at 4	4:00 P.M.	Knocke	d out the		at 4:30 P.	. M .

No. 2 Feeder.

Help No 1 with his weighing. Feed the furnace putting in coke evenly distributed them 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 observate tions in following table. Post on No. 3.

No.	Charge	Tim Ore	e Coke		feed floor f charge.	qoT	hot or co	old	Signature
1		**************************************	1:45	ananarina va anna kan kandan dha d	ana an t- na sala an Alimpini an an an	un a stade fan bien	Cold	ан фаланданын татын байн олуны тануу тануу та	Powell
2			1:5 0				Cold		
3			1:55				Cold		**
4									"
5		2:10	2:10	4 •	8"		Cold		11
6		2:25	2:25			Fair	ly cold		72
7		2:37	2:37			Med	ium		79
8		2:47	2:47			"			P4
9		2:57	2:57			"		,	Helper
10		3:09	3:09			"	hot		**
11		3:17	3:17			"	hot		11
12		3:27	3:27						n
13		3:37	3:37						n

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 eak 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		lst Tap	Helper
2:25	2:26		2nd tap	**
2:30	2:30-50"		Very liquid	11
2:36	2:36-45"		"	11
2:41	2:42	•	"	11
2:55	2:56		n	J.V‼S.
3:00	3:01		n	J.V"S.
3:03	3:04		"	**
3:15	3:16		n	"
3:22	3:23		2 [,] coke left out chg.	"
3:27	3:28		Slag liquid	"
3:35 3:43 3:45 3:55 4:04 4:12	3:36 3:44 3:46 3:56 4:05 4:13		" " Matt ë came out first	11 11 17 17 11

-10-

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		n
2 :3 6	2.0	Good		11
2:41	2.0	Good		**
2:55	5.0	Too hot		77
3:00	5.0	too hot		"
3:15	5.0	too hot		Ħ
3:22	5.0	Good		"
3:27	5.0	Good		77
3.35	4.5	G0 0 d		J"V.S.
3:43	4.5	Good		Shanks
3.50	2.0	G00 d		n
3:55	2.0	Good		n
4:00	2.0	(ન ૦૦ તે		"
4:12	2.0	Good		n

No. 5 Slagman, etc.

Look after the slag pots, note the appearance of the shag, 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	l	Slag thick	Helper
2:25	l	Slag thick	"
2:30	l	Good	11
2:36	l	Good	"
2:41	l	Good	"
2:55	l	Good	"
3:00	l	Good	"
3:05	l	Very liquid	Π.,
3:15	l	Very liq uid	"
3:22	l	Very liquid	"
3:27	l	Good	11
3:35	l	G 00 a	"
3:43	1	Good	"
3:45	1 1 1 1 1	Good	n
3:55	1	Good	11
4:04	l	Good	**
4:12	Ц,	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.

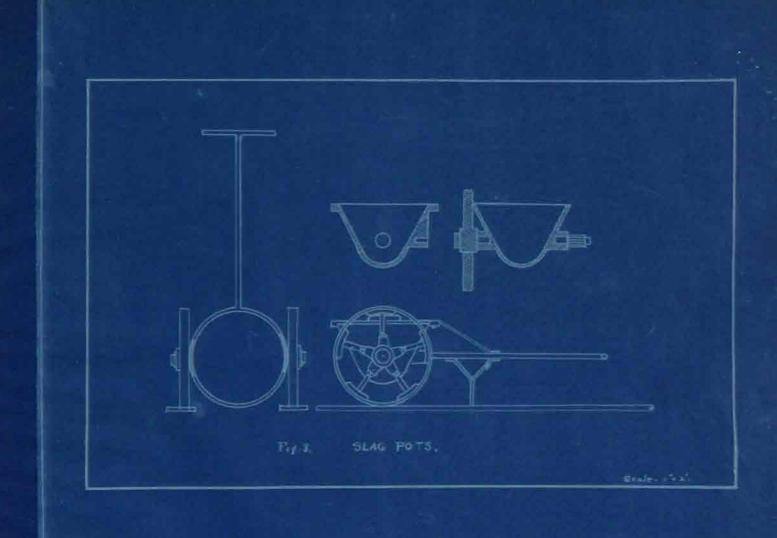
The pressure of blast used was five inches of water during time ore was being charged. In "blowing in" and "blowing out", two inches pressure was used.

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 igon 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.

-13-



SiO₂ 34.14 % FeO 39.90 % CaO 15.90 % Al₂O₃ 4.4 % Ca 1.4 %

Slag as calculated was

SiO₂ 30 % FeO 45 % CaO 15 %

 $(9/10 \text{ Al}_20_3 \text{ figured as FeO.})$

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.

and cend to No	• ~ •					í	
Charge Time	Ore WT.	Iron Ore	Slag L:	imestone	Coke	Sil.Rock	Name "
11.45%	710.	*	17		60	-	nicipor.
2 /. 50			17	Que d e e	60 	BH BH BH BH	
31.55	98 bui 95 bu	Sun Sin Sin Sin	106		40	5	· •
4	846 MH 844 844	\$2. W. #* #*	21 2	tras data data data data	40	10	
5 2.09	17.7	l	48,5	7.0	19		
6 2:25	35.5	1	48.5	14.0	19	Bu ()	
7 2:37	35.5	l	48.5	14.0	19	02 b- 4m 4m	· •
8 2 :47	35.5	1	48.5	14.0	19 ²	40 20 km 85	• 1
9 2:57	35.5	1	48.5	14.0	19		,m
10 3	35.5	l	48.5/	14.0	19	900 tau 800 kau	
11 3:17	35.5	2	48.5	14.0	19	94 Str. 91 85	
12 3:27	35.5 V	1	48.5ν	14.0 -	19 $^{ u}$	Ball 8% 8% 8%	
13 3 37	17.7~]	48.5	7.0	19	ens ens ens das	3
14	e.						
15		a barran		- - -			
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14 110 200	I. A.	- ** 's*			میرنو ب	9 D (24)	

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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 filter 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 not or cold, record your observations in the following table. Post on No 3.

710.0f.	TIME	Dist. or Beed-	Top	Fur nace	Tic mar ky	Simatura
Chge.	Ore Coke	of Char	Hot or Cold.	Tight & boose,		
. 1.	1.45		L. A. L.		• . •	Pound
2.	1,50				nan andronan in the transformer water of the target	11
3.	1.55					1/
4.			5			//
5.	2.10 2.10	. 4 8 "			n tanana tanan ta	•1
<u> </u>	2:25 2:25		Finily colif.		n ann a' fir a' sao saonan an firstaineach	/ /
<u>7.</u>	2: 2 2:31		Madium	a substances	n - material advector as see in - material in a value of s	
8.	2:47 2:47		and the second sec			11
4.	3:37 2:57		е. 9 литет - 11.7 год Полен Карансканска санаран гола, кото на так	and the second sec	u sementar o trata constructor a semenara	origer
	3:09 3:09		Millet	and the second		11
	3:12:2:13		a the main			
1	3:27 27	1	1			
13.	3:37 3:20					"
14.						
ce.					**	
1.60		7				een seventeen ook in een sold somsettemend L
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.

Annual contraction and a subscription of the second	۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰۰ ۲۰۰		in a start water and the start of the	
Time of Tap	Time of Plug	Interval	Slag Notes & Remarks	Names
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2 j8		alah sebagai kata sebagai sebag	CA Tapa	the Classes
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404	409		A:	•
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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 tuyeresbright, dull or black. Post on duties of No 5. Record observations.

	Alle alle a francés de la contra		. P				
ſime	Pressure of blast	Temp,H.O. C.	App	ea ra n Tuyer	ce of es	Remarks	Signature
218	٤, ٩	Hovel				. 1	Stanky,
2 30	2.0	food			ř.)
236	2,0	Good .				•	, , ,
2	A # 0	- 4 A.					1
27.5		78-22					1
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315	5.0	The Part of the State				and a second	
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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.

<u>Fime</u>	No. Taps	Slag notes & remarks	Signature
2, 4		Slag tuck	HE CAL
225	1	// '	(, ,
30	,	- Jood.	11
7 36			
2011		٤ /	· ,
> 1 " "		17 .	•/
340		<i>(,</i>	
203	/	Veryfiguid	:
3 :5	//		
2,7 2	,	٠,	
327	•	Jood.	<i>t</i> .
335		1.*	3
373		"	
3.15	-	. //	
2 × 3	1		
12 g #		o. ''	1
412	x /	a -	