OPERATION GOVERNMENT ROASTING PLANT
P.O. BOX 118
KWE KWE
ZIMBABWE

CONTACT Mr. Jimmy A. James, Manager

TELEPHONE Kwe Kwe 2868

DATE OF VISIT 30 June 1982

LOCATION On the outskirts of the town of Kwe Kwe, located about three hours drive south of Salisbury on the Bulawayo road.

INTRODUCTION The GOVERNMENT ROASTING PLANT is operated by the Zimbabwe government to treat sulfide flotation concentrates produced by numerous small mining and tailings recovery operations throughout Zimbabwe.

There are currently about twelve concentrate suppliers to the roaster and leaching plant.

The KWE KWE roasting plant uses equipment of very old vintage, but it has been maintained in excellent working order. The EDWARDS roasters are the best run of any observed in the course of this investigation with the most sophisticated fume recovery plant of EDWARDS roasters.

Despite relatively low sulfur content of some of the concentrate feed, the roaster operates without any external fuel source - it is completely autogenous.

A second roasting operation, also an EDWARDS roaster treats roaster dust to yield a relatively high grade arsenic oxide product for which there is a market.

A visit to the KWE KWE roaster is highly recommended, although it is unlikely that a new EDWARDS roaster would be constructed today, since the availability of fluid bed roasting technology.

This old plant contains many very old pieces of equipment and is fascinating for anyone interested in the evolution of metallugical equipment. The surprisingly good operating condition of the equipment does credit to the maintenance staff on this remote plant.

HISTORY The GOVERNMENT ROASTING PLANT was first brought into production in 1937. New EDWARDS roasters were built in 1941 and 1942. There are two duplex EDWARDS roasters, each with 56 rabble arms.

There are numerous small mines in Zimbabwe producing sulfide concentrates containing gold which are often also rich in arsenic and antimony. Few, if any of these small mines are large enough to support their own roasting plant. Consequently, the KWE KWE roasting plant has played a major role in the development of the gold mining industry of Zimbabwe. Additional information on the history of the roasting plant is provided in an old DECO writeup on the plant, written by Mr. T.S. Cleary, a former manager of the plant.

GOVERNMENT ROASTING PLANT, KWE KWE
TYPICAL ROASTER FEED & GOLD RECOVERIES

	Au g/t	AS %	Sb %	% S	OTHER %	RESIDUE AFTER LEACH Au g/t	Au g/t	GOLD RECOVERY FREE %	CYANIDED %	TOTAL %
CAM & MOTOR MINE[1]	72	3.1	*4.17	10.4	Ni 0.1 Cu 0.17 Pb TR	22.8	81.5	NIL	71.7	71.7
CHARLIESONA MINE[1]	172.1	12.8	0.15	16.1	Pb 0.02 Ni 0.16 Cu 0.16	73.6	206.0	NIL	64.3	64.3
CHARLIESONA MINE[1]	135.6	9.2	0.1	14.1	Cu 0.28 Ni 0.32	29.4	N/A	N/A	N/A	N/A 78.3
B.O. 1336[1]	88.7	7.8	3.7	21.0	Cu 0.12 Pb 0.20	22.4				74.8
RIVERLEA[2]	181.2	24.8	0.62	25.5		23.2	171.5	10.9	75.6	86.5
INDARAMA MINE[1]	51.1	10.0	1.4	24.8	Cu 0.14	8.2	38.7	18.9	59.9	78.8
ROASTER CHARGE[3] BLENDED CONCS. TESTRUN 10-17 FEB. 1975	56.8	3.3	1.0	22.0	Cu 0.11	7.2	69.8	34.9	54.8	89.7
COMPOSITION OF ROASTER DISCHARGE	69.8	0.53	0.63	1.4						

* Anomalously high gold level in this residue.

1 100% Concentrate Feed

2 Blend 70.6% Concentrate, 29.4% Silica

3 Blend 33.5% Lion, 16.5% Cake, 16.5% Indarama, Silica 33.5%

FEED FOR ROASTER

Currently, about .twelve mines supply concentrates to the roaster. Relatively high tonnages of concentrate are shipped from the tailings retreatment plant at the old CAM & MOTOR mine at Eiffel Flats. Their concentrates are low in sulfur and relatively high in antimony with some arsenic.

Various concentrates are blended so that 'hot' roasting concentrates with high sulfide content are blended with those containing lower sulfur such as the CAM & MOTOR concentrate. Concentrate from the LION mine is said to be particularly 'hot'.

Samples of concentrate are tested at the Government Metallurgical Laboratories in Salisbury, who test the leach recovery anticipated for the concentrate when it is roasted in the EDWARDS roasters. Typical concentrate characteristics are shown in the table.

ROASTER CAPACITY

Roaster capacity according to CLEARY (1946), averaged 485 t per month per roaster, excluding 40-50 tons per month of fluedust that were recycled. The roasters were then operated to give a 12 hour residence time.

Currently, residence time is 7-8 hours and fluedust is treated separately in a smaller EDWARDS roaster, consequently one would expect capacity of the roasters to be slightly higher than it was in the 1946 description.

ROASTING PERFORMANCE

The data shown in the inserted table shows total recoveries of gold from roasted calcine ranging from 64-90%, which are not all that impressive.

It must be remembered, that these figures are the results of simulated laboratory scale tests of submitted feed, that are used to compute payment for concentrate and it is likely that they include some measure of conservatism.

The relatively low indicated recoveries probably also reflect the relatively high antimony levels in the concentrates treated as antimony is known to cause recovery problems.

It is unfortunately impossible to compare the performance of roasters by comparing recovery results unless all the compared roasters were treating the same concentrate.

Actual roaster recovery based on a test run on a blended feed from 10-17 February 1975, yielded an overall gold recovery of 89.7%, which is relatively good, but the concentrate blend appears to have also been relatively low in antimony.

PENALTIES

There are no penalties for arsenic or lead values. There is, however, a penalty for antimony on a sliding scale depending on both the gold content and the level of antimony in the ore.

For example, for a concentrate with 65 g Au/t and 3.0% Sb, the penalty is Z$ 4.94 per ton. For a 65 g Au/t concentrate, with 4.1% Sb, such as the cam and motor concentrate, the penalty is Z$ 13.55/t. Considering the deletorious effects of antimony on subsequent leaching, one cannot

[PLATE XXVI.

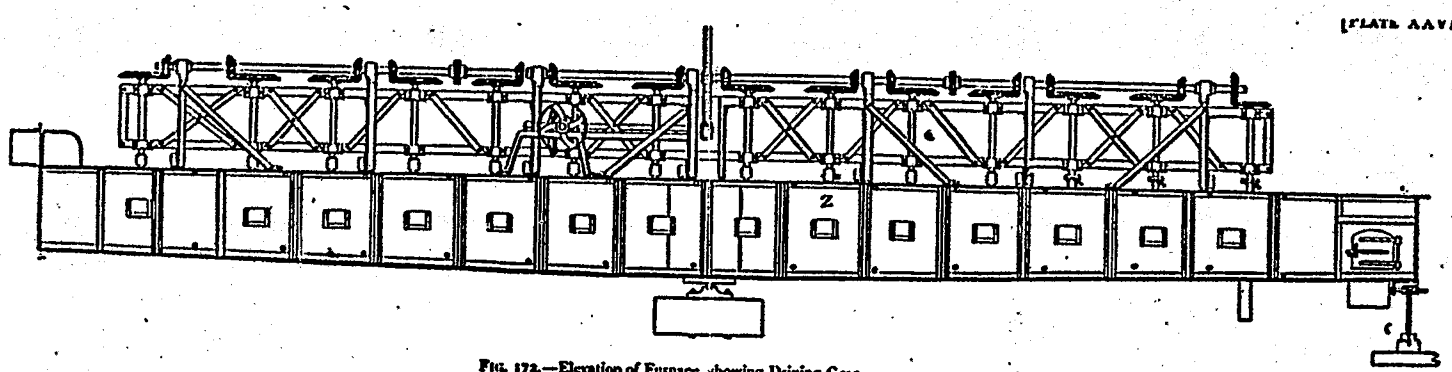


Fig. 172.—Elevation of Furnace, showing Driving Gear.

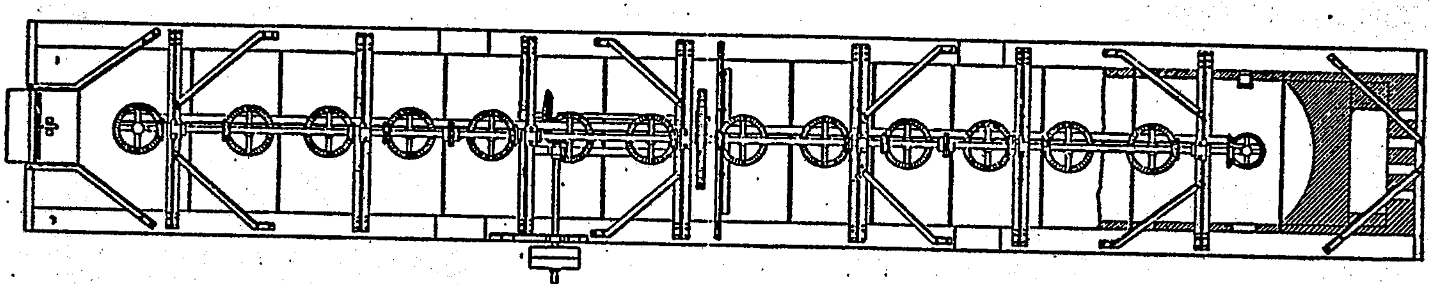


Fig. 173.—Plan of Furnace Part in section, showing Fireplace and Discharge Opening.

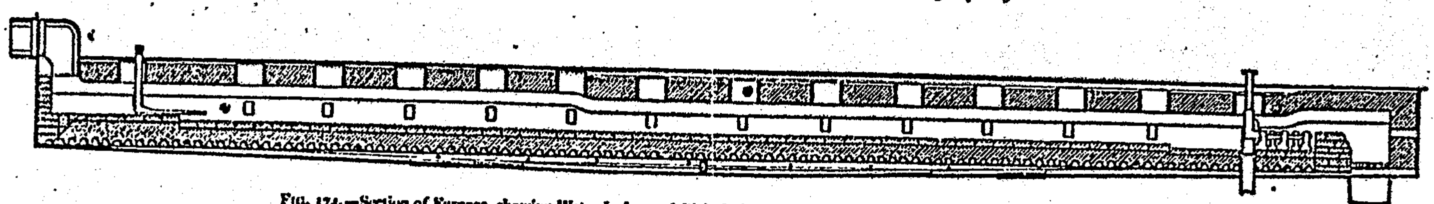


Fig. 174.—Section of Furnace, showing Water Jacket and Plain Rabble, Fireplace, Air-Holes, and Cast-Iron Rabble Boxes.

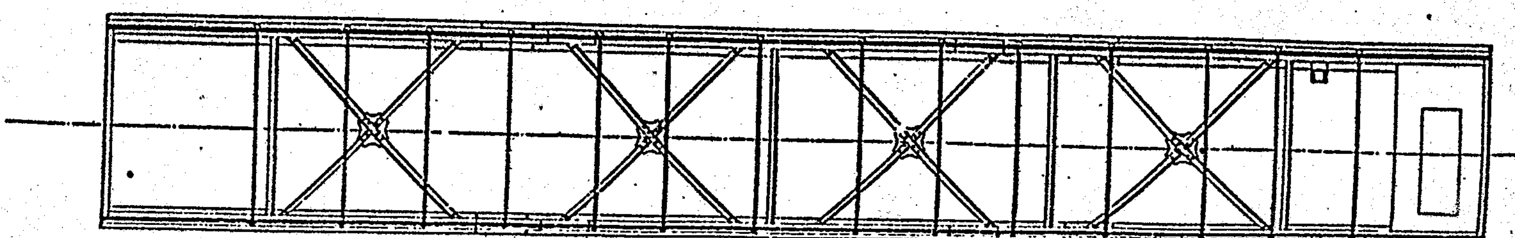


Fig. 175.—Plan of Bottom of Furnace, showing Bearing.

help wondering whether the antimony penalties reflect the higher price of gold that is being locked up by the antimony, or whether the scale was worked out at the old US$ 35/oz gold price.

There are penalties also for copper and cobalt in excess of 0.10% at the rate of Z$ 5.00 per unit in excess of 0.10%, and Z$ 2.00 per unit of nickel. If moisture exceeds 8%, a further penalty of Z$ 6.00 per dry ton is imposed.

TREATMENT CHARGE

A treatment charge of Z$ 40 per metric ton of concentrate is charged by the roaster.

SAMPLING & BLENDING

All concentrates are delivered to the roaster by road transport. On arrival the concentrate is shovelled by hand into wheelbarrows and weighed. Each wheelbarrow load, is sampled, which means that, 17-20 samples are drawn per ton of concentrate. The tare weight of each wheelbarrow is deducted from the scale weight. Samples are placed in a drum and mixed. Each concentrate is stockpiled separately in a large shed pending outcome of the sample assays.

Four samples from the sample drum are drawn. One is assayed by the roaster laboratory, one is assayed by the customer's laboratory and the third by a neutral laboratory. A fourth sample is kept in reserve.

Concentrate from the various stockpiles is blended to give 15-17% sulfur in the feed to the roaster. This has been found to result in a roast temperature of 650-700°C maximum.

In order to blend, nine barrowloads are dumped onto a conveyor - each barrow holds about 80 Kg of concentrate. The concentrate is loaded into a hopper which feed a blender-mixer followed by a hammermill, which breaks the lumps. The blended concentrate is stored in bins from which it is fed via a conveyor belt into the end of the EDWARDS roasters.

ROASTER FEEDING

The roasters are fed by a flat belt conveyor and chute as shown in the paper inserted at the end of this trip report.

ROASTING

The GOVERNMENT ROASTING PLANT employs two duplex EDWARDS roasters, each with 56 rabble arms. A diagram illustrating an earlier model EDWARDS roaster with 13 rabble arms of a simplex design, is included to give a general idea of the principles of design of an EDWARDS roaster. In the duplex design there are two parallel rows of rabbles both rotating in opposite directions to advance the calcine. More details are included at the end of this trip report.

CONCENTRATE RESIDENCE TIME

Residence time at KWE KWE is now 7-8 hours for the whole roasting process. It is noted that earlier operations averaged 12 hours travel time in the hearth.

WORKING ENVIRONMENT

A slow speed fan draws fume from the roaster which maintains a slight negative pressure in the roaster and draws off the volatiles. This keeps

Temperature is gauged by examining the color of the hot calcine which is a dull cherry red at the correct operating temperature. Roaster operators claim that they can gauge the 'right' temperature quite readily by the color. It is noted that in earlier operations, temperature was recorded by a 2-leg pyrometer in each furnace with automatic CAMBRIDGE recorders.

In this case, the temperature has been measured in the hottest zone at 650-700°C maximum. The temperature drops off steadily from this point to both the feed and discharge ends of the roasters.

The air supply to the roaster bed is regulated to create four distinct roasting zones.

Zone 1: Closed Air Ports. Concentrate is heated slowly by radiation from the center of the roaster. Arsenic volatilizes as concentrate advances from the feed port to the combustion zone.

Zone 2: Sulfide Combustion. Air supply is permitted at a controlled rate to allow the sulfur to burn. Temperature is allowed to reach 650-700°C in this zone.

Zone 3: Cooling. The air ports are now fully open. Most of the sulfur has already burnt, so there is no runaway combustion.

Zone 4: Discharge Zone. Calcines are rabbled into a cast iron chute from which they are moved by a rake into a tank. During the rake discharge, they are sprayed with water to quench and transferred as a slurry to a tank. The Calcine slurry is screened over a sievebend en route to the ball mill.

CALCINE DISCHARGE

Calcine is advanced through the roasters by a series of rotating rabbles driven by an overhead cam. Beneath the last rabble, there is a cast iron chute in the hearth floor which is wet at the bottom, into which the calcine drops at the discharge end of the roaster. Calcine is removed from the wet trench by a reciprocating rake conveyor which drags out the wet calcine. Dusting is further controlled by water sprays installed inside the trench, so that by the time the calcine leaves the trench it is in the form of a quenched slurry.

The wet calcine slurry passes through a coarse static screen to remove any grossly oversize particles and pumped to the milling circuit from a sump. The system is old fashioned but simple.

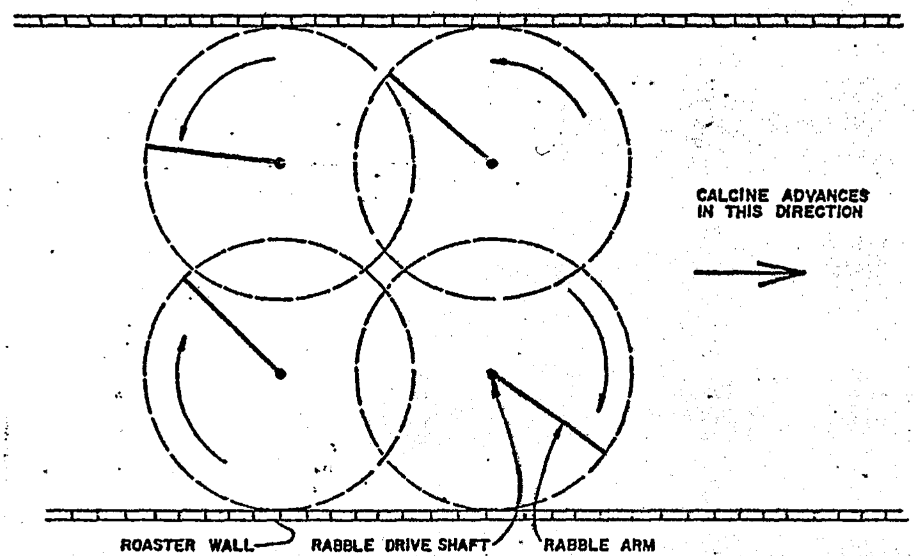
the working environment around this EDWARDS roaster much more pleasant than was observed at any other EDWARDS roaster that was visited.

ROASTER FIRING

Contrary to the practise at other EDWARDS roaster operations, including those that treat concentrates that are much higher in sulfide content, the KWE KWE roaster now burns autogenously with no added fuel.

It is noted, that during earlier years, the fireboxes used to be fueled by wood for the whole operation and plans were to modigy fireboxes for coal firing.

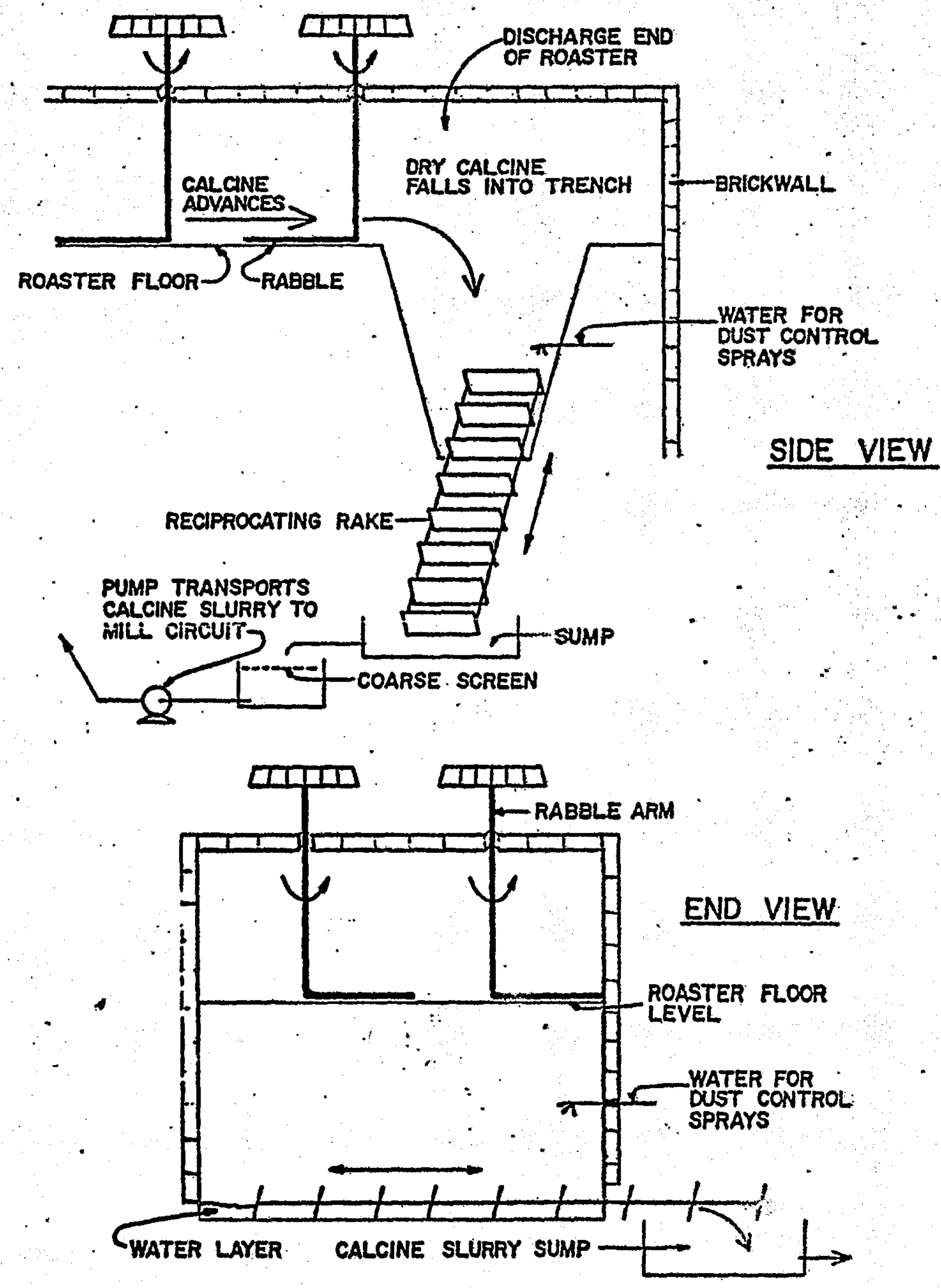
DUPLEX EDWARDS ROASTER
(PLAN VIEW)



ROASTER TEMPERATURE

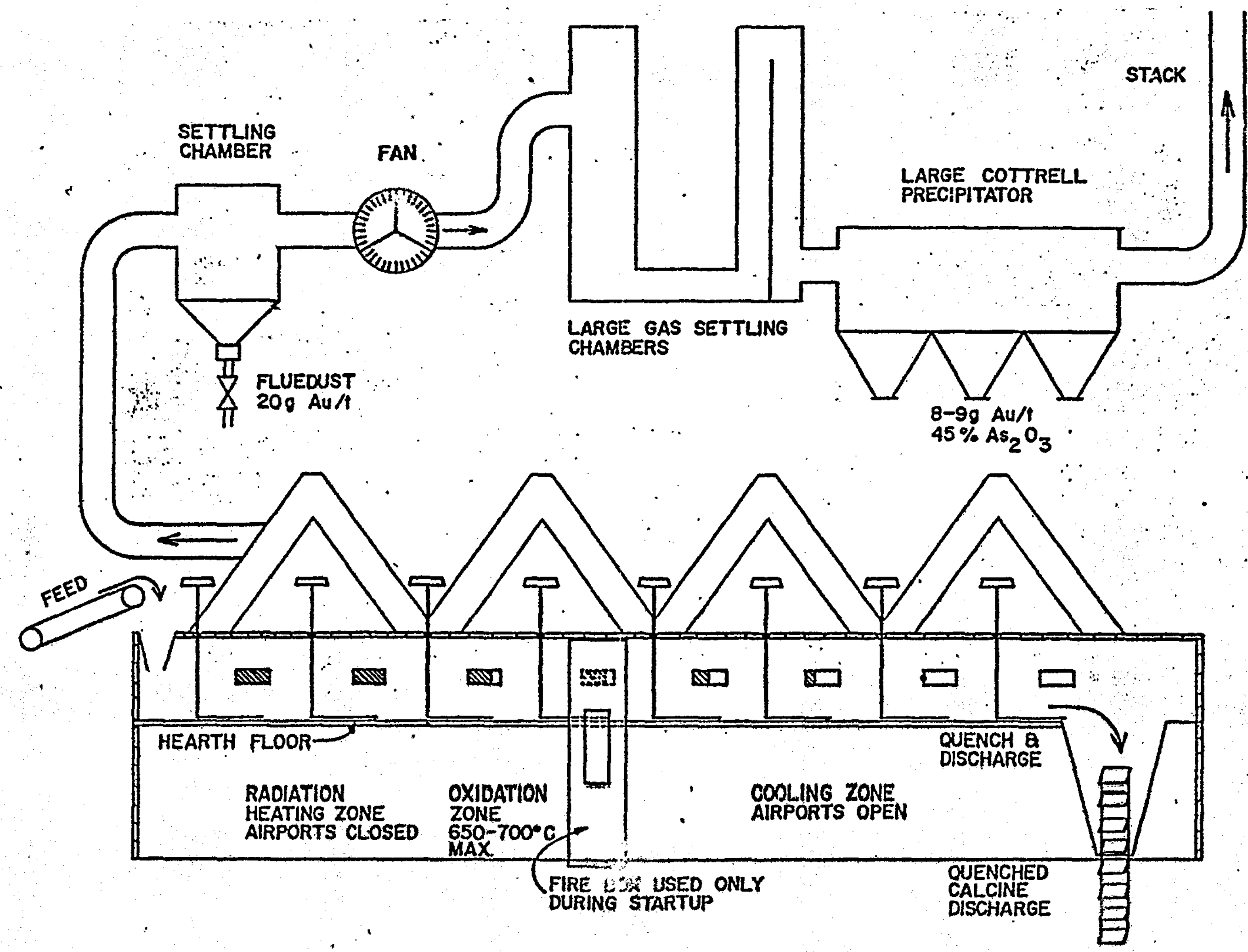
Roaster temperatures are controlled by the sulfur content in the blended feed and regulation of the air supply in the sulfide combustion zone of the roaster. This is achieved by adjusting the air ports along the sides of the roasters.

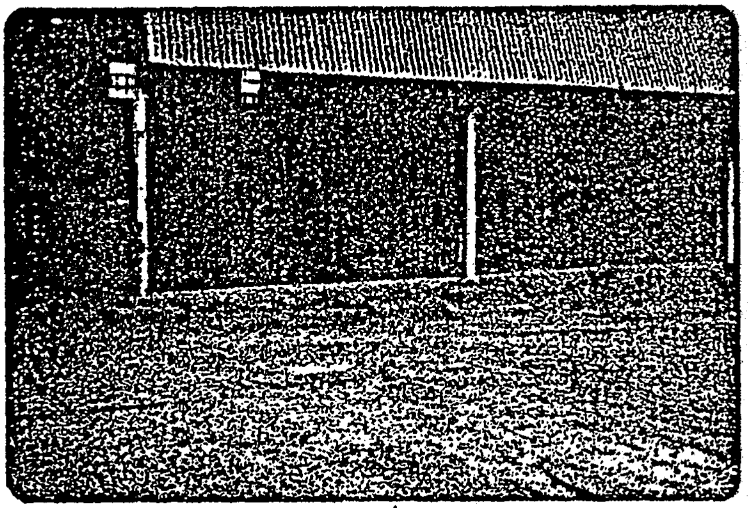
CALCINE DISCHARGE FROM EDWARDS ROASTER



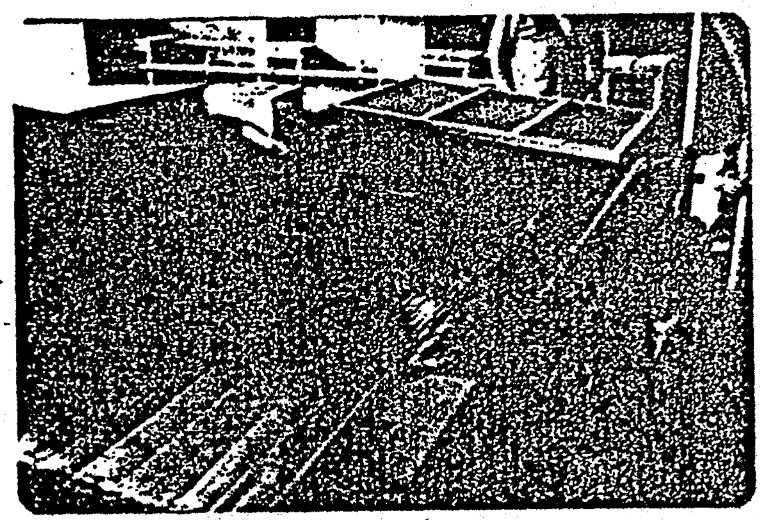
GOVERNMENT ROASTING PLANT

(KWE KWE, ZIMBABWE)





EDWARDS ROASTER AT KWE KWE



GALLAGHER BELT CONCENTRATOR AT KWE KWE

FLUE DUST

Fumes are drawn off the roaster through the roof via zig-zag ductwork as shown in the diagram. The reason for the zig-zag configuration is to prevent the buildup of large particles on the floor of the duct. Should fume accumulate on the ductwork, it will in time, slide back down the sloping duct into the furnace.

Most of the arsenic fume volatilises in the first stage of the furnace which is cooler and at the end of the ductwork that is closest to the gas cleanup train.

The KWE KWE roaster employs a more sophisticated gas cleanup system than any other EDWARDS roaster currently in operation. It includes a settling chamber to collect larger particles, two large settling chambers in series, a LODGE COTTRELL electrostatic precipitator and a stack.

Flue dust collected in the first settling chamber runs 20 g Au/t on the average. Further down, the gastrain particles collected in the LODGE COTTRELL precipitator run 8-9 g Au/t, but this dust is also high in arsenic and is used as feed for the secondary arsenic treatment plant.

Arsenic is recovered as quantitatively as possible from the roaster exhaust, nonetheless, only about 80% is accounted for. No attempt is made to recover the SO_2 which is allowed to escape up the stack. The roaster is located in a peri-urban area, yet no adverse environmental affects resulting from the gas emmissions were obvious in the area.

GOLD RECOVERY FROM CALCINES

The present calcine treatment plant is shown in the flowsheet illustration inserted below and is described in the paper by T.S. Cleary. However, there have been several changes since Mr. Cleary's 1946 description.

Main changes include the installation of a sievebend to classify the calcine ahead of the grinding and gravity circuit. Another change is the insertion of gravity recovery after the oversize has been ground, and the insertion of cyclones in the grinding circuit to replace the older rake classifier. Another change has been the insertion of a GALLAGHER table as the primary gravity concentrating device.

Two conditioning tanks have been inserted after the water washing thickeners to adjust pH by lime addition ahead of cyanidation.

A drum filter has been inserted to recover solution from the thickened CCD tailings. This solution is returned to the No. 2 CCD thickener and is bound to contain gold values that in the old circuit were discharged to the tailings dam.

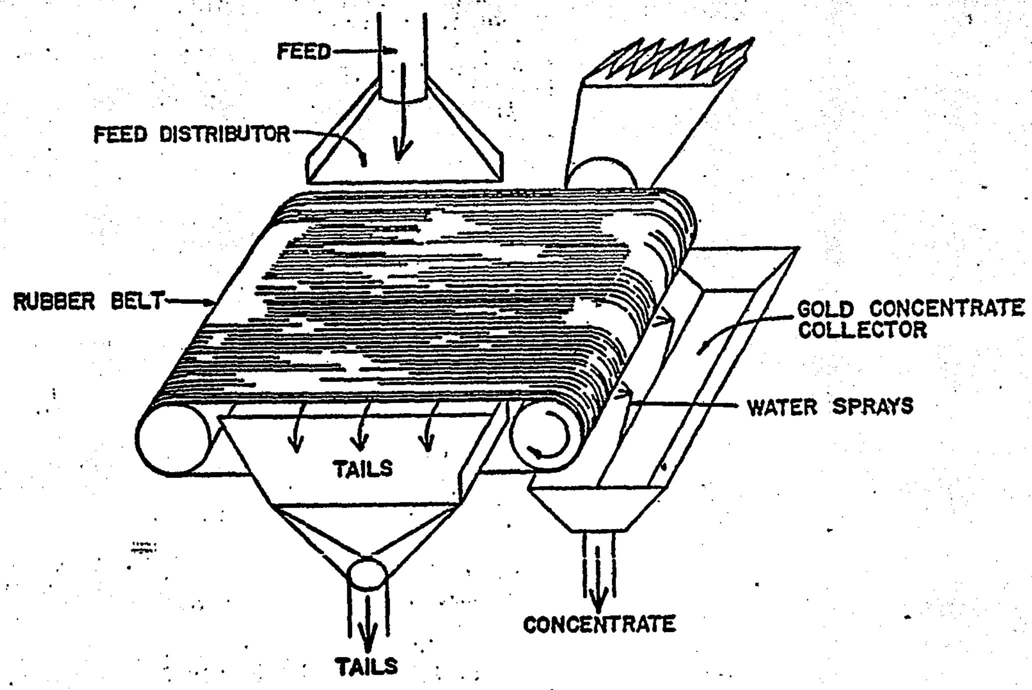
Several observations of possible interest were made at the calcine treatment plant:-

1. GALLAGHER BELT

   The GALLAGHER belt uses a travelling rubber belt to concentrate gold in the riffles. The belt material is identical to that used on riffle belt concentrators in South Africas and on the WARMAN riffle belt concentrator in Australia, and also as is used to line plane tables. The rubber riffles, about 0.25 inches deep, are not symmetrical.

The main difference between the GALLAGHER belt and the riffle belt is that the belt is moved acros the flow of feed pulp rather than against it.

GALLAGHER BELT



The GALLAGHER belt is a simple device that is said to have been developed in Rhodesia and was also not encountered elsewhere.

2. After roasting, the calcines frequently also contain water soluble base metals which would interfere with subsequent cyanidation. Accordingly, they are water washed in two thickeners arranged in series to wash counter currently.

Calcine is pumped from the cyclone overflows in the grinding circuit to the first of the two 20'Ø x 7' washing thickeners. According to Cleary (1946), and it is unlikely much has changed since then, except possibly as a result of the reduced roaster residence time, sulfide content in the calcine after roasting should be below 2% and the $SO_4^=$ level in the liquid phase would typically be 10-20 g/l.

The washing thickeners measure 20'Ø x 7' and are constructed of concrete. Rake speed is 0.2 rpm powered by 3 HP motors. Underflow of each unit is at 50-55% solids. About 50% of the washwater is discharged to waste, and it assays from trace to 0.03 g Au/t.

Whenever base metals are associated with sulfide concentrates roaster feed, this calcine washing step is a must.

3. PRE-AERATION

Prior to leaching and after water washing, the calcines are pre-aerated in two stages also arranged in series. Lime is added to maintain an excess of 0.004% CaO. The purpose of this step is to be sure to oxidise any ferrous iron to ferric. Ferrous ions consume cyanide and oxygen during the subsequent cyanidation step and would interfere with gold leaching efficiency. Another advantage of pre-aeration is that it provides some additional opportunity to oxidise any soluble sulfides to sulfates, thereby eliminating any addtional interfering species. This step allows pH to be adjusted by lime addition to yield a uniform pulp, which avoids localized areas in the pulp of either very high or very low pH which can interfere with leaching as well. It is believed that pulp density is reduced from 50% solids to around 33-1/3% solids in this stage.

4. CYANIDE LEACHING

Gold is leached in four 10'Ø x 10' DENVER downdraft tube mechanical agitators. Cyanide strength is maintained at 0.12% NaCN and CaO at 0.02%.

The downdraft tubes extend upwards to just below the surface of the pulp and as pulp is drawn down, a vortex forms that drags air down with the pulp. The effectiveness of the aeration that results is very clear judging by the larger number of well dispersed air bubbles that rise back up through the pulp across the whole surface of the agitators.

The units currently in use appear to be the same as those described by Cleary (1946), which were equipped with 7½ HP motors. Approximate residence time in the leaching step is 16 hours.

The best estimates of cyanide and lime consumption are those given by Cleary (1946), at 5-6 lbs. NaCN per ton and 15-20 lbs. lime per ton.

Cleary (1946), observed that steel impellers require replacing after 5000 tons treatment. Their life appears to be extendable by at least 2½ times if the impellers are coated with rubber.

5. SOLID/LIQUID SEPARATION

Leached pulp at 30% solids, is fed to the first of four 28'Ø DENVER standard lowhead CCD thickeners in concrete tanks. Thickener underflow is advanced at 50% solids.

Clearly, at recent gold prices, a four-stage dilution wash would be inadequate. Consequently, the addition of a 6' x 6' drum filter for an additional separation stage is commendable. It was not noted whether the drum filter cake is washed or not. The filter must have been installed shortly after Cleary's (1946) paper, as it appears to be of a very old design, although still in good operating condition.

6. SOLUTION METERING & RECORDING

Of particular interest is the method used for recording the volume of pregnant solution advancing from the CCD tanks to clarification and zinc precipitation. The unit installed is a LEA MASS recorder, which consists of a V-notch weir fitted with a float to monitor the level which is in turn connected to a cam which drives a disc connected to an odometer in such a way, that the volume passing the weir is calibrated to the number registering on the odometer.

7. When antimony is present in the concentrate feed, this can readily be detected by the presence of a gunmetal grey colored scum that floats on the surface of pulps in the conditioning and cyanide leaching agitators.

8. Large amounts of residues from the secondary arsenic plant running 27-30 g Au/t and around 9% as have been accumulated in a stockpile at the plant.

9. There are also very large amounts of accumulated flue dusts running around 9 g Au/t and much higher in As.

10. The stack has been in operation for about 30 years. It is constructed from concrete with an inner surface about 1" thick of expanded metal reinforced cement. A section of this was recently drilled to test its condition. It was found to be in perfect condition, indicating that the SO_2 rich roaster gases do not appear to attack cement.

SECONDARY ARSENIC PRODUCTION

About 70-80% of all the arsenic in the feed is collected as flue dust with an arsenic level of about 45% As_2O_3. About 80 tpm of this flue dust is collected.

The flue dust produced from current operations, together with that from the accumulated stockpile, is fed to a separate small EDWARDS roaster which is completely sealed, i.e. all the air ports are closed. This roaster is maintained at 250°C and diesel fired.

The As_2O_3 volatilises and is condensed in a condensing tower from which it drops into a bin as a saleable product with 96-97% As_2O_3 purity. About 16-22 tpm is produced.

The residue from the secondary arsenic roaster contains 28-32 g Au/t and about 9% As_2O_3 and is currently being stockpiled for future treatment.

The arsenic product is sold locally to a company called RODIA (PTY) LTD. in Harare (Salisbury). Some is exported to the U.S.A.

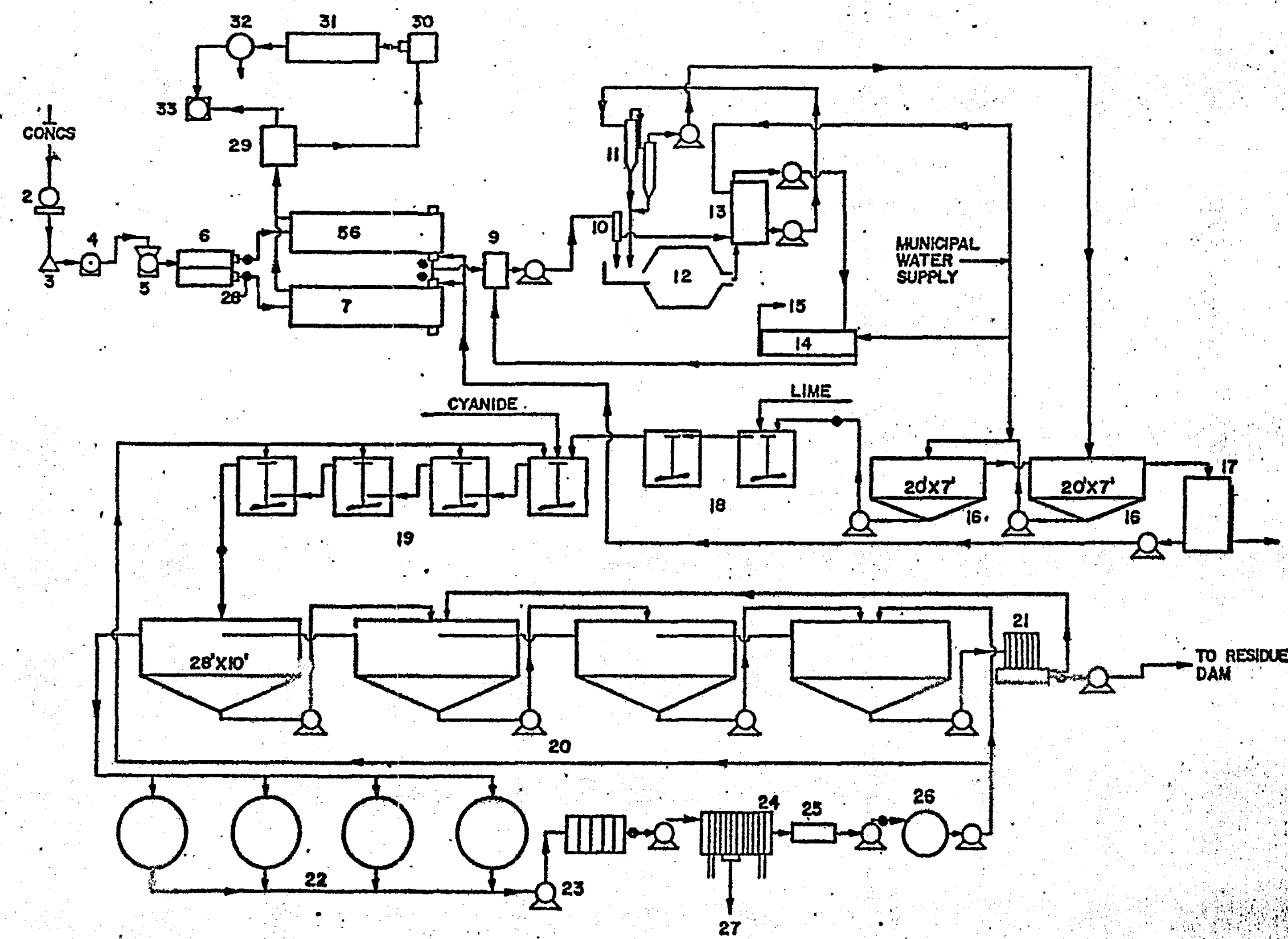
The secondary arsenic treatment plant appears to be both simple from an equipment standpoint and easy to operate. More complete details would be available from the plant manager.

GOVERNMENT ROASTER PLANT

KWE KWE, ZIMBABWE

1981 FLOWSHEET

1 CONC. RECEIPTS
2 WEIGHING & SAMPLE
3 STOCKPILE
4 MIXER
5 HAMMER MILL
6 BINS & FEEDERS
7 EDWARDS ROASTERS
8 PUSH CONVEYORS
9 SUMP
10 SIEVE BEND
11 CYCLONES
12 3' x 4' BALL MILL
13 GALLAGHER TABLE
14 JAMES TABLE
15 AMALGAMATION
16 WATER THICKENERS
17 W. TICKENER OVERFLOW TANK
18 PH CONDITIONERS
19 WALLACE AGITATORS
20 COUNTER CURRENT THICKENERS
21 DRUM FILTER
22 SAND CLARIFIERS
23 LEAF CLARIFIER
24 FILTER PRESS
25 TONNAGE RECORDER
26 BARREN SOLN. TANK
27 CLEANUP & SMELT
28 SAMPLE POINTS
29 LODGE COTTRELL
30 BIN & FEEDER
31 ROASTER
32 CONDENSER
33 STACK
34 As_2O_3 PRODUCT



THE ROASTING PLANT
Que Que, Southern Rhodesia, Africa

By T. S. Cleary, Manager, The Roasting Plant

Introduction

Que Que (pronounced Kwek-we) is approximately a geographical centre of the Colony of Southern Rhodesia.

The town, elevation 4,000', is on the main line of the Southern Rhodesia Railways, and the main road which parallels the rail passes through the town. From Que Que a spur 1¼ miles long terminates at Plant siding.

Function, of the Plant is to be of assistance to Southern Rhodesia mining by purchasing and treating gold-bearing concentrates, slag, or other valuable metal bearing products.

At any given time from 40 to 60 mines or prospects depend for revenue by sales to the Plant. Lacking this disposal and sale facilities many mining operations could not function. Annual purchases by the Plant average £100,000.

Some of the supplying properties are short-lived, some have many productive years history, and mines as far apart as the Eastern Transvaal and the Northern Congo sell products here.

Control, in matters of policy, etc., is exercised by a Board. Funds where necessary and essential, are provided by the Southern Rhodesia Treasury in terms of Parliamentary votes.

History

First operations were commenced in 1938, and were confined to the purchase and treatment of concentrates. By the end of 1945 some 45,000 tons of concentrates containing over 100,000 ounces of gold have been dealt with.

The original plant consisted of an Edwards type 56 rabble Duplex Furnace with flue system, and Cottrell precipitation unit. The roasted product was concentrated on James tables and the high grade portion amalgamated or sold as "black sands" when amalgamating difficulties arose. Table tails were dewatered, classified, ground in tube mills, cyanided in pachucas, filtered and discarded. Precipitation was effected with zinc shavings. True recovery of gold averaged 60% AS_{203} with 10 to 15 dwts gold per ton content.

It became imperative that resulting financial losses be halted. From mid 1942, use of a new 56 rabble Edwards furnace, combined with improved roasting, reduction of dust losses, and better usage of the old cyanide section and Cottrell, brought gold recovery to +90%, and an arsenic product to 85% AS_{203} with gold content of 3 to 4 dwts per ton.

Mr. T. S. Cleary, Author and Manager of The Roasting Plant, Que Que, pauses a moment with his favorite dog outside the family home in Southern Rhodesia.

Simultaneously, construction by Plant Staff of a new cyanide circuit commenced. Contractors constructed a Tavener type Pan and Cupel furnaces, and in 1945 an additional 56 rabble Edwards furnace was completed. To this was added a new dust-settling system and stack. An up-to-date metallurgical laboratory was also built by Plant staff.

This renewed and reconstructed Plant, now in full use, is the subject of this article.

Power. Power is purchased from the Southern Rhodesia Electricity Supply Commission. Main line input is at 80,000 volts, stepped down in Plant substation to 550 volt, 50 cycle, 3 phase. Tariff is a maximum demand charge of 10/-per KVA plus an energy charge of 0.5 pence per unit. Power factor is 0.9.

Water. River water is normally available throughout the year sufficient for rabble cooling. A supply of approximately 1,000 gallons per hour from a bore-hole and pumping unit within Plant grounds, is used for other purposes.

Labour. Normal complement is 18 Europeans and 90 Natives, the latter used but slightly on even semi-skilled work. Of the 18 Europeans, chemical and assay work require four. Two men are engaged in Tavener operations. A mill-foreman and three operators form the roasting and cyaniding staff, and a mechanical staff of two men are necessary for general maintenance and varied construction, as is one builder.

Purchases

Concentrate tonnages per lot will vary from 1 to 50, and contain from 1 to 20 or more ounces Au. per ton. Gold (and silver in slag) are alone purchased. No premiums are paid for arsenic or sulphur, but penalties are imposed for certain base metals in concentrates, as shown later.

At this time the Plant is not equipped to treat concentrates containing high copper or antimony, but can accept high lead-gold material and treat in Tavener furnaces.

Weighing, Sampling, Assaying. Purchase is made on dry weight. Seller or representative may be present at weighing and sampling. Weights are accurately determined, and suppliers are provided with a "Weight Certificate" which gives details of gross, moisture, net, etc.

Dusting, in dry lots, and excessive moisture in the other extreme, limit automatic sampling, and for the most part tube or augur cutting is resorted to.

Samples for assaying and moisture are taken simultaneously, immediately following weighing and opening of containers. The bulk sample secured by cutting is coned and quartered on a steel plate, and the final sample reduced in the Assay Office to four equal portions.

The sample secured for moisture determination is dried in an electrically heated water drying oven. Of the four portions taken for assay, and/or, analysis, one portion is held by the Plant, the second portion is sent to the supplier's designated assay office for check. The third is held for umpire, if necessary, and the fourth held against emergency or dispute. Disagreement of gold assays exceeding 5% between Plant and outside assay, result in umpire.

Payment

Payment is made on the average of agreed assay values, or if umpire assay has been resorted to, on the average of the umpire assay and the one nearest to it. 85% of the agreed total gold content of a consignment is paid for at the ruling local price of gold (172/3d per ounce Rhodesian currency).

Treatment Charge. Concentrates purchased treated at 45/- per ton.

Realization. All gold produced in the Colony sold to banks. Total bank charges against the se[...] exceed 2/- per fine ounce.

Electrolytically refined gold assaying 999.5 [...] produced at the Plant, met bank charges of 2[...] pence to 27.27 pence per fine ounce.

Resultingly it is necessary for the buyer to [...] a "realization charge" against suppliers, and at present a charge of 1/11d per fine ounce is levied against the Seller.

Penalties. In the case of concentrates, table sh[...] acceptance limits, free from penalty, and penalty [...] limit is exceeded.

Impurity	Limit	Penalty
Copper, Nickel, Cobalt	0.5%	24/- per unit
Lead	0.1%	5 × % deduction
Antimony, Bismuth	1.0%	of Au. plus basic 15[...]

By-Products

Weighing, sampling, etc., is substantially [...] same as for concentrates. For clean slag, payment is up to 96% of the agreed gold content of a consignment and 75% of the silver. Treatment charge is £5 per ton with a minimum of £2.10.0. for less than one ton lots.

In the case of purchases of other products, agreement of charges, per cent payment, etc., is arranged between Seller and Plant Manager.

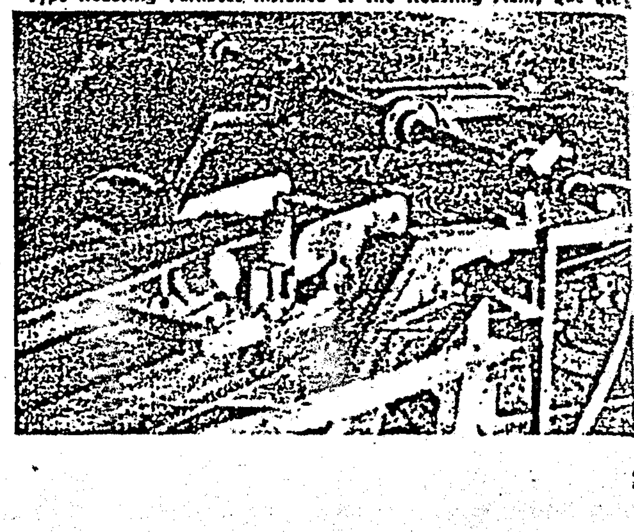
Plant and Treatment Processes

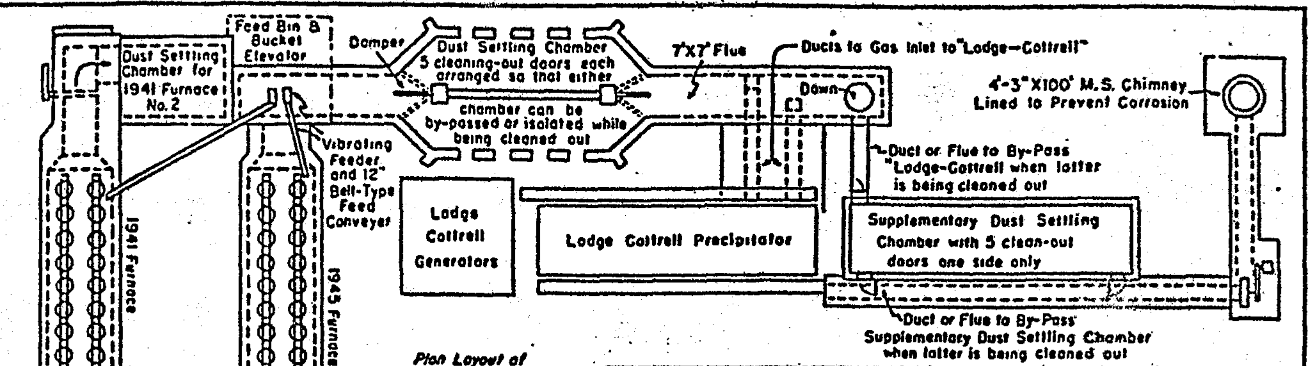
Concentrates, Stockpiling. Following purchase identity of material is lost, as, knowing within limits the Au. As. S., contents, the newly sampled lot [...] stockpiled, and the procedure permits a more or less standard roasting condition becoming applicable [...] a given stockpile, which is normally prepared for [...] ensuing month's operation.

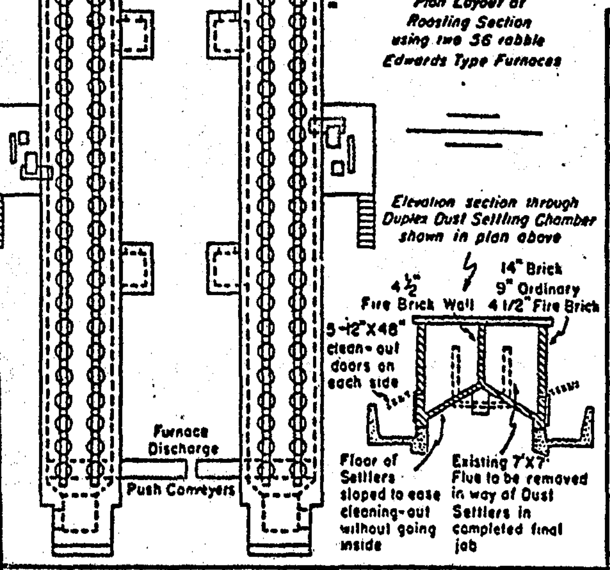
On a drawing from the stockpile, the mix [...] passed through a stationary screen with 3/8" openings, the oversize returned and crushed through 15"x10" crushing rolls, and the product re-screened.

Elevation of the screened feed to storage b[...]

This flat belt conveyor and chute feeds one of the 56-rabble Edw[...] Type Roasting Furnaces installed at the Roasting Plant, Que Qu[...]







ove the furnaces is by bucket elevator which is wered by a 5 h.p. motor, belt speed at 160′ p. m.

rnace Feed, from storage bins is controlled by 2A ffrey vibrator feeders to flat belts, which convey vibrating feeder discharge to the furnace feed ppers. The hoppers in service terminate within a clearance of the rabbles, at the mid point between . 1 and No. 2 sets of rabbles.

asting, is performed in two, 56 rabble, Duplex wards type furnaces. Hearth area is 115′ long x wide. Slope is ¼″ per foot.

ve. A 20 h.p. 1,000 r.p.m. slip-ring motor, con- nption @ 12-14 amps, drives the standard mech- sms of each furnace. Two-stage speed reduction, h Croft variable speed gears, gives choice of rab- speeds, ranging from 1 revolution in 45 seconds revolution in 135 seconds.

Stems, rabbles, and shoes or tynes, are of cast ı, locally made. Shoe renewal frequency is one per 500 tons concentrates roasted.

l, at present is indigenous timber. Consumption rages 90 cords per month per furnace. Moisture tent of wood is 25-30% (in dry season). Thermal ue (estimated) 4,000 B.T.U. per dry lb. Costs, at nt. £1 per cord. Coal as fuel, with automatic king, is planned, in order to conserve timber.

Fire Boxes. Each furnace has five fire boxes built in and staggered, as illustrated, with final box being situated at the discharge end. This last is very seldom used. Firebox hearth area is 5′x3′. Inlet cross section from firebox to hearth, 4′x1′.

Roasting Temperature. Normally maintained at a maximum of 650° C. and very seldom exceeding 700° C.

Temperature Recording is effected from a 2-leg pyrometer in each furnace with automatic recording by use of Cambridge Recorders.

Rabble Cooling is performed with unfiltered river water, the discharge temperature of which is 40-45° C. The volume of water through this system is 40-50 g.p.m., per furnace.

Roasting of Concentrates. With varying tonnages and variable grades of materials treated, variations in this circuit and in the ensuing cyanide section are the rule. Average roasting time is 12 hours travel in hearth.

Tonnages, roasted, per furnace, over a period of several years, averages 485 tons per month. This does not include the return addition of 40-50 tons per month of flue dust from the settling chambers. Table I below gives casual screening analyses of furnace feed, furnace discharge, and residues, and Table II gives typical monthly averages of day by day feed, and corresponding discharge date:

View through a furnace inspection door shows rabble arms turning the roasting concentrate.

TABLE I

GRADING ANALYSES OF COMPOSITE SAMPLES FOR FEBRUARY 1946

ROASTER FEED

Tyler series	% by weight	Au. dwts/ton	% of total gold content
+ 65	21.3	71.0	14.4
— 65+100	8.4	64.6	5.2
—100+200	24.4	79.9	18.6
—200+325	12.0	146.4	16.8
—325	33.9	139.7	45.0
	100.0	104.9	100.0

ROASTER DISCHARGE

Tyler series	% by weight	Au. dwts/ton	% of total gold content
+ 65	12.6	75.0	6.9
— 65+100	10.5	76.1	5.9
—100+200	29.4	107.6	23.2
—200+325	15.2	195.9	21.9
—325	32.3	177.5	42.1
	100.0	136.2	100.0

FINAL RESIDUE

Tyler series	% by weight	Au. dwts/ton	% of total gold content
+200	0.4	9.3	0.5
—200+325	4.0	5.6	3.1
—325	95.6	7.3	96.4
	100.0	7.2	100.0

COMPOSITION OF GRADING FRACTIONS
COMPOSITE ROASTER FEED, FEBRUARY 1946

Tyler series	% by Weight	% Fe.	% As.	% S.	%SiO2 & insoluble
+ 65	21.3	32.4	14.4	23.5	21.9
— 65+100	8.4	28.5	11.7	20.8	28.9
—100+200	24.4	29.5	10.1	21.1	30.4
—200+325	12.0	31.2	14.3	24.3	22.5
—325	33.9	23.4	23.1	16.5	25.1
Original	100.0	28.0	15.1	19.9	25.1

PERCENTAGES IN THE GRADING FRACTIONS

Tyler Series	% Fe.	% As.	% S.	% SiO2 & insoluble
+ 65	24.5	20.4	24.5	18.1
— 65+100	8.5	6.6	8.6	9.4
—100+200	25.6	17.2	25.2	28.9
—200+325	13.3	12.6	14.3	10.5
—325	28.1	43.2	27.4	33.1

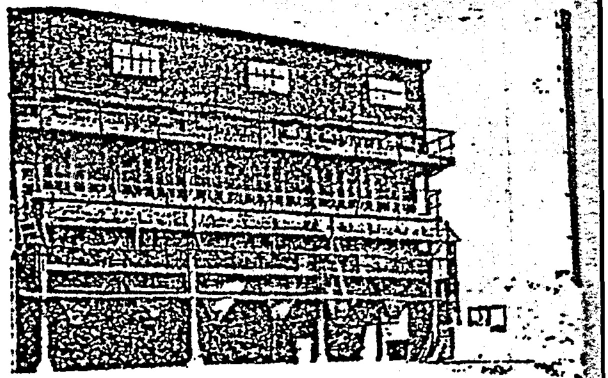
TABLE II

TYPICAL ANALYSIS—ROASTER FEED

Feed	"A"	"B"	"C"
Au.	47.49 dwts.	68.91 dwts.	79.45 dwts.
As.	8.20%	6.98%	10.53%
S.	17.06%	24.05%	17.44%
Fe.	25.76%	29.40%	23.31%
H_2O	6.13%	4.18%	4.54%

ROASTER DISCHARGE

Feed	"A"	"B"	"C"
Au.	64.02 dwts.	85.91 dwts.	91.729 dwts.
Ag.	10.12 dwts.	13.27 dwts.	9.66 dwts.
As.	0.71%	0.38%	0.58%
S.	1.50%	0.77%	0.68%
SO_4	2.72%	1.53%	1.74%
Fe..	30.32%	47.05%	30.78%



Model 7 twin type Lodge-Cottrell precipitation unit with a ... the auxiliary settling chamber and stack on the right.

Specific gravity of the discharge, roasted solid is ...

Furnace discharge of roasted product is via ... 18" diameter hoppers, to push, or scraper conve... one conveyor to each furnace, and each drive... 3 h.p. motors. Conveyor flights are at 1' inter... and 20" wide.

Quenching of the roast is performed by ... spraying with a protecting cover box 36"... which is constructed and built into the fur... walls, and forming a dust seal over the convey...

Temperature reduction, avoidance of dust los... and primary washing is thereby performed. Pr... uct is then concentrated and cyanided.

Flue system. Butterfly controls are located at ... throats of each furnace. Dust collected in the du... settling chambers is returned to the furnace ... Tonnage collected and so returned is between 1 ... 2 tons per day, and averages 5-6 dwts Au. ... 25-40% As_2O_3. Cross section of each half of cha... is 9'x12' and length of chamber is 30' exclu... the tapered ends. Floors are sloped, enabling ... clean-out to cars, through five cast-iron doors ... each side of the chamber.

As shown in layout a flue from the sett... chamber to the electrified auxiliary chamber ... available, and if necessary, by-pass fumes norm... treated in the Cottrell.

Lodge Cottrell precipitator. This machine ... Model 7 twin type standard unit, capacity be... 400,000 cu. ft. of gases per hour at N.T.P. ... operated at as high an H.T. potential as poss... close to 85,000 volts with lead current at 50-60 m... amps.

Manual rapping of the electrode tubes res... in deposition of the precipitated arsenical dust ... 12 hoppers, which are hand cleaned daily.

Arsenic production. Cottrell hopper product, ... until recently, averaged 50 tons per month, bu... now reduced being necessarily dependent upon ... As. content of treated concentrates. Product a... ages 80-85% As_2O_3 and from 3 to 3.3 dwts. Au.

Wartime conditions, import restrictions, etc., ... sulted in this arsenic being one of the few st... sources of South African supply, and contract s... are made to the African Explosives and Chem... Industries, Ltd., who, after sublimation of this p...

uct at their Salisbury plant, manufacture cattle dip, and return their residues to this Plant where it is added to normal roasting furnace feed.

Contents of this residual sludge are +10% As. in the form of an iron arsenide, and 20-30 dwts. Au. per ton. Sulphur at present escapes to waste.

Concentration, Amalgamation, Grinding

Solids, expelled by the push conveyors from the furnaces, enter a feed box and with additional water, are pumped to an oversized concentrating table.

The high grade table product, 600-1,000 lbs. per 24 hours, is amalgamated, after grinding, without reagents, in a 4'x3' barrel. The barrel tails are run into a mechanical Batea with 44" bowl, and thence over an amalgam plate.

In two years operation, 45% of the total recovered gold was secured by amalgamation, with a mercury loss of 0.17 ounces, per recovered ounce of gold. Procedure is standard and normal. Amalgam tails join the table middlings and tails, and are pumped to the classification and grinding circuit.

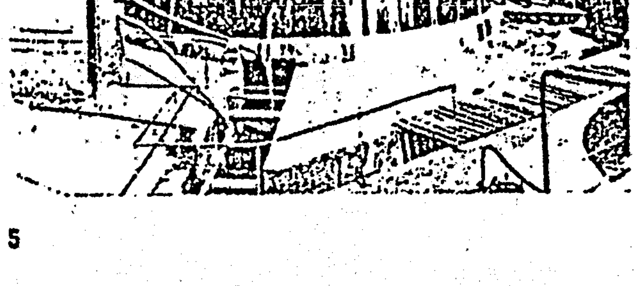
Classification and Grinding Circuit. Separation is made in a 14'8"x4' rake type simplex classifier, overflowing at 8-10% solids, grind at 99% —200 mesh Tyler series. Classifier sands gravitate to a 4'x3' Ball Mill, driven by a 20 h.p. motor at 29 r.p.m.

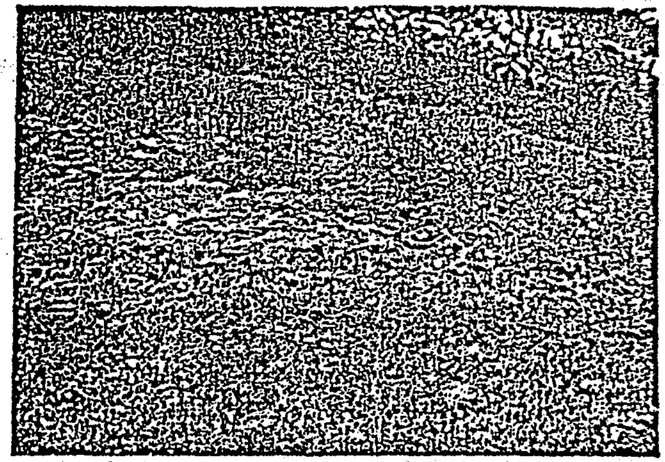
Ball load is maintained at 4,000 lbs. by daily make up of 2½" locally made cast-steel grinding balls. Consumption is 2.75 lbs./ton. Liner wear is 1½ lbs. per ton. Liners are locally made cast steel. Mill discharge at 75% solids is pumped to the concentrating table, thus closing this circuit.

Washing Thickeners receive the classifier overflow, grind as above, with S. content of solids under 2%, and SO_4 in liquid varying from 10 to 20 g.p.l. Units operate in 20'x10' concrete tanks with 9" walls.

Rake speed is 1/5 r.p.m. 3 h.p. motors, and drives through V belts with flat belt drive to diaphragm pumps, are employed. Pumps are one 2" Denver Simplex and one 3" Geco.

One of four 28' x 10' Denver Standard Lowhead Thickeners, mounted in concrete, form the counter-current decantation circuit. 50% solids are pumped from thickener to thickener by 2" Denver Diaphragm Pumps.





Aeration of agitator pulp is shown in one of the four 10' x 10' Denver (Patented) Super Agitators and Conditioners used for preagitation and cyanidation. Metal impeller replacement is one per 5000 tons treated. Rubber covered impellers exceed 12,000 tons without sign of wear.

Underflow of each unit is at 50-55% solids. 50% of wash water is run to waste, assaying trace to 0.02 dwts. Au.

Cyanidation

Agitation. Agitation is conducted in four 10'x10' Denver (patented) Super Agitators and Conditioners, each equipped with 7½ h.p. motor and operated in concrete tanks with 8" walls. Inter-connecting pipe lines readily permit by-passing each or any agitator. Provision is made for the rapid and easy discharge of tank contents.

Preagitation is performed in the first agitator at 50% solids. Lime and cyanide are added, as is barren solution to No. 2 agitator. Dilution of pulp is reduced to 30-33⅓% solids in this agitator, and 16 hours agitation in cyanide solution is approximately the contact time. KCN is maintained by regular addition, at about 0.12%, and CaO at 0.02%.

Cyanide consumption, variable, is between 5 and 6 pounds per ton. Lime consumption (itself a variable) is between 15 and 20 pounds per ton.

Impellor replacement in the case of metal impellors is one per 5,000 tons treated. One rubber covered impellor, after 12,000 tons of solids have passed through the agitator, shows no sign of wear.

Counter-Current Decantation. Four 28'x10' Denver Standard Lowhead Thickener mechanisms, also mounted in concrete tanks, form the counter-current decantation circuit.

Pulp at 30% solids, leaving No. 4 agitator, gravitates to No. 1 thickener feedwell. Solids at +50% are pumped by 2" Denver Simplex Diaphragm pump to No. 2 thickener, and so on.

Barren solution from the precipitation unit is pumped at the rate of 240-250 tons per 24 hours to No. 4 thickener, overflowing as pregnant solution from No. 1.

The underflow of No. 4, unfiltered and pumped at 50-55% solids, forms the final tailing pumped by

5

a 2″ C.A.C. rubber lined pump to the tailings dam.

The ratio of solution to solids in this circuit averages 22:1. Rake speed of mechanisms is 1/7 r.p.m. Tanks are fitted with discharge piping in the walls such that emergency dumping of contents may be rapidly performed.

In three years service no mechanical or operational defects in either agitators or thickeners have arisen, and metallurgical results gained have been good. As noted in Table III below, solution feed of the counter-current decantation circuit, less solution discharge to waste is consistently +99%.

TABLE III

AVERAGES OF PLANT DAILY ASSAYS

FEBRUARY 1946

Roaster Feed	= 93.495 dwts.—ton (diluted)
True Head	=101.384 dwts.—ton (on basis of purchased value)
Roaster Discharge	=135.528 dwts.—ton (on basis of purchased value)
Classifier O'Flow	=108.193 dwts.—solid & 0.017 dwts. solution.
No. 1 Agitator Feed	=104.479 dwts.—solid & 0.014 dwts. solution.
*No. 4 Agitator Disc:	= 21.750 dwts.—solid & 44.474 dwts. solution.
**No. 4 Thickener Disc:	= 7.050 dwts.—solid & 0.051 dwts. solution.
True Head—Tail	= 93%

*Counter-Current Decantation Circuit Head.
**Final Tails.

EXTRACTION—SOLIDS

Roaster Feed—Tails	=92.46%
Roaster Discharge—Tails	=94.79%
Classifier Overflow—Tails	=93.48%
No. 1 Agitator Feed—Tails	=93.34%

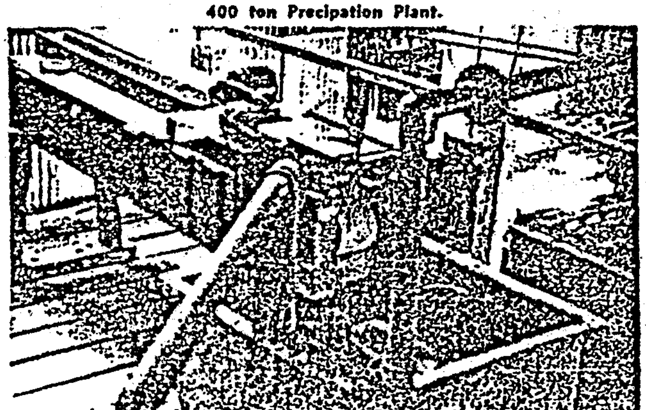
EXTRACTION—SOLUTIONS

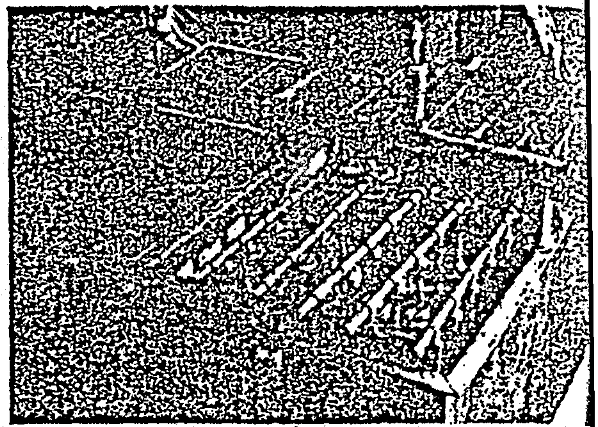
No. 1 Thickener Feed—No. 4 Thickener Disc.=99.88%

Precipitation. The overflow of No. 1 Thickener is primarily clarified in one of two sand clarifier tanks and is then pumped to a Denver Equipment Co. 400 tons per 24 hours capacity Precipitation Plant.

This is a standard unit containing a 30 leaf clarifier; 2′x7′ vacuum receiver; zinc dust feeder, etc., and is utilized with two precipitation tanks each of which accommodates 60 socks. A Lea Recorder registers and charts solution tonnage passing

Zinc dust is fed via flat belt feeder to a mixing tank in the Denver 400 ton Precipation Plant.





One of two 60 sock precipitation tanks.

through the circuit, and the barren solutio[n] pumped from storage tanks to No. 4 thickener [f]well. No solution is discarded except the 45-[…] content of the final tailings.

Continued drip sampling is maintained from pregnant and barren solution streams. Operati[on of] the unit is normal and trouble-free. Gold reco[very] is normally at [illegible]%.

Average pregnant solution (12 months)	=1.6928[…]
Average barren solution (12 months)	=0.0104[…]

Reagent consumption is within accepted li[mits] and averages:—

Zinc Dust	@ 0.05 lbs. per ton.
Lead Nitrate	@ 0.012 lbs. per ton.

Precipitate Treatment. Precipitate is washed [f]the inner of the collecting socks, collected, [acid] treated, and water washed in a wooden mec[han]ical agitator. The treated slime is pumped [to] Johnson press, and on transfer for melting, is fl[uxed] with borax, nitre and silica sand, or other reag[ents] depending on nature of precipitate, and melted [to] buttons in either an oil-fired vertical furnace u[sing] pots and liners, or a Rockwell type furnace.

Gold Recovery

During the financial year of 1945, the follo[wing] distribution has been certified:—

Au. in Purchased Concts.	=13,065.4 fine ozs.	=100.0[…]
Au. Banked	=12,286.4 fine ozs.	= 94.0[…]
*Au. in Arsenic	= 106.7 fine ozs.	= 0.8[…]
**Au in Slag	= 118.5 fine ozs.	= 0.9[…]
Balance	=residues to waste.	

*Gold in arsenic is largely recovered as noted abov[e].
**Gold in slag, the product of precipitate treatme[nt] recovered by addition of this material to Ta[…] furnaces.

Costs

It should be noted that these costs are [b…] against 480 tons per month concentrates tre[ated.] Using two Edwards furnaces and treating [...] tons per month, costs per ton are 60% of a[…] Assaying costs include test work, assays and [an]alytical determinations of samples received [from] regular and potential suppliers.

General charges include non-operational European salaries, medical fees, bank charges, postage, telephone, advertising, transport, stationery, water, leave pay reserve, workmen's compensation, insurances, fees to board members and auditor, and traveling expenses.

Costs during the financial year 1944/45, on breakdown, include:

	Cost per ton
Receiving and Sampling	£— .4.0
Conveying	£— .1.6
Roasting	£—11.4
Cottrell	£— .2.4
Grinding and Classification	£— .5.5
Concentration and Amalgamation	£— .4.6
Cyanidation	£—13.5
Precipitation	£— .3.10
Refining (Smelting)	£— .2.10
Tailing disposal	£— .-.2
Research	£— .-.11
Assaying and Analytical	£— .9.1
General Charges	£—17.6

Assay Office

The Assay Staff consists of a chemist, and three European assayers, and is equipped to conduct all normal assays and chemical determinations. Existing furnaces are being replaced by more modern equipment, i. e., Denver Fireclay Oil-burning units.

10-11,000 units are conducted monthly at a cost of 5d per unit. "Unit" table used is:

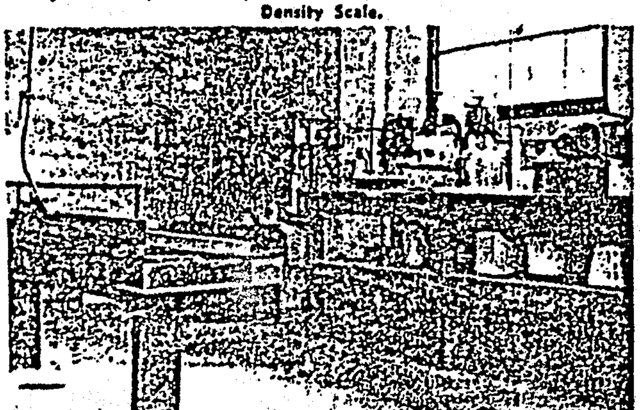
Au.=	5	Co.=	50	Ni.=	30
Ag.=	5	Cu.=	8 (Iodide)	Pb.=	4
As.=	18	Cu.=	4 (Permang.)	S.=	5
Bi.=	50	Cr.=	75	Sb.=	18
CaO.=	6	Fe.=	6	SiO_2.=	10
C.=	150	Insol.=	4	WO_3.=	30

Laboratory

The laboratory is equipped with a Denver (patented) Super Agitator and Conditioner, Concentrating Table, Ball Mill, Rod Mill, Mineral Jig, Float Machine, etc. Equipment in use permits normal test-work to be performed.

Electrolytic equipment has been made up permitting production of gold and silver exceeding 999 fine, by the normal two-stage refining methods.

All normal test work can be performed in the laboratory which includes a Denver (Patented) Super Agitator and Conditioner, Concentrating Table, Ball Mill, Rod Mill, Mineral Jig, Flotation Machine and Pulp Density Scale.



Tavener Furnace

To date the small amount of 240 tons only have been purchased and treated, the lot averaging 26 ounces Au. per ton.

Procedure, following analysis of charges of about 20 tons each, is to flux with litharge, scrap iron, or other medium, melt in the Pan furnace, and collect gold and silver in a lead bath.

The lead bullion formed is tapped to bars of about 70 pounds each, and these are then cupelled in the cupel furnace. Lead is removed as PbO. and re-used, the bullion residue on the cupel is collected, melted to bars and then banked.

The slag tailings, rabbled from the Pan furnace, account for 2% of total gold, and remaining 98% is accounted for in gold banked, by-products produced, and lock-up in the Pan furnace hearth.

Special Purpose Plant

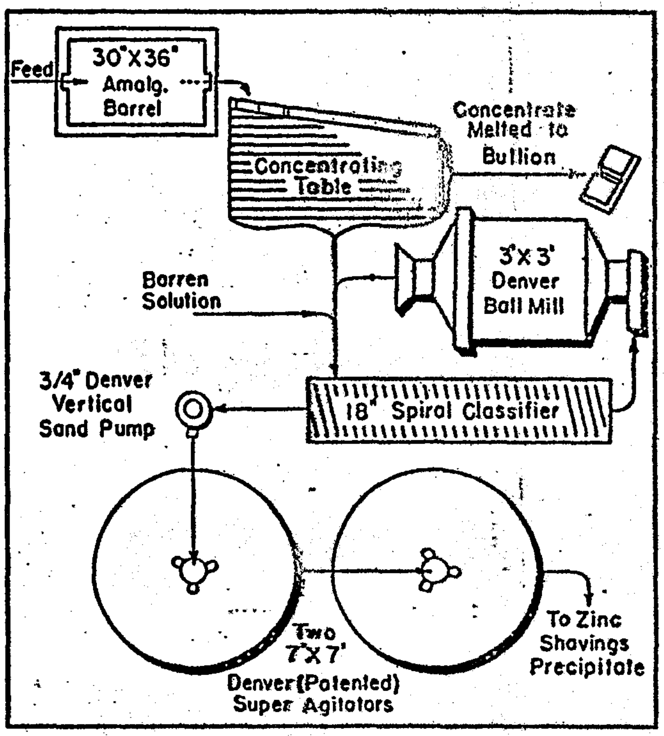
This section has been recently assembled, and is used entirely for batch treatment of high-grade consignments which may be amenable to cyaniding without roasting. Materials treated are either slag or concentrates as the case may be, and, in initial use, this self-contained unit has proved very satisfactory.

Residue Dump Retreatment Plant

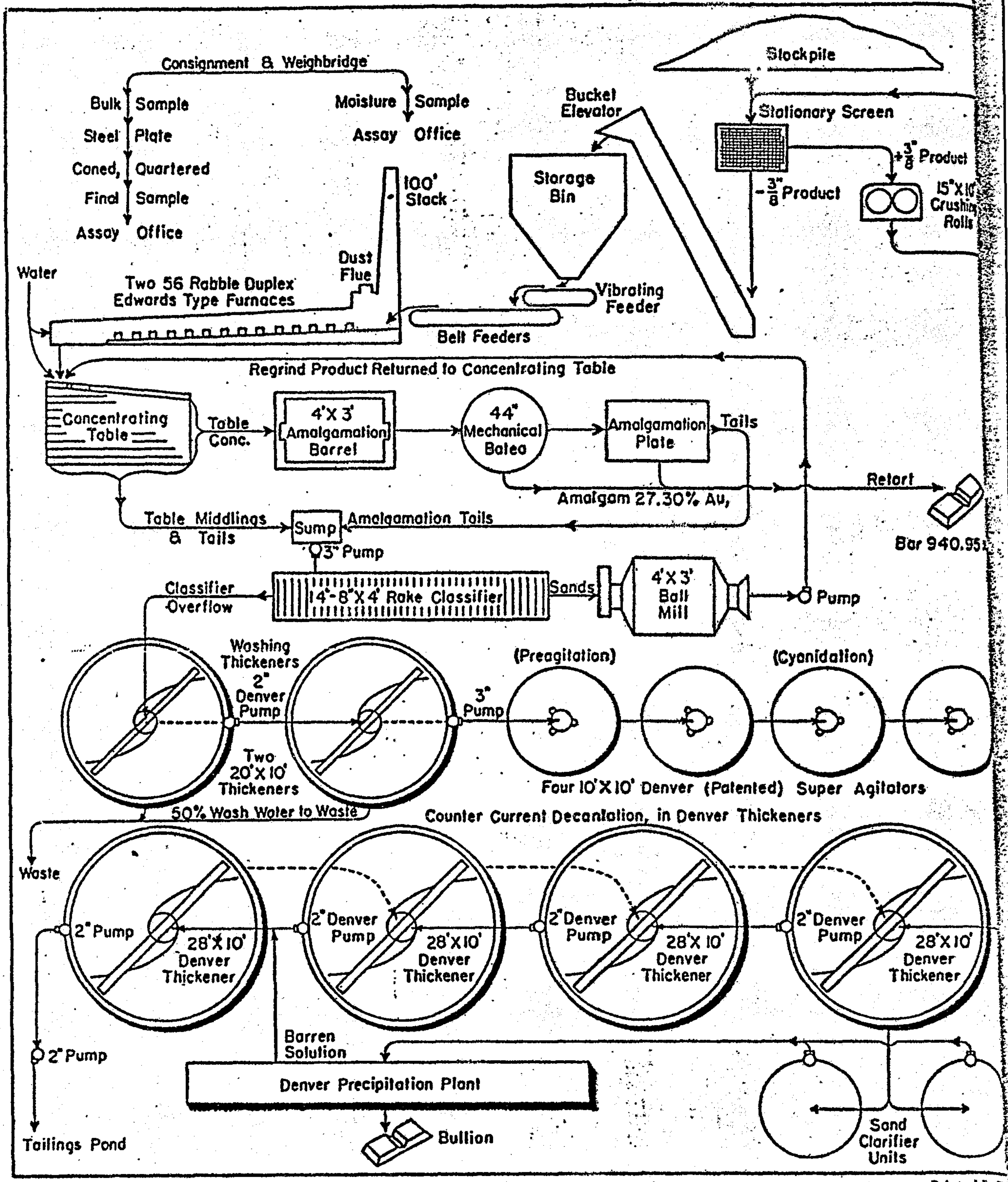
A known tonnage of accumulated high-grade tailings warrant re-treatment, and a plant is now being assembled with the object of retreating this dump.

Future plans include the possibility of installing furnaces to treat high-grade copper-gold concentrates, and antimony-gold concentrates.

FLOWSHEET...SPECIAL PURPOSE PLANT



FLOWSHEET . . . THE ROASTING PLANT, QUE-Q



Yellowknife, Northwest Territories
Canada X1A 2M2
Telex 034-4-5514
Phone 403/873-6301

Giant
YELLOWKNIFE MINES LIMITED

February 24, 1984

Mr. R.M. Kadenhe,
Manager,
The Roasting Plant,
KWEKWE, Zimbabwe

Dear Mr. Kadenhe:

Re: Treatment of Arsenical Gold Concentrates

We have read with interest your letter of February 13, 1984 and are pleased to advise you that we are indeed prepared to provide you with a 'design package' of fluosolids technology as practiced as our mine.

Due to the increasing interest in fluosolids technology, Giant Yellowknife Mines Limited has, in conjunction with our parent company Falconbridge Limited, recently begun marketing the expertise we have gained over many years of fluosolids roasting of arsenical ores. Fortunately, we have experienced the conversion from Edwards type roasters to dual stage fluosolids roasters at our own plant and so are aware of many of the potential difficulties.

Given the variety of concentrates treated, your queries regarding fluctuating feed compositions and effects of high antimony concentrations are questions that we too would be most likely to seek answers to in considering changes such as you propose. As you are no doubt aware, the subject is quite complex and would perhaps be better addressed during your visit this summer. A few general observations may however be appropriate.

As a general rule fluosolids roasters do not respond as well to abrupt changes in feed characteristics as do the Edwards type. The important feed characteristics to consider from an operating aspect are particle size, sulphur content, moisture content, specific gravity and antimony concentration. Since the fluosolids roaster is less flexible in responding to changes in feed conditions it is likely that very careful blending of the various concentrates will be required. In this regard too, it has been our experience that antimony levels in excess of 1% in the feed over a period of a few days will result in serious roaster upsets requiring replacement of the bed.

/..continued page two

Scotch® BRAND 7664 "Post-it" Routing-Request Pad

ROUTING - REQUEST

Please

- [ ] READ
- [ ] HANDLE
- [x] APPROVE

and

- [ ] FORWARD
- [ ] RETURN
- [ ] KEEP OR DISCARD
- [ ] REVIEW WITH ME

To KB

For your approval before I mail for KSM

Date

From J

We would be happy to host a visit of representatives from your plant and, if desired, could arrange a tour of the Falconbridge roasting plant as well. Please let us know your wishes on this matter.

I have forwarded a copy of your letter and this response to Mr. P.J. Raleigh, Head of the Falconbridge Engineering Group, who will contact you directly to discuss how we could best be of assistance in developing a suitable design package for your requirements.

Yours truly,

GIANT YELLOWKNIFE MINES LIMITED

K.S. Morton
Mill Superintendent

KSM:jh

c.c. K. Blower
T. Riordon
P.J. Raleigh

The Roasting Plant, Kwekwe

Telephone No. 2868

Telegraphic Address
"ROASTER, KWEKWE"

REF. G/R/3

P.O. BOX 118,
KWEKWE

13th February, 1984

ESTABLISHED IN 1937 IN TERMS OF THE ROASTING PLANT ACT (CHAPTER 204) TO CARRY ON THE BUSINESS OF DEALING IN AND TREATING ORES, CONCENTRATES AND THE PRODUCTS AND BY-PRODUCTS THEREOF

Metallurgical Superintendent,
Giant Yellowknife Mines, Ltd.,
Yellowknife,
N.W.T.

Dear Sir,

re: TREATMENT OF ARSENICAL GOLD CONCENTRATES.

I write to inquire if you could be in a position to supply us with a "design package" of the fluosolids technology used at your Mines, and an estimate of the cost for a 60 T.P.D. roaster.

We are a parastatal body, custom-treating concentrates from refractory (arsenical) ores from our Zimbabwean Mines. The roasting stage is performed in two Edwards Roasters which were commissioned in 1940 and have been operated ever since. The calcine goes through the conventional cyanide, C.C.D. and merril-crowe zinc precipitation process. At present we just can manage about 30 T.P.D. of concentrates into the roasters, with not very satisfactory results on recovery, presently at 75% on average i.e. a residue of about 11 - 13 g/t to the dam.

We are now therefore trying to replace the old Edwards Roasters, and my Board of Directors has decided on acquiring a fluosolids roaster (double-bed).

Since we custom-treat, our source of feed concentrates is very varied as shown by the enclosed schedule of analysis and gold distribution (on size fractions) of some of our suppliers and our composite feed. The bulk of the concentrates are from as mined-ores and a few are from dump-retreatment. It may be of interest that it has been our experience that those concentrates of dump retreatment origion and with an Antimony content in excess of 1,5%, do have some deterimental effect on the process. So, any information you could supply from your experience, of antimony behaviour in the fluosolids, and effects of flutuating composite feeds will be very much appreciated.

Finally, I am also asking if it would be possible to visit your group of Mines sometime between May and July, 1984 if arrangements were made.

Your assistance and any other advice you could give, would be greatly valued.

Yours faithfully,
The Roasting Plant.

MR. RM KADENHE.
MANAGER.

1) RIVERLEA MINE (AS ? MINED ORE CONCENTRATE)

CONCENTRATE ANALYSIS

Au (g/t)	% Fe	% S	% As	% Sb	% Cu	% N	% Pb
60,80	14,90	18,02	8,30	0,20	0,10	0,04	Tr.

GRADING ASSAY ANALYSIS

Screen Size X10 - 6 M	Wt. g	% Wt Distrbn.	Cu mm	Au g/t	%Au Distrbn.	Cu mm
+ 300 mm	1,6	0,19	0,19	24,0	0,09	0,09
- 300 + 212	4,0	0,48	0,67	40,0	0,32	0,41
- 212 + 150	22.8	2.74	3.41	42,0	1,94	2,35
- 150 + 106	45,3	5,44	8,85	82,8	7,61	9,96
- 106 + 75	45,4	5,45	14,30	90,4	8,32	18,28
- 75	714,2	85,70	100,00	56,4	81,72	100,00
TOTAL	833,3	100,00			100,00	

Calculated Head Grade (Au) : 59,15 g/t

2) CAM & MOTOR (DUMP-RETREATMENT CONCENTRATE)

CONCENTRATE ANALYSIS

Au g/t	% Fe	% S	% As	% Sb	% Cu	% Ni	% Pb
39,80	5,95	5,06	1,71	1,55	0,14	0,08	Tr.

GRADING & ASSAY ANALYSIS

Screen Size 10^{-6}M	Wt. g	% Wt Distrbn.	CUMM	Au g/t	% Au Distrbn.	CUMM
+ 300	-	-	-	-	-	-
- 300 + 212	-	-	-	-	-	-
- 212 + 150	-	-	-	-	-	-
- 150 + 106	-	-	-	-	-	-
- 106 + 75	4,4	0,76	0,76	0,24	0,61	0,61
- 75	576,5	99,24	100,00	38,90	99,39	100,00
TOTAL	580,9	100,0			100,0	

CALCULATED HEAD GRADE (Au) : 38,61 g/t

CALCULATED HEAD GRADE - Au : 45,19 g/t

N.B. The Calculated Head Grade is consistent with current grade for the concentrates supplied by this mine, circa 48 g/t.

5) APPROXIMATE CURRENT FEED TO EDWARDS ROASTERS :

CONCENTRATE ANALYSIS

Au (g/t)	% Fe	% S	% As	% Sb	% Cu	% Ni	% Pb
49,10	21,30	15,70	5,30	0,80	N O T	D O N E	

......./3

3) INDARAMA MINE (AS - MINED ORE CONCENTRATE)

CONCENTRATE ANALYSIS

Au g/t	% Fe	% S	% As	% Sb	% Cu	% Ni	% Pb
46.10	21,85	24,83	8,30	1,40	0,12	0,06	0,10

GRADING AND ASSAY ANALYSIS

Screen Size 10^{-6}M	Wt. g	% Wt Distrbn.	CUMM	Au g/t	% Au Distrbn.	CUMM
+ 300	54,1	2,04	2,04	39,6	1,60	1,60
- 300 + 212	80,3	3,03	5,07	38,0	2,30	3,90
- 212 + 150	310,6	11,73	16,80	26,0	6,10	10,00
- 150 + 106	345,6	13,05	29,85	28,0	7,30	17,30
- 106 + 75	256,0	9,67	39,52	39,2	7,60	24,90
- 75	1601,5	60,48	100,00	62,0	75,10	100,00
TOTAL	2648,1	100,0			100,0	

CALCULATED HEAD GRADE (Au) : 49,95 g/t

4) BAR 20 MINE (AS-MINED ORE CONCENTRATE)

CONCENTRATE ANALYSIS

Au (g/t)	% Fe	% S	% As	% Sb	% Cu	% Ni	% Pb
54,40	30,40	22,16	18,50	0,10	0,10	Tr.	Tr.

GRADING & ASSAY ANALYSIS

Screen Size 10^{-6}M	Wt. g	% Wt Distrbn.	CUMM	Au g/t	% Au Distrbn.	CUMM
+ 300	178,4	14,57	14,57	32,8	10,6	10,60
- 300 + 212	6,0	0,49	15,06	34,0	0,4	11,00
- 212 + 150	23,9	1,95	17,01	33,5	1,4	12,40
- 150 + 106	50,7	4,14	21,15	40,0	3,7	16,10
- 106 + 75	56,4	4,62	25,77	50,0	5,1	21,20
- 75	908,7	74,23	100,00	48,0	78,8	100,00
TOTAL	1224,1	100,00			100,0	

CALCULATED HEAD GRADE - Au : 45,19 g/t

N.B. The Calculated Head Grade is consistent with current grade for the concentrates supplied by this mine, circa 48 g/t.

5) APPROXIMATE CURRENT FEED TO EDWARDS ROASTERS :

CONCENTRATE ANALYSIS

Au (g/t)	% Fe	% S	% As	% Sb	% Cu	% Ni	% Pb
49,10	21,30	15,70	5,30	0,80	N O T	D O N E	

GRADING - ASSAY ANALYSIS

Screen Size 10^{-6}M	Wt g	% Wt Distrbn.	CUMM	Au G/t	% Au Distrbn.	CUMM
+ 300	167,6	3,60	3,60	40,0	2,7	2,7
- 300 + 212	53,1	1,14	4,74	64,4	1,4	4,1
- 212 + 150	209,9	4,50	9,24	57,2	4,7	8.8
- 150 + 106	292,8	6,29	15,53	61,6	7,1	15,9
- 106 + 75	276,7	5,94	21,47	61,4	6,6	22,5
- 75	3657,9	78,53	100,00	53,6	77,5	100,0
TOTAL	4658,0	100,00			100,00	

CALCULATED HEAD GRADE - Au : 54,30 g/t

OPERATION GOVERNMENT ROASTING PLANT
P.O. BOX 118
KWE KWE
ZIMBABWE

CONTACT Mr. Jimmy A. James, Manager

TELEPHONE Kwe Kwe 2868

DATE OF VISIT 30 June 1982

LOCATION On the outskirts of the town of Kwe Kwe, located about three hours drive south of Salisbury on the Bulawayo road.

INTRODUCTION The GOVERNMENT ROASTING PLANT is operated by the Zimbabwe government to treat sulfide flotation concentrates produced by numerous small mining and tailings recovery operations throughout Zimbabwe.

There are currently about twelve concentrate suppliers to the roaster and leaching plant.

The KWE KWE roasting plant uses equipment of very old vintage, but it has been maintained in excellent working order. The EDWARDS roasters are the best run of any observed in the course of this investigation with the most sophisticated fume recovery plant of EDWARDS roasters.

Despite relatively low sulfur content of some of the concentrate feed, the roaster operates without any external fuel source - it is completely autogenous.

A second roasting operation, also an EDWARDS roaster treats roaster dust to yield a relatively high grade arsenic oxide product for which there is a market.

A visit to the KWE KWE roaster is highly recommended, although it is unlikely that a new EDWARDS roaster would be constructed today, since the availability of fluid bed roasting technology.

This old plant contains many very old pieces of equipment and is fascinating for anyone interested in the evolution of metallugical equipment. The surprisingly good operating condition of the equipment does credit to the maintenance staff on this remote plant.

HISTORY The GOVERNMENT ROASTING PLANT was first brought into production in 1937. New EDWARDS roasters were built in 1941 and 1942. There are two duplex EDWARDS roasters, each with 56 rabble arms.

There are numerous small mines in Zimbabwe producing sulfide concentrates containing gold which are often also rich in arsenic and antimony. Few, if any of these small mines are large enough to support their own roasting plant. Consequently, the KWE KWE roasting plant has played a major role in the development of the gold mining industry of Zimbabwe. Additional information on the history of the roasting plant is provided in an old DECO writeup on the plant, written by Mr. T.S. Cleary, a former manager of the plant.

GOVERNMENT ROASTING PLANT, KWE KWE
TYPICAL ROASTER FEED & GOLD RECOVERIES

	Au g/t	AS %	Sb %	% S	OTHER %	RESIDUE AFTER LEACH Au g/t	Au g/t	GOLD RECOVERY FREE %	CYANIDED %	TOTAL %
CAM & MOTOR MINE[1]	72	3.1	*4.17	10.4	Ni 0.1 Cu 0.17 Pb TR	22.8	81.5	NIL	71.7	71.7
CHARLIESONA MINE[1]	172.1	12.8	0.15	16.1	Pb 0.02 Ni 0.16 Cu 0.16	73.6	206.0	NIL	64.3	64.3
CHARLIESONA MINE[1]	135.6	9.2	0.1	14.1	Cu 0.28 Ni 0.32	29.4	N/A	N/A	N/A	N/A 78.3
B.O. 1336[1]	88.7	7.8	3.7	21.0	Cu 0.12 Pb 0.20	22.4				74.8
RIVERLEA[2]	181.2	24.8	0.62	25.5		23.2	171.5	10.9	75.6	86.5
INDARAMA MINE[1]	51.1	10.0	1.4	24.8	Cu 0.14	8.2	38.7	18.9	59.9	78.8
ROASTER CHARGE[3] BLENDED CONCS. TESTRUN 10-17 FEB. 1975	56.8	3.3	1.0	22.0	Cu 0.11	7.2	69.8	34.9	54.8	89.7
COMPOSITION OF ROASTER DISCHARGE	69.8	0.53	0.63	1.4						

* Anomalously high gold level in this residue.

1 100% Concentrate Feed

2 Blend 70.6% Concentrate, 29.4% Silica

3 Blend 33.5% Lion, 16.5% Cake, 16.5% Indarama, Silica 33.5%

FEED FOR ROASTER

Currently, about .twelve mines supply concentrates to the roaster. Relatively high tonnages of concentrate are shipped from the tailings retreatment plant at the old CAM & MOTOR mine at Eiffel Flats. Their concentrates are low in sulfur and relatively high in antimony with some arsenic.

Various concentrates are blended so that 'hot' roasting concentrates with high sulfide content are blended with those containing lower sulfur such as the CAM & MOTOR concentrate. Concentrate from the LION mine is said to be particularly 'hot'.

Samples of concentrate are tested at the Government Metallurgical Laboratories in Salisbury, who test the leach recovery anticipated for the concentrate when it is roasted in the EDWARDS roasters. Typical concentrate characteristics are shown in the table.

ROASTER CAPACITY

Roaster capacity according to CLEARY (1946), averaged 485 t per month per roaster, excluding 40-50 tons per month of fluedust that were recycled. The roasters were then operated to give a 12 hour residence time.

Currently, residence time is 7-8 hours and fluedust is treated separately in a smaller EDWARDS roaster, consequently one would expect capacity of the roasters to be slightly higher than it was in the 1946 description.

ROASTING PERFORMANCE

The data shown in the inserted table shows total recoveries of gold from roasted calcine ranging from 64-90%, which are not all that impressive.

It must be remembered, that these figures are the results of simulated laboratory scale tests of submitted feed, that are used to compute payment for concentrate and it is likely that they include some measure of conservatism.

The relatively low indicated recoveries probably also reflect the relatively high antimony levels in the concentrates treated as antimony is known to cause recovery problems.

It is unfortunately impossible to compare the performance of roasters by comparing recovery results unless all the compared roasters were treating the same concentrate.

Actual roaster recovery based on a test run on a blended feed from 10-17 February 1975, yielded an overall gold recovery of 89.7%, which is relatively good, but the concentrate blend appears to have also been relatively low in antimony.

PENALTIES

There are no penalties for arsenic or lead values. There is, however, a penalty for antimony on a sliding scale depending on both the gold content and the level of antimony in the ore.

For example, for a concentrate with 65 g Au/t and 3.0% Sb, the penalty is Z$ 4.94 per ton. For a 65 g Au/t concentrate, with 4.1% Sb, such as the cam and motor concentrate, the penalty is Z$ 13.55/t. Considering the deletorious effects of antimony on subsequent leaching, one cannot

[PLATE XXVI.

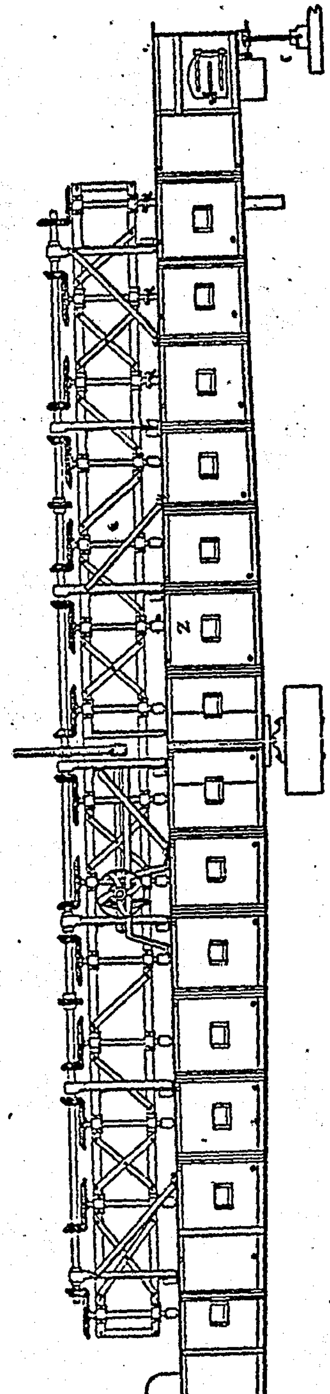


Fig. 172.—Elevation of Furnace, showing Driving Gear.

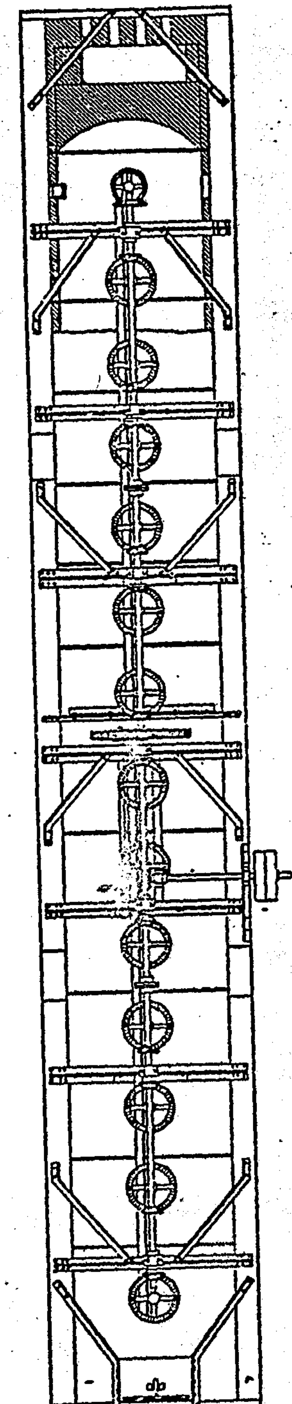


Fig. 173.—Plan of Furnace Part in section, showing Fireplace and Discharge Opening.

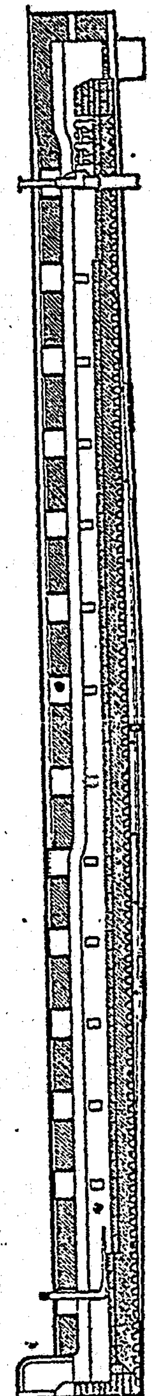


Fig. 174.—Section of Furnace, showing Water Jacket and Plain Rabble, Fireplace, Air-Holes, and Cast-Iron Rabble Boxes.

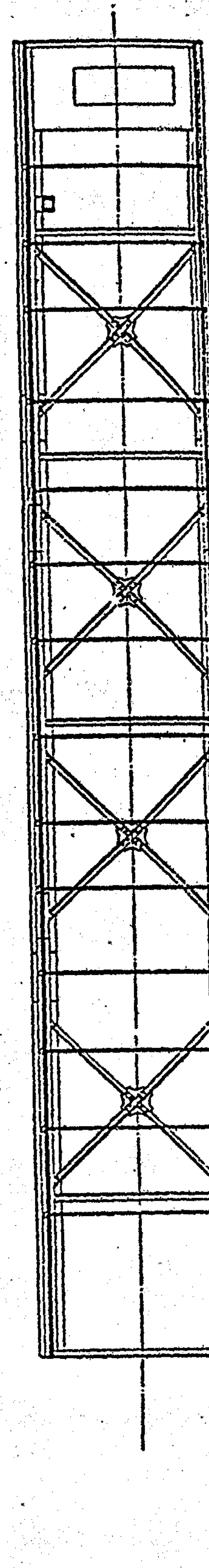


Fig. 175.—Plan of Bottom of Furnace, showing Bearing.

help wondering whether the antimony penalties reflect the higher price of gold that is being locked up by the antimony, or whether the scale was worked out at the old US$ 35/oz gold price.

There are penalties also for copper and cobalt in excess of 0.10% at the rate of Z$ 5.00 per unit in excess of 0.10%, and Z$ 2.00 per unit of nickel. If moisture exceeds 8%, a further penalty of Z$ 6.00 per dry ton is imposed.

TREATMENT CHARGE

A treatment charge of Z$ 40 per metric ton of concentrate is charged by the roaster.

SAMPLING & BLENDING

All concentrates are delivered to the roaster by road transport. On arrival the concentrate is shovelled by hand into wheelbarrows and weighed. Each wheelbarrow load, is sampled, which means that, 17-20 samples are drawn per ton of concentrate. The tare weight of each wheelbarrow is deducted from the scale weight. Samples are placed in a drum and mixed. Each concentrate is stockpiled separately in a large shed pending outcome of the sample assays.

Four samples from the sample drum are drawn. One is assayed by the roaster laboratory, one is assayed by the customer's laboratory and the third by a neutral laboratory. A fourth sample is kept in reserve.

Concentrate from the various stockpiles is blended to give 15-17% sulfur in the feed to the roaster. This has been found to result in a roast temperature of 650-700°C maximum.

In order to blend, nine barrowloads are dumped onto a conveyor - each barrow holds about 80 Kg of concentrate. The concentrate is loaded into a hopper which feed a blender-mixer followed by a hammermill, which breaks the lumps. The blended concentrate is stored in bins from which it is fed via a conveyor belt into the end of the EDWARDS roasters.

ROASTER FEEDING

The roasters are fed by a flat belt conveyor and chute as shown in the paper inserted at the end of this trip report.

ROASTING

The GOVERNMENT ROASTING PLANT employs two duplex EDWARDS roasters, each with 56 rabble arms. A diagram illustrating an earlier model EDWARDS roaster with 13 rabble arms of a simplex design, is included to give a general idea of the principles of design of an EDWARDS roaster. In the duplex design there are two parallel rows of rabbles both rotating in opposite directions to advance the calcine. More details are included at the end of this trip report.

CONCENTRATE RESIDENCE TIME

Residence time at KWE KWE is now 7-8 hours for the whole roasting process. It is noted that earlier operations averaged 12 hours travel time in the hearth.

WORKING ENVIRONMENT

A slow speed fan draws fume from the roaster which maintains a slight negative pressure in the roaster and draws off the volatiles. This keeps

Temperature is gauged by examining the color of the hot calcine which is a dull cherry red at the correct operating temperature. Roaster operators claim that they can gauge the 'right' temperature quite readily by the color. It is noted that in earlier operations, temperature was recorded by a 2-leg pyrometer in each furnace with automatic CAMBRIDGE recorders.

In this case, the temperature has been measured in the hottest zone at 650-700°C maximum. The temperature drops off steadily from this point to both the feed and discharge ends of the roasters.

The air supply to the roaster bed is regulated to create four distinct roasting zones.

Zone 1: Closed Air Ports. Concentrate is heated slowly by radiation from the center of the roaster. Arsenic volatilizes as concentrate advances from the feed port to the combustion zone.

Zone 2: Sulfide Combustion. Air supply is permitted at a controlled rate to allow the sulfur to burn. Temperature is allowed to reach 650-700°C in this zone.

Zone 3: Cooling. The air ports are now fully open. Most of the sulfur has already burnt, so there is no runaway combustion.

Zone 4: Discharge Zone. Calcines are rabbled into a cast iron chute from which they are moved by a rake into a tank. During the rake discharge, they are sprayed with water to quench and transferred as a slurry to a tank. The Calcine slurry is screened over a sievebend en route to the ball mill.

CALCINE DISCHARGE

Calcine is advanced through the roasters by a series of rotating rabbles driven by an overhead cam. Beneath the last rabble, there is a cast iron chute in the hearth floor which is wet at the bottom, into which the calcine drops at the discharge end of the roaster. Calcine is removed from the wet trench by a reciprocating rake conveyor which drags out the wet calcine. Dusting is further controlled by water sprays installed inside the trench, so that by the time the calcine leaves the trench it is in the form of a quenched slurry.

The wet calcine slurry passes through a coarse static screen to remove any grossly oversize particles and pumped to the milling circuit from a sump. The system is old fashioned but simple.

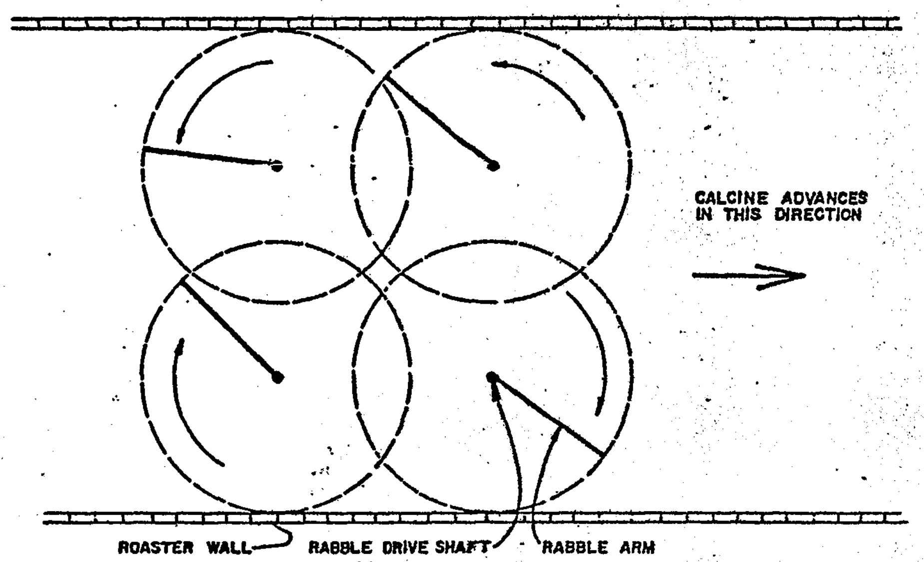
the working environment around this EDWARDS roaster much more pleasant than was observed at any other EDWARDS roaster that was visited.

ROASTER FIRING

Contrary to the practise at other EDWARDS roaster operations, including those that treat concentrates that are much higher in sulfide content, the KWE KWE roaster now burns autogenously with no added fuel.

It is noted, that during earlier years, the fireboxes used to be fueled by wood for the whole operation and plans were to modigy fireboxes for coal firing.

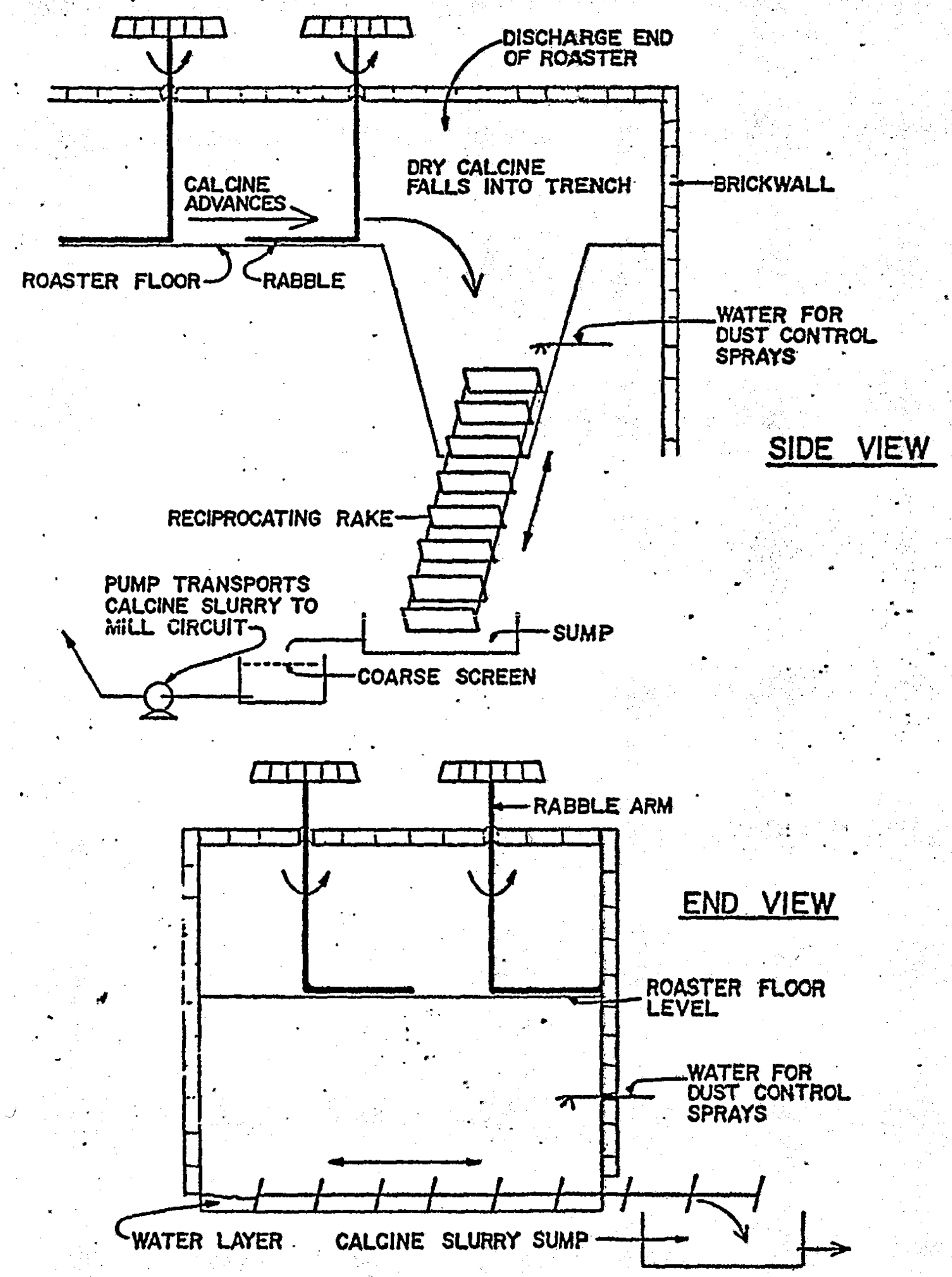
DUPLEX EDWARDS ROASTER
(PLAN VIEW)



ROASTER TEMPERATURE

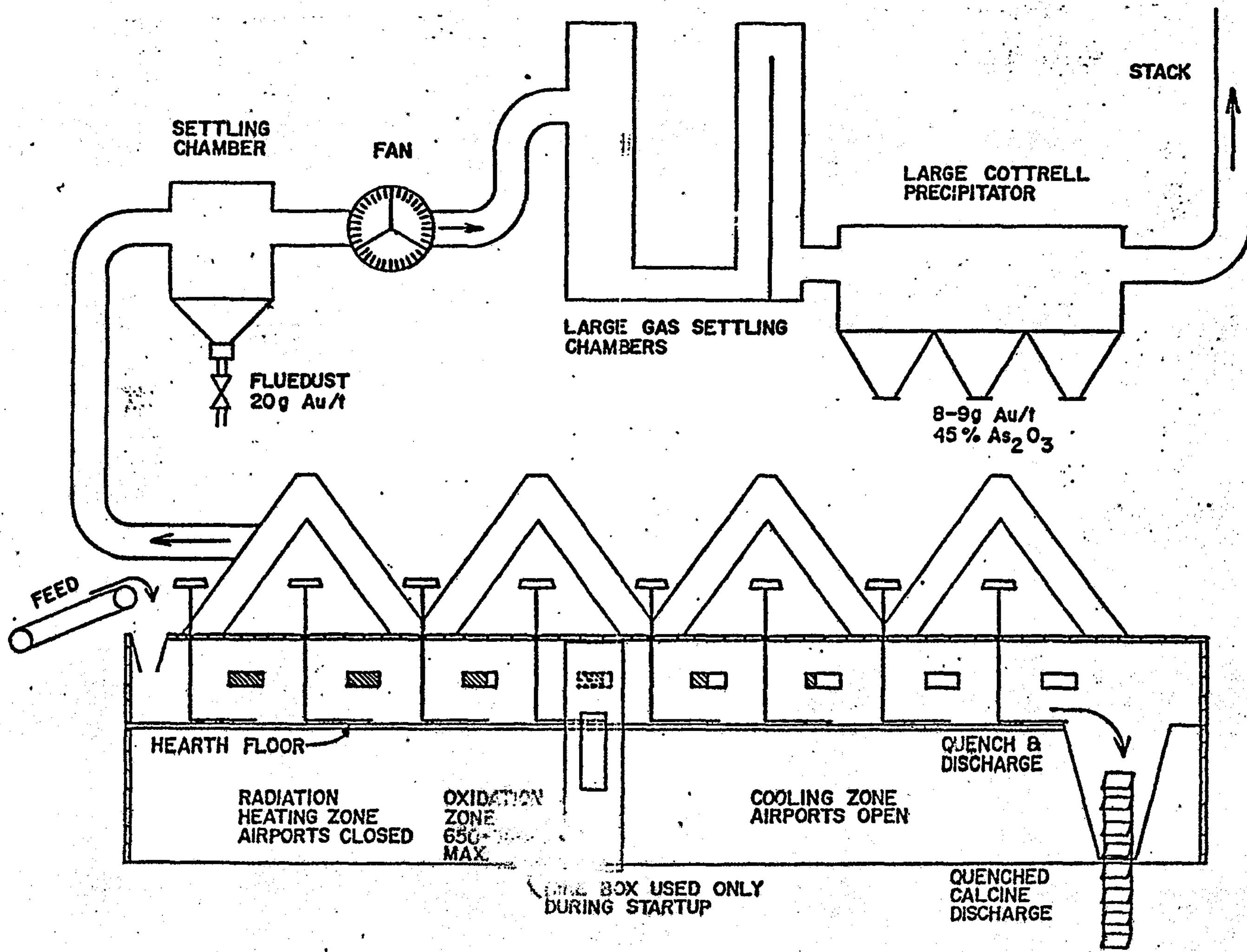
Roaster temperatures are controlled by the sulfur content in the blended feed and regulation of the air supply in the sulfide combustion zone of the roaster. This is achieved by adjusting the air ports along the sides of the roasters.

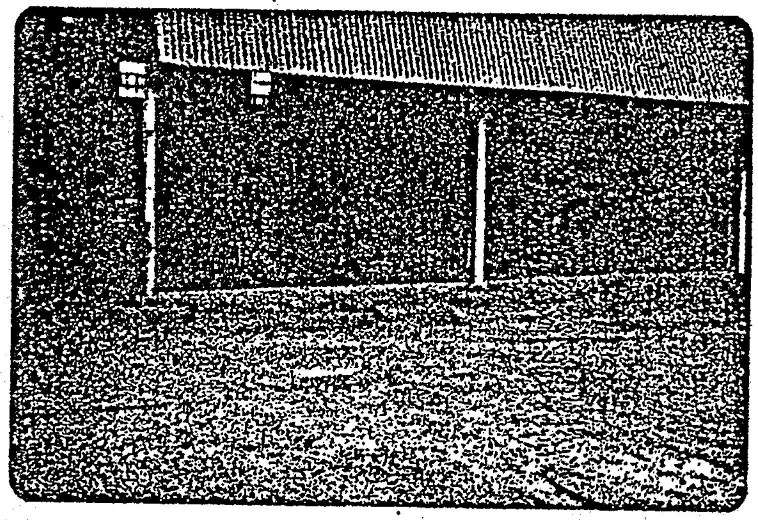
CALCINE DISCHARGE FROM EDWARDS ROASTER



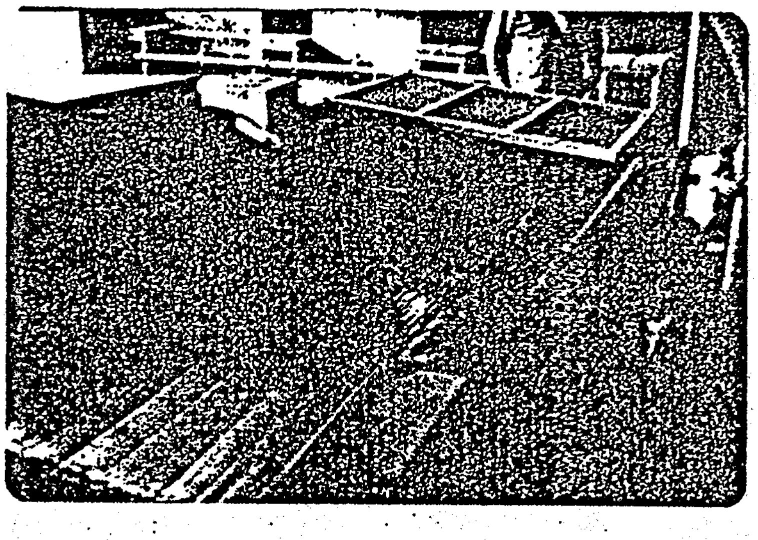
GOVERNMENT ROASTING PLANT

(KWE KWE, ZIMBABWE)





EDWARDS ROASTER AT KWE KWE



GALLAGHER BELT CONCENTRATOR AT KWE KWE

FLUE DUST

Fumes are drawn off the roaster through the roof via zig-zag ductwork as shown in the diagram. The reason for the zig-zag configuration is to prevent the buildup of large particles on the floor of the duct. Should fume accumulate on the ductwork, it will in time, slide back down the sloping duct into the furnace.

Most of the arsenic fume volatilises in the first stage of the furnace which is cooler and at the end of the ductwork that is closest to the gas cleanup train.

The KWE KWE roaster employs a more sophisticated gas cleanup system than any other EDWARDS roaster currently in operation. It includes a settling chamber to collect larger particles, two large settling chambers in series, a LODGE COTTRELL electrostatic precipitator and a stack.

Flue dust collected in the first settling chamber runs 20 g Au/t on the average. Further down, the gastrain particles collected in the LODGE COTTRELL precipitator run 8-9 g Au/t, but this dust is also high in arsenic and is used as feed for the secondary arsenic treatment plant.

Arsenic is recovered as quantitatively as possible from the roaster exhaust, nonetheless, only about 80% is accounted for. No attempt is made to recover the SO_2 which is allowed to escape up the stack. The roaster is located in a peri-urban area, yet no adverse environmental affects resulting from the gas emmissions were obvious in the area.

GOLD RECOVERY FROM CALCINES

The present calcine treatment plant is shown in the flowsheet illustration inserted below and is described in the paper by T.S. Cleary. However, there have been several changes since Mr. Cleary's 1946 description.

Main changes include the installation of a sievebend to classify the calcine ahead of the grinding and gravity circuit. Another change is the insertion of gravity recovery after the oversize has been ground, and the insertion of cyclones in the grinding circuit to replace the older rake classifier. Another change has been the insertion of a GALLAGHER table as the primary gravity concentrating device.

Two conditioning tanks have been inserted after the water washing thickeners to adjust pH by lime addition ahead of cyanidation.

A drum filter has been inserted to recover solution from the thickened CCD tailings. This solution is returned to the No. 2 CCD thickener and is bound to contain gold values that in the old circuit were discharged to the tailings dam.

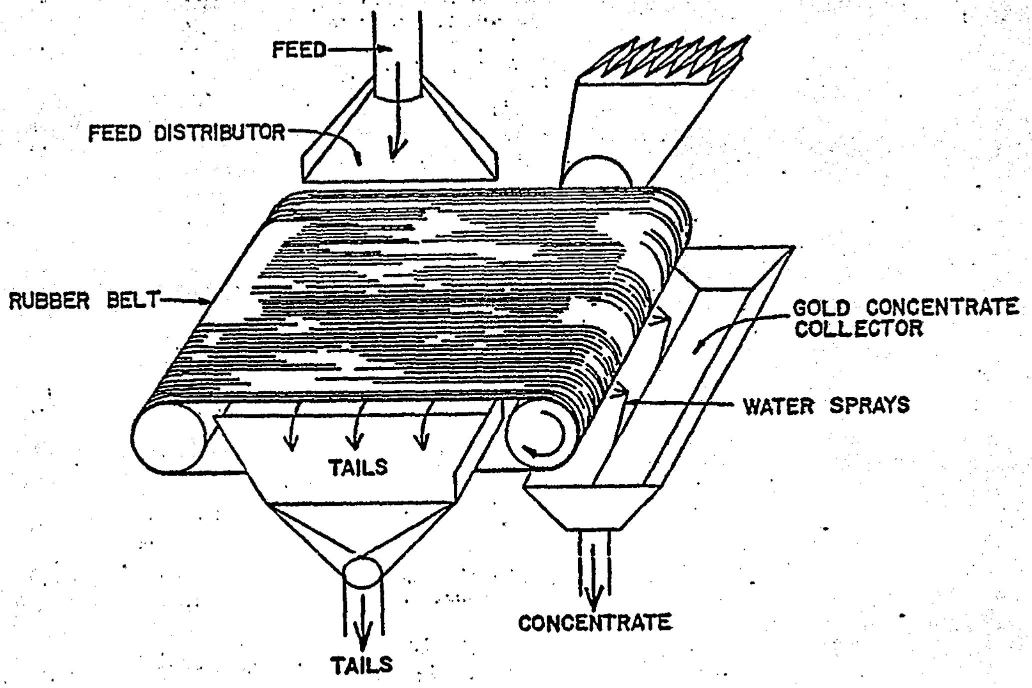
Several observations of possible interest were made at the calcine treatment plant:-

1. **GALLAGHER BELT**

   The GALLAGHER belt uses a travelling rubber belt to concentrate gold in the riffles. The belt material is identical to that used on riffle belt concentrators in South Africas and on the WARMAN riffle belt concentrator in Australia, and also as is used to line plane tables. The rubber riffles, about 0.25 inches deep, are not symmetrical.

The main difference between the GALLAGHER belt and the riffle belt is that the belt is moved acros the flow of feed pulp rather than against it.

GALLAGHER BELT



The GALLAGHER belt is a simple device that is said to have been developed in Rhodesia and was also not encountered elsewhere.

2. After roasting, the calcines frequently also contain water soluble base metals which would interfere with subsequent cyanidation. Accordingly, they are water washed in two thickeners arranged in series to wash counter currently.

Calcine is pumped from the cyclone overflows in the grinding circuit to the first of the two 20'Ø x 7' washing thickeners. According to Cleary (1946), and it is unlikely much has changed since then, except possibly as a result of the reduced roaster residence time, sulfide content in the calcine after roasting should be below 2% and the $SO_4^{=}$ level in the liquid phase would typically be 10-20 g/l.

The washing thickeners measure 20'Ø x 7' and are constructed of concrete. Rake speed is 0.2 rpm powered by 3 HP motors. Underflow of each unit is at 50-55% solids. About 50% of the washwater is discharged to waste, and it assays from trace to 0.03 g Au/t.

Whenever base metals are associated with sulfide concentrates roaster feed, this calcine washing step is a must.

3. PRE-AERATION

Prior to leaching and after water washing, the calcines are pre-aerated in two stages also arranged in series. Lime is added to maintain an excess of 0.004% CaO. The purpose of this step is to be sure to oxidise any ferrous iron to ferric. Ferrous ions consume cyanide and oxygen during the subsequent cyanidation step and would interfere with gold leaching efficiency. Another advantage of pre-aeration is that it provides some additional opportunity to oxidise any soluble sulfides to sulfates, thereby eliminating any addtional interfering species. This step allows pH to be adjusted by lime addition to yield a uniform pulp, which avoids localized areas in the pulp of either very high or very low pH which can interfere with leaching as well. It is believed that pulp density is reduced from 50% solids to around 33-1/3% solids in this stage.

4. CYANIDE LEACHING

Gold is leached in four 10'Ø x 10' DENVER downdraft tube mechanical agitators. Cyanide strength is maintained at 0.12% NaCN and CaO at 0.02%.

The downdraft tubes extend upwards to just below the surface of the pulp and as pulp is drawn down, a vortex forms that drags air down with the pulp. The effectiveness of the aeration that results is very clear judging by the larger number of well dispersed air bubbles that rise back up through the pulp across the whole surface of the agitators.

The units currently in use appear to be the same as those described by Cleary (1946), which were equipped with 7½ HP motors. Approximate residence time in the leaching step is 16 hours.

The best estimates of cyanide and lime consumption are those given by Cleary (1946), at 5-6 lbs. NaCN per ton and 15-20 lbs. lime per ton.

Cleary (1946), observed that steel impellers require replacing after 5000 tons treatment. Their life appears to be extendable by at least 2½ times if the impellers are coated with rubber.

5. SOLID/LIQUID SEPARATION

Leached pulp at 30% solids, is fed to the first of four 28'Ø DENVER standard lowhead CCD thickeners in concrete tanks. Thickener underflow is advanced at 50% solids.

Clearly, at recent gold prices, a four-stage dilution wash would be inadequate. Consequently, the addition of a 6' x 6' drum filter for an additional separation stage is commendable. It was not noted whether the drum filter cake is washed or not. The filter must have been installed shortly after Cleary's (1946) paper, as it appears to be of a very old design, although still in good operating condition.

6. SOLUTION METERING & RECORDING

Of particular interest is the method used for recording the volume of pregnant solution advancing from the CCD tanks to clarification and zinc precipitation. The unit installed is a LEA MASS recorder, which consists of a V-notch weir fitted with a float to monitor the level which is in turn connected to a cam which drives a disc connected to an odometer in such a way, that the volume passing the weir is calibrated to the number registering on the odometer.

7. When antimony is present in the concentrate feed, this can readily be detected by the presence of a gunmetal grey colored scum that floats on the surface of pulps in the conditioning and cyanide leaching agitators.

8. Large amounts of residues from the secondary arsenic plant running 27-30 g Au/t and around 9% as have been accumulated in a stockpile at the plant.

9. There are also very large amounts of accumulated flue dusts running around 9 g Au/t and much higher in As.

10. The stack has been in operation for about 30 years. It is constructed from concrete with an inner surface about 1" thick of expanded metal reinforced cement. A section of this was recently drilled to test its condition. It was found to be in perfect condition, indicating that the SO_2 rich roaster gases do not appear to attack cement.

SECONDARY ARSENIC PRODUCTION

About 70-80% of all the arsenic in the feed is collected as flue dust with an arsenic level of about 45% As_2O_3. About 80 tpm of this flue dust is collected.

The flue dust produced from current operations, together with that from the accumulated stockpile, is fed to a separate small EDWARDS roaster which is completely sealed, i.e. all the air ports are closed. This roaster is maintained at 250°C and diesel fired.

The As_2O_3 volatilises and is condensed in a condensing tower from which it drops into a bin as a saleable product with 96-97% As_2O_3 purity. About 16-22 tpm is produced.

The residue from the secondary arsenic roaster contains 28-32 g Au/t and about 9% As_2O_3 and is currently being stockpiled for future treatment.

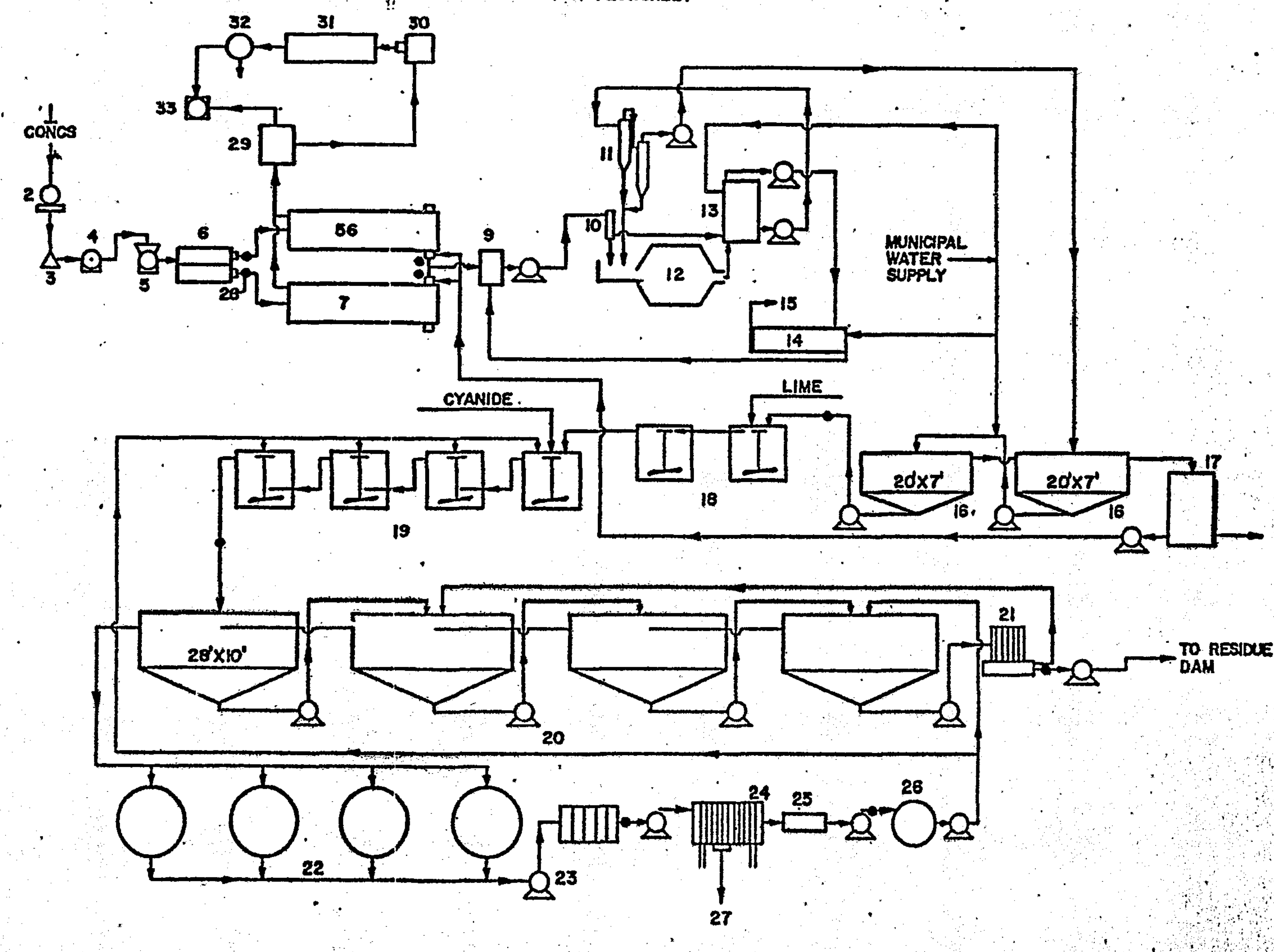
The arsenic product is sold locally to a company called RODIA (PTY) LTD. in Harare (Salisbury). Some is exported to the U.S.A.

The secondary arsenic treatment plant appears to be both simple from an equipment standpoint and easy to operate. More complete details would be available from the plant manager.

GOVERNMENT ROASTER PLANT

KWE KWE, ZIMBABWE

1981 FLOWSHEET



1 CONC. RECEIPTS
2 WEIGHING & SAMPLE
3 STOCKPILE
4 MIXER
5 HAMMER MILL
6 BINS & FEEDERS
7 EDWARDS ROASTERS
8 PUSH CONVEYORS
9 SUMP
10 SIEVE BEND
11 CYCLONES
12 3' x 4' BALL MILL
13 GALLAGHER TABLE
14 JAMES TABLE
15 AMALGAMATION
16 WATER THICKENERS
17 W. TICKENER OVERFLOW TANK
18 PH CONDITIONERS
19 WALLACE AGITATORS
20 COUNTER CURRENT THICKENERS
21 DRUM FILTER
22 SAND CLARIFIERS
23 LEAF CLARIFIER
24 FILTER PRESS
25 TONNAGE RECORDER
26 BARREN SOLN. TANK
27 CLEANUP & SMELT
28 SAMPLE POINTS
29 LODGE COTTRELL
30 BIN & FEEDER
31 ROASTER
32 CONDENSER
33 STACK
34 As_2O_3 PRODUCT