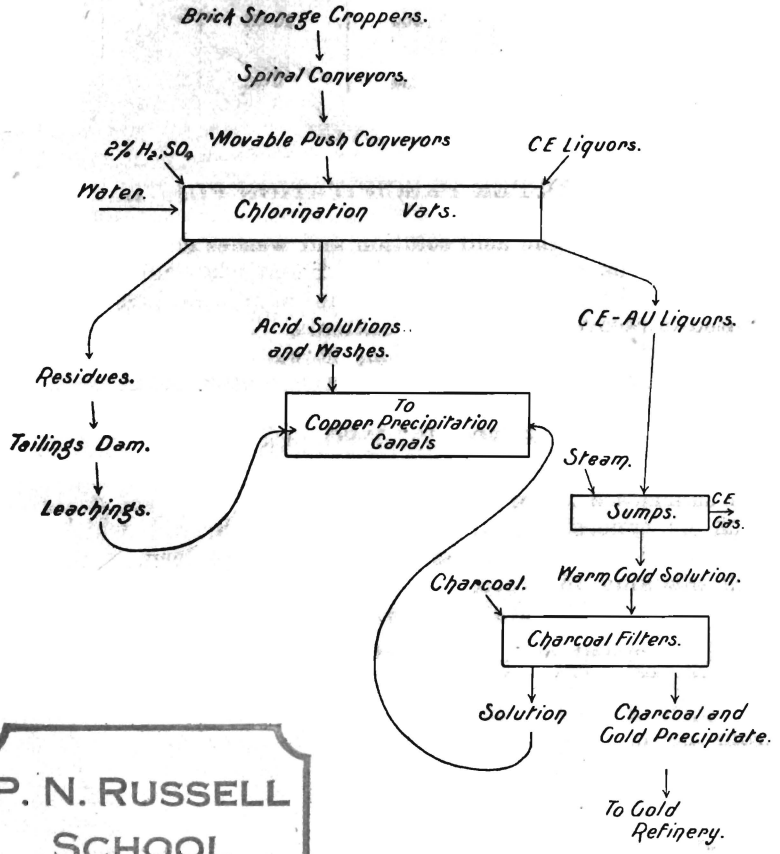
FLOW SHEET (Chlorinating)



P. N. RUSSELL SCHOOL OF ENGINEERING

W. H. WARREN COLLECTION

THE FOLLOWING STATEMENT SHOWS THE AMOUNT OF ORE TREATED, AND THE YIELD OF GOLD AND COPPER FROM 1902 TO 1910.

Year ending 31st May.	Tons Ore Treated.	Gold.		Copper.	
		Yield oz.	Value per Ton dwts.	Yield tons.	Value per ton %
1902	93,169	66,758	14·33	19	...
1903	123,126	65,404	10·62	78	...
1904	118,060	58,934	9·98	141	...
1905	109,296	62,034	11·35	177	...
1906	108,736	58,866	10·82	304	..
1907	115,466	61,370	10·63	364	...
1908	117,770	64,149	10·89	372	...
1909	106,952	48,284	9·03	453	·423
1910	124,122	57,217	9·19	499	·402

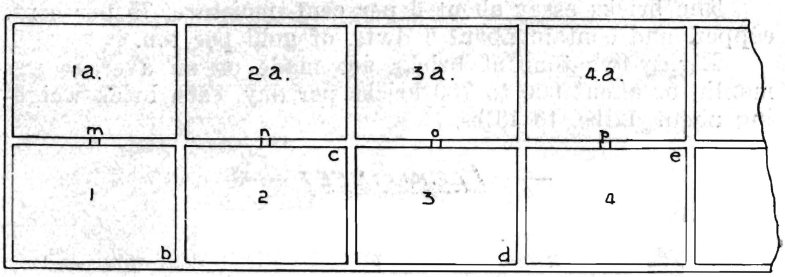
THE COPPER PRECIPITATION PLANT.

In this plant the acid solution and washes carrying copper and traces of gold from the Mundic Works, and the mine water mixed with leachings from the mundic tailings dam are treated to recover their copper contents. The treatment simply consists of passing the solutions through canals containing scrap iron, on which the copper is precipitated.

$$CuSO_4 + Fe = FeSO_4 + Cu.$$

The canals are arranged in double rows. They are made of brick or concrete, cement faced. Those through which the acid solutions run are first lined with 6lb. lead, and then with planking to protect the lead; those through which the mine waters and leachings from the dam run are unlined.

The amount of copper in the acid solutions and washes from the Mundic Works varies greatly according to the amount of copper in the ore being treated; the amount in the leachings from the dam and the mine water, which are mixed together, averages about 10 grains per gallon. All the solutions after treatment assay only traces of copper (under $\frac{1}{2}$gr. per gallon). All the solutions after treatment run into a large tank, made of galvanised iron, lined with about 6in. of concrete, and cement faced. In this tank are placed old wire ropes, etc., which are too big for the boys to handle for cleaning. So far this tank has not been cleaned out, but there is no doubt that there is some copper in it, deposited by means of the scrap iron in it. From this tank the solutions are returned to the Mundic Works, and are used for sluicing out the residues, and in time of drought for making fresh solutions. The canals are arranged as per sketch. Both rows connect by an



Plan

opening at the top in the division wall, as shown. The compartments in each row connect with one another as follows:— 1 with 2 by means of a vertical slot opening near the bottom of the compartment at the corner b, 2 with 3 by means of a round openng near the top of the compartment at the corner c, 3 with 4 by means of a vertical slot opening near the bottom of the compartment at corner d, 4 with 5 by means of a round opening near the top of the compartment at the corner e, and so on. Similarly, 1a, 2a, 3r, etc., are connected. The solutions are thus made to flow downwards in one compartment, upwards in the next compartment, and so on.

The method of cleaning up is as follows: The channels m and n, and the opening at c are closed. The incoming stream into 1 is deflected into 1a, it flows and mixes with the solution there through 1a, 2a, into 3a., etc., from which some of the solution flows into 3, 4, etc., through the channels o, p, etc. The boys then pick out the large lumps of iron, washing off any loose copper precipitate, and place them on 1a and 2a. The finer material and copper precipitate is then shovelled and scooped out and placed in trucks. The coarse lumps of iron are then returned to 1 and 2, and the passages opened.

To clean out 3 and 4, the channels at o, and p, and the openings at c and e are closed, and the above process repeated. The boys working about this plant wear rubber boots.

The finer material and copper precipitate is then screened, and the coarse material returned to the canals. The material, passing through the screen, is made into rough bricks in wooden moulds, slightly dried, and made into bricks in a hand-machine. These pressed bricks are air dried, and sent to the converter plant.

The copper precipitate contains sulphates of iron, etc., which act as a binding material and forms a hard brick.

The bricks assay about 3 per cent. moisture, 75 per cent. copper, and contain about 5 dwts. of gold per ton.

Eighty-five tons of bricks are made on an average per month, or about 600 to 700 bricks per day, each brick weighing about 12lbs. to 13lbs.

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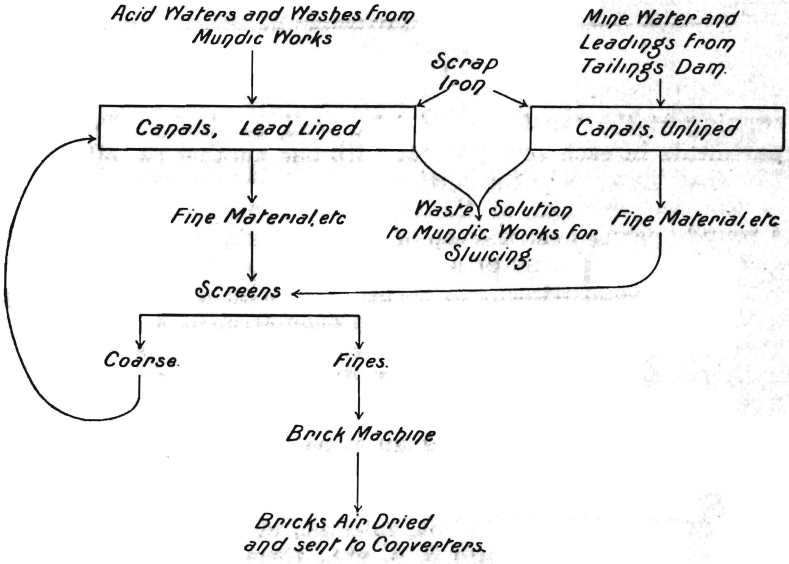

THE GOLD TREATMENT PLANT.

In this plant, the charcoal and gold precipitates from the West and Mundic Works are treated. The charcoal and gold precipitate, after removal from the filters, are placed in wooden trucks, fitted with lids or covers, which are then locked. These trucks are drawn by electric motor to the gold-treatment plant. The plant is in two sections, one section being used for treating the charcoal, etc., from the West Works, and the other for that from the Mundic Works, so that the actual gold recovered by each works is known.

The plant consists of—

2 Charcoal burning-off furnaces.
2 Reverberatory gold-smelting furnaces.
5 Crucible refining furnaces.
1 Oxygen electric generating plant.
1 Strong room.
1 Jaw breaker.
1 Set of rolls.

The charcoal burning-off furnaces are of the ordinary long hearth roasting reverberatory type. Each furnace is 38ft. 6in. long by 12ft. wide, built of red brick, and lined inside with 4½in. of firebrick. The total hearth area is 408 sq. feet. The height of centre of roof from hearth is 2ft. 6in. The hearth is flat, and not broken into steps. The grate measures 6ft. by 3ft.; firebridge, 4ft. by 18in. There are four charging hoppers on top, connecting to four openings, 12in. in diameter in the roof. The working doors along each side, seven in number, are about 30in. long by 15in. high, and are spaced 5ft. 9in. centres. The hearth is made of fireclay tiles, set on tamped fireclay, set on brickwork. The tiles are removed periodically, crushed, sieved, any coarse gold picked out, the remainder serves as a flux in subsequent smelting operations, or sent to the blast furnaces at the copper reduction plant.

The reverberatory gold smelting furnaces resemble small copper reverberatory smelting furnace, but the hearth is made up of a moveable cast-iron pan, lined with bricks and fireclay tiles. This pan is screwed up into place after the fashion of the test in an English Cupel furnace. The opening for the pan is 7ft. 7in. long by 4ft. 6in. wide. The pan is made in section to slope to one side, in which there is a tap hole, by means of which the gold and slag may be tapped out. The fire-box is 4ft. square, and is 2ft. deep from the fire-bars to the fire-bridge, and 5ft. 2in. to the roof. The fire-bridge is 26in. wide by 36in. long. The pan is charged through an opening, 9in. square, in the roof.

The bricks, etc., from the pan are removed periodically, and treated in a similar manner as the tiles, etc., of the burning-off furnaces. Wood fuel is used in all of the above furnaces.

There are four small crucible refining furnaces, and one larger one. They all resemble a circular assay furnace. The small ones measure 18 inches internal diameter, and 26in. deep to the fire-bars. Coke fuel.

All the furnaces connect with a main flue. This flue is cleaned out periodically, and flue dust collected is mixed with the charge for the gold-smelting furnace.

Method of Treatment.—The charcoal, with its gold precipitate, is discharged through sliding doors in the bottom of the trucks into the charging hoppers above the burning-off furnaces. Then it flows into the furnace, and is spread out by hand by means of rabbles. The charcoal is then burnt to an ash, twice taken five to six days, during which it is continually turned over. Sometimes the charcoal is not burnt to ash, but a little carbon is left in to reduce any oxide of iron (Fe_2O_3) in the subsequent smelting.

Analysis of ash produced:—

SiO_2	...	...	...	10 - 77 %
Fe	...	...	...	6 - 50
CaO	...	...	...	·5 - 2
Au	...	...	...	2 - 20

The ash is then scraped out from this furnace, and fluxed with soda carbonate, borax, crushed bricks, return slag, etc., and charged into the pan in the smelting furnace and there smelted. When smelted, the slag is tapped off first, and lastly the gold bullion. Time taken, eight to ten hours.

AVERAGE ANALYSIS OF GOLD BULLION PRODUCED.

		West Works.		Mundic Works.
Au	...	82 per cent.	...	92 per cent.
Cu	...	12	...	5½
Ag	...	3	...	1
Pb	...	1	...	·1
S	...	·2	...	·2
Fe	...	·6	...	1

A bisilicate slag is aimed at. This slag is sent to the copper blast furnaces.

The gold bullion is then refined by means of Rose's oxygen process.*

The bullion, about 5,000 ounces per charge, is melted in a large salamander pot, fitted with a clay liner, in the crucible melting furnace. When melted, it is covered with a layer of sand and ground fused borax mixed and compressed oxygen forced in through clay pipes (similar to those used in Miller's chlorine process) to the bottom of the charge. The pipes are ⅛in. to 3-16in. internal diameter, and have four slits, about 3in. long, at the end inserted in the charge. The pipe rests on the bottom of the pot, and the oxygen, coming through the pipe, is distributed into the molten metal through these slits. The pipes must be heated up before insertion into the molten bullion, otherwise it would crack. The oxygen, bubbling through the molten mass, oxidises the base metals, which are then slagged by the layer of borax and sand.

At periods the slag is removed by means of a skimmer, and more flux added. This is repeated until the gold is considered sufficiently refined. This is judged by the slag skimmed off, and by the manner in which the oxygen bubbles through the molten mass. Time taken, three days. The bullion is refined to about £4/3/- per ounce, and is then poured into ingots.

* See Transactions I.M.M., Vol. xiv., page 378.

The slags assay under 20 ounces of gold per ton, and are sent to the copper blast furnaces. The oxygen is generated electrolytically from a solution of caustic soda. It is conveyed to a small gasometer, and then pumped by a small hand-pump into a drum to the required pressure. From the drum it is led to the clay pipes through rubber tubing.

Number of employees, 13.

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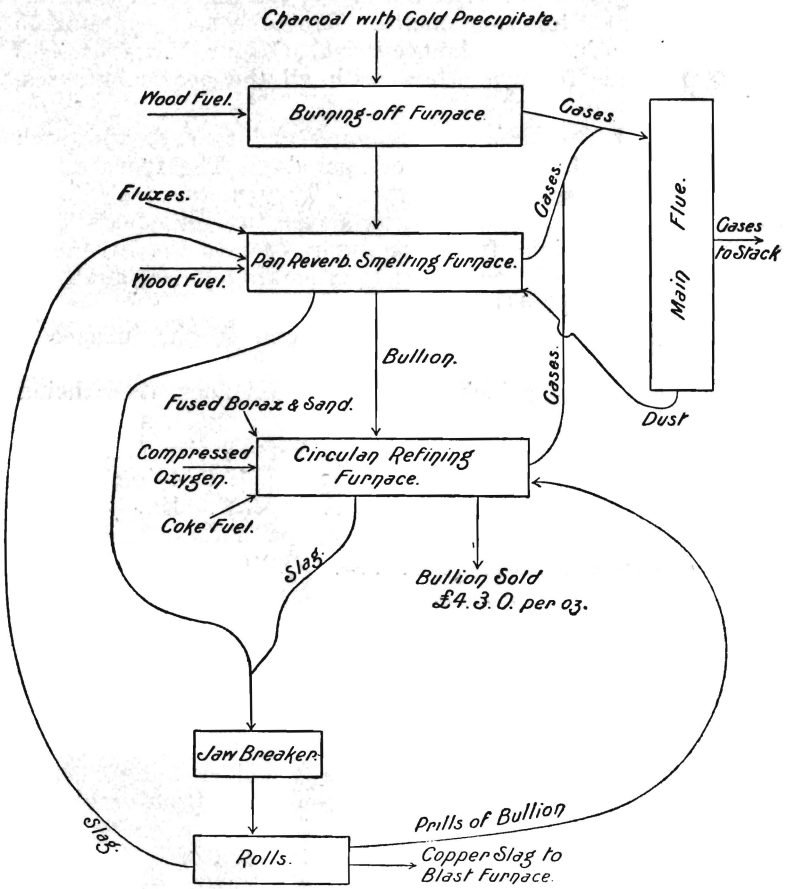

THE COPPER REDUCTION PLANT.

This plant treats the copper-gold ore. Capacity of the plant is 600 tons of ore per day. The treatment consists of direct smelting with fluxes and coke in blast furnaces, and then converting the matte so obtained into blister copper in converters.

The fluxes used are:—

(1) Limestone, assaying 50 per cent. CaO 4 per cent. SiO_2.
(2) Ironstone, assaying 81 per cent. FeO 5 per cent. SiO_2.

The limestone flux is obtained from Marmor, twenty-five miles from Rockhampton; the amount used averages about 11,000 tons per month. The ironstone flux is obtained from Iron Island, 100 miles north of Keppel Bay; the amount used averages about 3,000 tons per month. The coke used contains 15 per cent. of ash. The plant consists of four blast furnaces and two stands for converters, with all the necessary accessories.

The blast furnaces are arranged end to end, and each has a capacity of 200 tons of ore per day. The furnaces are of the usual water jacketed type. They measure 190in. by 48in. at the tuyeres, and the area at the tuyeres equals 63.33 sq. feet. The height from the dump floor to the tuyeres is 6ft., and to the feed floor 22ft., thus making the height from tuyeres to the feed floor 16ft.

The height of ore or smelting column in the furnace is 9ft. 6in.

The furnaces are jacketted to the feed floor, there being two tiers of jackets.

The overall measurements of the bottom tier are:—

Height	7ft.	4½in.
Width	3ft.	1in.

And those of the top tier are:—

Height	10ft.	9in.
Width	2ft.	11¾in.

The water space in all the jackets is 5½in., the water inlets 1½in. in diameter, and the water outlets 2in. in diameter.

The lower jackets are sixteen in number, five on each side (including one tyings jacket in front), two on each side, and below these one tapping jacket on each end.

The end jackets are perpendicular, the sides being bushed. They all extend down to and rest upon the bottom or hearth plate. The upper jackets are sixteen in number, six on each side, and two on each end. The top tier are of 5-16in. mild steel plate. The bottom tier are of the same, except that they are copper-faced, but as these wear out they are replaced by mild steel, mild steel proving as effetive and much cheaper in first cost.

The water inlets are placed about 2ft. from the top of each jacket, the water outlets being near the top. On entering the jacket the water inlet pipe is deflected down, so that the incoming stream of water is forced towards the bottom of the jackets, with the result that the water in the jacket is kept in constant agitation, and the temperature of the jacket uniform.

There are 20 tuyeres on each side, each 3¼in. in diameter, and spaced 9¼in. centres, double tuyere boxes being used. Slag escapes and peep holes are provided on each tuyere. The air main is 36in. in diameter, and the wind sleeves, connecting the tuyere boxes with the bustle pipe, are 5in. in diameter. Butterfly valves are provided on the bustle pipes, near the main, and gate valves in the main itself. The amount of air supplied to each furnace is 14,000 cubic feet per minute, under a pressure of 23 ounces.

The jackets are cleaned out every fortnight. If they are not cleaned, the scale accumulates at the bottom, and the jackets burn through there.

The bottom or hearth plate is of cast iron, 2.12 inches thick, and it is carried on cast iron columns.

The sump spout, situated in the middle of the front side of the furnace, is of cast iron, cooled by water, circulating in heavy wrought iron pipe coils, cast in the spout, and it is attached to a tymp jacket made of copper plate.

Draining spouts are provided at each end; these are used in blowing down and in emergencies. They are closed during running with clay stoppers. These spouts are attached to the small tapping jackets, one at each end.

There are two fore-hearths to each furnace, the main one being circular, 12ft. in diameter, and it is made of boiler-plate steel, lined with 12in. of chrome brick. Each main fore-hearth has four matte tap holes. The auxiliary fore-hearth is rectangular, being 8ft. by 4ft. 6in., also lined with chrome brick, and has two matte tap holes. The chrome bricks are made on the company's works, being made of 2 to 3 parts fireclay and 1 part of chrome ore, 35-40 per cent. Cr_2O_3. The tapping breasts are of cast iron, kept cool by water circulating in heavy wrought iron pipe coils cast in them.

The slag is conveyed to the dump by horse, in double bowl pots, each holding about 1 ton of slag. The matte is conveyed to the converter ladle in hand-pots, each holding 3 cwts. each.

Six electrically driven centrifugal pumps are used for circulating the water in the works.