6252.

De Beers Consolidated Mines, Limited. Jagersfontein Mine.

DE BEERS CONSOLIDATED MINES, LIMITED.

JAGERSFONTEIN MINE

HISTORY.

Jagersfontein Mine (see Plan 1) was proclaimed in 1871 and for several years many companies, groups and individuals mined side by side on their various claims. The New Jagersfontein Mining and Exploration Company was formed in 1887, and by 1891 had acquired virtually the whole mine. Due to the depression the Mine closed down in 1932; it was leased by De Beers Consolidated Mines, Ltd., in 1940, was opened in 1947 and has since re-opening been managed by De Beers.

Sinking the main shaft started in 1904 but the first skip was hoisted only in February, 1911, after many delays ranging from underground water, to a world diamond slump. Underground mining using the chambering method started at this time but open pit working continued as well, the ground from the open pit being tipped down an orepass to the 900' level and hoisted up the shaft. Open pit mining ceased altogether in 1913.

Until the close-down in 1932 ground was treated in several small washing plants spread out over the property. The later ones had crushers but the earlier ones were for washing only, the breaking down of ground being done on the "floors" system; ground from the Mine was laid out on the veld for several months, where the natural weathering processes, assisted by watering and ploughing, caused it to pulverise. The early washing plants were therefore placed close to areas of flat veld suitable for floors, and close to koppies, up which a skip haulage could be laid for tailings disposal.

At the time of re-opening a new plant was built, this included a primary crushing plant, and secondary crushing by means of rolls. Jagersfontein is essentially a low grade mine and, in common with many other diamond mines, the grade decreases with depth. Varying between 10 and 12 carats per 100 loads (1 load - 16 cu. ft. or approx. 1600 lbs) until 1913, the grade fell steadily to 7 at the time of close-down in 1932, and since the re-opening has varied from 3 to 6½ carats per 100 loads.

Also characteristic of Jagersfontein is the occurrence of occasional blue-white gems of exceptionally good quality; the most outstanding of these was the

972 carat "Excelsior", found in 1893. It is these alone which make it possible to mine this low-grade Kimberlite economically - revenue per load is by no means a linear function of grade.

The concentration ratio varies from 50 to 100 million to 1.

<u>DESCRIPTION OF OREBODY</u>.

The orebody is a near vertical Kimberlite pipe 1420' x 1010' on surface narrowing to a fissure 270' wide at a depth of 2500' which will be the ultimate mining limit.

Kimberlite is a volcanic ultra-basic rock in which olivine has been almost entirely altered to serpentine. The more important diagnostic minerals are garnet, ilmenite, chromediopside and mica. These are usually present in minute quantities but are rarely absent.

Normal Kimberlite (blue ground) is grey, grey green or grey-blue in colour and characteristic of it are inclusions, sometimes enormous boulders or dolerite or other igneous rocks.

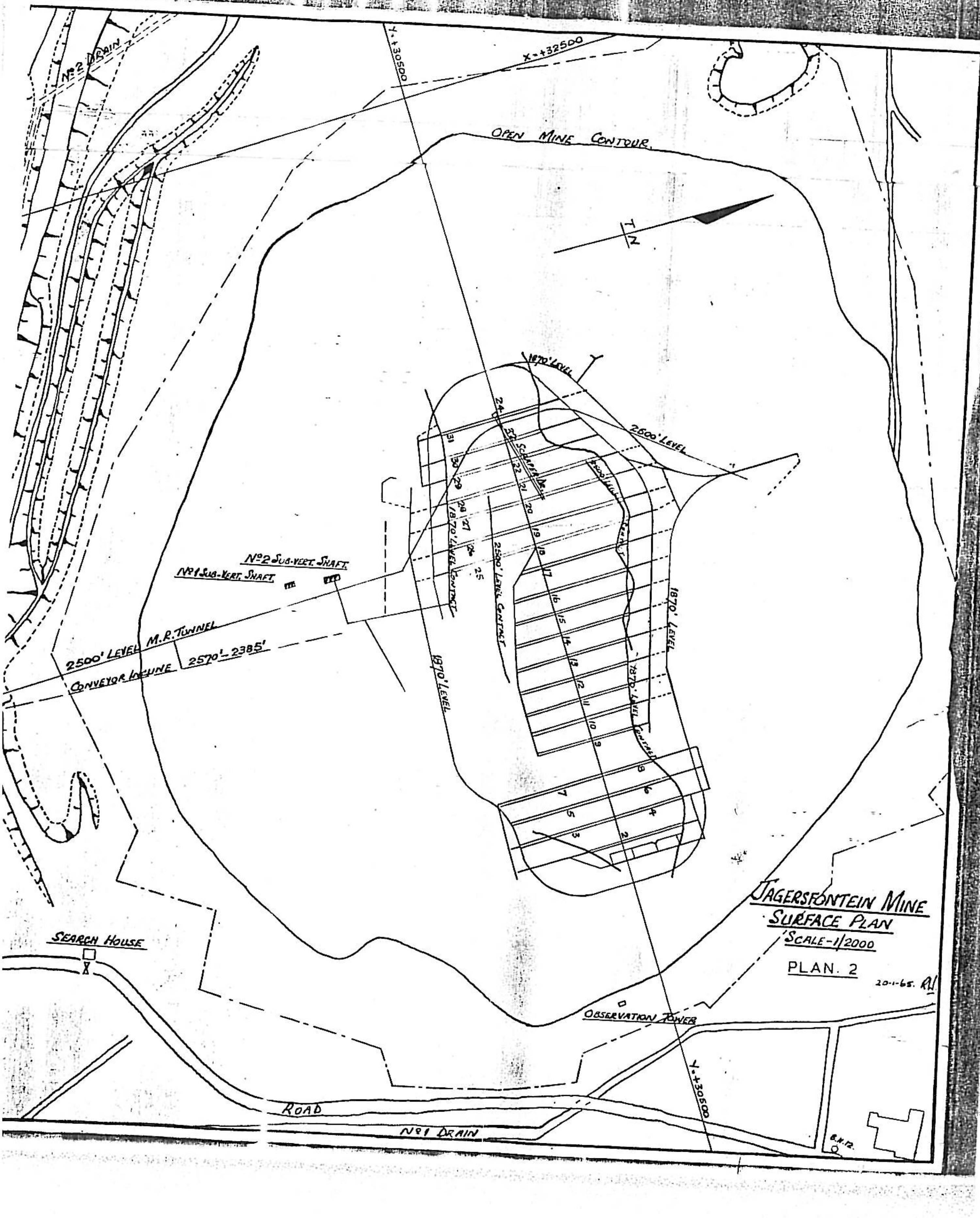
In all exploited diamondiferous pipes there is evidence of several Kimberlite intrusions giving rise to varying diamond contents over a cross-section of the mine. At Jagersfontein, one of these intrusions of particularly low-grade Kimberlite, locally known as "grey" ground, occupies a large portion of the Southern section of the pipe to the 2500' level from where it veres away to the east. Whenever possible "grey" ground is excluded from the mining limits but due to its friable nature it is in fact impossible to ensure that caving of this ground is entirely eliminated.

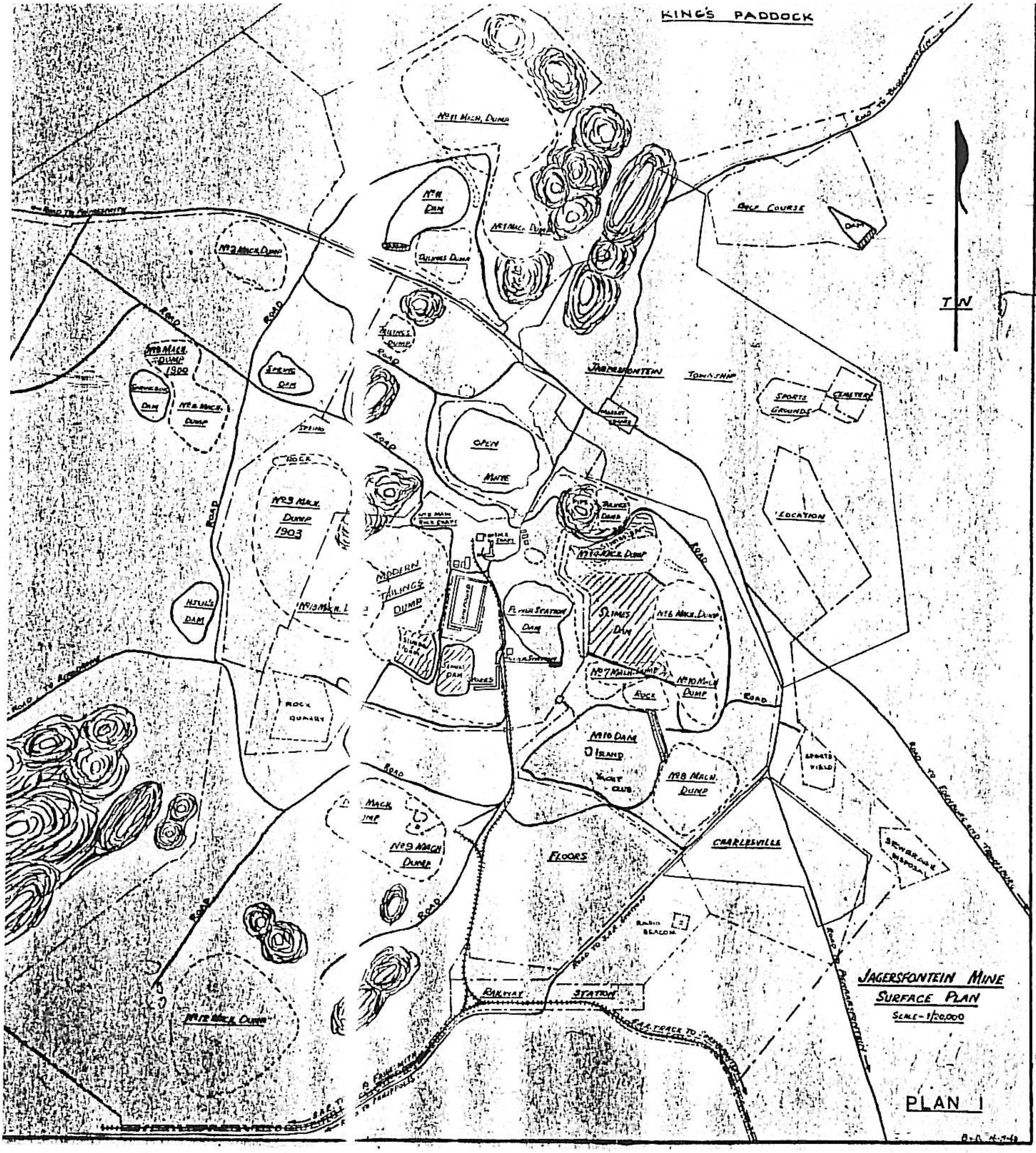
The country rock at Jagersfontein is Beaufort shale of the upper Karroo system containing numerous dolerite sills, varying in frequency and thickness through the depth of the Mine, being predominantly shale in the lower levels and dolerite above the 1000' level.

A borehole drilled from the 1950' level indicates the granites of the basement complex at 3362' below surface or 1238' above sea level.

<u>LAYOUT OF MINE</u> (See Plans 2 & 3)

Mining operations have lowered the overburden to approximately 1000' below surface at its lowest point, and this loose overburden lies at its angle of repose so that it meets the side of the pipe at from 700' to 900' below surface. The overburden consists mainly of ground which has fallen in from the rock walls of the pipe and at present dimensions of the "big hole" on surface are 1640' x 1500'. About one million tons fall in annually and the nett drop in the


No 2 DRAIN
Y = +30500
X = +32500
OPEN MINE CONTOUR
T.N.
1870' LEVEL
2600' LEVEL
SCRAPER DR.
No 2 SUB-VERT. SHAFT
No 1 SUB-VERT. SHAFT
2500' LEVEL M.R. TUNNEL
CONVEYOR INCLINE
2570' - 2385'
1870' LEVEL CONTACT
2500' LEVEL CONTACT
1870' LEVEL
JAGERSFONTEIN MINE
SURFACE PLAN
SCALE - 1/2000
PLAN. 2
20-1-65.
SEARCH HOUSE
OBSERVATION TOWER
ROAD
No 1 DRAIN
Y = +30500
B.M.12.


KING'S PADDOCK
No 11 MACH. DUMP
No 11 DAM
No 1 MACH. DUMP
TAILINGS DUMP
No 2 MACH. DUMP
GOLF COURSE
DAM
T N
ROAD
TAILINGS DUMP
No 8 MACH. DUMP 1900
SPRING DAM
No 4 MACH. DUMP
JAGERSFONTEIN
TOWNSHIP
SPORTS GROUNDS
CEMETERY
OPEN MINE
ROCK
No 3 MACH. DUMP 1903
LOCATION
MODERN TAILINGS DUMP
No 13 MACH. DUMP
SLIMES DAM
No 6 MACH. DUMP
FLOTATION DAM
No 7 MACH. DUMP
No 10 MACH. DUMP
ROCK QUARRY
No 10 DAM
ISLAND
YACHT CLUB
No 8 MACH. DUMP
SPORTS FIELD
No 9 MACH. DUMP
FLOORS
CHARLESVILLE
SEWERAGE DISPOSAL
RADIO BEACON
RAILWAY STATION
No 12 MACH. DUMP
JAGERSFONTEIN MINE
SURFACE PLAN
SCALE - 1/20,000
PLAN 1

open mine is consequently only 20' per year.

No. 1 Main Rock Shaft is roughly 1200' from the pipe and there are cross-cuts to the pipe on the 900', 1350', 1950', 2500' levels and an incline from 2385' to 2570' level. No. 2 Main Rock shaft serves as a second outlet and a return air shaft.

The first Block Cave installation at Jagersfontein Mine was developed on the 1870' level, and produced successfully until May 1968. The main features of the level were 32 concrete lined scraper drifts, a diesel loco haulage in the wall rock, an underground crusher, storage passes, conveyor system and surge bin. Hoisting was from the 1980' lever station and production averaged from 162,000 loads to 171,000 loads.

The second Block Cave installation (see Plan 3) was developed on the 2500' level and consisted initially of eight double ended scraper drifts, supported with T.H. yielding arches, a diesel loco haulage, an underground crusher, conveyor system and a loading station on the 2470' level. The ninth drift was developed during 1968/69 in a central pillar which was left intact originally to act as an abutment during the initial caving period, and is concrete lined.

Production commenced in May 1965, and very soon it became apparent that the yielding arches could not stand the strain and would have to be replaced with concrete. As an indication 54% of the drifts had been lost by December 1967. Replacing with concrete during production has continued steadily and to date all of the drifts are concrete lined. Production is at the rate of 118,000 loads per month.

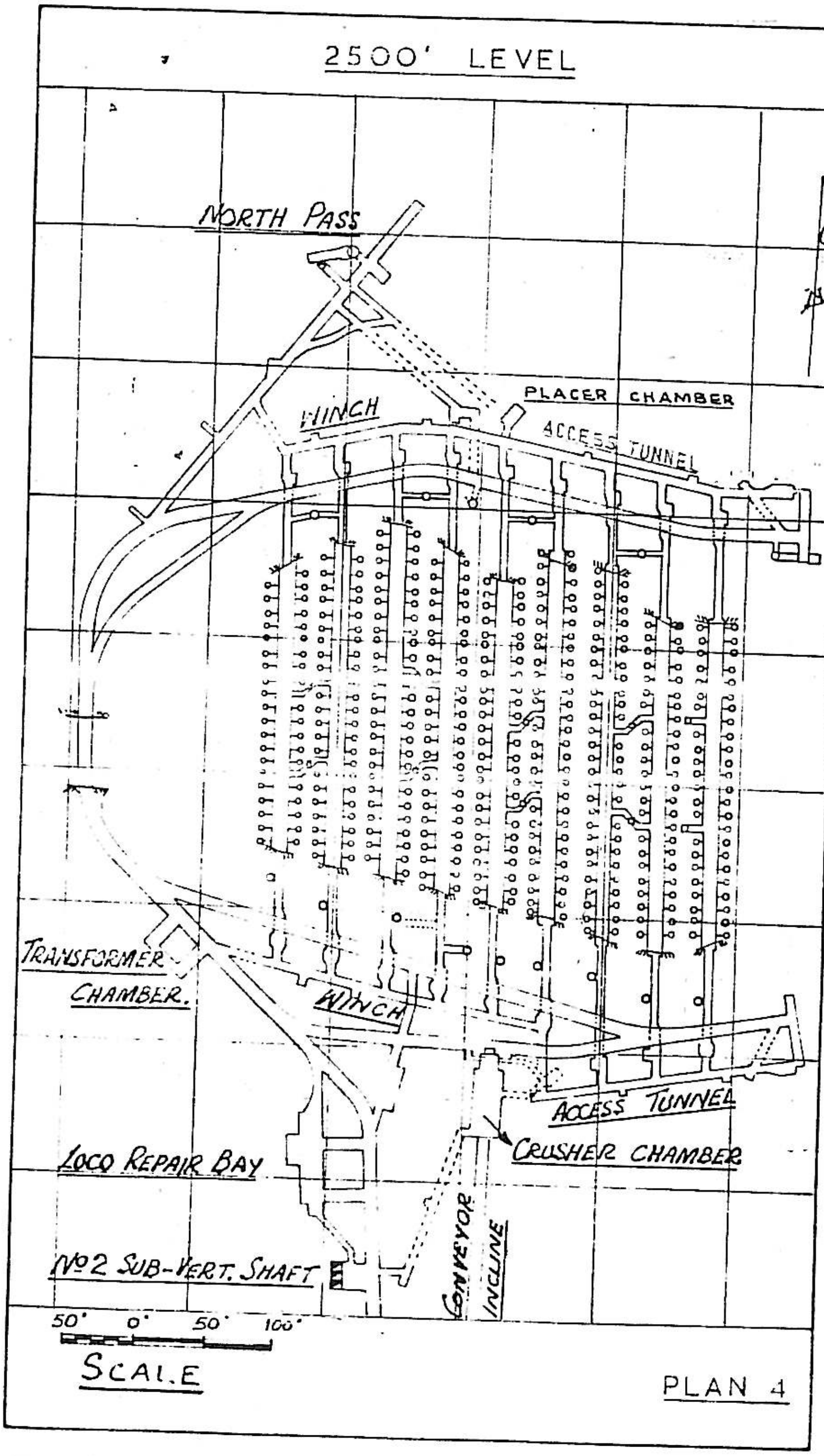
VENTILATION.

The mine is ventilated via the No. 1 Main Rock Shaft to all sub vertical shafts, stepways and necessary levels, upcasting from the 2500' level through the North, No. 3 and No. 5 passes to the main fan on the 1200' level. The fan exhausts 135,000 c.f.m. at 2½" water guage via the open mine on 720' level and No. 2 Main Rock Shaft.

UNDERGROUND WATER.

For the size of the mine the quantity of water pumped is high (14 million gallons per month). The water is pumped from 2530' and 1980' levels to the 1380' level and thence to surface.

Details of the three pumping stations are as follows:-


2500' LEVEL
NORTH PASS
PLACER CHAMBER
WINCH
ACCESS TUNNEL
TRANSFORMER CHAMBER.
WINCH
ACCESS TUNNEL
CRUSHER CHAMBER
LOCO REPAIR BAY
Nº2 SUB-VERT. SHAFT
CONVEYOR INCLINE
50' 0' 50' 100'
SCALE
PLAN 4

(a) 1380' level: 2 Pulsometer pumps, 17 stage 300 H.P. 2000 volts and delivering 20,000 gallons per hour each. 1 Sulzer pump, 7 stage, 280 H.P. 2200 volts and delivering 18,000 gallons per hr. Sump capacities are one settler of 88,000 gallons and two main sumps of 120,000 and 130,000 gallons.

(b) 1980' level: 2 Sulzer pumps, 6 stage, 110 H.P. 2000 volts, each delivering 15,000 gallons per hour. Sump capacities are two of 200,000 gallons each.

(c) 2500' level: 2 Sulzer Pumps, 7 stage, 275 H.P., 2200 volts, each delivering 30,000 gallons per hr. Sump capacities are one settler of negligible capacity and two main sumps with a combined capacity of 400,000 gallons.

TREATMENT PLANT.

Introduction.

Diamond recovery is a sphere of its own and the procedure is quite distinct from the recovery of any other mineral. Firstly the ratio of concentration required is fantastically high, approximately 20 million to 1, Jagersfontein's present concentration ratio is 88 million to 1. (Gold at 10 dwts/ton would require a concentration ration of only 1 in 48 thousand). Secondly, in diamond recovery the end-product must be recovered intact and undamaged, as distinct from most metallurgical operations, and thirdly, it is essential that the percentage recovery be as high as possible, as the loss incurred could be financially of a high order, as the value of individual stones is dependent on several factors, such as size, shape, colour and absence of flaws.

1 Metric carat is 0.2 grams.

BRIEF DESCRIPTION OF THE VARIOUS SECTIONS OF THE PLANT.

Crushing Plant. (For current practice see attached flow sheet Fig 1.)

The Crushing Plant is adjacent to the mine headgear and handles all the ground hoisted, 375 loads per hour plus 25 loads per hour from stockpiled ground and ground for re-treatment from old dumps. (1 load = 16 cu. ft. approx. 1600 lbs).

Waste rock is removed by hand sorting and the remaining blue ground is reduced from minus 6 inches to 1-1/4 inches by means of Primary and Secondary crushing and screening.

Washing Plant. (See attached flow sheet Fig. 2)

From the crushing plant the ground is conveyed to the storage bins of the washing plant where it is distributed equally to the 10 sections of the plant by vibrator feeders at 75 loads per hour per section, 9 sections only being run.

The Rotary Washing Pan.

As this forms the basis of primary concentration it will be described in greater detail.

Construction.

The washing pan is an annular-shaped vessel formed by two concentric walls constructed of steel plate. The outer wall is 14 ft. in diameter and 20 in. high and the inner wall is 6 ft. in diameter and 12 in. high. Between these walls the annular space has a flat cast iron bottom with renewable chilled cast iron liner plates. A sliding door fitted in this bottom, permits the complete cleaning of the pan when required.

Operation.

The relatively high specific gravity of the diamond (3.5) together with the comparatively small quantities of other heavy minerals, such as ilmenite (4.5), garnet, diopside, etc., permits of a relatively easy separation from the low density gangue minerals by means of these rotary pans.

The feed is continuously introduced tangentially to the outer circumference of the pan. The launder by which the ground and puddle enter is inclined to give the feed a velocity approximately the same as the revolving mass in the pan.

The stirring action of the rakes keeps the mass in a state of semi-suspension, allowing the heavier minerals to settle and the lighter minerals to float and escape over the inner weir. When a pan is washing at the rate of 40 loads per hour the discharge tailings run about 1½ inches high over the outlet weir. At the outer circumference the level is some 4 inches higher. The specific gravity of the mass in the pan (approximately 1.5 to 1.6) is controlled by the regulation of make-up water until the required electrical loading is obtained.

The rotary motion imparted to the contents of the pan, together with the hydraulic gradient due to the incoming feed, cause the contents to take up a spiral path from inlet to outlet. The speed of rotation of the mass is about half that of the pan teeth and this speed decreases rapidly downwards due to the friction drag against the pan bottom. As the density of the mass increases towards the bottom the outward thrust of the pan teeth becomes more effective thus forcing the concentrates to the outer circumference of the pan.

Extraction of Concentrates.

Concentrates in kimberlite of specific gravity approaching and exceeding that of the diamond only constitute 0.25 per cent of the ore. However with a valuable product, such as the diamond, a high factor of safety is allowed. A primary concentrate of 2 per cent of the original feed is obtained, heavy media separation and grease tables being used for the final concentration.

Primary concentration is done in three stages. Ore fed to the primary or coarse pan is unsized below 1¼". Prior to entering the pans the ground is mixed with puddle (a viscous mixture of water and kimberlite at a S.G. of 1.430)

The lighter constituents of the feed overflowing the weir of the inner periphery, pass over 3/8" x 1 1/8" long slot screens. The oversize from these screens passes through rolls set at 3/8" and rejoins the screen undersize which in turn constitutes the feed to the secondary pans. At this stage "make-up" water is added for pan control.

The overflow from the secondary pans passes over 7 mesh screens. The 7 mesh constitutes the tailings while the -7 mesh is pumped through hydrocyclone classifiers. The cyclone underflows are fed to the tertiary pans for the final stage of primary concentration. The overflow of the cyclones returns as puddle and recirculates through the plant.

Disposal of Tailings.

As in all concentrating plants, the disposal of tailings constitutes a problem, here especially as the tailings contain up to 13 per cent moisture. All tailings, - 3/8" +.095 inches, are conveyed to the tailings dump for disposal by flingers which are short centre, high speed conveyors travelling at 2,400 ft. per minute. These flingers deposit the tailings a distance of 40 ft. away in the desired direction.

Excess puddle is pumped to slimes dam, and constitutes 12 - 15% of the head feed to the Washing Plant.

Recovery Plant (See attached flow sheet Fig. 3)

In the production of diamonds, recovery, which is the final concentration of the ore following the initial concentration by crushing and washing, has always been kept in a separate department. This has been mainly for security reasons as the very high concentration effected in the washing process gives a rich concentrate with visible values, requiring treatment under careful security control.

The 2% concentrate from the Washing Plant is screened over 7 mesh, with the -7 mesh reporting, via cyclones, to the recovery plant fine tables. All -28 mesh is discarded.

The +7 mesh is conveyed to the Heavy media separation plant where current practice reduces this +7 mesh concentrate to a 6.5% sink concentrate.

The 5' diameter cone is charged with a mixture of "knapsack" cyclone grade ferrosilicon (85% iron, 15% silicon) and water, and operated at 3.03 density top, and 3.22 density bottom. Control of medium density in the cone is by increasing or decreasing the amount of ferrosilicon delivered from the densifier.

The density is checked half-hourly by taking S.G. readings from top and bottom of the cone. Viscosity tests are done daily.

The sink product, +0.6 loads per hour, is fed to the grease tables and belts for final recovery.

Diamonds which occur in kimberlite are peculiar in that their surfaces are not wetted when they come into contact with water. Water is used in all stages of diamond recovery, both as a medium of conveyance and as a cleansing agent. If a diamondiferous concentrate of this type is fed to an inclined grease surface over which flows a stream of water, the diamonds adhere to the grease, and the associated minerals are washed away.

In the final process of diamond recovery, grease is applied to the upper surface of the deck or table which is inclined a few degrees from the horizontal. The modern type of grease table, which has been evolved since 1897, consists of steel decks, 4 feet wide and 2½ feet long, each having three steps 9 inches broad, with a drop of 2 inches between them. These decks slope at an angle of 15 degrees to the horizontal and are vibrated with an amplitude of 1/32 inch, at a frequency of 50 cycles, by electromagnetic vibrating units. The object of the motion thus imparted to the table is to get a better spread of the diamondiferous gravel, so that the diamonds are able to make contact with the grease, and at the same time the gravel may easily be removed by a stream of water applied for this purpose. The diamondiferous gravels are dropped from a height of three or four inches onto the grease surface. This is done to enable the diamonds to make a slight indentation in the grease which improves their capacity to adhere.

The term "grease" is not accurate, but it has become popular through usage. The substance applied to the table surface is a mixture of two grades of petroleum jelly, one of which is harder than the other. The proportions are varied to make a harder or softer mixture as required. The hardness of the mixture to be used on the grease table depends on the temperature of the water applied over the surface of the grease and the size of the particles in the diamondiferous concentrate treated. The higher the water temperature, and the coarser the gravel, the harder should be the mixture used.

The diamonds which adhere to the grease with about an equal quantity of gangue material, are removed by scraping with a large knife, and the surface of the table is redressed with a layer of new petrolatum. The scrapings are placed in 28 mesh stainless steel screen cloth covered containers which are agitated in boiling water for initial degreasing and finally degreased by immersing in tricloroethylene vapour.

Grease table tailings at this stage are normally discarded to tailings but, due to the fact that a percentage of our ground comes from old dumps, provision has had to be made for refractory diamonds.

A refractory diamond is one that will not adhere to grease due to salts attached to its surface. These salts produce a film which is completely wetted when in contact with water, and this film of water surrounding the diamond prevents contact between the diamond surface and the grease, which is necessary for adherence.

All concentrates after passing over our +7 mesh grease tables are therefore treated with a flotation reagent, which makes the diamonds water repellant. These concentrates are run over grease belts, which are more suitable than grease tables, for the recovery of refractory diamonds.

FINAL CLEANING AND SORTING.

This process which is done in Kimberley entails:-

1) Hand sorting of the coarse material
2) Milling of the fine material
3) Electrostatic separation
4) Flotation
5) Acidising.

VALUATION.

After acidising the diamonds are delivered to the Central Sorting Office of the Diamond Producers Association for classification and valuation.

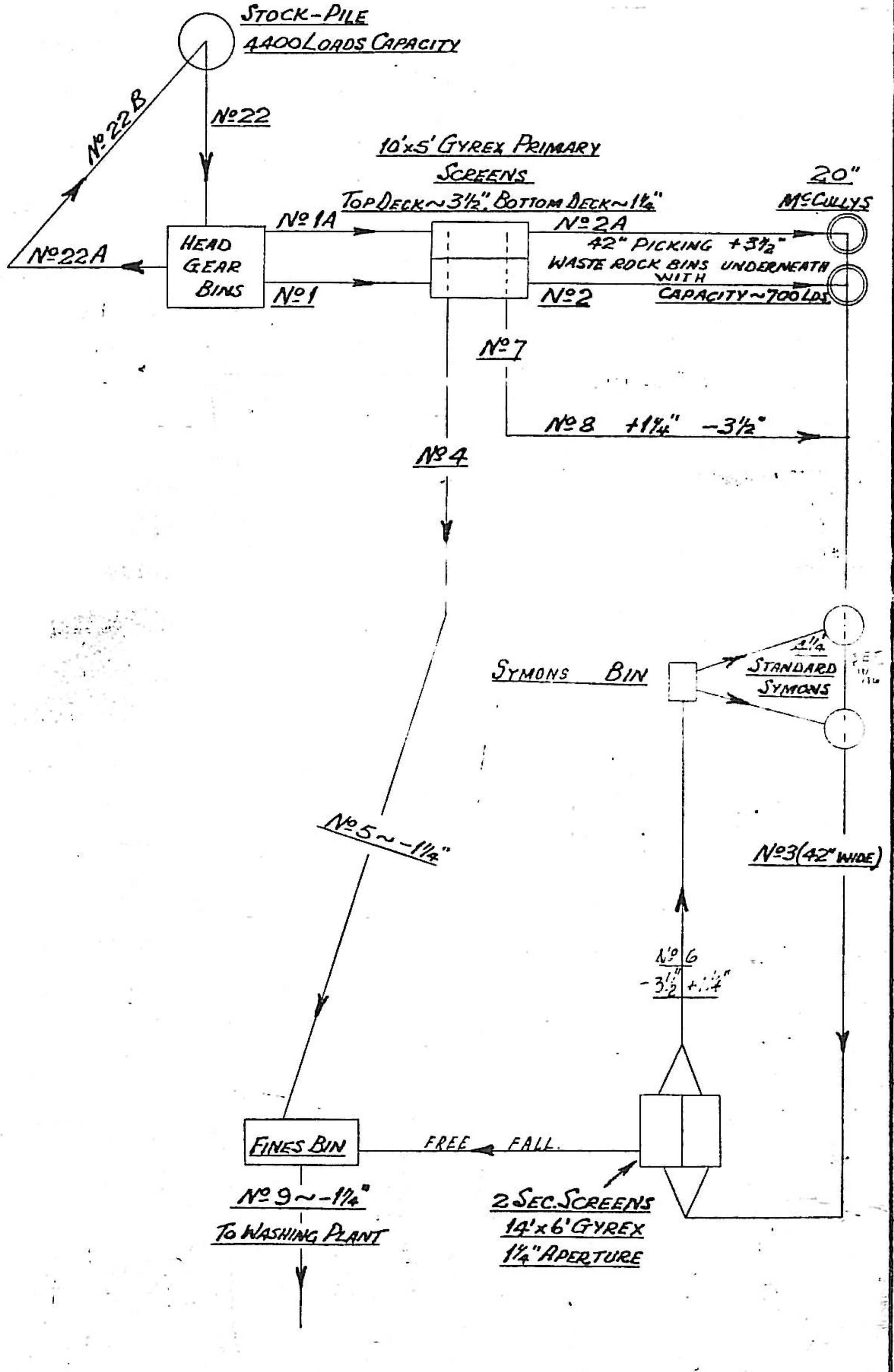
LABOUR.

Total European	19
Total African	94

JAGERSFONTEIN MINE

FLOW SHEET SORTING AND CRUSHING PLANT

DIAGRAMMATIC



ALL BELTS 36" WIDE UNLESS MARKED. CONVEYORS NUMBERED.

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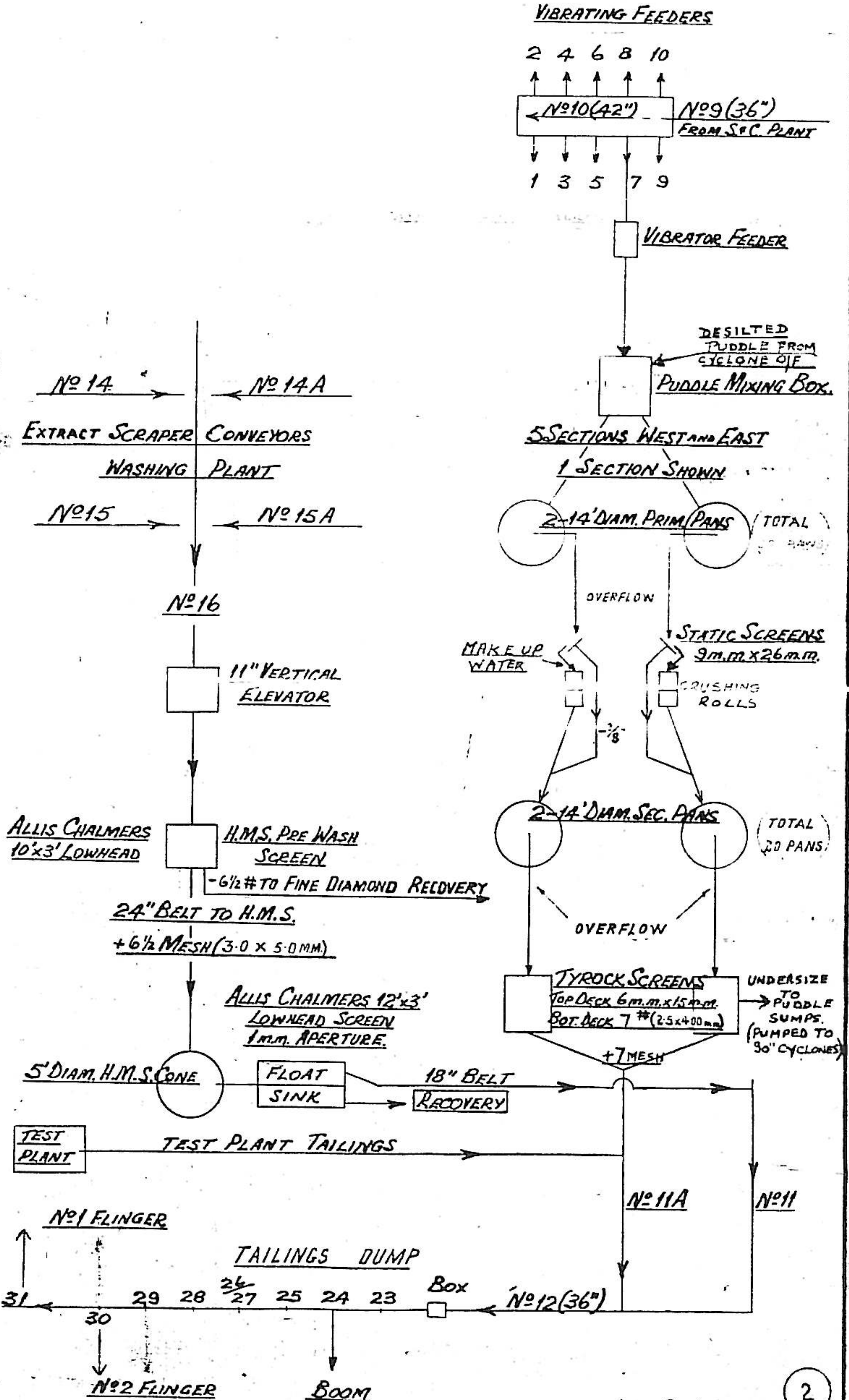
JAGERSFONTEIN MINE

FLOW SHEET ~ WASHING PLANT AND TAILINGS DUMP

DIAGRAMMATIC



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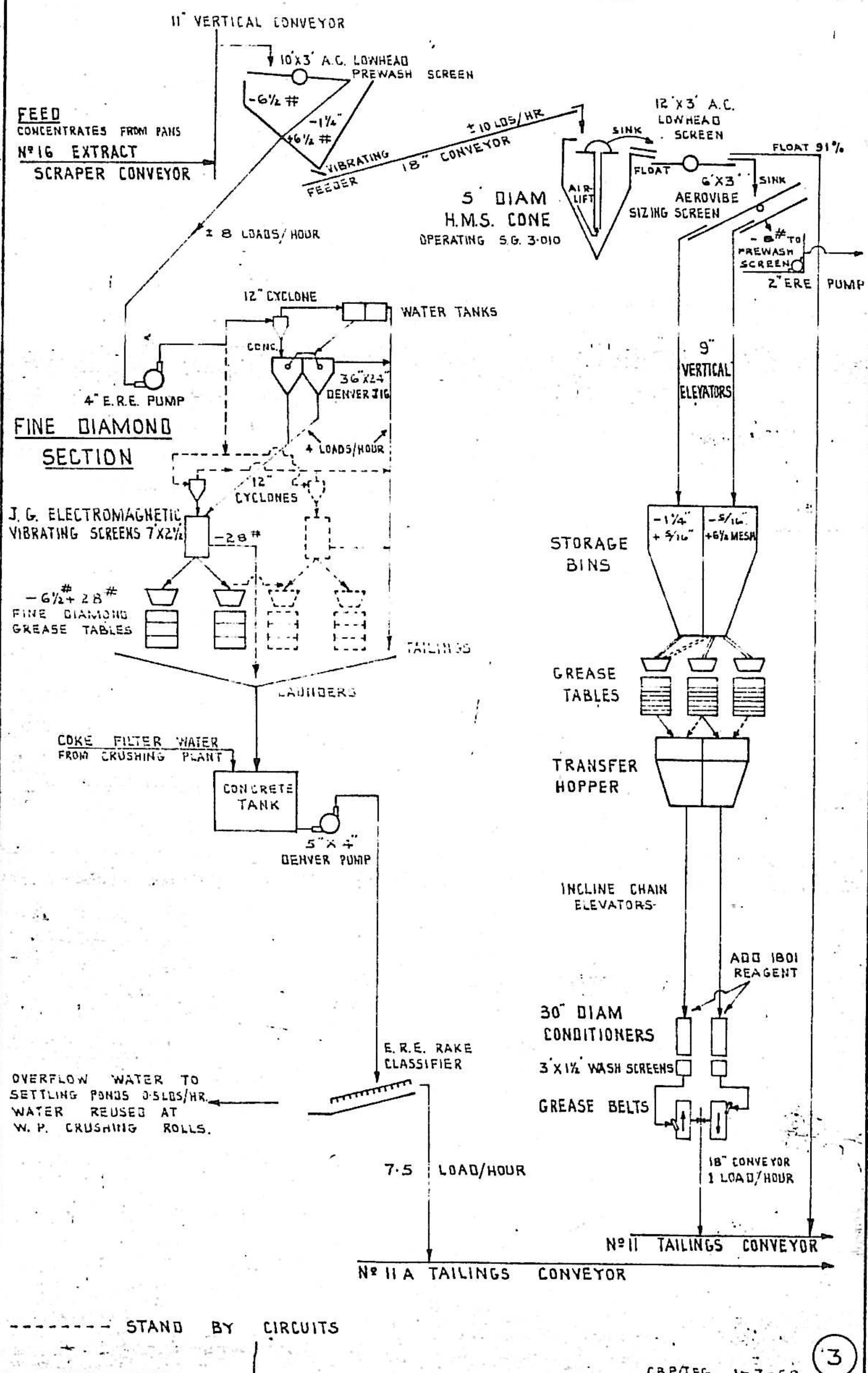
JAGERSFONTEIN MINE

FLOW SHEET ~ H.M.S. & RECOVERY PLANTS



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POWER.

Steam and electric power is generated on the Mine.

(a) Rock Shaft.

Steam power is used at the Rock Shaft to drive the Winding Engines and Compressors. The Rock Hoist which is a Yates and Thom double expansion vertical cylinder engine developing 2,500 H.P. has a 12 ft. parallel drum; a H.P. cylinder diameter of 35" and a LP cylinder diameter of 54"; size of skip - 10 ton payload. This hoist was installed in 1908 and in 1910 was reputed to have hauled 1,000 tons of ore per hour continuously for eight hours from the 900' level.

This machine has hoisted almost 50 million tons of ore with only one major breakdown which occurred in 1954 when the crankshaft fractured.

The Man Hoist develops 1,000 H.P., and the steam compressors have an output of 5,000, 4,000 and 1,000 cfm respectively.

Seven Babcock and Wilcox water tube type of boilers fitted with superheaters are installed to supply 40,000 to 50,000 lbs. of steam per hour at a pressure of 150 lb. per sq. inch.

Water supply for the boiler feed water is a mixture of underground water and water pumped from a surface dam which is approximately five miles from the Mine. All water is settled and chemically treated before being used in the boilers.

(b) Power Station.

The electric power supply is generated at the Mine's Power Station which has five turbo alternators generating a total of 5 M.W. at 2,200 volts. In addition to supplying all electric power demand for the Mining and Recovery operations, power is supplied for the electric reticulation of Jagersfontein Town and Fauresmith Town, which is seven miles from the Mine.

There are six Babcock and Wilcox boilers having a steam raising capacity of 62,000 lbs. of superheated steam per hour at 200 lb. per sq. inch.

Cooling water required for the condensers is obtained from a dam adjacent to the Power Station.

ROCK CRUSHER.

The Surface Rock Crushing Plant which produces 8,000 cu. yds. of ballast for the S.A. Railways per month, plus 3,000 cu. yds. of crushed stone for the Mine, Department of

Roads and contractors per month - a total of 11,000 cu. yds. per month.

Waste dolerite from underground mining operations, plus dolerite from old Surface Waste Dumps, is transported to the Crusher Plant by 22 Ton Tip Trucks.

A Quarry was developed approximately 3 miles from the Crushing Plant, and in the event of a shortage from the waste dumps rock can be obtained from this source.

The vehicles for the loading and transporting of dolerite from the Quarry will consist of two 22 ton Tip Trucks and a T.S. 250 Aveling Barford front end loader.

The Crushing Plant has two closed circuits. The primary circuit has a 18" x 32" Telsmith Jaw Crusher, a S36" Secondary Gyrasphere crusher and a 4 ft. x 10 ft. two deck screen.

Ballast and -2½ + 1" aggregate is produced in this circuit. For aggregate of minus 1" the rock is passed to the secondary circuit consisting of one S36" Gyrasphere Crusher and an 8 ft. x 4 ft. double deck screen. By adjusting the crusher setting and changing the screen cloths, all sizes of aggregate can be produced.

WATER.

The water requirements of the Mine and Town are met from underground (80%) and "The Woolwash" (20%) a storage dam on the Process Spruit 5 miles from Jagersfontein. The capacity of the Woolwash is at present 124 million gallons and has silted up to the extent of 24 feet against the main wall.

There are five other storage dams on the farm but only two are of any use namely the Power Station dam (capacity 32 million gallons) which serves as a cooling dam and No. 10 dam (capacity 109 million gallons) from which water can be pumped in cases of emergency.

HOSTEL.

The hostel has a population at present of approx, 587. This is by no means the hostels maximum as it has been known to accommodate up to 2,400 in the early days.

The tribal distribution is as follows:-

Lesotho	28%
Xhosa	31%
Tsana	39%
Zulu	2%

60% of them speak either English or Afrikaans.

De Beers have now achieved a permanent labour force in all their hostels. The men are contracted for an average period of 8 months, and are then permitted to go home for a maximum of 4 months. Call up cards are sent to their homes when they are required to return and they are paid a travelling bonus on return up to a maximum of R20.00 depending on their length of service.

They feed and cook for themselves, a system which they much prefer to communal dining halls. A free issue of soup daily before going to work and a pint of Jabula (a type of vitaminised Maheu) during the course of the shift is given to assist them with feeding. They are medically examined at the beginning and end of every contract, and at 6 months intervals they are chest X-Rayed for pneumoconiosis purposes.

An allowance scheme for African workers reaching the age of 60 years has been introduced, and the amount depends on length of service, being a minimum of R96 per annum, and a maximum of 50% of earnings.

Generous rewards are paid for handing in picked up diamonds. During 1968 a total of R24,563 was paid out to African employees, this sum includes two maximum bonus rewards of R9622 and R10,000. The same scale of rewards is paid to Europeans, but they very seldom find any diamonds, largely because the African does all the manual work underground.

<u>WELFARE</u>.

There is a church hall in the hostel and regular services are held. These services are well attended.

Two full time teachers are employed and educational literacy and vocational classes are held. Banking facilities are also available.

Sport is very popular and facilities are provided for soccer, tennis, athletics, boxing and bowls.

Cinema shows are held every week and are well attended. M.G.M. supply the main feature and serial but in addition there is a safety film on hazards encountered at their work in "FANAGALO" a derivation of their own language.

To cater for the medical needs of the Africans in the hostel there is a hospital with 42 beds, a modern operating theatre, sterilising room and X-Ray department. Until recently all X-Ray work on Europeans and Africans, Mines personnel and "Townsfolk" was done by the Mine. Now the local hospital has installed an X-Ray unit which relieves the mines unit of "outside" work.

EUROPEAN WELFARE.

Recreational facilities available are golf, rugby, cricket, tennis, bowls, swimming and yachting.

Cinema shows are screened weekly at the Town Hall through the Municipality and monthly at the Recreation Club through the Mine. A local theatre club caters for the cultural side with occasional shows from the O.F.S. Performing Arts Council.

Jagersfontein,
29th January, 1969.