SINKING THE SOUTH SHAFT, WEST RAND CONSOLIDATED MINES, LIMITED.

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The development of the Main Reef Series in the property of the West Rand Consolidated Mines, Ltd., was originally carried out from the five three-compartment incline shafts sunk in the footwall of this series to a vertical depth below the surface of approximately 700 ft. The second stage of development was accomplished from two compound shafts to a further vertical depth of approximately 2,000 ft. to the plane of the 27th Level. Below this level there remains within the Company's boundaries an undeveloped area measuring some two miles along the strike and one and a half miles along the line of dip, the estimated maximum vertical depth of this reef being assumed to be within a distance of 5,000 ft. from the surface.

Various means of opening up this area were considered, with the result that a final decision was made to sink a five-compartment vertical shaft which would intersect the Main Reef at a vertical depth of 3,600 ft. below the surface. This shaft was placed approximately midway between the eastern and western boundaries of the mine, and little latitude was available if heavy watercourses already encountered in the mine were to be avoided in sinking operations. The shaft is of the wide rectangular type, five compartments, the inside of timbers measuring 10 ft. by 5 ft., the measurements outside of timbers being 29 ft. 6 in. by 11 ft. 6 in., and the excavated area was approximately 31 ft. 6 in. by 13 ft. 6 in.

The long axis of the shaft, which lies with the dip of the reef, is on an approximate north and south line.

In order that active sinking with a complete crew could be put in hand at one month's notice, it was decided to proceed with the sinking of that portion of the shaft which would be in soft measures requiring concrete, and with the erection of the headgear, winders, boilers, and other necessary plant for sinking operations. This work was started in September, 1929, and working continuously with a small staff, all equipment was installed ready for active sinking in November, 1930. At this date it was considered that actual sinking operations could be deferred, and as a result no further work was done until the beginning of December, 1931, when everything was got ready for an active sinking programme to start from the beginning of 1932.

PRELIMINARY SINKING.

Preliminary sinking was started in September, 1929, using a jib crane and 16 cu. ft. pans of ordinary 18 in. gauge mine trucks. An area of 6 ft. by 8 ft. was sunk during the months of September

and October to a vertical depth of 38 ft. to ascertain the suitability or otherwise of the selected position for this shaft, and, immediately this work was completed, a start was made with the erection of the necessary plant for sinking operations.

During the month of January, 1930, the shaft was excavated to its full size and was sunk to a vertical depth of 60 ft., when owing to the nature of the country passed through it was decided to suspend sinking and concrete the walls of the shaft to this depth. The concreting of this shaft is shown in Fig. 7, the minimum thickness of concrete at any portion in the shaft being 2 ft. 6 in. This concrete was reinforced with 30 lb. rails, a rectangle being formed at every 6 ft. of depth. Two rows of holes were drilled at about 4 ft. 6 in. centres at an angle of 45° to a depth of approximately 6 ft., old 9 ft. welded steel, $1\frac{1}{4}$ in. diameter, being placed in these holes as shown in Fig. 7.

Immediately this portion of the shaft had been completed, sinking was resumed to a vertical depth below the collar of 86 ft., the face at this depth being in medium grain quartzites, and dipping south-east at an angle of approximately 45°. It was considered that normal sinking could be carried out from this point, and that there would be no necessity for concreting below a vertical depth of 78 ft. from the collar. This assumption was later borne out by actual fact, and concreting was continued for a further 23 ft. to a vertical depth of 78 ft. below the collar, as shown in Fig. 7.

The main bearers supporting the steel collar sett were all 16 in. by 6 in. " I " Section, full details of which are shown in Fig. 7. The main bearers were then installed, and the permanent shaft timbering hung from these bearers in position down to the point where concreting had been stopped. The shaft timber was blocked, and all work below the collar completed during the month of May, 1930, after which the collar was covered in during the erection of the steel headgear.

SURFACE EQUIPMENT.

Headgear.—The headgear is 105 ft. in height from the shaft collar to the centre line of sheave wheels. It is fitted with a small overhead gantry with a 5-ton spur gear travelling block on each gantry for skip changing. The headgear has four main winding compartments equipped with 14 ft. diameter sheaves, and one compartment has 8 ft. diameter sheave in which is installed a small cage. All cables and columns will be installed in this compartment.

Temporary tip gear and timber chutes lined with $\frac{3}{8}$ in. plate were provided in the four compartments used for sinking, these being placed below the permanent tip and apron which were later installed without interfering in any way with sinking operations.

Surface Waste Disposal.—A flat-bottom concrete bin 48 ft. long by 21 ft. wide by 11 ft. deep, and capable of holding 550 tons of rock when filled up to the point of the chutes, was built, the bottom of this bin being 11 ft. below the level of the collar sett.

Rock from the shaft bottom which passed over the chutes above mentioned went over grizzleys placed at 12 in. centres, and lying at an angle of 20° from the horizontal. The product eliminated by these

grizzleys was broken by hand. There were 3 ft. by 2 ft. chutes in this bin which filled a 30 cu. ft. skip, this skip transferring the rock from the headgear bin to a conical dump. The skip was operated by a 50 h.p. single-drum electric hoist having a 24 in. diameter drum 25 in. wide and using $\frac{3}{4}$ in. diameter rope. As the conical dump extended, side-discharge trucks were employed for the purpose of building out the sides of the dump. A tip was installed on the ramp leading to the conical dump so that the waste rock could be lowered into an ordinary mine truck at surface level while extending the tipping point.

Winding Plant.—No. 1 compartment, on the north end of the shaft, in which all columns, cables, etc., will eventually be installed, is served by a 13 in. by 26 in. geared "Robey" Winder of 250 h.p. with 6 ft. diameter drums 20 in. wide. One drum only is used for this compartment, on which is a 1 in. diameter winding rope.

Nos. 2 and 3 compartments are served by a 470 mm. diameter by 750 mm. diameter by 1,500 mm. stroke double tandem compound "Petzold" winding engine, direct coupled, of 1,200 h.p., having 12 ft. diameter drums 4 ft. 6 in. wide. The winding ropes on this engine are $1\frac{3}{8}$ in. diameter.

Nos. 4 and 5 compartments are served by a 30 in. by 60 in. twin high-pressure drop valve "Robey" Winder, direct coupled, of 1,200 h.p., having 12 ft. diameter drums. The winding ropes on this hoist are $1\frac{3}{8}$ in. diameter.

Compressor Plant.—Housed in the same building as the three winders on the west side of the shaft is a 4,100 cu. ft. steam-driven "Dingler" compressor complete with intercooler and condensing plant. This compressor provided air for use in the shaft only, the pressure being kept at approximately 90 lb. per sq. in.

The air receiver of this compressor was coupled with a main from the mine supply in case of any failure of this plant.

Boiler Plant.—Adjoining the winding engine house is a boiler plant which consists of five 250 h.p. "Babcock & Wilcox" water tube boilers. Two of these units were used for sinking to a depth of 2,900 ft., after which a third was brought into use. These boilers were fitted with "Pillatt" perfect combustion super-heat pressure rocking furnaces. The working pressure of these boilers is 160 lb. per sq. in.

In conjunction with the boilers are two "Green's" Fuel Economizers. The chimney is 7 ft. 6 in. in diameter and 120 ft. in height.

There are two "Weir" feed pumps having a capacity of 4,500 gallons per hour, and a 24,000 gallons feed water tank serves as a reservoir for the boilers. The bunkers, which are situated on the west side of the boiler plant, have a capacity of 360 tons.

Fitting Shop.—Close to the headgear is a small fitting shop equipped with a motor-driven drilling machine of the sensitive type, capable of drilling holes up to $\frac{13}{16}$ in.

This shop was principally used for dismantling, inspection and renovation of rock-drill equipment after each blast.

Timber Yard.—All timber used in the shaft was delivered by means of an overhead electric loco. running over a 24 in. gauge line direct from the store yard to a special timber yard measuring 115 ft. in length by 71 ft. in width. One-half of this area is roofed over.

The equipment of this yard consists of a 24 in. swing pendulum saw, motor-driven ; a 30 in. circular saw bench with fixed table, belt-driven, and a motor-driven machine capable of boring holes up to a diameter of 2¼ in.

Explosives Magazine.—This was erected 500 ft. from the shaft, and is capable of storing sufficient explosives for several days' consumption.

Ventilating Fan.—The shaft is ventilated by means of a special 39 in. diameter high-pressure multi-vane fan of the " Sirocco " type, and belt-driven. It is capable of delivering 6,650 cu. ft. of air per minute through 4,300 ft. of 22½ in. diameter galvanized piping. The fan is driven by a 50 h.p. motor at a speed of 170 r.p.m.

Offices, Store, and Change Houses.—Permanent brick buildings were erected to serve as offices, store, European change house, ambulance room, banksmen's cabin, capped fuse store, and native change house, the latter building being sufficiently large to permit of all natives employed in the shaft changing and bathing in it. This building is steam-heated, and facilities were provided for the drying of clothes. An ample supply of bread and coffee was at all times available for all native employees.

Lighting.—The area in the neighbourhood of the shaft was illuminated at night time by means of floodlights placed on special towers erected for this purpose. A small transformer was housed in a building for this purpose, and was also used to supply lighting through leads to the shaft bottom.

General.—All material was delivered by an electric overhead trolley loco. running on a 24 in. gauge line, which connected the shaft to the mine siding and mine store. This loco. operated on day shift only, and by having sufficient trucks the service proved highly satisfactory. The coal supply to the bunkers was maintained with this loco. service.

SHAFT AND SINKING EQUIPMENT.

Sinking Skips and Cage.—A small cage was installed in No. 1 compartment which was used entirely for the shaft timbermen's work. Only one driver was employed during the 24 hours on an 8-hour shift.

Nos. 2, 3, 4 and 5 compartments were served by skips, the capacity of each skip being 50 cu. ft., equivalent to 2½ tons of broken rock, the height of the skips being 3 ft. 4 in. The distance from the bottom of the skip to the top of the bridle was 48 ft., and there was an iron rung ladder from the top of the skip to the top of the bridle. To facilitate the rapid removal of the skips from the shaft, bridles were made in three sections.

Ladders.—A chain ladder reached from the manifold platform to the shaft bottom. From the manifold platform upwards, iron rung ladders reaching from one sett to the next were always kept in place for a

distance of 15 setts from the manifold platform. As the chain ladder was lowered, so the top ladder covering one sett was removed and brought to the bottom.

Ventilation.—The shaft bottom was ventilated by means of 22½ in. diameter galvanized ventilation piping which was carried in No. 1 compartment. This piping was made in 15 ft. lengths, equivalent to two setts, and air was blown through the piping into the shaft bottom.

Air Main.—6 in. diameter flanged joint air main was carried in No. 1 compartment on the opposite side to the ventilation piping. This main was made up of piping of standard lengths 22 ft. 6 in. overall, equivalent to three shaft setts.

Water Column.—The water supply for the drills in the shaft bottom was provided by a 2 in. diameter column having flanged joints and 22 ft. 6 in. overall length. Water was supplied from the surface and the pressure was reduced by breaking the pipe at different intervals in the shaft when it became excessive.

Drinking water was supplied in canvas buckets attached to the bridle of each skip.

Lighting.—Two 7/18 rubber insulated wires were carried in No. 1 compartment on the east wall plate and provided the power for lighting the shaft bottom with a cluster made up of four 100-watt lamps. These wires were fastened with insulators to the wall plates at intervals of 15 ft. Temporary extensions at the bottom were made up by adding 25 ft. lengths of 7/20 wire until sufficient advance had been made for the installation of a 300 ft. length of 7/18 permanent main. The circuit was controlled with a double pole switch at the shaft collar, the lighting voltage being 110.

Shaft Signals.—The usual pull bell signalling system was used throughout the sinking operations, a ⅜ in. flexible wire rope being suspended in each compartment. As sinking proceeded this wire was lowered by hand-operated crab winches on which spare rope for extension purposes was always kept available.

An electric pull bell system provided for the interchange of signals between the winding engine driver and the banksman on duty at the collar of the shaft.

Rock Drills and Hoses.—The Consolidated Pneumatic Tool Co.'s "C.P.5," drill, equipped as a "sinker" was used for drilling in the shaft bottom. It was fitted with spring handles, which were afterwards replaced with a fixed handle at no inconvenience to the operator. The machine was fitted with anvil blocks and used 1 in. hexagon shank steel.

Twelve machines were in commission for sinking, the number for drilling in the shaft bottom ranging from 10 to 12 according to the nature of the ground passed through.

Four C.P.10 jackhammers were used for hitch drilling purposes.

All rock drills were thoroughly examined once every 24 hours in the rock drill shop at the shaft head, where broken or damaged parts only were replaced. In cases where the machines required other than the replacement of broken parts they were sent to the central rock drill shop for this purpose.

The air hoses were 1 in. internal diameter and 75 ft. in length, whilst the water hoses were $\frac{1}{2}$ in. diameter and also 75 ft. in length.

One-inch hexagon hollow drill steel was used for drilling in the shaft bottom with the C.P.5 sinkers. This steel was cut into five different lengths, viz., 2 ft. 6 in., 3 ft., 4 ft. 3 in., 5 ft. 6 in., and 7 ft. overall; no collar was needed on this steel as the machines were fitted with anvil blocks. The square bits on this steel were $2\frac{1}{4}$ in., $2\frac{1}{16}$ in., $1\frac{7}{8}$ in., $1\frac{11}{16}$ in., and $1\frac{1}{2}$ in. gauge respectively. Depending entirely on the nature of the ground being drilled, the number of bits used per hole varied from two to five.

The steel used for drilling the hitches with four C.P.10 jack-hammer machines was $\frac{7}{8}$ in. hexagon hollow, 3 ft. long, with a $7\frac{1}{4}$ in. shank fitted with a rubber collar, the square bit being 2 in. gauge.

All steel was transported to the central drill shop for sharpening, and sufficient steel was kept in commission so that no sharpening was necessary from noon on Saturday until Monday morning.

General.—Each native lasher was supplied with a special steel toe to fit over his boot, which facilitated the loading of rock on to the shovel. In addition, this steel toe acted as a foot protector and prevented many injuries.

Final Equipment.—In No. 1 compartment adjacent to the east wall plate will be a 12 in. air main with available space for a duplicate when required in the future.

All cables required in the shaft will be attached to the north end plates.

Adjacent to the west wall plate in No. 1 compartment will be a complete pump column installation.

There will be two main pump stations in the shaft, one at the 36th Level and the other at the 14th Level, the vertical head of these pumps being approximately 2,000 ft. in each case.

There will be two 10 in. water columns, and one 6 in. column handling sludge from each set of pumps.

Nos. 2 and 3 compartments, with four runners in each compartment, will for the present be used for two two-deck cages. In addition to handling men and material, arrangements have been made to haul rock in trucks in these cages.

Nos. 4 and 5 compartments will be used for rock hoisting only in skips of a capacity of five tons.

Should this service be found to be inadequate, the winding plant will be increased to provide for a greater load being lifted at one time.

WATER IN SHAFT BOTTOM.

Water from the shaft bottom was at first removed by bailing with galvanized buckets into the skips. This method, which required the services of as many as eight natives at one time, was later replaced by the use of a special " Quimby " turbine pump which was operated by one native.

SINKING OPERATIONS.

Sinking operations started on the 31st December, 1931, at a vertical depth of 86 ft. below the surface, and were continued with three eight-hour shifts working weekdays and Sundays until the 29th January, 1933, when the final depth of 3,921 ft., equivalent to 3,835 ft. sunk, was reached. These shifts changed every week, the morning shift going to night shift, the afternoon shift to morning shift, and the night shift to afternoon shift. By doing this, the shift working on Saturday morning, and finishing at 3.0 p.m., resumed work at 11.0 o'clock on Sunday night after an interval of 32 hours. During this interval the remaining two shifts worked eight hours and were off duty for eight hours.

The sequence of work as carried out by one shift is described hereunder for a morning shift working from 7.0 a.m. to 3.0 p.m.

The white sinker in charge, together with five natives and his helper with five natives, went down in Nos. 2 and 4 compartments at 7.0 a.m. They examined the shaft and cleaned down the timber. From the manifold they examined and barred down the sides and ends of all loose rock until the shaft bottom was reached. The electric flood-lights were hung below the bottom sett and approximately 30 ft. from the shaft bottom.

At 7.30 the remainder of the native shift, consisting of a further 45 natives, was lowered into the shaft bottom, and lashing immediately started. Lashing was continued with a full gang of approximately 55 natives until all rock had been removed.

At 11.0 a.m. the 1 in. air and ½ in. water hoses were put down in their proper positions for drilling and connected up to the manifold, the positions for these hoses when 10 machines were used in the shaft bottom being as follow :—

4	air	and	4	water	hoses	in	No. 4	compartment,	2	on each side.
2	,,		2	,,	,,		No. 3	,,	1	,, ,,
2	,,		2	,,	,,		No. 2	,,	1	,, ,,
2	,,		2	,,	,,		No. 1	,,	1	,, ,,

All hoses were hung behind the wall plates.

At 12.0 noon the rock drills were lowered to the shaft bottom in either No. 4 or No. 5 compartment. The sump under No. 3 compartment was first blown over with a blowpipe with a view to exposing sockets and misfired holes. These were plugged, and the sketch made of the holes drilled during the previous shift was used for the purpose of locating the sockets. The sinker in charge supervised this operation, and, in the event of any misfires having been discovered, took personal charge of the blowing out of explosives.

The blowing over and cleaning of the shaft bottom continued until the entire shaft bottom had been completed and all loose rock removed, sockets located and plugged.

At 12.15 p.m. 10 rock drills commenced drilling, and all natives employed on lashing were sent to the surface. All shovels, picks, etc., used by the lashers were sent to the surface and the skips in all four compartments handed over to the shaft timbermen for the installation of setts, guides, etc., as required.

At 1.45 p.m., while drilling was being completed, either No. 4 or No. 5 skip was lowered into the bottom of the shaft, and machines, drill steel and other equipment no longer required were loaded into it.

Nos. 2 and 3 skips were used for bailing water, and after the water had been removed, explosives, capped fuses, charging sticks, etc., were lowered into the shaft bottom. The remaining rock drills, together with the balance of steel and other equipment, were then sent to the surface. The charging up of 85 holes was then proceeded with, and a sketch on a specially prepared form was made of the positions of the holes actually drilled. One lot of hoses from the manifold was sent to the surface in No. 2 skip whilst charging up was proceeding.

At 2.20 p.m., when charging up had been completed, the lights were turned off and the cluster loaded into No. 2 skip together with the balance of hoses. The manifold air taps were opened and No. 2 skip sent to the surface. Blowpipes, charging sticks, etc., were then sent to the surface in either No. 4 or No. 5 skip.

At 2.30 p.m. the No. 3 skip was lowered to below the bottom sett, 20 ft. from the shaft bottom, and No. 5 skip was lowered to the shaft bottom for blasting purposes. The blasting signal was then given, and immediately a reply had been received lighting up was proceeded with by the European sinker and his helper, assisted by six natives.

The usual round consisted of 85 holes drilled to depths ranging from 3 ft. 6 in. to 5 ft. 6 in. according to the hardness of the ground being passed through. 12 ft. fuses were used, and the explosives cartridges were 1 in. diameter by 8 in. in length of either 50 per cent. or 60 per cent. nitro-glycerine content. The usual quantity of explosives used for one blast was approximately 150 lbs. The primer was placed at the bottom of the hole, double fuses being used in the sump and four corner holes.

Acetylene bucket lamps were used for lighting the shaft bottom whilst lighting-up was in progress, and all fuses were cut at the time of ignition. Immediately all the fuses had been lighted the two Europeans and six natives proceeded to the surface in No. 5 skip. When the banksman on duty at the surface had ascertained that the full complement from the shaft bottom had reached the surface, No. 3 skip was then signalled by him to be raised away from the blasting zone. The shaft was then allowed to ventilate for an interval of at least twenty minutes so that the succeeding shift could proceed to follow the same routine, commencing at 3.0 p.m.

Should it have been impossible to maintain this schedule, the complete sinking gang remained on duty until the round had been completed and blasted, the following shift going on after the usual interval for ventilation.

The maximum speed of sinking was accomplished between vertical depths of 700 and 2,600 ft. from the surface, during which period the routine as outlined above frequently required more than eight hours to complete due to the big tonnage broken per blast.

The possible number of rounds which could have been blasted, on an assumption of three rounds per twenty-four hours, for the period March to July, inclusive, was 459, whereas the number of rounds actually blasted was 452.

SHAFT TIMBERING.

The following are the details of the timber and accessories used in the shaft :—

The shaft setts are of pitch pine, cross-section dimensions being as follow :—

Wall Plates, End Plates and Dividers	9 in. × 9 in.
Corner Studdles	8 in. × 8 in.
Intermediate Studdles	10 in. × 4 in.

The setts were placed at 7 ft. 6 in. centres and were hung with ten sets of hanging bolts $1\frac{1}{8}$ in. diameter with $\frac{1}{2}$ in. steel plate washers.

The guides used are 30 ft. in length, covering four setts, of 8 in. by 4 in. section, and were attached to the guide chairs with seven bolts, two at each end and one at each of the intermediate chairs. The guides in Nos. 1, 2 and 3 compartments were made of pitch pine, while in Nos. 4 and 5 compartments the timber used for guides was Australian " Karri."

As soon as all the permanent columns and cables have been installed, No. 1 compartment, with a small cage, will be retained for inspection purposes, Nos. 2 and 3 compartments will be equipped with two cages, each running on four guides, whilst Nos. 4 and 5 compartments will be used for hoisting rock.

It is intended to use pitch pine guides in No. 2 compartment with one cage and " Karri " guides in No. 3 compartment with the other.

Stations were cut at the 6th, 14th, 32nd and 36th Levels.

A transfer station was cut approximately 40 ft. below the plane of the 36th Level, and the main loading station a further 60 ft. below the transfer station, as shown on the attached geological section, Fig. 8.

Complete steel setts were installed at the collar of the shaft and at the 14th, 32nd and 36th Level stations, supported in each case on six " I " section steel joists 16 in. deep by 6 in. wide.

TIMBERING ROUTINE.

The routine work of the shaft timbermen, of whom four were employed, was as set out hereunder.

At 7.0 a.m. two timbermen and fourteen natives transported the setts and placed them at the collar of the shaft. The necessary slings, shackles, etc., were then attached to facilitate the maximum speed of lowering this material by the banksman when required by the timbermen. The necessary blocks were cut, stage planks examined, and other requirements made ready for lowering into the shaft.

At 8.30 one timberman and seven natives went down in No. 4 compartment to the second sett from the bottom and placed the stage planks, blocks and wedges in Nos. 4 and 5 compartments.

At 8.45 one timberman and seven natives went down in No. 2 compartment and placed stage planks, blocks and wedges in Nos. 1, 2 and 3 compartments.

At 9 o'clock two plumb lines were lowered, one in No. 5 compartment and the other diagonally opposite in No. 1 compartment.

At 9.15 sett blocking was started by two timbermen, and this work was usually completed by 12.0 noon. Immediately afterwards the stage planks were lowered to the bottom sett and hanging bolts and ropes were fixed for the hanging of the next sett, after which the timbermen and their boys, together with their equipment, were raised to the surface.

Immediately the skips were released by the sinkers in the bottom of the shaft after drilling had started, the timbermen lowered a sett and hung it in position, which operation was usually completed within half an hour. The timbermen then proceeded to the surface to prepare the requirements for the following shift.

At 3.0 p.m. pipes, stages and other requirements were got ready and transported to the shaft head. At 4.0 o'clock the cage in No. 1 compartment was used to lower the manifold. No. 1 compartment was then completely staged over. Nos. 2 and 3 compartments were staged as far as possible, only leaving a clearance for the skip to pass through. Any extensions necessary to the ventilation, air and water pipes were then proceeded with. The overall lengths of all classes of piping were in multiples of 7 ft. 6 in., this distance being the centre of the shaft setts. The top safety ladders were then taken off and put on the bottom setts.

Immediately drilling started in the shaft bottom the skips were taken over by the shaft timbermen and used in connexion with the extension of guides.

All hitches for shaft bearers were cut on this shift, the time taken to cut a hitch 15 in. to 18 in. deep being approximately 10 hours. Six bearers were installed in the shaft every 200 ft. as follows :—

One bearer under the north end plate, and a second under the divider between Nos. 1 and 2 compartments.

100 ft. below these two bearers, four bearers were installed as follows :—

One under the north end plate, a second under the divider between Nos. 1 and 2 compartments, a third under the divider between Nos. 3 and 4 compartments, and a fourth under the south end plate.

The bearers are of " I " beam section 8 in. deep by 6 in. wide. Each bearer was cut to a definite length and, to facilitate installation, was made in two pieces with fishplates fitted for joining up.

On this shift the skips could not be used by the shaft timbermen until after a total of 20 skips of rock had been hoisted from the shaft bottom.

There were two men employed with twelve native assistants between them. No timbermen were employed on the night shift, and the men coming on morning shift one week changed to afternoon shift on the following week.

SHAFT PLUMBING.

The position of the shaft setts in relation to the collar sett was checked at intervals of 50 ft. by the mine surveyor. Two plumb lines were used, being placed in the north-western and south-eastern compartments of the shaft, respectively. Both these wires were placed at a distance of 5 in. from the adjacent wall and end plates. The permanent guides on the collar sett ensured the correct position of the wires being maintained.

A light weight was attached to the wires while they were lowered to the desired position, after which a 30 lb. plumb bob was substituted for this light weight. After ascertaining that the wires were hanging free, measurements were made from each wire to the adjacent wall and end plates, a mean of from six to twenty swings being taken as an average. Any corrections, if necessary, having been made, the sett plumbed to was then used for the shaft timbermen's lines, and the exact position of all intermediate setts was then ascertained.

CONNEXIONS TO EXISTING WORKINGS.

The following connexions were effected to existing workings :—

1. 6th Level at an elevation of 863 ft. below the collar connected with the 6th Level of existing workings of the Flora Shaft of the Battery Reef Series.
2. At 1,860 ft. below the collar, the shaft is connected with both the Battery Reef 14th Level, Flora Shaft, and Main Reef 17th Level, West Shaft.

   A main pumping plant is being installed at this level which will eventually pump the water collected from all sections of the mine to the surface.
3. The 32nd Level, at a distance of 3,280 ft. below the collar, connects with a winze sunk on the Main Reef Series in the East Shaft Section of the mine.

EUROPEAN SHAFT SINKING CREW.

The sinking was carried out under the supervision of a " Master Sinker," whose appointment carried all the duties and responsibilities imposed upon the manager as far as shaft sinking and operations accessory thereto are concerned.

The complete European staff was as follows :—

3	Sinkers at 25s. per shift.
3	Sinkers' Helpers at 21s. per shift.
1	Head Timberman at 25s. per shift.
3	Timbermen at 25s. per shift.
7	Winding Engine Drivers at 24s. per shift.
3	Banksmen at 17s. 6d. per shift.
1	Fitter at 22s. per shift.
3	Firemen at 17s. per shift.
1	Loco. Driver at 17s. per shift.
1	Sett Maker at 25s. per sett installed.
1	Shaft Clerk at a fixed salary.
1	Master Sinker at a fixed salary.
Total ... 28	

The following bonuses, based on the monthly footage accomplished, were paid to the men engaged in the sinking of this shaft :—

Monthly Footage accomplished.	Sinkers (3) Head Timberman (1). (4)	Sinkers' Helpers (3) Timbermen (3). (6)	Engine Drivers (on rock hoists). (6)	Banksmen (3) Auxiliary Hoist Driver (1). (4)	Fitter. (1)
	s. d.	s. d.	s. d.	s. d.	s. d.
Up to 200 feet ...	3 0	2 0	0 8	0 6	0 4
201–230 feet ...	12 0	8 0	2 6	2 0	1 4
231–260 feet ...	16 0	10 8	3 4	2 8	1 9
261–290 feet ...	20 0	13 4	4 2	3 4	2 2
291–300 feet ...	24 0	16 0	5 0	4 0	2 8

301–330 feet inclusive ... ... a bonus of £3/10/– per foot
331–360 feet inclusive ... ... a bonus of £4/ –/– per foot
Over 360 feet ... ... a bonus of £5/ –/– per foot
} Distributed on the basis as set out below.

BASIS OF DISTRIBUTION OF BONUS FOR FOOTAGE ADVANCED OVER 300 FEET.

Sinkers and Head Timbermen ...	10% each at 4	=	40%
Helpers and Timbermen	6% „ 6	=	36%
Winding Engine Drivers	2½% „ 6	=	15%
Banksmen and Auxiliary Hoist Driver	2% „ 4	=	8%
Fitter	1% „ 1	=	1%
			100%

An example of the bonus awarded to a sinker for a footage of 340 ft. is as follows :—

200 feet at	3/– per foot	... ...	£30	0 0
30 „	12/– „	... ...	18	0 0
30 „	16/– „	... ...	24	0 0
30 „	20/– „	... ...	30	0 0
10 „	24/– „	... ...	12	0 0
30 „	70/– „	£145 distributed at 10%	14	10 0
10 „	80/– „			
340			£128	10 0

The sett maker received a flat rate of 25s. per completed sett installed. He prepared the timber required for setts, runner and other accessory timber required in connexion with sett installation.

The runners were supplied to the sett maker squared and planed ready for cutting to true length and boring by him.

The following conditions were laid down with regard to the bonuses above mentioned, viz. :—

1. The measurement month is from 7.0 a.m. on the day before the last of the month to the same time and day of the following month. In addition, the shaft will be measured for its depth at 7.0 a.m. on the first day of each calendar month.

2. Bonuses will be paid in the proportion that the actual shifts worked bear to the total shifts possible per month.

3. No bonus will be paid to any man who is discharged or resigns during a month.

4. When station cutting or other extraordinary work is being done, the bonuses as set down above will not apply.

The sinker's helper was responsible for blowing over, washing, and preparing the sketch, as required in terms of Regulation 100 (13) (b). The sinker was the responsible person under whom the preparation of the sketch and other requirements of Regulation 100 (13) (b) were performed. The master sinker was held responsible for inspecting and initialling daily the sketches so prepared by each shift.

A notable feature in connexion with the sinking of this shaft was that no changes whatever were made in the European personnel engaged, the same men who started work on the 31st December, 1931, being employed when the final depth was reached on the 29th January, 1933. This was possible by employing as " banksmen " miners holding blasting certificates, and these men were used to relieve men employed in the shaft who were off work as the result of sickness or minor injury.

NATIVE SHAFT SINKING CREW.

The complete native complement for the sinking of this shaft was 239, of which 190 were allotted to occupations below the collar of the shaft.

The rates of pay and bonuses for natives were laid down as follow :—

Machines :	Handle Boys	...	3/–	flat rate	plus	bonus	of	1d.	per ft.	drilled.
	Spanner Boys	...	3/–	„	„	„		¾d.	„	„
Shovelling	... ...	...	3/–	„	„	„	as	detailed		below.
Timbering	... ...	...	3/–	„	„	„		„		„
Supervision	... ...	...	3/6	„	„	„		„		„

All the above-mentioned natives received a clothing allowance of 7d. per shift, out of which they paid for their oilskins, etc.

The following bonuses could be paid, at the master sinker's discretion, to shovellers and timber boys working in the shaft. These bonuses are based on the weekly footage measured on each Monday morning :—

Footage Sunk per Week.	Shovellers.	Timber Boys.
	Per shift. s. d.	Per shift. s. d.
65	0 3	0 1½
70	0 6	0 3
75	0 9	0 4½
80	1 0	0 6
85	1 3	0 7½
90	1 6	0 9

These bonuses were to be paid weekly from a special bonus ticket.

The following are the rates of pay per shift of natives who were employed on the surface during the sinking of this shaft :—

Sett maker's boys	From	1/8	to	2/–	...	Average	1/11
Engine room boys	„	1/8	„	2/–	...	„	1/9
Store boys	„	1/6	„	2/2	...	„	1/8
Change house boys	„	1/10	„	2/–	...	„	1/11
Disposal of waste boys	„	1/6	„	4/–	...	„	1/11¾
Bank and general surface boys ...	„	1/6	„	2/–	...	„	1/9
Sundry	„	1/10	„	2/6	...	„	2/2
Transport		1/8			...	„	1/8
Rock drills and steel	„	1/8	„	2/1	...	„	1/11
Boiler plant	„	1/8	„	2/3	...	„	2/–

Some important details in connexion with the employment of native labour on this shaft may be summarized as follows :—

1. To maintain a total complement of 190 natives for work below the collar of the shaft, there were engaged and started on this work a total of 830 natives between the 31st December, 1931, and the date on which the shaft reached its final depth.
2. There were 151 desertions, of which number 48 were recovered and returned to work at the shaft.
3. The maximum earnings on any one shift by any native was 16s. 4d.
4. The highest earnings in any one period of 30 consecutive days was £14 1s. 6d., this amount being exclusive of a clothing allowance of 7d. per shift worked.
5. On the date on which the shaft reached its final depth the number of natives who had started work within the first 30 days of the commencement of sinking and were still employed was eight.
6. Special attention was at all times given to the feeding and care of the boys employed on this work.

ACCIDENTS AND SICKNESS.

There were no fatal accidents to Europeans during the course of sinking operations.

Eight natives were either killed or fatally injured from the following causes :—

Struck by falling stone	2
Drilled into misfired holes	2
Fall of rock in shaft	2
Fell from timber into shaft	1
Struck by falling material	1
TOTAL	8

In addition to these fatalities the Native Hospital statistics record the following :—

	Number of Cases.		Shifts Lost.	
	Under-ground.	Surface.	Under-ground.	Surface.
Accidents	578	8	4,860	73
Sickness	407	12	1,721	53
Totals ...	985	20	6,581	126
Grand Totals ...	1,005		6,707	

The total of 6,707 shifts lost through sickness and accident, as shown above, would have been sufficient labour to carry on full sinking operations for an average calendar month.

EXTRACTS FROM SHAFT LOG BOOK.

The following items are extracted from the shaft log book :—

31.12.31 Sixty holes were blasted at 4.30 after the first shift's drilling, which was started with eight machines; only one of the original eight remained in commission at the end of the shift. This difficulty continued on the following shifts due to the lack of experience of the native operators.

3.1.32 Natives complained of the arduous nature of the work, started laying off, and two deserted. First sett of timber hung taking 2½ hours. Shaft timberman avoided a serious accident, after falling off the bottom sett, by catching the winding rope.

8.1.32 Whilst lowering timber from surface, galvanized shackle, carrying two dividers and one end plate, broke, and timber fortunately jammed itself across the dividers. Hoist driver pulled sinker into headgear.

20.1.32 Clutch of " Petzold " hoist broke whilst hoisting rock from shaft bottom, and skip was held in the shaft on brakes. No injuries.

4.2.32 Hardness of ground encountered necessitated the introduction of five jumpers to drill one hole.

19.2.32 Replacement of 50 per cent. explosives by 60 per cent. explosives on the 16th of the month showing definitely improved results.

15.3.32 Complete station sett hung at 6th Level, taking an overall time of 3 hours and 40 minutes.

4.4.32 First fatal accident occurred to a native during charging-up operations. Apparently hit by a falling stone.

27.4.32 Sinker injured, having his right foot crushed, a stone falling from side of shaft.

29.4.32 Native fell from manifold platform 70 ft. to the shaft bottom. Practically uninjured owing to his oilskin coat being almost new.

6.5.32 Native injured on the 29th April resumed duty.

27.5.32 An explosion occurred in the shaft bottom whilst a round was being lighted up. Sinker, his helper, and natives escaped, and three minutes later a further explosion occurred, there being at this time no persons in the shaft bottom.

30.5.32 Six steel bearers and complete sett installed at 14th station, taking an overall time of nine hours.

4.8.32 Blasting accident through drilling into a misfire. Two natives killed and six injured. European sinker slightly injured.

11.9.32 Native killed in shaft bottom from fall of rock.

13.9.32 Rock breaking very badly, leaving very long sockets. Massive formation and no bedding planes to break to.

8.10.32 No. 3 skip overwound into headgear, damaging skeleton, and putting this hoist out of action for a period of seven hours.

12.10.32 Steel station sett installed at the 32nd Level station, taking an overall time of 6½ hours.

22.10.32 Serious fall of ground on the 32nd Level station whilst full shift of natives under the supervision of the sinker was working in the shaft bottom. Of a total of 56 natives at work at the time, two were fatally injured, eight seriously injured, and eleven received minor injuries. Rescue work was difficult owing to timber and rock blocking each compartment. Native killed through portion of the hood of No. 2. skip becoming detached and falling down the shaft, striking the native who was riding in No. 3. skip.

26.10.32 First blast at 3.0 p.m. to-day after accident on the 22nd of the month.

30.10.32 Sinking seriously handicapped through loss of natives owing to accident on the 22nd. This shift to-day had in it 13 only of the original 56 natives belonging to it on the date of the accident. In addition to the 21 natives who were injured in the accident a further 22 natives were lost to this gang through minor injuries, refusal to work, desertions, etc.

10.11·32 South Reef intersected at a vertical depth of 3,484 ft. from the collar of the shaft, the dip being 22°.

26.11.32 Main Reef intersected at a vertical depth of 3,613 ft. from collar on the north end of the shaft, the dip being 16°.

29.11.32 North Reef intersected at a vertical depth of 3,639 ft. from collar, at the north end of shaft, the dip being 21°.

14.12.32 Sinking stopped for the purpose of cutting the 36th Level station.

26.12.32 No work done—Christmas holiday being observed.

4.1.33 Sinking resumed after an interval of 21 days, during which period the 36th Level station was cut and complete station timbering installed.

9.1.33 Sinking temporarily stopped and cutting of 36th Level transfer station commenced.

12.1.33 A native employed on the manifold platform about 60 ft. from the shaft bottom is assumed to have been struck by a skip and was killed.

16.1.33 Sinking resumed after a complete stoppage of seven days for station cutting.

22.1.33 Sinking stopped for the purpose of cutting excavations for main loading chutes.

25.1.33 Sinking resumed on morning shift.

29.1.33 Final blast in shaft occurred at 5.30 a.m. on the morning of the 30th, the measurement after the cleaning out of this round to the shaft bottom being 3,921 feet from the collar.

11.3.33 First skip loaded at the main filling chutes at 8.30 p.m., all arrangements being satisfactory.

FOOTAGE ADVANCES.

The attached geological plan (Fig. 8) shows the footage advanced during each calendar month until the shaft had reached its final depth. For cost purposes the measurements were taken on the morning of the

day prior to the last day of each calendar month, and all statistics are based on these periods ; consequently, the footages differ slightly from the calendar month advances.

Year.	Month.	Shaft Advances.	
		Calendar Month.	Measurement Month.
1929	September	19	19
	October	19	19
1930	January	10	10
	February	34	34
	March	4	4
1931	December	7	Nil
1932	January	303	290
	February	317	315
	March	400	396
	April	389	389
	May	420	418
	June	316	325
	July	359	354
	August	300	308
	September	304	300
	October	216	222
	November	239	235
	December	120	138
1933	January	145	145
	Totals	3,921	3,921

October, 1932 — The low footage advance of 216 ft. for the calendar month was a direct result of the accident which took place on the 22nd, the advance for the first 21 days being 195 ft. Although sinking was resumed on the 26th it was necessary to discontinue work after two blasts due to bad ground introduced through faulting. Sinking was again resumed on the 30th, so that the advance for the month of 216 ft. represents only 24 days' actual sinking.

November, 1932 — The low footage for this month can be directly attributed to the disorganiztaion of work owing to the previous month's accident, and to the large number of inexperienced natives distributed amongst the sinking gangs.

December, 1932 — The footage of 120 ft. represents 13 days' sinking, the balance of the month being occupied in cutting the 36th Level station.

January, 1933 — The advance of 145 ft. represents 17 days' sinking, the remaining 12 days being occupied in cutting excavations at the 36th Level transfer station and loading bins.

New world's records for vertical shaft-sinking were created as follows :—

1. 420 ft. for the 31-day calendar month of May.
2. 389 ft. for the 30-day calendar month of April.
3. 1,209 ft. for the three consecutive months of March, April and May, with an average of 403 ft. per month.
4. 3,690 ft. for one calendar year, with an average of 307 ft. per month.
5. In an overall sinking period of 396 days the shaft was advanced 3,835 ft., while in addition to this excavations for the main station, transfer station and loading bin at the 36th Level were completed.

6. The maximum tonnage broken and hoisted from the shaft bottom in any one day was 570 tons, equivalent to 15 ft. of sinking ; this being accomplished on the 20th May at a vertical depth of 1,750 ft. below the collar.

STATISTICS, COSTS AND STORES CONSUMED.

Statistics.	May, 1932 (418 ft.).	Total Sinking (3,835 ft.).
Average number of machines	10	10
Total machine shifts	930	10,780
No. of holes drilled	7,849	86,124
Total footage drilled	37,370	342,977
Footage drilled per foot sunk	89·2	89·4
Number of rounds blasted	91	1,034
Average number of holes per round	86	83
Average footage drilled per round	410·7	331·7
Explosives used—60%—cases	186	2,238
Explosives used—50%—cases	94	765
Total cases of explosives used	280	3,003
Quantity of Nitro-Glycerine used—lb.	7,930	86,265
Footage sunk per 100 lb. Nitro-Glycerine used ...	5·27	4·45
Number of misfired holes	57	879
Average number of misfired holes per round	·63	·85
Percentage of misfired holes on total blasted ...	·73	1·02
Number of skips of rock hoisted	6,379	58,137
Tons of rock hoisted	15,948	145,344
Number of setts of timber installed	54	520
Tons hoisted per foot sunk	38·2	37·9

European Labour : The total number of shifts worked by the complement of 28 Europeans employed on both surface and underground work was 10,478.

Native Labour : The total number of shifts worked by an average of 211 natives employed on both surface and underground amounted to 83,568.

Timber Consumption: The total consumption of timber for all purposes was 74,051 cu. ft., equivalent to 18·9 cu. ft. per foot of shaft timbered.

STORES CONSUMED.

The principal items of stores consumed were as follows :—

SHAFT SINKING.	
Capped fuses, bundles	3,491
Fuse Lighters	9,610
Carbide, lb.	5,780
Hard Hats	659
Rubber Suits	46
Gum Boots, pairs	44
Lashing Shoes, pairs	112
Explosives, 50% cases	765
„ 60% cases	2,238
Shovels	1,408
SHAFT TIMBERING.	
Bolts, Nuts and Washers, lb.	34,927
Nails, lb.	3,552
Carbide, lb.	4,840

SHAFT TIMBERING—(*continued*).	
Hard Hats	70
Rubber Suits	18
Gum Boots, pairs	11
Angle Iron, lb.	17,815
1⅛ in. Round Iron for hanging bolts, lb.	180,586
Channel Iron	146,713
Timber, Deal, ft.	2,904
Pitch Pine, cu. ft.	67,553
" Karri," cu. ft.	4,046
HOISTING.	
Bell Wire, ft.	27,900
VENTILATION.	
22½ in. Galvanized Piping, ft.	4,000
DUST ALLAYING.	
½ in. Hose, ft.	1,400
Piping, 2 in., ft.	4,160
CHANGE HOUSES.	
Coffee, lb.	1,910
Sugar, lb.	6,660
Milk, gallons	389
ROCK DRILLS AND STEEL (Sinking).	
1 in. Hoses, ft.	1,650
Rock Drill Lubricant, lb.	2,079
1 in. Hollow Drill Steel, lb.	44,430
C.P. 5 Sinking Rock Drills	12
ROCK DRILLS AND STEEL (Timbering).	
1 in. Hoses, ft.	180
⅞ in. Hex. Hollow Drill Steel, lb.	2,100
C.P. 10 Jackhammers	4
BOILER PLANT.	
Steam Coal, tons	10,019
COMPRESSED AIR.	
Bar Iron, lb.	2,930
6 in. Piping, ft.	4,319
Flanges, 6 in.	356

SINKING COSTS.

The total cost of sinking 3,921 ft. amounted to £111,564 9s. 8d., equivalent to £28 9s. 1d. per foot sunk. This cost included an amount of £4,388 13s. 3d. for the sinking, concreting and timbering of the first 86 ft. below the shaft collar, equivalent to £51 0s. 8d. per foot.

The detailed costs for the total footage accomplished, as well as those for the month of May, are as shown hereunder :—

Details.	MAY, 1932.		TOTAL (3,921 feet).	
	Total Cost.	Cost per foot.	Total Cost.	Cost per foot.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Sinking	4,007 1 7	9 11 9	47,523 7 8	12 2 5
Timbering... ...	3,571 11 8	8 10 11	37,913 19 2	9 13 5
Hoisting	1,161 3 0	2 15 7	12,847 2 3	3 5 6
Bailing	20 16 10	0 0 11	514 8 9	0 2 8
General Charges ...	986 7 10	2 7 2	12,765 11 10	3 5 1
TOTALS ...	9,747 0 11	23 6 4	111,564 9 8	28 9 1

MONTHLY COSTS.

	Monthly.			Progressive.	
	Footage sunk.	Total Cost.	Cost per foot.	Footage sunk.	Cost per foot.
		£ s. d.	£ s. d.		£ s. d.
To 31 Dec. 1931	86	4,388 13 3	51 0 8	86	51 0 8
January, 1932	290	9,846 18 2	33 19 1	376	37 17 3
February ...	315	8,673 7 7	27 10 8	691	33 3 1
March	396	9,932 6 6	25 1 8	1,087	30 4 3
April	389	9,807 17 0	25 4 3	1,476	28 17 11
May	418	9,747 0 11	23 6 4	1,894	27 13 4
June	325	8,699 19 3	26 15 5	2,219	27 10 8
July	354	9,309 5 8	26 5 11	2,573	27 7 3
August ...	308	8,645 1 4	28 1 4	2,881	27 8 9
September ...	300	8,586 16 1	28 12 5	3,181	27 11 0
October ...	222	7,059 15 1	31 16 0	3,403	27 16 6
November ...	235	7,259 10 3	30 17 9	3,638	28 0 6
December ...	138	4,551 3 11	32 19 7	3,776	28 4 2
January, 1933	145	5,056 7 11	34 17 5	3,921	28 9 1
Totals ...	3,921	111,564 9 8	—	3,921	28 9 1

DETAILS OF COSTS.

Details.	May, 1932 (418 feet).		Total (3,921 feet).	
	Total Cost.	Cost per foot.	Total Cost.	Cost per foot.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
European Wages—				
Flat Rates ...	1,200 16 6	2 17 6	15,180 10 3	3 17 5
Bonuses	1,590 16 10	3 16 1	14,132 5 5	3 12 1
Miners' Phthisis, Accident Assurance and Leave Pay ...	211 19 3	0 10 1	2,140 10 11	0 10 11
Total Cost European Labour	3,003 12 7	7 3 8	31,453 6 7	8 0 5
Native Wages—				
Flat Rates ...	1,288 11 1	3 1 8	15,076 17 8	3 16 11
Bonuses	220 17 6	0 10 7	1,472 19 7	0 7 6
Compound and Hospital	305 0 10	0 14 7	3,491 16 6	0 17 10
Total Cost Native Labour ...	1,814 9 5	4 6 10	20,041 13 9	5 2 3
Workshops	359 10 1	0 17 3	3,243 3 9	0 16 7
Rock Drills, Steel and Sharpening	227 0 1	0 10 10	6,108 12 3	1 11 2
Sampling, Surveying and Assaying	7 11 8	0 0 5	288 15 2	0 1 5
Purchased Power	75 11 2	0 3 7	863 16 7	0 4 5
Purchased Water	91 18 2	0 4 5	1,458 0 5	0 7 5
Sanitation	5 12 0	0 0 3	88 8 4	0 0 5
Sundry Costs ...	1 0 0	—	43 15 7	0 0 3
Contracts (Sundry)				
Preliminary Sinking	—	—	1,011 0 0	0 5 2
Total Cost Sundry Charges	768 3 2	1 16 9	13,105 12 1	3 6 10

DETAILS OF COSTS—(*continued*).

Details.	May, 1932 (418 feet).		Total (3,921 feet).	
	Total Cost.	Cost per foot.	Total Cost.	Cost per foot.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Native Clothing Allowances ...	169 13 10	0 8 1	1,871 8 5	0 9 7
Stores :				
Bolts, Nuts, Washers and Nails	60 13 1	0 2 11	524 11 6	0 2 8
Cement and Sand	2 18 6	0 0 2	1,045 0 0	0 5 4
Carbide, Lamps and Spares ...	8 5 9	0 0 5	140 15 0	0 0 9
Clothing (including Iron Lashing Shoes) ...	25 11 6	0 1 3	609 7 9	0 3 1
Coal	511 17 6	1 4 6	7,319 4 7	1 17 4
Boiler, Engine and Compressor Spares ...	41 10 0	0 2 0	367 6 4	0 1 11
Electric Cable, Wire, Fittings and Spares ...	17 8 10	0 0 10	180 13 3	0 0 11
Explosives—				
Gelignite ...	500 7 4	1 3 11	5,402 6 3	1 7 8
Capped Fuse and Fuse Lighters ...	166 14 1	0 8 0	1,805 9 3	0 9 2
Bar Iron for Hanging Bolts	124 13 4	0 5 11	1,147 11 7	0 5 10
Angle & Channel Iron	52 14 8	0 2 6	560 6 6	0 2 10
Steel Bearers ...	56 4 3	0 2 8	765 11 10	0 3 11
Piping and Fittings ...	118 5 2	0 5 8	1,370 10 10	0 7 0
Ventilation Piping	60 18 9	0 2 11	591 11 3	0 3 0
Timber (all classes)	2,104 4 9	5 0 8	20,662 18 3	5 5 5
Tools (Shovels, Hammers, Picks, Handles, etc.)	19 17 3	0 0 11	378 8 0	0 1 11
Rope—Wire and Manilla and Chain	31 2 10	0 1 6	361 6 4	0 1 10
Lubricants ...	28 6 11	0 1 4	370 0 5	0 1 10
All other Stores	59 7 5	0 2 11	1,489 9 11	0 7 7
Total Cost of Stores (including Native Clothing Allowances) ...	4,160 15 9	9 19 1	46,963 17 3	11 19 7
Total Cost ...	£9,747 0 11	£23 6 4	£111,564 9 8	£28 9 1

COST OF SHAFT WITH COMPLETE EQUIPMENT.

The total estimated expenditure in connexion with this shaft from the time the site was first selected until the complete equipment will have been installed, including the cost of two large pumping installations capable of handling all underground water, may be summarized as follow :—

(*a*) Actual cost of surface equipment installed for shaft sinking.
(*b*) Actual cost of sinking the shaft.
(*c*) Estimated cost of additional surface requirements at present under construction.
(*d*) Estimated cost of two main pumping plants, together with necessary columns, which are at present being installed at the 14th and 36th Levels.
(*e*) Estimated cost of shaft equipment in excess of that which was required for actual sinking purposes.
(*f*) Estimated cost of main stations, bins, ore-passes, etc.

(*a*) *Actual cost of surface equipment installed for shaft sinking :—*

1.	Main road to shaft head	£1,198	2	0
2.	Locomotive line to bunkers and shaft head ...	5,463	7	1
3.	Trolley line locomotive with necessary timber and coal trucks	3,900	18	0
4.	Air and water main, cables, transformer house, etc.	4,059	19	1
5.	Offices, stores and equipment	634	15	0
6.	European and native change houses ...	2,232	16	6
7.	Headgear complete with foundations, surface bin, and waste rock disposal arrangements ...	18,892	3	7
8.	Winding engines erected, with building complete	19,122	3	2
9.	Compressor erected, with building, cooling pond, etc.	3,484	14	10
10.	Boiler house with complete equipment, including bunkers	19,404	1	1
11.	Signalling arrangements	625	6	0
12.	Sinking skips, cages, ropes, etc.	2,684	0	3
13.	Fitting shop, with equipment	278	5	2
14.	Timber shed and equipment	673	11	0
15.	Ventilation fan installed	588	9	0
16.	Master sinker's dwelling	1,010	10	4
	TOTAL	£84,253	2	1

(*b*) *Actual cost of sinking the shaft :—*

1.	Preliminary sinking, including cost of concreting and collar sett to a vertical depth of 86 ft.	£4,388	13	3
2.	Cost of sinking from 86 ft. to final depth of 3,921 ft.	107,175	16	5
	TOTAL	£111,564	9	8

(*c*) *Estimated cost of additional surface requirements at present under construction :—*

1.	Permanent ore and waste bins, together with permanent surface loading arrangements ...	£17,736	0	0
2.	Surface transport arrangements	6,000	0	0
3.	Transformer station	6,578	0	0
4.	Additional change house accommodation ...	2,756	0	0
	TOTAL ESTIMATED COST	£33,070	0	0

(*d*) *Estimated cost of two main pumping plants, together with necessary columns, which are at present being installed at the* 14*th and* 36*th Levels :—*

1.	14th Level pump station complete with columns, cables, etc.	£28,502	0	0
2.	36th Level pump station, complete with columns, cables, etc.	46,500	0	0
	TOTAL ESTIMATED COST ...	£75,002	0	0

(*e*) *Estimated cost of shaft equipment in excess of that which was required for actual sinking purposes :—*

1.	Permanent cage and skip installations, including winding ropes, together with necessary timber, goods and steel trucks for transporting material	£9,495	0	0
2.	Installation of additional runners for operating cages on four guides instead of two	3,000	0	0
3.	Installation of 12 in. air main, bell and lighting cables, together with accessories ...	8,788	0	0
	TOTAL ESTIMATED COST ...	£21,283	0	0

(*f*) *Estimated cost of main stations, bins, ore-passes, etc. :—*

1.	Total cost of main stations, cross-cuts, ore-passes, fan chambers, etc.	£39,842	0	0
2.	Shaft operating costs during the period of carrying out the above work since completion of actual shaft sinking	20,000	0	0
	TOTAL ESTIMATED COST ...	£59,842	0	0

	GRAND TOTAL ESTIMATED COST OF SHAFT WITH COMPLETE EQUIPMENT (Items (*a*) (*b*) (*c*) (*d*) (*e*) and (*f*) as detailed above)	£385,014	11	9

CONCLUSION.

Although record progress was recorded in the sinking of this shaft, coupled with record low costs per foot of sinking, I would advocate that a shaft sunk for a similar purpose should consist of six compartments of the same measurements inside timbers, *i.e.*, 10 ft. by 5 ft., instead of five compartments.

My reasons for this may be briefly summarized as follow :—

1. Opportunity would exist for an improvement in the speed of sinking due to there being three winding engines using six skips for shaft cleaning, instead of two engines using four skips for this purpose in the case of a five-compartment shaft.
2. The small excess cost for the extra timber required for the additional compartment would in all probability be balanced by the increased rate of sinking accomplished reducing other costs to a corresponding degree.
3. The speed of winding for the permanent equipment would be considerably reduced owing to there being space for two engines operating four skips, instead of two. The load of these skips could also be reduced, which, coupled with the reduction in hoisting speed, should considerably reduce the cost of shaft maintenance.
4. The addition of an extra compartment would increase the air capacity of the shaft for ventilation purposes by a further 20 per cent., which, although not absolutely necessary, would always be advantageous.

W. Reid : The author has described the sinking of a rectangular shaft in great detail and his paper will be a valuable reference, especially as a number of world's records for vertical shaft-sinking were broken during the sinking of this shaft. Mr. McLean and his staff are to be congratulated on the achievement of sinking a vertical shaft at the record rate which they maintained.

Since it may be of interest to members, I have made a few notes on the sinking of No. 17a Sub-Vertical Circular Shaft at the Crown Mines. This shaft is in process of being sunk from the 24th to the 48th Level ; 24th Level is 3,843 ft. and 48th Level will be 7,500 ft. below the surface ; the rock temperature at 48th Level will be around 100°F. At present the shaft is 150 ft. below the 41st Level, 6,500 ft. below the surface and the rock temperature is about 96°F.

Ventilation.—13,000 cu. ft. of air per minute is delivered to the bottom through a 30 in. galvanized iron pipe, water gauge 7½ in., by a 35 in. high-pressure Sirocco fan, the length of piping at present is 2,700 ft., temperature at intake 68° dry, 67° wet, temperature at discharge of pipe=83° dry, 74° wet and the temperature in the bottom of the shaft with 40 natives lashing is 80° dry and 78° wet bulb. The smoke from the blast is exhausted from No. 17a and delivered to the surface through 22 in. galvanized iron pipes by a 30 in. high-pressure Sirocco fan situated on 24th Level and assisted by a similar fan on the surface on No.

17 Shaft Bank ; the quantity exhausted from the bottom is 6,400 cu. ft. per minute. These two fans are run for an hour after blasting, and during this period the intake of the delivery fan is throttled down to reduce the quantity delivered to the bottom to 5,500 cu. ft. per minute. The sides of the shaft at the depth we have now reached stand up very badly and only about 12 ft. can be left open, which means that after every four blasts a concrete curb is put in and the shaft bricked up.

The sinking routine of a circular shaft is very similar to that given by Mr. McLean for the rectangular shaft, except that more time is occupied in lashing, owing to there being only two 3-ton buckets instead of four 2½-ton skips for cleaning out.

An eight-hour shift's work is as follows :—

Blasting interval		30 minutes.
Blowing over stage and lowering shift		30 ,,
Lashing	4 hrs.	30 ,,
Blowing over bottom and drilling	1 hr.	40 ,,
Charging up and blasting		50 ,,
	8 hrs.	

Twelve machines or more are used for drilling over according to the hardness of the rock and two, three or four lengths of steel as required to give the necessary length of hole ; 60 per cent. gelignite is used throughout and all holes are blasted electrically by low tension delay action electric fuses, four delays being used. 52 to 55 holes are drilled per round. Misfires are of rare occurrence.

European Staff.		*Receives.*
1 Mine Captain, Monthly Salary	100% of	Sinking Bonus
3 Sinkers at 25s. per shift	100% each	Sinking Bonus.
3 Helpers at 20s. per shift	60%	,, ,,
1 Stageman at 20s. per shift	60%	,, ,,
3 Banksmen at 17s. 6d. per shift	20%	,, ,,
3 Engine Drivers at 25s. 8d. per shift	20%	,, ,,
14		

Sinking Bonus : Up to 150 ft. per month 6/– per ft.
,, 199 ,, ,, 8/– ,,
200 ft. and over ,, 10/– ,,

Native Complement.—Forty-two natives on each shift in the bottom, six on the bank on each shift, and one on each engine driver's shift.

The rates of pay and bonus for natives are as follows :—

Handle Machine Boys.—A flat rate of 2s. to 2s. 2d. for 35 ft. drilled, thereafter 1d. per foot, marked 85 ft. when drilling, so that maximum rate per shift is 6s. 4d.

Spanner Boys are paid a flat rate of 1s. 10d. to 2s. for 35 ft. drilled, thereafter ½d. per foot drilled, and marked 85 ft. when drilling.

Lashing Boys.—A flat rate of 1s. 10d. to 2s. per shift plus a bonus of 6d. to 1s. per shift according to work performed.

During walling the natives required on the stage are paid the flat rate plus a bonus of 1s. ; the natives working on 24th Level during the walling period receive no bonus.

An average of about 120 shifts are lost per month due to accident and sickness.

The cost of sinking and walling 660 ft. sunk during the months of February, March and April, 1932, is as follows (after this, stations were cut every month and a true cost of shaft-sinking is not obtainable) :—

Sinking	£8,431 13 8	=	£12 15 6	per ft.
Walling	4,191 13 10	=	6 7 0	„
Winding, 17a	2,412 17 1	=	3 13 1	„
Ventilation running costs	123 2 3	=	0 3 9	„
Equipment (including ventilation pipes, water and air pipes)	620 9 7	=	0 18 10	„
TOTAL 17a	£15,779 16 5	=	£23 18 2	„
Winding, No. 17 Shaft	2,584 16 3	=	3 18 3	„
Tramming to Dump	666 19 7	=	1 0 3	„
TOTAL, including Winding at 17 Shaft	£19,031 12 3	=	£28 16 8	„

In conclusion, I should like to ask Mr. McLean if he did not consider equipping the shaft with steel instead of the wooden guides used.

B. D. Bushell : To sink a big rectangular shaft 3,835 ft. in 13 months and cut three stations leaves me rather breathless because, as I remarked at the last discussion on shaft-sinking, there was little to choose up to that date in the aggregate sinking rate of three dry shafts since two rectangulars at West Springs and Springs Mines averaged 156 ft. and 158 ft. per month respectively, and the Randfontein circular 155·5 ft. per month over the whole sinking period. Now West Rand Consolidated comes along with 295 ft., and one has to adjust one's standard all over again.

Turning to details, the provision of coffee and bread for the natives at any time of the day or night is an excellent scheme, as is also the use of the steel toe cap to assist in shovelling.

The sinking crews are almost the same as those required over 20 years ago when we had 26 men without pumpmen but including a drill sharpener, and our natives averaged 211 per day overall.

About October, 1920, I wrote a memorandum on the subject of shaft-sinking, when the No. 2 Shaft at Daggafontein had just been completed, in which I advocated increasing the number of holes drilled per round from 40—the average of the Dagga shaft—to 50 or 60 for any new work.

I note that the West Rand shaft averaged 83 holes per round drilled just under 4 ft. deep on average and broke 3·71 ft. per round against our 1·96 ft. at Dagga—the area of the two shafts being 425 sq. ft. and 418 sq. ft. respectively.

In the Dagga shaft we used 9·131 ft. of runners per foot sunk for four compartments, when only eight were theoretically needed, the excess representing wastage of temporary guides due to blasting plus about 3 per cent. loss in cutting. The wastage amounted to over £700 in money at the then current price, and I recommended the use of steel temporary runners for future work. I wonder what Mr. McLean did and what if any was his wastage.

The work performed in this West Rand Consolidated shaft constitutes a series of remarkable and notable achievements that Mr. McLean, his master sinker and sinking crews, both white and black, have every reason to be proud of, and I beg to offer them my mite of praise and congratulations.

21st April, 1933.