THE COPPER SMELTER AT GHATSILA

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Abstract

The layout of the plant descriptions and operations of the different equipment at the works of Messrs Indian Copper Corporation Ltd., Ghatsila, have been briefly described. The smelter treats froth-floated chalcopyrite concentrate containing 24-26 per cent Cu to produce a matte containing 40-42 per cent Cu. The conversion of the matte to blister copper in converters has been described. The refined copper contains 0·25 per cent Ni. The refining practice has been detailed.

Introduction

THE only copper smelter in India forms a part of the Moubhandar Works of The Indian Copper Corporation Ltd. which also accommodate the concentrator, foundry, rolling mill and power plant. It is located on the north bank of the Subarnarekha river at a distance of about two miles from Ghatsila Railway Station with an assisted siding connecting it to the main line. The construction of the plant was started in 1927 and the first copper was produced in December 1928.

A layout of the plant is shown in Fig. 2. Its production capacity today is 7000 long tons of refined copper per annum and from the commencement of operations in 1928 to the end of 1952 a total of 573,623 long tons of concentrates have been treated giving a production of 137,660 long tons of refined copper.

The plant includes a roaster, reverberatory furnace for matte smelting, three Great Falls type upright converters, three refining furnaces, two of which are tilting, an electric lift and an overhead crane. There are two waste-heat boilers connected to the reverberatory furnace and a motor-driven turbo-blower for converter air is situated in the power house which is adjacent to the smelter building. Compressed air for the refineries and other odd jobs is supplied by a central compressor unit consisting of two compressors — one horizontal and one vertical type. The main feature of design is compactness without over-congestion. Two circular storage bins and twelve bedding bins, each holding 400 tons and 30 tons of concentrates respectively, are also situated within the plant. This close arrangement cuts down internal transportation to a minimum and leads to a great economy in cost of production, but inevitably leaves no room for future expansion.

The total floor area covered by the plant including storage bins, departmental stores and flux yard is approximately 2300 square yards. An arrangement of narrow gauge railway track provides for a smooth flow of raw materials and products.

A sectional view of the converter aisle and reverberatory furnace, including the over-

FIG. 1 — A VIEW OF THE POWER HOUSE AND SMELTER BUILDING

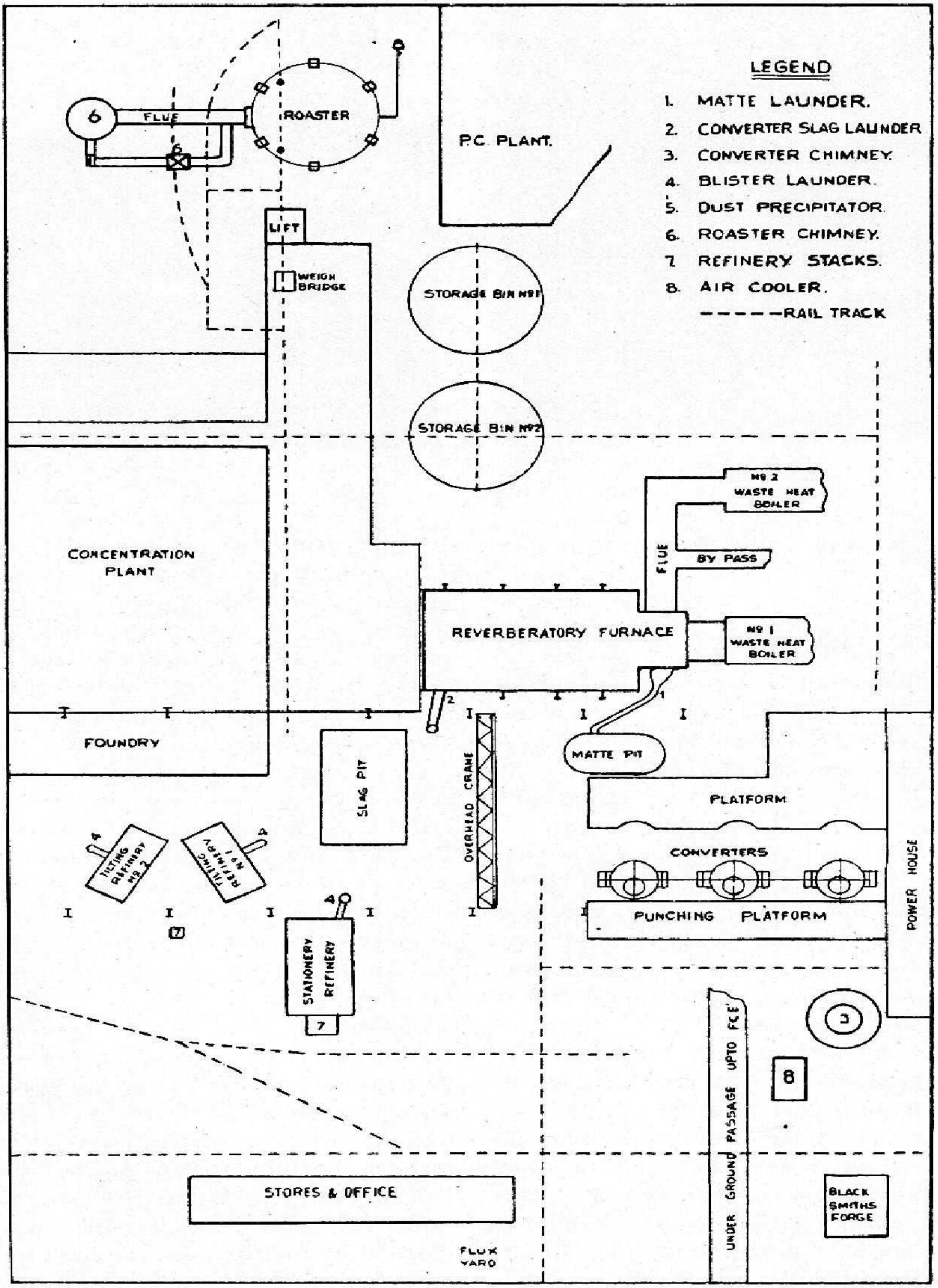


FIG. 2 — LAYOUT PLAN OF SMELTER EQUIPMENT

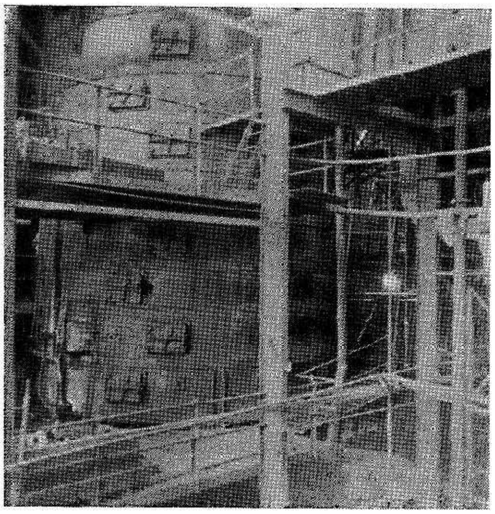


FIG. 3 — A VIEW OF THE ROASTER

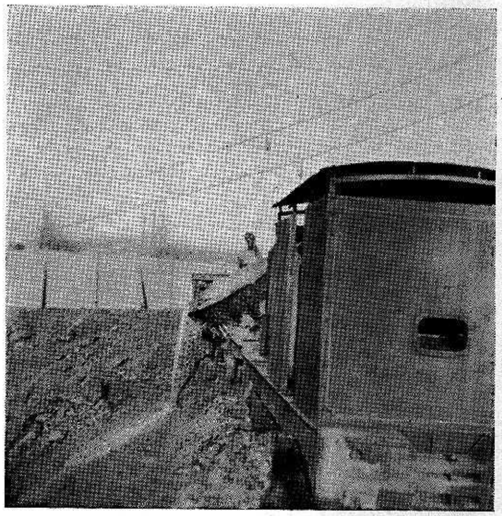


FIG. 4 — DUMPING OF SLAG

head crane, is given in Fig. 5 and a flow sheet is shown in Fig. 6.

Metallurgy and General Description

The smelter treats a flotation concentrate containing Cu, 24-26 per cent; S, 28-31 per cent; Fe, 27·5-29·5 per cent; insolubles, 8-11 per cent; and moisture, 5-7 per cent, the mineral being chalcopyrite. It is self-fluxing and no extra burden is normally required in the reverberatory furnace for slag formation. Matte grade is controlled by the addition of calcine, but the copper content of the matte should not exceed 50 per cent otherwise there would not be sufficient sulphur to provide the heat for completion of the operation of converting. When concentrate stocks are low and the higher rate of smelting impossible, direct smelting of the raw concentrate is practised.

In this case a 25 per cent copper concentrate melts down to a matte grade of 40-42 per cent. Slight improvements in the grade can be effected by charging more secondaries containing copper but little sulphur. The matte fall approximates to 30 per cent when the smelting is direct and 25 per cent when calcines are included in the charge.

Apart from copper, nickel is the only other metal of importance present in the concentrates in any appreciable quantity. About 50 per cent of the total amount of nickel entering the reverberatory furnace is removed in the dump slag (assay value shows 0·2-0·25 per cent Ni) and the balance is taken up by the matte. A partial removal of nickel takes place in converter and refinery slags and the refined copper contains 0·4-0·6 per cent. Owing to the beneficial effects of small amounts of nickel in brass sheet no serious attempts are made to reduce the nickel content below 0·6 per cent. Converter and refinery slags and converter chippings which contain nickel are charged back to the reverberatory furnace. This cycle of operations inevitably leads to nickel concentration in the furnace bath, especially towards the end of a furnace campaign and high-nickel matte settles on the bed of the reverberatory furnace together with magnetite, thereby raising the furnace bottom to an undesirable extent. Every year just before the smelter is shut down for general repairs, the furnace bed is cleaned by melting and the high-nickel matte and magnetite removed. The remaining portions are chipped out after the furnace has cooled down. This material, which may

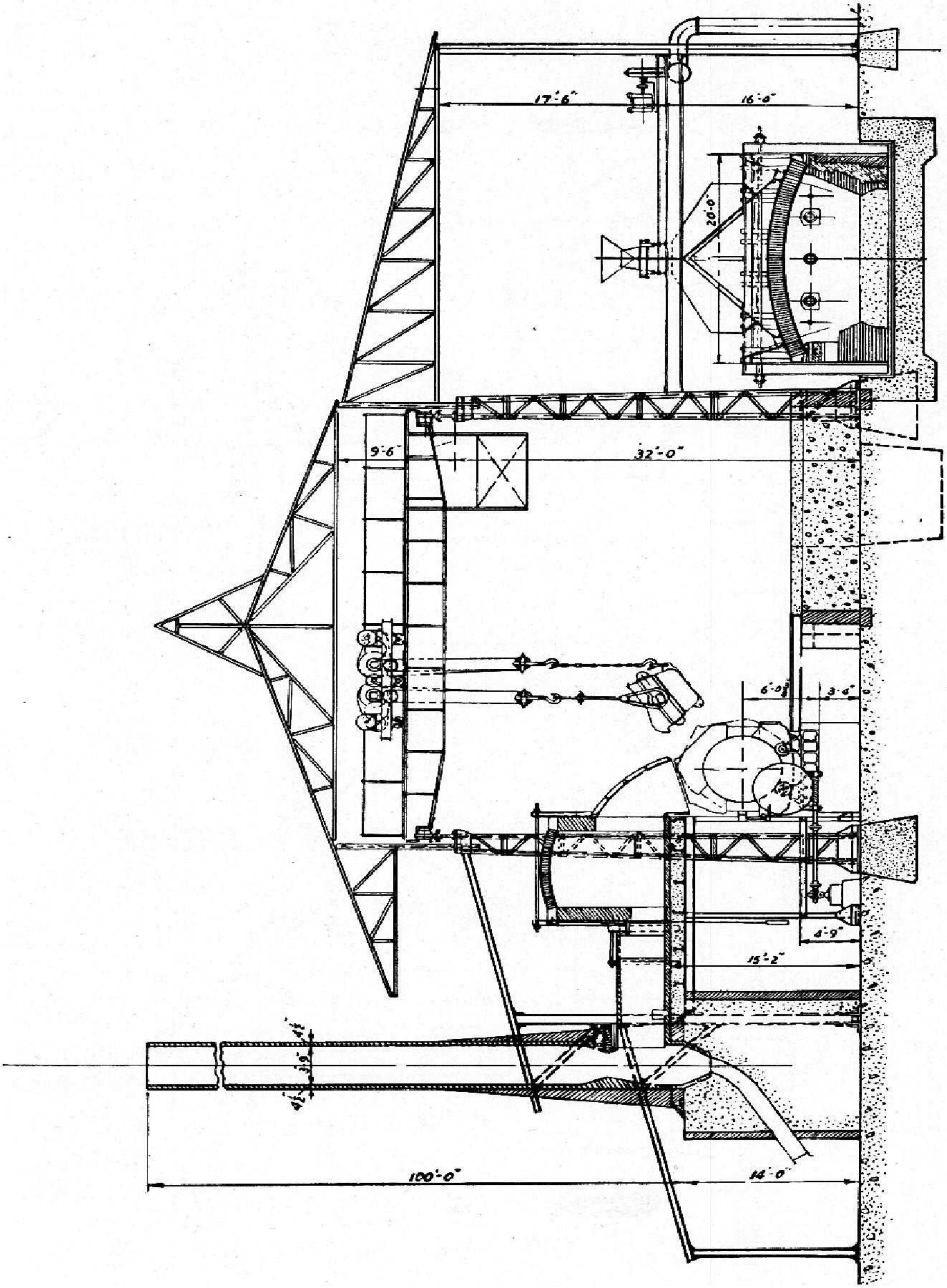


FIG. 5

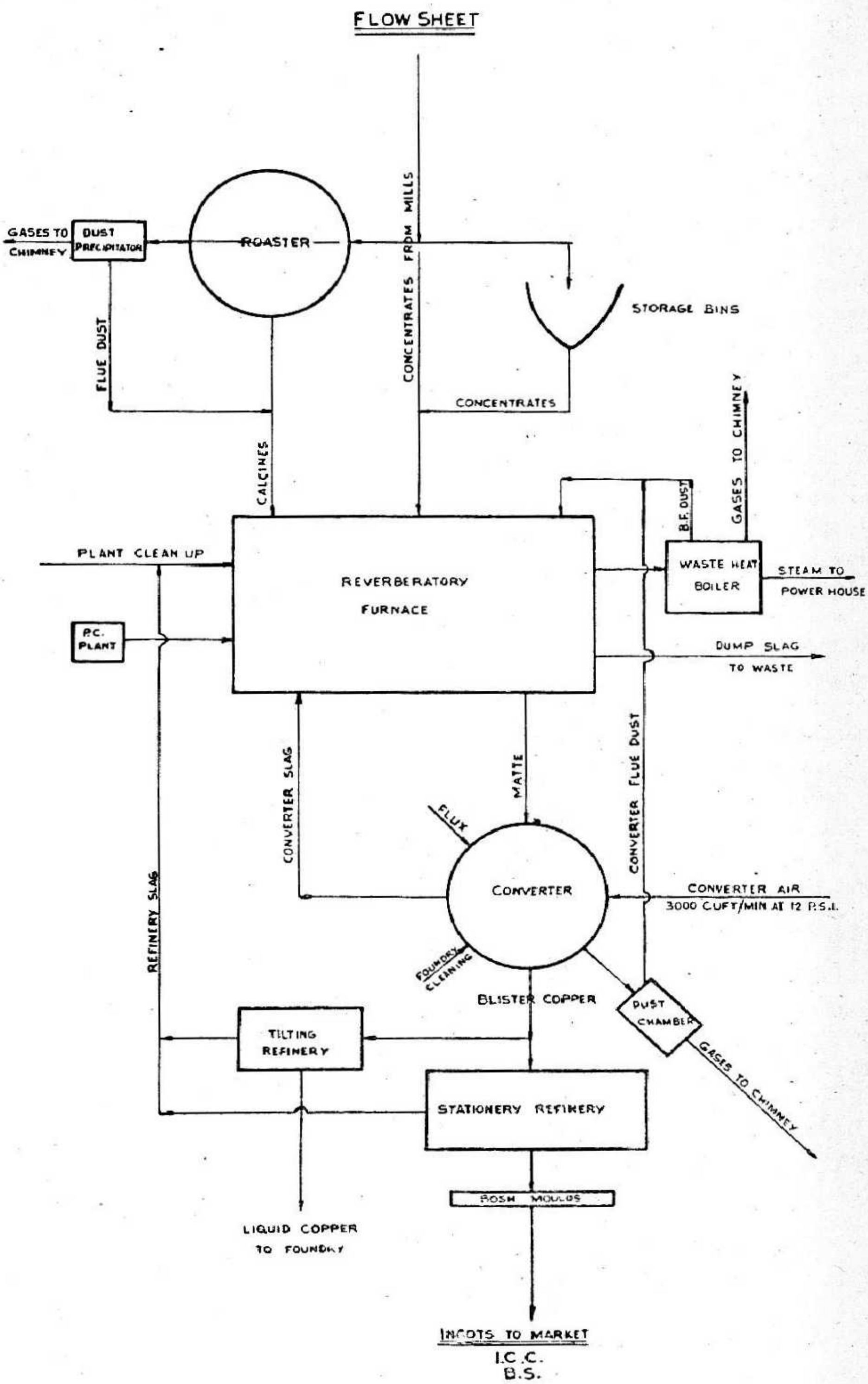

FLOW SHEET
GASES TO CHIMNEY
DUST PRECIPITATOR
ROASTER
CONCENTRATES FROM MILLS
STORAGE BINS
FLUE DUST
CONCENTRATES
GASES TO CHIMNEY
CALCINES
B.F. DUST
PLANT CLEAN UP
REVERBERATORY FURNACE
WASTE HEAT BOILER
STEAM TO POWER HOUSE
P.C. PLANT
DUMP SLAG TO WASTE
CONVERTER SLAG
MATTE
CONVERTER FLUE DUST
FLUX
CONVERTER
CONVERTER AIR 3000 CU.FT/MIN AT 12 P.S.I.
REFINERY SLAG
FOUNDRY CLEANING
BLISTER COPPER
DUST CHAMBER
TILTING REFINERY
GASES TO CHIMNEY
STATIONERY REFINERY
BOSH MOULDS
LIQUID COPPER TO FOUNDRY
INGOTS TO MARKET
I.C.C.
B.S.

FIG. 6

contain up to 15 per cent of nickel, is not charged back to the furnace but has in the past been sold to refineries capable of treating this material, but plans have been made to treat it at Moubhandar and sell to the overseas refineries a high-grade nickel matte. Should the running of the furnace become irregular due to the building up of the bed, this is rectified by 'boiling', that is by blowing compressed air through ¾ in. pipes directed on to the affected area in the skimming bay. Boiling very near the walls is avoided. Frequent tapping of matte and laundering it back into the furnace has also been found effective.

Magnetite formation in the various smelter operations and its ultimate settling on the reverberatory furnace bed has now become the deciding factor in prolonging campaigns and the presence of nickel appears to accentuate this problem.

At Moubhandar attempts are being made, by putting pieces of green poles in ladles at the time of pouring slag, to reduce the magnetite in the converter slag, which contains the bulk of this oxide.

The concentrates are received in open cars from the mill and are either charged, after weighing and sampling, direct to the reverberatory furnace and roaster or stocked in the storage and bedding bins. Normally 8-10 cars of concentrates (each car weighing about 1500 lb. net) are fed to the roaster and 30-35 cars are charged into the reverberatory furnace in each shift. Concentrates high in moisture (over 8 per cent) are not charged direct and these are sent to the bedding bins where they have time to dry before being used.

Roaster

The roaster is a 20 ft. diameter, eight-hearth, Herroshoff type furnace and is installed at the extreme north end of the plant. A pictorial elevation is given in Fig. 8. It is of standard design and is lined throughout with first-grade firebricks. The charging platform is 33 ft. above the floor level and continuous charging is maintained by an endless rubber feed belt, placed below the feed hopper, which is always kept full with concentrates. The belt is moved at a fixed speed of 7 ft. per minute by a 3 h.p. motor through a system of chain-driven gears. Although there are two charge holes, the tonnage to be roasted is such that only one feeder is in operation at a time. The main shaft carrying the rabble arms is driven by a 25 h.p. motor through a system of pulleys giving four different speeds. A centrifugal fan supplying the necessary air is driven by the same motor. The amount of air is regulated by a plate damper fixed in the air duct. The concentrates are self-roasting and the only heat required is for the initial warming of the furnace and the starting of the reactions, and this is supplied by oil burners fixed to alternate hearths (Nos. 3, 5 and 7).

FIG. 7 — SLAG BEING REMOVED FROM THE REVERBERATORY FURNACE

The roaster is equipped with a Buell microlector dust separator, which collects about 50 per cent of the dust carried by the exit gases. To obtain the maximum dust recovery it is essential to keep the draught as low as possible. An exhaust fan with a plate valve at the exit opening for controlling

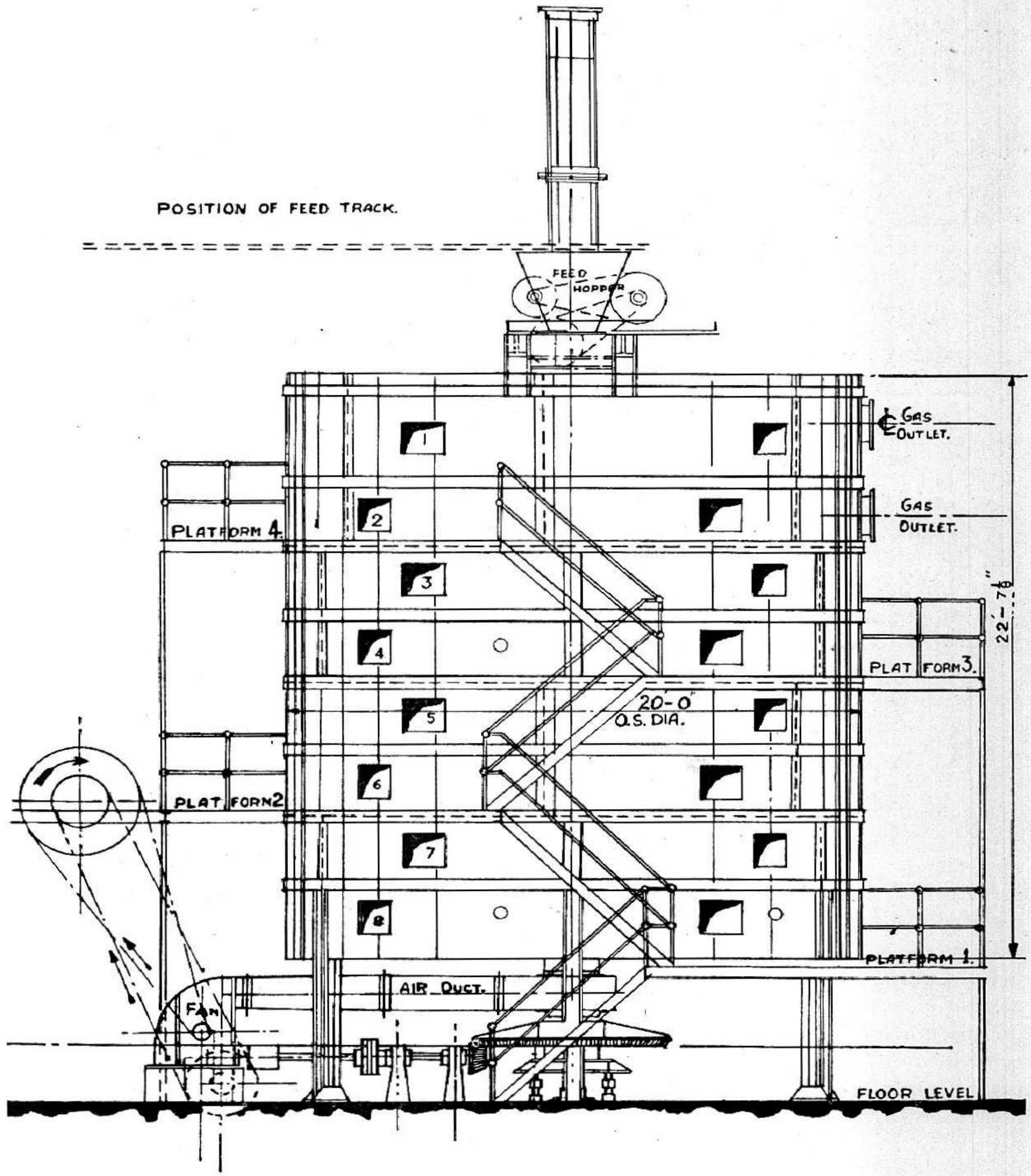


FIG. 8

the suction supplements the chimney draught and draws off through the separator the hot gases from the two upper hearths of the furnace. A direct flue also connects the hearths to the chimney and is used as a bypass in case of an emergency. The brick-lined chimney is 120 ft. high and of 3 ft. outside diameter at the top. Due to corrosive

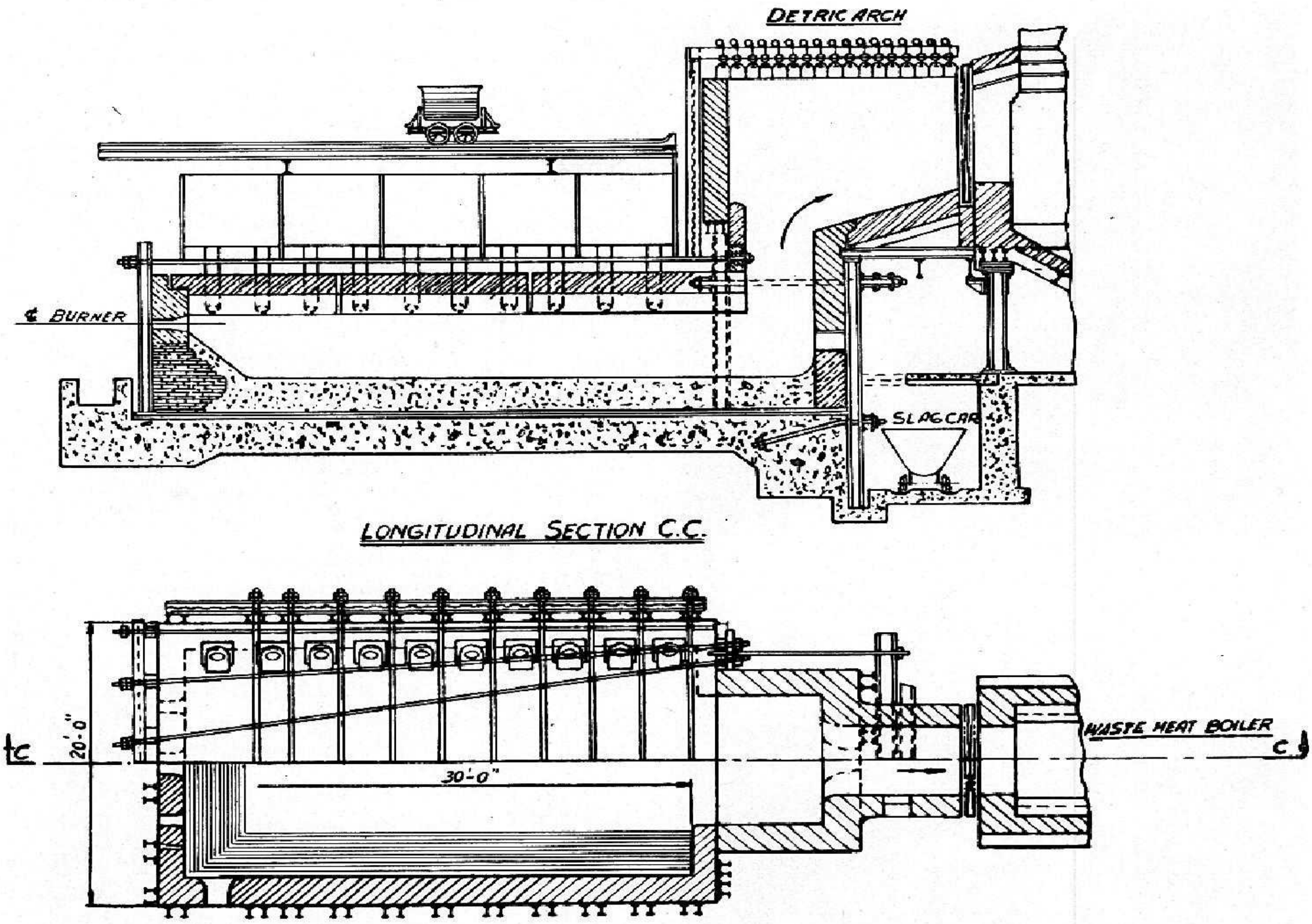


FIG. 9 — REVERBERATORY FURNACE

nature of gases it requires careful maintenance.

Calcines from the bottom hearths discharge through two openings into specially designed closed cars which minimize the losses due to dusting. The degree of the roast is controlled by the amount of air entering the furnace, by the temperature of the various hearths and by the speed of rabble shaft. A good roast should give calcines having less than 4 per cent sulphur. The gases escape at a temperature of about 300°C. and contain 4-7 per cent SO_2.

Reverberatory Section

The reverberatory furnace is almost centrally situated in the plant and forms the nucleus of all smelter operations. Compared to modern furnaces of large dimensions ranging from 100 to 130 ft. in length, the one at Moubhandar is very small — being but 20 ft. wide × 42 ft. long. The furnace has been in operation since December 1928 and has given comparatively little trouble.

It rests on a solid concrete foundation 8 ft. in depth. Eleven pairs of buck-stays on each side set in the foundation to a depth of 2 ft. rise vertically to a height of 9 ft. 6 in. above ground level. They are connected by 2 in. diameter tie rods at the top of the arch. The burner wall is supported by six buck-stays and four tie rods hold the furnace lengthwise as shown in Fig. 9. Four buck-

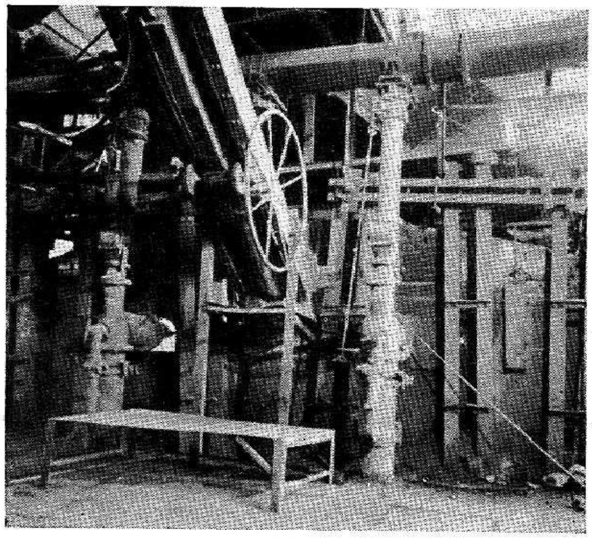


FIG. 10 — BACK END OF THE REVERBERATORY FURNACE; BURNERS, TELESCOPING CHUTE FOR CALCINE CHARGING AND THE P.C. RING MAIN CAN BE SEEN

FIG. 11 — SIDE-VIEW OF THE REVERBERATORY FURNACE, SHOWING THE BUCK-STAYS, TIE ROD ENDS, CHARGE BINS AND THE RAIL TRACK

stays of similar dimensions support the front wall. A reinforced concrete wall was built around the foundation to retain the entire structure in position, but at present both longitudinal and lateral expansion are quite noticeable.

The original silica bottom has been completely replaced by magnetite, matte and slag. The side walls and arches are made of silica bricks and chrome brick is used in the back wall up to about 2 ft. from the bottom, over which silica bricks are laid to complete the rest of the wall. Three to four courses of chrome brick are also laid on the inner side of front wall after every three lines of silica brick. Magnesite bricks are used for the tap hole and the surrounding zone which is separated by one course of chrome brick from the adjoining silica lining.

The roof is constructed of sprung arches in three sections with a radius of 20 ft. 6 in. At the end of the third or front section there is a 2 ft. 3 in. wide double arch (verb-arch) which forms part of the uptake flue construction. The skew backs are housed in 10 in. wide steel channels at a height of 5 ft. from the floor and are bolted to the buck-stays. Except for improvements in the mode of charging and in the design of the flue to No. 2 waste-heat boiler, which now starts from the skimming bay itself, there has been no other appreciable change from the original design.

The charging of concentrates and secondaries was formerly effected by discharging them from bottom discharge cars which delivered the charge into pipes leading to charge holes in the furnace roof ten on each side. At present there are only eight charge holes distributed as three, four and one in the front, central and back sections of the roof. Sloping bins made of steel plates are connected through chutes to the charge hole castings placed centrally over each charge hole. The castings are made in two pieces and are bolted together after placing them in position. A rail track 16 ft. above the ground forming the first floor provides for haulage of concentrates and secondaries up to the top of the furnace from where they are emptied into the charge bins from ordinary side tipping wagons. Two walkways, one on each side, just above the chutes give ample space for examining the holes and poking the charge when required. The entire weight of the rail track over the furnace, the charge bins and the chutes is supported by two heavy I-beams running across the furnace between two building columns. Calcines are charged through a telescopic chute which enters the door situated between the burners of the furnace.

There are two pulverized coal burners placed 8 ft. apart and 4 ft. above the ground in the back wall. Pulverized coal approximately 65 per cent —200, 25 per cent +200, and 10 per cent +100 mesh with about 18 per cent ash content is supplied from the central P.C. plant (Holbeck). Two centrifugal fans driven by 22 h.p. motors are installed at the furnace top at rail track level and provide the necessary secondary air for combustion. Only one fan is used at a time and the other is maintained as a standby. The refineries and roaster furnaces, the blacksmith's forge and the concentration plant drier burners also draw their requirements of air from this source.

An electric lift of 3 tons capacity, operated by a 10·5 h.p. motor, serves the reverberatory furnace and the roaster. It is provided with the standard rail track and can accommodate one car at a time. It is used for raising up all the concentrates, secondaries and calcines to the first floor for direct charging or to the second floor for storage and roaster charging as the case may be.

Of the twelve bedding bins one is occasionally used for storing calcines and is kept reserved for that purpose. The bedding bins discharge on to the first floor whereas the circular bins have discharge openings about 6 ft. above the ground floor and cars have to be lifted up again after receiving concentrates from them.

Slag is removed from the furnace through a door in the centre of the front wall. An underground tunnel, as shown in Fig. 9, is provided for the slag removal. Two slag cars carrying pots of cast steel — each holding about 5 tons of slag — are used alternately. They are hauled by a small diesel locomotive to the dump about one furlong away from the plant. The pots are given a clay wash before receiving molten slag from the furnace. The slag 'notch' is closed by a clay dam and is opened by driving through it steel bars.

Two tap holes are provided in the skimming bay side wall at different levels for the

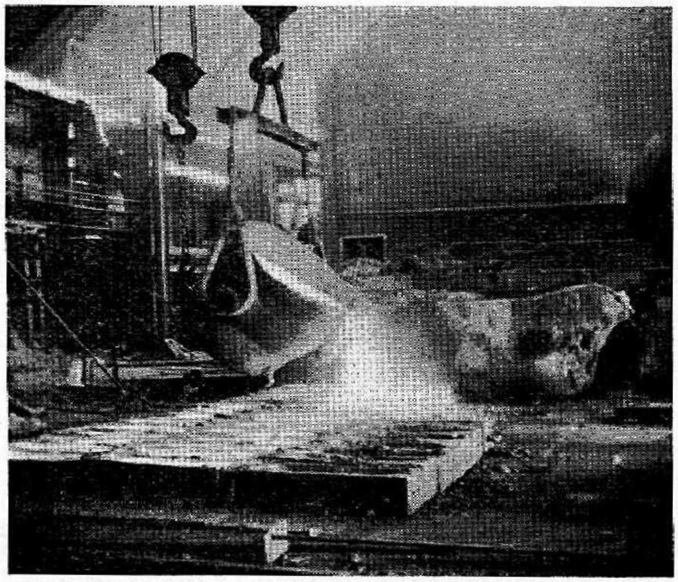


FIG. 12 — BLISTER BARS BEING CAST; THE MATTE LAUNDER AND THE MATTE PIT CAN BE SEEN IN THE BACKGROUND (LEFT SIDE)

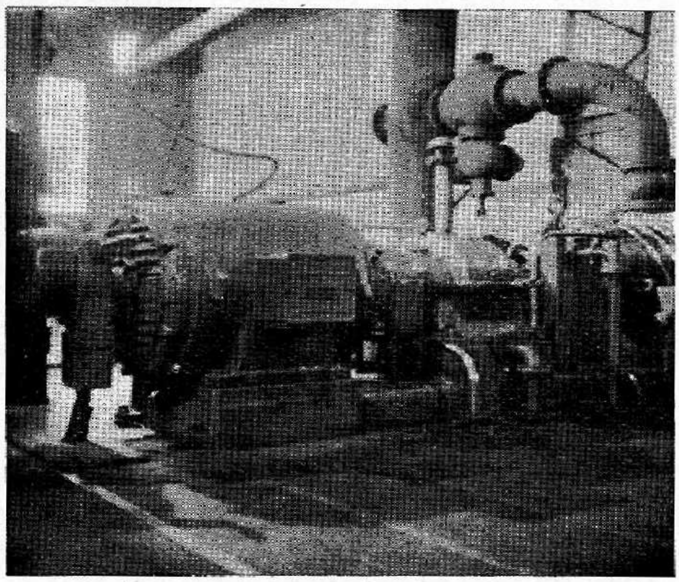


FIG. 13 — THE MOTOR-DRIVEN TURBO-BLOWER WITH THE MAIN AIR PIPE AND RELEASE VALVE

removal of matte. Normally the lower hole is used and it is plugged with clay, with a $\frac{7}{8}$ in. drill steel bar driven through it, which is kept moving. At the time of tapping, the bar is removed and the matte flows by gravity into a cast steel ladle placed in the matte pit. If the bar becomes jammed, oxygen under pressure is used for opening up the hole. A 2 in. thick tapping plate (20 × 20 in.) with a hole coinciding with the furnace tap hole is used to cover the brick-work. The plate is changed as soon as the hole becomes so enlarged as to cause difficulty in plugging. Changing of tap hole bricks is carried out without interrupting the furnace campaign, and to accomplish this the matte level in the furnace is lowered and the temperature is slightly reduced. The tapping plate is then removed and the old worn-out bricks are taken out up to a thickness of 9-12 in. and replaced with new bricks. A water jet is always at hand to chill any red spot developing during the process.

Combustion gases from the reverberatory furnace pass through either one of the two Stirling water tube boilers, each having a total heating surface area of 3308 sq. ft. Cut-off dampers made of square bricks fixed to a frame, inlaid with air-cooling pipes in case of No. 1 and made of cast iron in the case of No. 2, isolate the boilers from the furnace. Normally 11,000 lb. of steam at 300 p.s.i. and 750°F. is generated per hour and represents a heat recovery of about 45 per cent of the total fuel used. No. 2 boiler, when needed, can also be fired separately by pulverized coal. Tube surfaces are kept clean by frequent use of steam soot-blowers and compressed air lancing. Boiler campaigns average 3-4 months.

The furnace is operated on a fixed daily routine. Concentrates and secondaries are continuously emptied into the charge bins. Charging is carried out every two hours and slag is removed every four hours. An interval of at least one hour is allowed between the two operations. Calcines are charged as soon as the cars placed below the roaster discharge openings are full. Liquid converter slag when produced is poured into the furnace through a launder fixed in the side wall at the burner end. Matte is tapped as and when required by converters. Operating data for the last five years are given in Tables 1 and 2.

Converters

The original layout included two 72 × 96 in. 5 ton horizontal type converters im-

TABLE 1

	1948	1949	1950	1951	1952
	S/T	S/T	S/T	S/T	S/T
Concentrates	24663	26381	27180	27338	25836
Calcines	2275	3380	4570	6088	3145
Liquid converter slag	13905	14376	14133	13894	12279
Mixed matte slag	11535	12880	12708	15074	13944
Furnace and boiler flue dust	991	858	823	882	586
Roaster flue dust	77	186	94	83	51
Converter flue dust	—	167	260	172	160
Converter chippings	—	383	604	671	669
Matte produced	15296	16321	16873	17244	15379
Dump slag produced	23762	25467	26411	25840	22667
Total coal consumed (L/T)	9639	14855	9585	9355	9180
Estimated waste-heat recovery (L/T)	4998	5110	4970	4851	4760
Average grade of matte, % Cu	44·82	45·44	45·22	47·34	45·97

TABLE 2

	Concentrates				Dump slag					
	Cu	Fe	Insol.	Ni	Cu	SiO_2	FeO	Al_2O_3	CaO	Oxygen ratio
1948	25·126	28·61	10·33	0·358	0·356	34·35	54·55	7·27	1·87	1·143
1949	24·849	28·34	10·76	0·365	0·342	34·23	52·99	8·38	1·77	1·125
1950	24·169	27·84	11·94	0·333	0·355	34·73	52·02	8·66	2·10	1·141
1951	24·595	28·59	10·68	0·313	0·399	32·66	54·40	7·73	1·68	1·088
1952	24·410	28·00	11·93	0·298	0·405	33·14	53·59	7·81	1·79	1·098

ported from England, but they were found very unsatisfactory. In 1930 two Great Falls type vertical converters were installed. These converters had fourteen tuyeres and valves built in the wind box. In 1937 they were replaced by locally made converters having cast iron bottoms and tops with ¾ in. steel plates forming the central sections. These had only ten tuyeres of bigger diameter at a slightly higher level. The ball valves were individually connected by metal hoses to the wind box (pipe) placed at the trunion level. The converters in use today are of this design with the one modification, namely the use of cast steel in place of cast iron, which change was made in 1943.

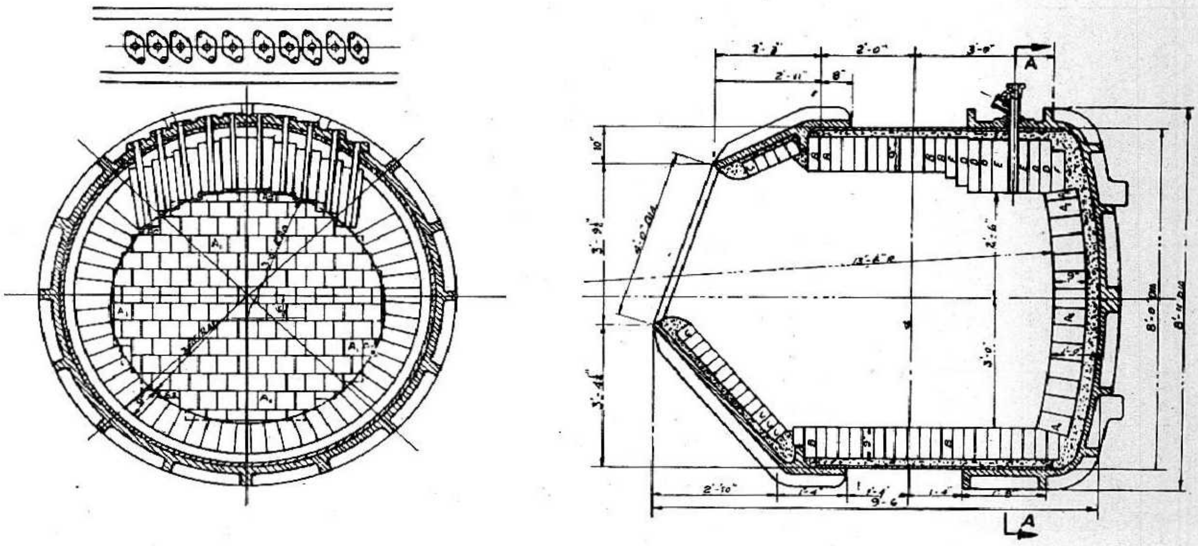
The converter gases were originally discharged into the reverberatory furnace stack, but in 1942 the converters were re-sited with the addition of a third converter. New dust chambers and an independent chimney were provided in the new arrangement.

The present general arrangement of the converter aisle is shown in Fig. 2. The aisle is 130 ft. long × 45 ft. wide and accommodates the three Great Falls type converters, blister moulds, overhead crane, two tilting refinery furnaces and brass foundry. The crane serving the converters, refineries and foundry is equipped with two hoists of equal capacity (25 tons each) and has a span of 40 ft. with crane rails 32 ft. above the ground.

The converters are placed opposite to the reverberatory tap hole, their centre being 9 ft. 8 in. above the floor level. The total area covered by converters including platforms and pits is 48 × 32 ft. Fig. 14 shows the details of shell construction and brickwork. The converters are lined with magnesite bricks except at the top where firebricks are used. The grouting used is a mixture of magnesite cement, pea magnesite, sodium silicate and pyrolyte (a neutral cement). The same mixture is used for fettling when required. Tuyere blocks are made of 15 in. magnesite bricks and the same thickness of lining is maintained in the tuyere belt. Tuyere line campaigns average about 7 months yielding 1000-1300 tons of blister copper. When a tuyere repair is made, the old lining from immediately below the tuyeres to about 2 ft. above is chipped out and the shell is patched if necessary. New tuyere pipes and bricks are then installed. The whole work of renewal takes about 24 hr.

Converter trunions rest on four (two on each side) 18 in. diameter wheels mounted on axles which rotate in bearings housed in strong tripod stands bolted to the foundation columns. One trunion has a gear ring which engages with a pinion on the riding wheel. This in turn is geared up to a 15 h.p. motor equipped with magnetic brakes and operated from the punching platform. No arrangement exists for mechanical turning of the converters in case of power failures.

Air for the converters is provided by a turbo-blower in the power house at a normal pressure of 12 p.s.i. at a rate of 3000 cu. ft. per minute. The motor-driven turbo-blower



SECTION ON A.A.

DETAIL OF CONVERTER 8'-0" VERTICAL TYPE.
SCALE 1/2" = 1 FT.

FIG. 14

is well maintained and overhauled annually. Blower breakdowns when they occur affect the punching, which is an almost continuous operation, and the puncher on duty at once turns down the converter. A compressed air hooter operated from the power house is also used in an emergency. Air volume is recorded by a flow meter in the superintendent's office and the presence is indicated by a pressure gauge near the puncher's platform. When the operating converter is turned down, a release valve situated near the converter control discharges the air to the chimney.

The converter hoods are made of cast iron and are in five pieces bolted together. They are fixed about 1 ft. above the converter by three long tie bolts connected to a channel just below the crane rails, and hang on the dust chamber casing. The dust chambers are built of ordinary firebricks and measure 7 ft. 3 in. × 9 ft. 2 in. × 10 ft. high inside dimensions. The flue opening can be closed or opened by a thick C.I. plate damper connected by a wire rope to a counter weight and is operated from the punching platform.

Only one converter is blown at a time, but continuity of operation is maintained by using two converters alternately. As soon as the blow in one is finished, the other which has already been charged with matte is turned up and a new cycle of operation started. Six to seven charges giving 18-24 tons of blister copper according to the grade of matte are blown in 24 hr. The converter capacity is reduced by the formation of magnetite necessitating cooling, chipping and re-heating up with lump coal which takes about seven days. Thus after every 7-8 days one converter is shut down and another is started. Chipping is carried out with pneumatic chipping hammers and cleaning of the dust chambers, hoods, flues, etc., and any other repair work is effected at the same time.

Quartzite, which occurs abundantly in the surrounding area, is used as flux and is charged

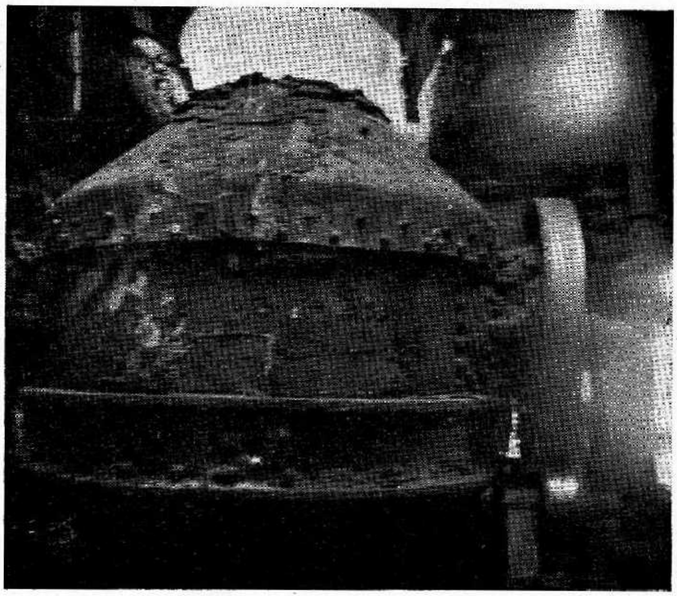


FIG. 15 — CLOSE UP OF A CONVERTER, SHOWING THE BOTTOM AND TOP CASTINGS BOLTED TO THE BODY PLATE

FIG. 16 — A VIEW OF CONVERTERS

into the converters by a ' boat ' made of mild steel plates. Local river sand was recently tried for fluxing, but the idea was dropped owing to operational difficulties and furthermore it had no economic advantage over quartzite.

In the converter cycle of operations, the converter is first charged with 6 tons of matte which is fluxed, blown and the slag poured off. Doubling or the addition of a further charge of 4-5 tons of matte follows and the operation is repeated. This time the slag is skimmed off and white metal (copper sulphide) is then blown to blister. The blister is removed in ladles protected by the skull left from the previous slagging. Doping, i.e. cooling, if the converter temperature rises too high, is carried out with ladle skull breakings, cold slag or matte.

A typical ' blowing ' cycle is as follows:

OPERATION	TIME, hr.	APPROX. DURATION, min.	
Converter charged	12·00	2	first slagging period
Flux added	12·05	1	
Cold dope added	12·30	1	
First slag removed	12·45	3	
Double charged	12·50	2	second slagging period
Flux added	12·53	1	
Second slag removed	14·05	3	
Final skimming	14·12	10	copper blow
Copper ready and blow finished	15·45		—

A monkey weight is used for breaking big pieces of secondaries. The ladles are made of cast steel and four of them — two for matte and two for slag and blister copper — are kept in regular use. They are given a clay wash before receiving matte or slag. The matte ladle bottom is further protected by a layer of converter slag which is poured in and allowed to solidify before tapping the matte. Efficient maintenance by welding helps to prolong the ladle life which ranges from 8 to 12 years.

Operating data for converters are given in Table 3 and typical recent analysis of various products is given in Table 4.

Refinery Section

The refining operations are carried out in three reverberatory type furnaces, two of which are tilting. Their total refining capacity exceeds the production of blister copper and at times one or the other furnace serves as a holding furnace. The furnace in the

TABLE 3

	1948	1949	1950	1951	1952
Matte treated, S/T	15196	16321	16873	17244	15379
Quartzite used, S/T	2518	2890	2308	2351	2116
Cleanings, S/T	1442	1317	1103	677	758
Blister produced, S/T	7030	7648	7876	8497	7263
Total blowing time, hr.	6826	7265	7401	7361	7308
Average grade of blister, % Cu	97·160	97·270	97·450	97·039	97·270
Percentage of Ni in blister	1·184	1·124	0·952	1·139	1·333

TABLE 4

	Cu	Fe	S	Ni	SiO_2	Al_2O_3	CaO
Concentrates	25·30	28·60	30·20	0·27	8·70	5·20	1·26
Calcines	27·50	29·40	3·83	0·28	—	—	—
Matte (low grade)	41·20	28·82	24·43	2·70	0·32	—	—
Matte (high grade)	50·70	18·80	22·80	5·27	0·62	—	—
Dump slag	0·36	43·10	1·03	0·23	33·75	8·96	2·11
Converter slag	3·17	53·10	0·63	1·90	26·66	1·34	1·15
Blister slag	44·16	13·80	1·08	17·40	9·28	—	—
Refinery slag	57·08	4·01	0·25	4·14	18·40	2·00	—
Roaster flue dust	18·05	—	14·48	—	—	—	—
Boiler flue dust	4·84	10·40	3·10	—	46·20	—	3·50
Converter flue dust	48·14	8·00	13·09	4·47	3·56	—	—
Converter chippings	36·66	30·10	3·86	9·59	6·22	—	—
Blister copper	97·12	0·05	0·14	1·01	—	—	—
Refined copper*	99·42	0·02	—	0·42	—	—	—

*Bi, 0·003; As, 0·003; Sb, 0·009; Se, 0·034; Te, 0·012.

old refinery as it is called is used for making ingots, while the new tilting furnaces are used for casting copper blooms for the rolling mill. Some of the refining capacity is also utilized for melting scrap from the rolling mill when available and this is generally done in the old refinery where it is ingoted.

Old Refinery

Construction of this furnace started early in 1938 and was completed by the middle of the same year. A comparatively deep reinforced concrete foundation of about 12 ft. was poured and thick cast iron-ribbed plates were installed on the periphery to a depth of 2 ft. in the concrete and rising 3 ft. 9 in. above it on the sides and 4 ft. 9 in. on the ends. These plates are provided with openings for doors, flue, burners and blister launder and support the furnace brickwork.

The furnace is so situated that the launder for charging liquid blister, placed on a separate frame at the firing end wall, just comes within the converter bay so that the converter crane can be used for charging. The launder can be easily removed for cleaning, etc.

Replacement of the detachable arches, discussed in a paper by Mr. H. C. Robson read before the I.M. & M., London, is carried out by two chain blocks sliding on I-beams fixed over the top of the furnace. Fig. 17 shows the arch in section and schema-

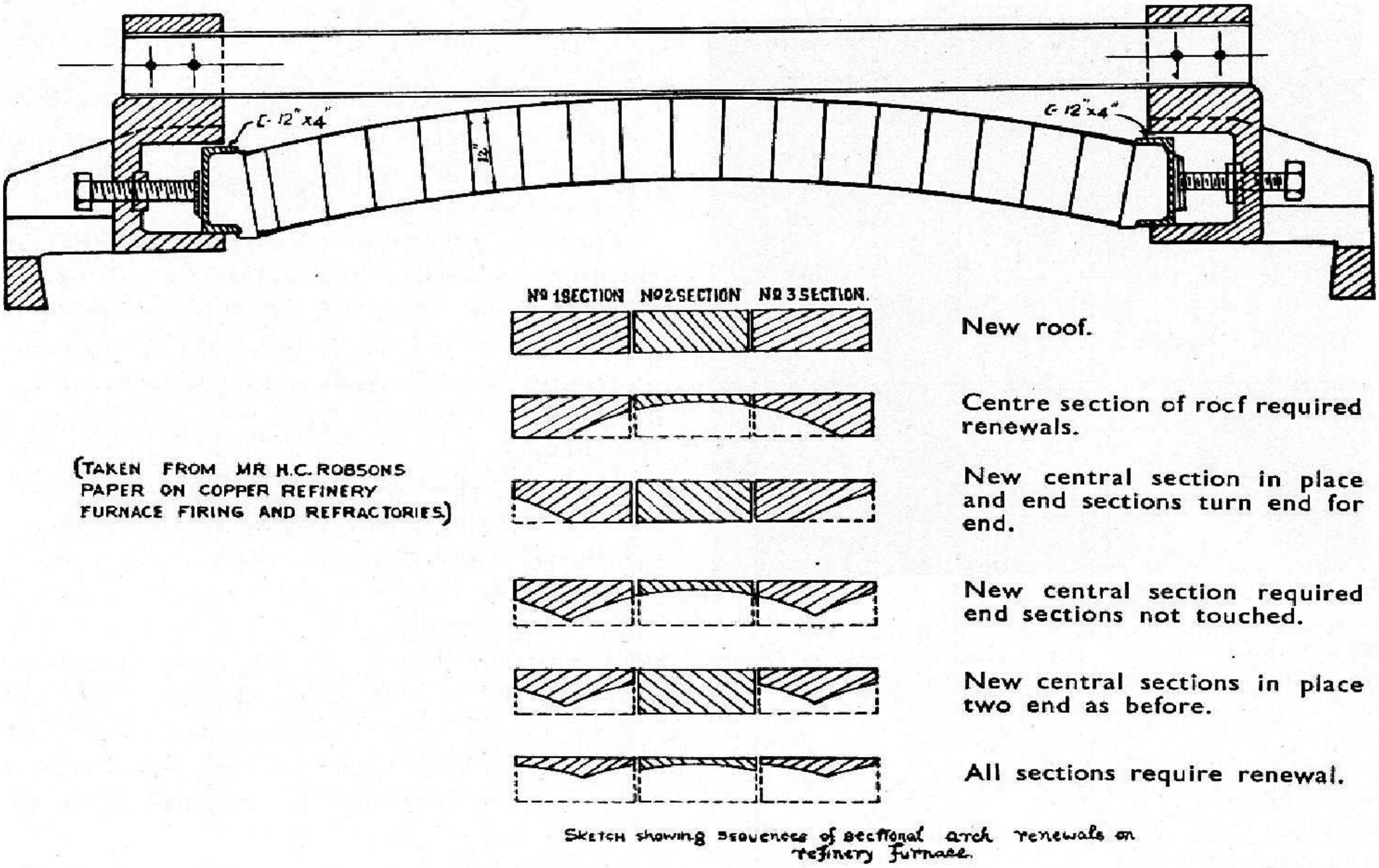


FIG. 17

tically explains the method adopted for obtaining the maximum life from the refractory material.

Silica bricks are used throughout the furnace. Fettling when required is carried out with a mixture of finely ground white quartz and fireclay in the ratio of 9 : 1 suspended in water and is ' shot ' on to the burnt places by a compressed-air gun.

The furnace when newly lined holds about 24 tons of blister and as the bricks wear out towards the end of a year's campaign its capacity increases up to 28 tons of copper.

Pulverized coal, tapped from the ring main, is used for firing. To guard against the jamming of the pipe connecting the mains to the burner, primary air carrying the coal dust is supplemented by compressed air. In case of emergencies an oil burner fitted by the side of pulverized coal burner is used. In spite of the many openings in the furnace, which cannot be closed properly, attainment of high temperatures has been made possible by the short flame burner and very low draught.

Charging and refining operations are carried out during the afternoon and night shifts and the refined copper is ladled out during the morning shift. Copper moulds, used for ingoting, are made at the furnace site as and when required.

The well-known procedure of slagging, oxidizing by compressed air and poling is practised for refining the charge. Poling is carried out by inserting three to four green poles at a time through the side doors and raising the rear ends by means of a chain block to keep the poles in the molten metal bath.

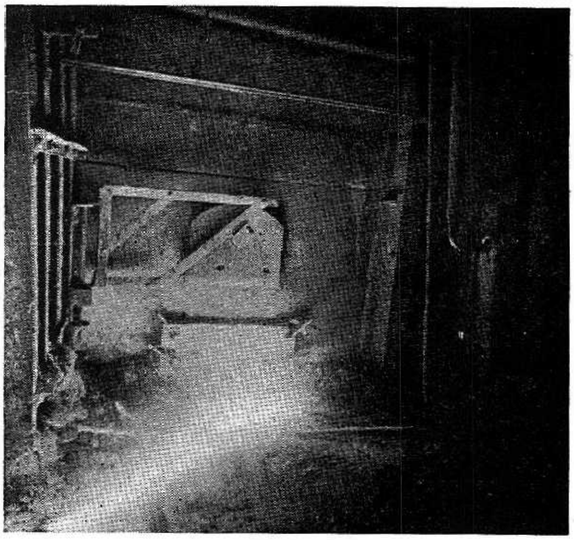


FIG. 18—MATTE BEING TAPPED FROM THE FURNACE, THE TAPPING PLATE WITH FIXING KEYS AND THE DOOR ABOVE THE TAP HOLE CAN BE SEEN

Tilting Refineries

These furnaces were installed in February 1946 when a portion of the converter aisle was requisitioned for the purpose. Both refineries, whose longitudinal central lines form an angle of 60°, are identical in construction and are placed 7 ft. above the ground level. Each is equipped with two trunions bolted to the body plates, which rest on bearings supported by reinforced columns; the back of the furnace rests on two hydraulic jacks operated from a platform in front of the furnace.

The lining consists of silica bricks housed in a steel plate body $15 \times 6 \times 5$ ft. high, having openings for poling doors, blister launder, burner, front door, and at the trunions the body plates are provided with expansion slots at the ends. The brick lining forms a U-shaped bottom with a radius of $1\frac{1}{2}$ ft. which serves as the hearth.

Detachable arches of the same design as the old refinery, already described, are placed on the side walls — their weight being taken up by projecting angles fixed to the side plates. Three to four arches depending upon the amount of blister treated are used in one year's operation.

A movable cast iron blister launder supported by a separate frame is placed on rails near the furnace opening and is removed as soon as the charging is over.

Pouring of refined copper is effected through a small 2 ft. launder fixed to the furnace shell below the front door which is closed by a mixture of clay and ground quartz up to the working bath level and is gradually cut as the copper level goes down in the furnace.

A tilting steel pot with a rammed finely ground firebrick lining is used for transferring the liquid copper to the water-cooled bloom mould. The pot is carried on a hand-operated turntable and is capable of being electrically rotated for pouring purposes through 360°. The capacity of the pot can be varied within wide limits by changing the lining thickness. The pot is kept hot between pourings by means of an oil burner.

The furnaces are fired by pulverized coal from one or other of two independent unit pulverizers (Buell) placed near a common chimney. Secondary air for combustion,

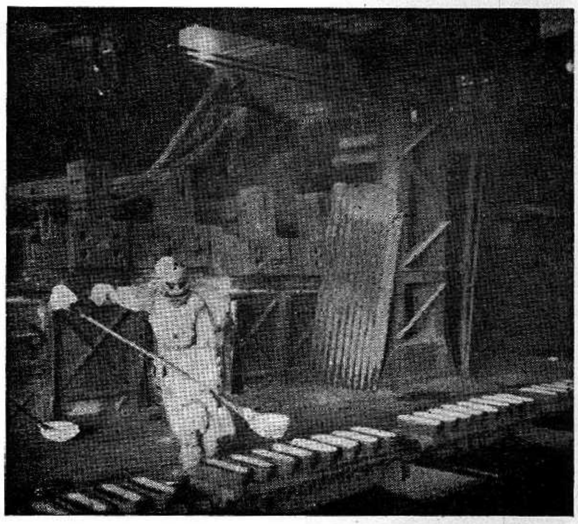


FIG. 19 — LADLING OF REFINED COPPER FROM THE STATIONARY FURNACE

as previously mentioned, is received from the main fan drum by a 6 in. pipe. Part of the waste gases is diverted through the coal storage bin placed at the furnace level from where dry slack coal is fed by gravity to the pulverizers.

Refining is carried out in each furnace in turn with 9-10-ton charges in the same way as in the old refinery. The poling on the tilting furnaces is effected through two doors using single poles and the poles are forced under the surface of the bath by air jacks instead of by a chain block as in the case of the old refinery.

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