12in. to 18in. in depth, into which the sides dip. The top portion or curtain of the chamber is supported in a framework of wood, to which the lead is secured by lead bands. The whole is supported on a strong wooden framework.

The Glover tower is 7ft. 6in. square, and 20ft. in height, packed with flints and bricks.

The Gay-Lusac tower is 5ft. in diameter, and 15ft. in height, filled with Guttiman earthenware balls. These balls have a rough surface, and are pierced with eight holes.

The sulphur dioxide is produced by burning brimstone, got from Japan, and pyrites obtained from the mine. Two and a half to three tons of brimstone are burnt per day. The brimstone is charged into a brick burner, 7ft. long by 5ft. wide, through a hopper in the roof. The burner is simply a rectangular brick chamber, fitted with a flue at one end to carry off the sulphur dioxide produce, and a sliding door on one side for the admission of air over the bath of molten sulphur. A jet of compressed air is also let in at the bottom of the burner; this keeps the bath in agitation, and enables the sulphur to burn quicker and more regular, and prevents any volatilization of it in the unburnt state. When once the sulphur is set burning, the heat arising from its own combustion is sufficient to render the operation continuous, fresh charges being added from time to time.

The iron pyrites is burnt in four ordinary pryites burners, 5ft. by 4ft. grate. Each burner burns one ton in twenty-four hours, reducing the sulphur contents from about 30 per cent. down to 2.3 per cent. The pyrites, like the brimstone, is self-burning, but the pyrites used must not clinker or clog, but remain open so as to let a good current of air through. The pyrites, when burnt, is discharged into the pit under the grate by simply turning the fire bars; it is then sent to the smelting works.

At the time of my visit experiments were being made with the gases coming from the top hearths of the Richard furnaces in the Mundic Works, and I am told that these experiments were meeting with success.

The nitric acid from which the oxides of nitrogen are derived is obtained by the action of concentrated sulphuric acid on Chili saltpetre (No. NO_3). The saltpetre and sulphuric acid are placed in cast iron pots, 5ft. long by 18in. wide, trough shaped in section. Thickness of metal, 1½in. to 2in. These pots are placed in an enlarged part of the flue from the sulphur burner, known as the "nitre oven." The pots are heated by the hot gases produced by the combustion of the sulphur, and the nitric acid fumes produced are carried forward along with the sulphupr dioxide gas, and are decomposed, producing oxides of nitrogen—

$$2HNO_3+SO_2=H_2SO_4+2NO_2.$$

This NO_2 makes up for the NO_2 lost during the cycle of chemical changes taking place due to leakage, defective absorption, and the reduction of a certain portion of it to N_2O. To make up for this loss of NO_2, about three to four parts of $NaNO_6$ are required for every 100 parts of sulphur burnt as pyrites. The air supplying the oxygen for the chambers is drawn in through the burners, the draught being maintained by means of the stack, and by adjustment of the doors of the burners, so as to admit the quantity of air found necessary by experience.

The steam necessary is blown into each chamber by means of an atomiser.

The reactions taking place are usually given as follows:—

(1.) $S+O_2=SO_2$

(2.) $4FeS_2+11O_2=2Fe_2O_3+4SO_2$

(3.) $NaNO_3+H_2SO_4=NaHSO_4+HNO_3$

(4.) $2HNO_3+SO_2=H_2SO_4+2NO_2$

(5.) $2SO_2+3NO_2+H_2O=2SO_2(HO)(NO_2)+NO$

(6.) $2SO_2(HO)(NO_2)+H_2O=2H_2SO_4+NO+NO_2$

(7.) $2NO+O_2=2NO_2$

Reactions 1, 3 and 4 take place in the sulphur burners, and in the flue leading from same; reaction 2 in the pyrites burners; reactions 5, 6 and 7 in the chambers.

The exit gases from the last chamber may still contain NO_2, and to save this the gases are passed up the Gay-Lussac tower, where it meets a descending stream of cold, strong sulphuric acid, by which the NO_2 is absorbed, nitro-sulphuric acid $[SO_2\ (HO)\ (NO_2)]$ being formed. The exit gases then pass through the stack into the atmosphere. In order to make use of the absorbed nitrogen compound, the acid which flows from the foot of the Gay-Lussac tower is pumped to the top of the Glover tower, situated between the burners and the first chamber. The hot gases from the burners pass up this tower on their way to the first chamber, and meeting with the descending stream of nitro-sulphuric acid, denitrification takes place.

$$2SO_2(HO)(NO_2)+SO_2+2H_2O=2NO_2+3H_2SO_4$$

$$2NO+O_2=2NO_2$$

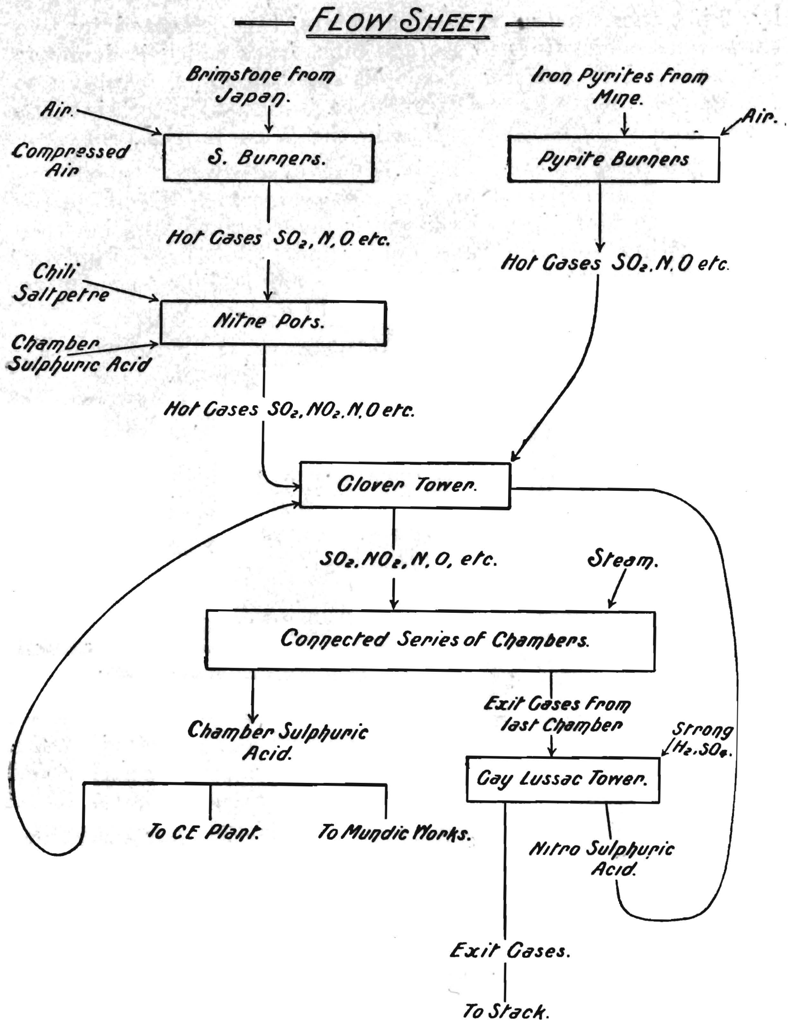
The gases from the Glover tower then pass into the first chamber. Besides the nitro-sulphuric acid, a quantity of chamber acid is also delivered into the top of the Glover tower. The effect of the hot gases on this dilute acid is to remove a portion of the water from it, thereby effecting a partial concentration, and furnishing the water demanded by the above reaction. The acids for the Gay-Lussac and Glover towers are forced up automatically by compressed air.

The chamber acid produced runs about 68-70 per cent. of H_2SO_4, Sp. Gr. 1.6. Above this strength the acid not only begins to dissolve the SO_2 and NO_2 in the chambers, but exerts a corrosive action on the lead. A daily continuous sample of the exit gases going to the stack is taken, and analysed for SO_2 and O. The SO_2 is kept below 3 grains per cubic foot, and the O under 6 per cent.

The number of employees on the works is seventeen.

Table showing amount in tons of H_2SO_4 manufactured, and also tons of pyrites, sulphur and nitre used:—

Year.	H_2SO_4 made.	FeS_2 used.	S used.	$NaNO_3$ used.
Ending May, 1907 ...	4,793	1,131	826	118
" 1908 ...	4,609	1,101	908	93
" 1909 ...	4,739	1,211	918	108
" 1910 ...	3,910	1,100	830	86



TREATMENT OF MUNDIC ORE AT THE MUNDIC WORKS.

Capacity of works, 400 tons per day. The average amount of ore treated per month is as follows:—

From open cut	2,810 tons,
From underground	7,430 ,,
Total	10,240 ,,

From the main storage and receiving hoppers at the works the ore passes through two Blake-Marsden jaw breakers, 24in.

by 13in., then to two revolving driers, then elevated by two chain bucket elevators to storage bins, from which it descends by gravity into fourteen No. 5 Krupp ball mills, crushing to 1,225 mesh, thence to two large storage bins. Up to this stage the treatment is similar to that in the West Works.

From these storage bins it is conveyed by two spiral conveyors to four belt and bucket elevators, which discharge the fine ore into four bins. Each bin is placed above and between two roasting furnaces, and hold about 12 hours' supply of ore. This supply is sufficient to give ample time to make repairs to the elevator, in case it should break.

There are eight roasting furnaces, and these were designed by the General Manager, Captain Richard.

RICHARD'S SHAFT FURNACE.

The principle of the furnace is the oxidation of the sulphides by causing the fine ore to fall in a finely divided stream through a current of heated air. To prevent the ore from falling through the furnace too rapidly baffles, in the form of arches, are arranged. These arches are perforated on the top, or have discharge holes near the base.

The furnace is 64ft. high, and stands on a base 11ft. 8in. wide by 29ft. 6in. long, the internal measurements being 7ft. by 25ft. 6in.

There are ten arches, six of which are perforated at the top and at the edges alternately (the first one being perforated at the edges) and the remaining four at the edges only.

The ore flows in a thin stream from several small openings in the bins, along narrow shoots, through twenty small openings in the top of the furnace. The amount of ore to any part of the top arch is regulated by any of the small openings in the closing bin. The ore piles itself up on the top arch until it commences to run through the holes near the base of the arch on to the second arch, from which it flows through holes in the centre on to the third arch, from which it flows through holes at the base on to the fourth arch, and so on until it meets the seventh arch. On this and remaining three arches the flow of ore is stopped by closing the discharge openings at the base of the arches by slide valves. On these arches the ore is hand-rabbled, and then discharged by opening the slide valves. The ore thus finally passes to the last hearth, which is flat. This hearth connects with the hearth (15ft. long by 10ft. wide) of a reverberatory furnace 25ft. long attached to the shaft. On this long hearth the ore is rabbled and worked along by hand, until it is considered to be sufficiently roasted, and is then discharged.

Each arch has four working doors on each side. The heated air is led over the reverberatory portion, up a short flue at the end, over the top of the lowest arch, over the length of the arch, up another flue, back over the next arch, and so on.

The fire-box measures internally 4ft. 2in. by 10ft. Fire-bridge is 2ft. thick. The discharge hole is 4ft. by 1ft.

The working doors along the long hearth are spaced 6ft. 4in. centres.*

Three men are required per furnace per shift to work the lower flat hearth and reverberatory, and one man to work the next four arches above. No labour is required on the arches above these. Each furnace roasts 13 to 14 tons in 8 hours, the cost of labour for the same time being 33s.

One furnace has the lower flat hearth and the reverberatory hearth mechanically raked, thus saving three men's labour. In this portion there are eighteen water-cooled shafts, 4in. in diameter, let in through the side walls of the furnace, and are driven by bevel gearing from a main shaft running along one side of the furnace. Each shaft carries 10 blades or rakes, spaced equidistant along the shaft, and arranged so as to make a complete circle around it. The rakes are solid, and measure 9in. by 6in. by 1in. thick. The rakes are twisted about their middle, and are fitted into and bolted to two lugs on the shaft. Each rake makes an angle of 45deg. with the centre line of the shaft, and is arranged in the opposite way to the preceding one. The shafts may be rotated either way, so that if it is judged that the ore is insufficiently roasted when it reaches the last set of rabbles, the ore may be returned in the opposite direction, and then brought forward again, and then discharged. This system of rabbling is meeting with success, and will no doubt be used with all the other furnaces in the near future.

The sulphur contents of the ore is reduced down to .35 per cent. total S,.23 per cent. being in the form of soluble sulphates, and .12 in the form of sulphides.

These furnaces connect with a main flue to a stack 170ft. in height by 8ft. octagonal. From each furnace a scraper conveyor takes the ore to large brick storage hoppers, thence by two spiral conveyors to three movable push conveyors, which fill the vats. These conveyors are on travelling frames, so that they can be moved laterally to any portion of the vat. The bottom of the conveyor is also fitted with removable plates, so that the roasted ore may be deposited at any position along its length. This combined with the lateral motion, enables any portion of the large vats to be filled.

* For diagrams see "Australian Mining and Metallurgy," by Donald Clark, p. 278.

There are twelve vats, built in the same manner as those at the West Works, but of a larger capacity, eight of 230 tons, two of 500 tons, and two of 1,000 tons.

When the vat is filled, water is admitted from below, and at the same time, a little is sprayed on the surface of the ore. When the water reaches the surface it is allowed to stand on for a few hours, and then drained off. Then a 2 per cent. solution of sulphuric acid is run on from the top, and is kept running on until the exit solution at the bottom of the vats gives no indication of the presence of copper on testing with ammonium hydrate. The vat is then filled with water, which is drained off at once. Sometimes when the amount of soluble iron salts coming through is small this water wash is omitted; if the amount is large, several washings may be required. The acid solutions and washes are pumped to the copper precipitation canals (to be described later). The acid wash acts in two ways, (1) it removes some of the copper, (2) it removes soluble sulphates of Fe, etc., which absorb chlorine and tend to clog the vat and to hinder percolation.

It thus cleans and loosens the charge in the vats, so that chlorine is saved. Only about 50 per cent. of the copper is leached out with the acid and washes. The copper unacted on is probably in the form of sulphide not roasted, or as cuprous oxide, which is only partly soluble in dilute sulphuric acid thus—

$$Cu_2O + H_2SO_4 = CuSO_4 + Cu + H_2O$$

or as both forms.

Ferrous sulphate may also precipitate metallic copper thus—$3\ Cu_2O + 2\ Fe\ SO_4 = 4\ Cu + Fe_2O_3 + 2\ CuSO_4$.

After all the resultant iron salts have been washed out with water, the chlorine solution (100 grains of chlorine per gallon) is run on to the surface of the charge in the vat from time to time in such quantities that the contents absorb same, and so leave as small amount of solution exposed to the atmosphere. If the vat leaches freely, and the escaping liquors are high in chlorine, the outlet valve is screwed up to enable the chlorine to do its work.

The average time of treatment with chlorine solution for the 230 ton vats is about 60 hours. At the end of about 48 hours, the exit solutions assay about 10 grains of free chlorine per gallon, and at the end about 45 grains. The last liquors, low in gold but strong in chlorine, are used again as first chlorine liquors on a new vat before going through the charcoal filters. New wash waters are run on.

After all the gold chloride, according to the sulphate of iron test, has been washed out, a little copper may still be coming away in solution, and these liquors, containing traces of gold, are run to the copper precipitation plant, thus accounting partly for the precipitate got assaying a few dwts. of gold per ton.

The ore is deposited from the liquors as in the West Works, by expelling free chlorine by steam and then running through charcoal filters. They are then pumped up and run through the copper precipitation plant, as they contain copper in solution, and also traces of gold, again, accounting for the gold in the copper precipitate got. The presence of copper in these solutions may be due to copper compounds, which are insoluble in dilute solution, being dissolved in the chlorine solution, and also to the solution of the metallic copper liberated by the reactions above. The force pumps used have lead-antimony cylinders and wooden plungers.

The vats are emptied by sluicing the residues out through three or four bottom discharge doors, each 12in. in diameter, The residues are sluiced to a large dam, where they are exposed to weather, and are leached by the continual discharge of water sluicing out the vats. The water draining from this dam mixes with the water pumped from the mine, and the mixed water is then pumped and run through a series of copper precipitation canals, when the copper in them is saved. This exposure to weather and leaching oxidises and dissolves out any copper sulphide left unroasted in the ore.

The chlorine liquor for this works comes from the chlorine generating plant. It is run to covered-in storage tanks, and as it flows in, it displaces some air and also some chlorine gas, also some chlorine gas is being continuously given off from the liquors. To save this chlorine, the exit gases from the storage tank, before escaping to the atmosphere, are passed up a tower 20ft. high, 2ft. in diameter, filled with stones, down which water is constantly trickling, when any chlorine gas is dissolved and saved. About 6lbs. of chlorine per ton of ore are consumed in this works.

Total number of employees, including maintenance hands =286.

Cost of treatment per ton of ore:—

	s.	d.
Crushing	3	6
Roasting	5	4
Acid treatment	0	11
Chlorination	4	1
Total	13	10

FLOW SHEET (Crushing & Roasting.)