The following is the method employed at the Cananea Smelting Works, Mexico, for lining large fore-hearths. The bottom of the fore-hearth or settler is lined with 10in. of fireclay brick, the upper layer of which is replaced by one layer of chrome brick directly underneath the spouts, and around the tap-holes. The sides are lined with 9in. of chrome brick, all the way up, the outsides of which are located 12in. from the $\frac{3}{4}$in. steel shell, the intervening space being filled up with a mixture of crushed silica and clay. This spongy siliceous and clayey material, being a non-conductor, serves as an insulator as well as an expansion safeguard.

The method of feeding and of taking off fumes is now being altered at Mount Morgan. Formerly, the fumes, etc., were taken off below the feed floor, there being no superstructure above the feed floor. At the time of my visit, three ovens had been altered, and the other will be altered shortly. Each of these three furnaces has a superstructure consisting of steel plate line with fireclay tiles, bolted to the inside. Surmounting this is a steel hood, which leads the gases and fumes either to a short, unlined vertical uptake, 3ft. internal diameter, or through a brick-lined goose neck, 6ft. internal diameter, to a large flue and dust chamber, running parallel to the furnaces and connected to a stack 250ft. by 11ft. octagonal. The whole of this superstructure rests upon a mantel frame of I beams, supported on four hollow square-ribbed columns, water cooled.

There are two narrow counterbalanced charging doors on each side of the furnace, and running the whole length of the furnace.

SMELTING PRACTICE.

The furnace charge is as follows:—

Ore	2,000lbs.
Limestone	1,050lbs.
Ironstone	425lbs.
Coke	315lbs.
Converter slags	
Four converter linings	
Clean ups, etc.	

These materials are taken from their respective hoppers in hand-cars by the wheelers, weighed, and then dumped on the feed floor near the charging doors. The feeders then shovel them into the furnace in the following order:—

Coke.
First ore.
Ironstone.
Limestone.
Second ore.

Eighty-seven per cent. desulphurization takes place in the furnace on the above charge, and the matte fall is 6½-7 per cent. of the weight of slag produced. The amount of coke on the charge is 9 per cent.

The slag and matte produced run through a trap spout in front of the furnace into the main fore-hearth. In this fore-hearth, the greater part of the matte separates and is tapped off periodically into hand-pots, wheeled and tipped into the converter ladle. More matte is produced at present than the converters can take. This excess matte is tipped into shallow cast iron launders, which have been previously clay washed to prevent sticking, and dried. This excess matte is then broken up, elevated by electric lifts to the feed floor, and added to the ore charges. The slag and the small amount of matte which does not settle out in the first fore-hearth overflow into the auxiliary fore-hearth. This fore-hearth saves about twenty-four shillings per day, and the matte is tapped from it once or twice a month. The depth of matte in the fore-hearths is ascertained by putting a steel rod vertically into the fore-hearth and allowing it to remain there for a little time. On drawing out the rod, the junction between the slag and matte is clearly indicated on the rod.

The slag then overflows into the slag-pots, drawn away by horses, and tipped over the dump. The dump is a overhanging one, and the edge has to be continually blasted off. Logs of wood are placed on all overflow spouts, so that the upper surface of the molten stream shall not chill.

The matte produced assays 32-40 per cent. Cu. The slag aimed at assays as follows:—

SiO_2	42	per cent.
FeO	33	„
CaO	21	„

A sesquisilicate slag, with a formation temperature of about 1150deg. C.

The following are actual analyses of slags produced at the time of my visit:—

SiO_2	43.64	42.78	41.76	44.24	40.78	41.12
FeO	32.50	33.60	33.46	32.26	34.16	31.12
CaO	20.56	19.63	20.68	20.03	21.86	23.78

The copper contents of the slag averages 1-100 part of the copper contents in the matte produced, so that when the matte assays 35 per cent. copper, the slag will assay about 35 per cent. of copper.

The slag assays 15-20 grains of gold per ton.

The flues are cleaned every day, and the flue dust is wetted down, and charged into the blast furnace.

The overflow water from the jackets is kept at a temperature of 180deg, Fahr. This water is then cooled to about 80deg. Fahr. by means of cooling towers.

BLOWING IN.

Wood to the height of a foot above the tuyeres is put into the furnace through the space left by the removal of the end lower jackets. These jackets are then replaced and all joints closed with a plugging mixture of fireclay. The wood is then set alight at each end of the furnace, and in the middle at the sump by means of old kerosene and oily cotton waste. Then 50 cwts. of coke are fed in evenly over the wood, then twenty slag charges, each consisting of 17 cwts. of slag and 2 cwts. of coke. Then follow alternate ore and slag charges until the charge reaches its proper level, which is 9ft. 6in. above the tuyeres. Then the slag charges are gradually eased off thus: 1 in 3, then 1 in 7, and so on, until one hour after the furnace is full no slag are added.

A gentle blast is employed at first, and when all the coke is fed in, it is gradually increased till the furnace is full. It takes about three hours from the time of lighting till the furnace is working on normal charges, when matte appears along with the slag.

All the blowing-in charges are weighed up beforehand and dumped near by on the feed floor, so that the furnace may be quickly filled.

The converters are 8ft. long by 6ft. in diameter. They are electrically operated, power being obtained from the main power plant. They are made of ½in. plate steel in two sections, so that the top half can be lifted off, leaving the lower portion accessible for relining. At one side is bolted the wind-box, which is the length of the shell, and is fitted with eleven 1in. ball tuyeres spaced 6in. centres. Two vessels are continually working and nine undergoing relining, etc.

The matte ladle is made of steel, clay lined, and holds about four tons of matte.

The wind pressure to the converters runs from 5½lbs. to 7lbs., and the wind volume 3,000 cubic feet per minute. Two men, viz.: the skimmer and the assistant, work on each converter, the skimmer having control. The assistant has to punch the tuyeres, that is, he inserts a bar right through the tuyeres into the interior of the converter; this keeps the tuyeres open and removes any noses formed by the chilling of the metal or matte by the cold blast.

A 25-ton crane, electrically operated by four motors, runs the whole length of the converter building, and is used for lifting converters, etc.

CONVERTER PRACTICE.

The molten matte is conveyed from the blast furnace forehearths by hand and tipped into the converter ladle, let down into a well in the ground. A small log of wood is kept burning in the ladle to prevent the surface of the matte from chilling. This ladle is then picked up by the crane when required, conveyed, and its contents of molten matte poured through a small clay-lined launder or "gun" into the converter. The ladle is then returned to the well, and on its way there all chilled matte is tipped and raked out. As soon as the matte is poured into the converter, the air blast is turned on slowly, and the converter brought to its proper working position, when the full blast is turned on. A newly lined converter stands 5-7 blows.

The practice is as follows:—

An initial double blow is given and then three or four single blows, and then the converter is relined.

For the initial double blow about 1½ tons of matte are first run in, and then this is worked up to white metal, i.e., the slagging stage. The converter is then turned down, the blast shut off, the slag poured off into a ladle, then the converter, turned up a little, and another one ton of matte run in. The blast is then turned on, the converter is brought again to its proper working position, and the charge worked again to white metal. Then the converter is again turned down, blast shut off, slag poured off, copper chips, cleanings, bricks, etc., added, the blast turned on and the converter brought to its working position. The whole is then blown to blister copper, the blast shut off and the blister poured into molds. In the remaining blows only one lot of matte is poured into the converter, this is blown to white metal, slag poured off, copper bricks added, and the whole then poured to blister.

For the third blow about 2¼ tons of matte are used. For the fourth blow 2¾ tons, and for the fifth blow 3¼ tons, the average charge being 2¾ tons.

Too much copper chips, bricks, etc., should not be added, otherwise the bath is chilled too much.

Table showing average times of blowing to blister, working on a 35-38 per cent. matte:—

———	Initial Double Blow.	Third Blow.	Fourth Blow.	Fifth Blow.
First Slagging	56 min.	65 min.	65 min.	65 min.
Pouring and Charging...	10 ,,	5 ,,	5 ,,	5 ,,
Second Slagging ...	50 ,,	...	...	...
Pouring and Charging...	5 ,,	...	...	...
Blister Making	35 ,,	35 ,,	52 ,,	65 ,,
Total time taken ...	156 ,,	105 ,,	122 ,,	135 ,,

The slag from the converters is poured straight into a ladle, which is then carried along by the crane, and its contents tipped out into cast iron shallow molds, and then sent to the blast furnace.

Just before pouring the blister into molds, the assistant holds an iron screen in the mouth of the converter, whilst the skimmer fashions a rough lip with clay on the lower side of the mouth. A small block of wood, which serves to keep back any slag or scum, is then thrown into the converter. The blister is then poured out into a clay-lined pouring spoon, 18in. long by 12in. wide, and thence into the molds. The slabs of blister thus got measure about 24in. by 18in. by 3in., and weigh about 2¼ cwts. each. The molds are arranged on a carriage, which runs directly beneath the converter, the pouring spoon resting on the molds. The pouring spoon prevents undue splashing. As each mold is filled, the carriage is pulled forward until the next mold comes underneath the mouth of the converter. When all the molds on the carriage are filled the whole lot is lifted up bodily by the crane and taken to the end of the building. Here they are chilled by water from a hose. The slabs of blister are then thoroughly cleaned, rough edges chipped off, etc., then weighed and sent to the Port Kembla Electrolytic Refining Works, N.S.W. These cleanings, etc., go back to the converter.

The blister assays—

Cu, 99-99.2 per cent.
Au, 14-15oz. per ton.
Ag, 2½oz. per ton.

The converter slag assays—

SiO_2, 33 per cent.
Cu, 1-3 per cent.

This slag is returned and smelted with the blast furnace charge.

In blowing matte to blister in a converter, the finishing points either for slag or blister can only be learned by experience.*

When a converter has finished its last blow, it is lifted off the blowing stand by means of the crane, and taken to one of the repairing stands. The top portion or cover of the converter is then unbolted and taken off. Water is then played into the vessel to cool the lining, and the skin of slag and any loose lining is removed. The coarse material goes to the blast furnace, whilst the fines go to the lining mill for embodiment in the mixture for lining the converters. A new lining is then put in; for this purpose the converter is transferred to the lining stand. The lining averages 18in. in thickness, and is made from the following materials:—

Siliceous Gold Ore ...	...	SiO_2 88 per cent.	
Fireclay	...	SiO_2 83 ,,	Al_2O_3 18·5
Copper Bearing Clay	...	SiO_2 57 ,,	

Analysis of mixtures used :—

Body Mixture ...	86·66% SiO_2 ;	8·25% Al_2O_3 ;	3·26% FeO
Cover Mixture ...	68·85 ,,	12·66 ,,	9·88 ,,

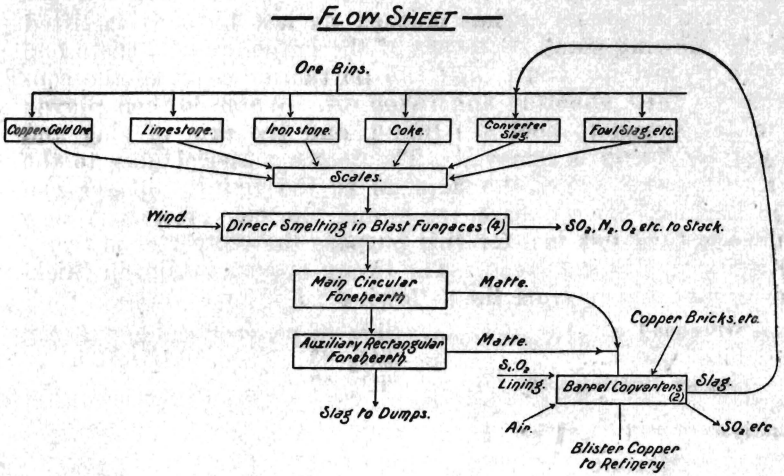
They are thoroughly mixed in a Chilian mill, with enough water so that the mixture just binds when squeezed in the hand. The damp moisture is then shovelled into the converter and tamped around a wooden centre or mould, put in in sections, and which shapes the internal cavity of the converter. The tamping is done by means of a tamping machine, operated by air. This machine resembles a rock drill, but a tamper is used instead of a drill. It is suspended on roller bearings on a beam, free to rotate radially around a post from which it is supported. The machine is counterweighted, and is moved back and forward on the beam and axially about its centre by hand.

The tuyere openings are made with a $\frac{5}{8}$in. round rod pushed through the tuyeres till they touch the wooden mould. The wooden mould or centre is then removed in sections. The top portion is relined by hand and then replaced, all loose lining being cleaned out of the vessel, it is then lifted by the crane on to the drying stand, and here the lining is allowed to dry, and is then baked by means of a small fire, kept going by a gentle blast until the vessel is required for use.

The blowing plant consists of: Seven No. 6 Connersville blowers, each of 10,000 cubic feet capacity, and electrically driven. These supply the air to the blast furnaces. Three Parsons surbo blowers each of 3,000 cubic feet capacity, electrically driven. These supply the air to the converters. One

* See Articles "Converting Copper Mattes," by H. Schroder, M.I.M.E., etc., in *Australian Mining Standard*, June 1st and 8th, 1910.

switchboard, comprising fourteen panels (17 circuits). The electric power is obtained from the Central Power Station.



The recovery of copper is about 88-89 per cent. The loss in slags, 10 per cent.; and unaccounted for, probably up the stack, 1-2 per cent. The recovery of gold is about 102 per cent. These figures are based on the actual gold and copper got compared with the amounts said to be present in the ores and fluxes by assay.

ALTERATIONS IN PROGRESS.

All the furnaces are being altered so that the fumes and gases may be taken off above the feed floor. The ironstone flux is to give way to a dense pyrite ore obtained from Many Peaks. This pyrite ore assays, on an average, as follows:—

Cu, 1-2 per cent.
Fe, 40 per cent.
S, 45 per cent.
Au, 6 grains per ton.
Silver, 6 dwts. per ton.

Limestone will still be used as a flux, but less of it will be required. The amount of air supplied will be increased to 17,000 to 18,000 cubic feet per minute at a presure of 35-40 ounces. A semi-pyrite smelting will be carried out, all of the ore being smelted direct. The percentage of coke on charge will be reduced to about 6 per cent., or even lower. It is expected that a lower grade matte will be obtained than at present. This matte will be tapped direct from the forehearth to the clay-lined ladle set in a pit between the furnaces.

This matte will then be blown to blister in converters. The shell of these converters will be 90in. in diameter, and 126in. long, the ends being ½in. and the barrel ⅜in. boiler plate. The initial charge will be about five tons of matte, each converter will have sixteen 1in. tuyeres. Three blowing stands will be used.

The tonnage will be increased to about 250,000 tons Mount Morgan ore, and 100,000 tons Many Peaks ore.

Limestone costs seven shillings per ton at the smelter bins. The Many Peaks ore will cost seventeen shillings and sixpence at the bins, whilst the intrinsic value is about thirty shillings per ton.

The ironstone costs at present twenty shillings per ton.

The use of Many Peaks ore will reduce the cost per ton of blister from the present price of about £48 per ton down to about £35 per ton.

THE FOLLOWING STATEMENTS MAY BE OF INTEREST TO MEMBERS.

PERIOD.	AMOUNT IN TONS USED TO PRODUCE 1 TON OF BLISTER.						All Contents in Blister Produced
	Ore.	Limestone.	Ironstone.	Coke.	Corivalen Linings.	Total.	
For Half-Year ending November, 1909	34·02	18·64	7·41	5·84	0·98	66·89	15·79
For Year ending May, 1910	32·97	17·60	7·15	5·5	0·92	64·14	15·37
Average to present ...	34·3	17·10	6·21	5·29	1·08	63·98	15·5

AMOUNT OF COPPER-GOLD ORE TREATED, AND OF LIMESTONE AND IRONSTONE USED.

Period Ending	Copper-Gold Ore. Tons.	Limestone. Tons.	Ironstone. Tons.
May, 1904 ...	3,466	153	...
Nov., 1904 ...	3,968	690	...
May, 1905 ...	12,955	...	...
Nov., 1905 ...	12,396	...	...
May, 1906 ...	44,409	8,283	...
Nov., 1906 ...	48,646	21,957	958
May, 1907 ...	49,658	24,280	7,803
Nov., 1907 ...	73,386	37,958	16,640
May, 1908 ...	89,692	51,128	21,397
Nov., 1908 ...	100,528	54,725	20,702
May, 1909 ...	86,503	44,577	14,650
Nov., 1909 ..	121,339	65,484	26,037
May, 1910 ...	98,850	50,042	20,911

Metals Produced.

For Half-Year Ending	From Chlorination.		From Smelter.		Total.	
	Gold. Oz.	Copper. Tons.	Gold. Oz.	Copper. Tons.	Gold. Oz.	Copper. Tons.
May, 1902 ...	65,018	19	...	...	65,018	19
Nov., 1902 ...	78,242	35	..	...	78,242	35
May, 1903 ...	65,342	43	...	...	65,342	43
Nov., 1903 ...	52,472	65	..	...	52,472	65
May, 1904 ...	57,430	76	...	...	57,430	76
Nov., 1904 ...	58,570	79	...	...	58,570	79
May, 1905 ...	63,710	98	...	...	63,710	98
Nov., 1905 ...	62,281	125	...	...	62,281	125
May, 1906 ...	52,229	179	2,677	179	54,916	358
Nov., 1906 ...	51,878	172	20,838	1,751	72,716	1,923
May, 1907 ...	46,045	192	26,377	1,972	72,477	2,164
Nov., 1907 ...	46,741	195	31,447	2,310	78,188	2,505
May, 1908 ...	38,419	177	36,484	2,810	74,903	3,056
Nov., 1908 ...	39,717	230	44,320	3,042	84,037	3,272
May, 1909 ...	25,803	223	28,502	2,304	54,304	2,527
Nov., 1909 ...	37,552	175	55,474	3,513	93,026	3,688
May, 1910 ...	31,952	324	53,889	3,050	85,841	3,374

In concluding this paper, I must express my thanks to the General Manager, Captain Richard, and his staff. No question was left unanswered, whilst every facility was given for gaining information at the works.