NOTES ON CEMENTATION AT VOGELSTRUISBULT GOLD MINING AREAS, LIMITED.

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When it was decided to adopt cementation in the sinking of the shafts through the dolomite at Vogelstruisbult the original intention was to drill deep holes by means of a diamond drill.

Shortly after the dolomite was entered a small chamber was cut at the south-west corner of the shaft at a depth of 200 ft. from the surface. From this chamber a hole was drilled parallel to the long axis of the shaft and pitched at such an angle that at a depth of 200 ft. the bottom of the hole would be opposite the north-east corner of the shaft.

The object of this hole was to explore for water-bearing fissures, and if water was met the scheme was then to cut a small chamber in the middle of the west wall of the shaft from which three 200 ft. holes were to be drilled for cementation. One of these holes was to be drilled vertically down and the other two inclined in a northerly and southerly direction respectively and parallel to the long axis of the shaft. The east side of the shaft was to be cemented by two holes, the original and a second hole drilled vertically down.

The rate of this diamond drilling in the cherty dolomite proved to be so slow—the hole was drilled to a depth of 126 ft. averaging 3 ft. a day—that it was decided to abandon the diamond drilling and to endeavour to drill holes for cementation by means of the sinking machines which are Ingersoll-Rand L74 machines. The first holes drilled were 15 ft. deep, 1 in. hexagon steel being used, the sets consisting of six drills in steps of 2 ft. 6 in. and the difference of gauge between bits was $\frac{3}{16}$ of an inch. The first drilling was slow and numerous holes had to be redrilled owing to the drills jamming, but as the natives improved under close supervision, the drilling became fairly easy. Four L74 machines were used to drill the long holes, and, when the natives became proficient, the sinker and his helper had no difficulty in supervising these machines.

When cementation of this series of 15 ft. holes was completed the shaft was sunk 11 ft., and then another series of 15 ft. holes was drilled and cemented.

The next step was an experiment with drilling 20 ft. deep holes which proved successful and sets were made up of eight drills in 2 ft. 6 in. steps, the first four of $1\frac{1}{4}$ in. steel and the second four of 1 in. steel, the difference of gauge between bits being $\frac{1}{8}$ of an inch, the first drill having a $2\frac{1}{4}$ in. bit.

A series of holes consisting of 20 holes around the shaft and three test holes as shown in Sketch A, Fig. 21, was usually drilled in from 16 to 20 hours, four L74 machines being used.

After cementation of this series of holes the shaft was sunk 17 feet, leaving a plug of 3 ft., which was considered adequate in the very compact dolomite, and another series of 20 ft. holes was drilled.

Finally 30 ft. deep holes were drilled, the sets consisting of 12 drills in 2 ft. 6 in. steps, the first four of 1¼ in. steel, the next five of 1 in. steel and the last three of ⅞ in. steel.

⅞ in. steel was not used from choice, but the longest bars of 1 in. steel obtainable in the country were 23 ft. However, the ⅞ in. steel has proved very satisfactory. The first series of 30 ft. holes took 41 hours to drill, but later took just under 30 hours. After cementation of the 30 ft. holes the shaft was advanced 27 ft.

After cementation of each series of deep holes was completed, three 20 ft. deep test holes A. B. and C. were drilled as shown in the Sketches A. and B., Fig. 21. The object of these holes was to ascertain if all water had been sealed off before sinking was resumed, and their position and direction was such that they would have intersected any fissures that the holes around the shaft had failed to intersect.

The series of 20 ft. holes was drilled at a 70° dip and 20° off the line of the long axis of the shaft and at 70° off the line of the short axis. The series of 30 ft. holes was also drilled at a 70° dip but at 30° off the line of the long axis of the shaft and at 60° off the line of the short axis. These directions in each case ensured an overlap of the holes.

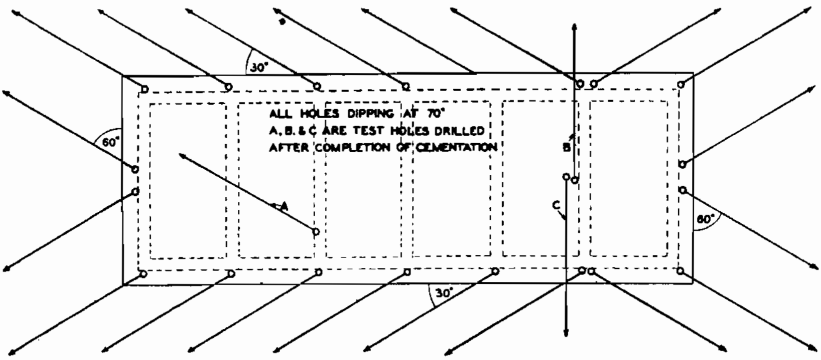
In the drilling of these deep holes the blowpipe was used to clean the hole thoroughly after each drill had been used. This precaution largely eliminated the trouble of jammed drills. The drill steel was laid out on the surface and was taken down as required. The drilling was started at one end of the shaft and all steel was sent down in the skip adjacent to the drilling. The sinking skip has a 48 ft. bridle on which there is a fixed ladder. The long steel was secured to this bridle by means of three clamps.

The drills, the bits of which were covered with sacking, were placed with the bit end in the skip. Each drill was fed direct from the skip to the hole and the blunted drill was similarly taken from the hole back to the skip.

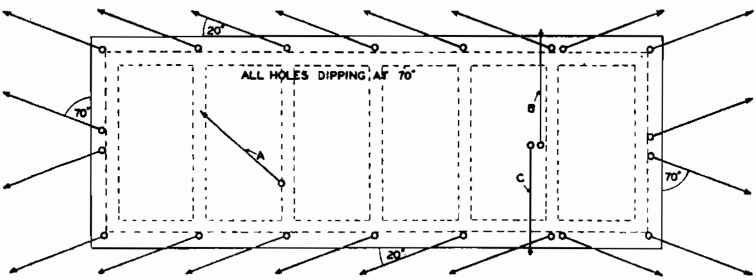
Steel not in use was not permitted to be in the shaft bottom, hence all danger of accidents occurring through unsecured long drills was eliminated.

CEMENTATION.

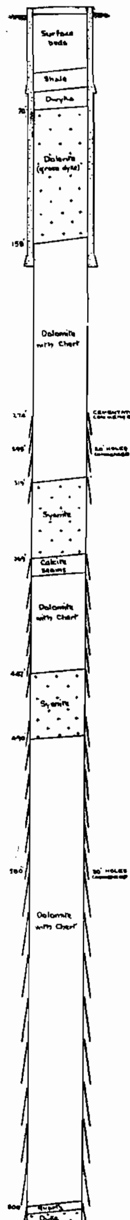
The cementation pumps, of which there were six, were located on the surface about 70 ft. west of the shaft. The columns for pumping cement into the holes were 1½ in. black piping. The holes were sealed off at 1,500 lbs. pressure at the pumps and at an increased pressure at the working face dependent on the depth. This black piping gave no trouble at all, except that the horizontal sections from the pumps to the shaft collar had to be disconnected and cleaned after each period of cementation.



SKETCH B 30 FT. HOLES



SKETCH A 20 FT. HOLES

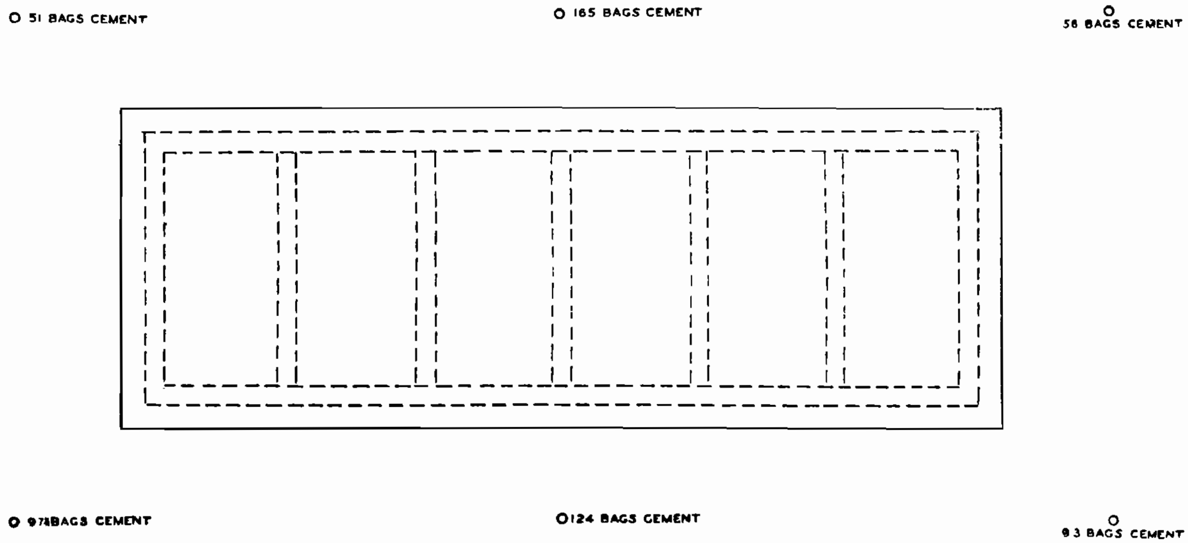


CEMENTATION OF NO. I SHAFT

VOGELSTRUISBULT G. M. AREAS LTD

REINFORCED CONCRETE MAT DIMENSIONS.

Area, 56′ 3″ × 50′ 0″ Depth, 2′ 6″ on outer edge of mat, graded to 4′ 0″ at shaft collar.



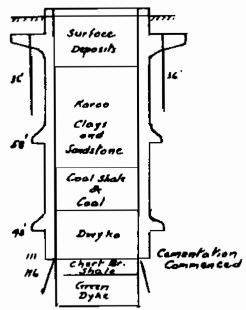


Fig. 22.

The drum connected to each pump contained approximately 35 gallons of water and the amount of cement used for a drum of water was 11 lbs. which gave just over 3 per cent. mixture. There was never any thickening of this mixture unless trouble was experienced when cement was breaking away near the hole due to the ground being slightly shattered by the blasting. When this occurred the mixture was thickened and on some occasions sawdust was added, but as soon as the breaking away had been taken up the original 3 per cent. mixture was reverted to.

There were no big fissures encountered, but usually the water was met in a network of fine fissures. Sometimes these fissures were interconnected, but far more frequently they appeared to be independent, as cement did not show up in one hole when another was being pumped.

The capacity of the 3 in. pumps was 480 gallons per hour and of the 2 in. pumps 240 gallons per hour.

As soon as the drilling of a deep hole was completed it was cased. A 5 ft. long 2 in. diameter pipe was inserted in the hole and a little lead wool was packed around this casing and then sika mixed with cement was filled in and the casing wedged up. Two hours were then allowed for this cement to set before pumping was started.

Pumping usually started six to seven hours after the drilling of the first holes was started. Before cement was pumped into any hole clear water was pumped for about half an hour. The object of this was to get the fissure as clean as possible. The last two drums (70 gallons) pumped before the hole was sealed off were always clean water. This prevented wastage of cement and kept the 1½ in. columns in the shaft clean.

From Table "C" (page 82) it will be seen that the average time for drilling and concreting a series of 20 ft. holes was approximately 48¾ hours, and for a series of 30 ft. holes approximately 49 hours 6 mins.

The cementation crew per shift consisted of four men and a leading hand—two men on the surface and two men at the shaft bottom. These men had nothing to do with the drilling of deep holes.

Month.	Footage Advance.	Remarks.
December	40	Sinking with two winches.
January	67	
February	68	
March	140	Three sinking hoists in commission.
April	176	
May	161	

Cementation was started at a depth of 274 ft. and finished at 799 ft. The cost per foot was £15 3s. 7d.

The residual water after cementation amounted to approximately 3 per cent. of the water in sight on the long holes.

At No. 2 shaft, owing to the water-logged condition of the ground due to heavy rains, a reinforced concrete mat was installed and six holes were jumped down around the shaft as shown in Fig. 22.

These holes were cased to a depth of 36 ft., at which depth they penetrated a soft sandstone. Cement was pumped into these holes at pressures varying from 150 lb. to 300 lb. per sq. in. in an endeavour to stiffen the sandstone.

Sinking was then continued to a depth of 111 ft. when water was encountered in chert breccia and the same routine of twenty 30 ft. holes was drilled around the shaft for cementation.

TABLE "C"

DATA OF EACH CEMENTATION.

Length of Holes drilled.	Commencement of drilling to end of cementation.	Cement Used. (Bags).	Gallons per hour of water encountered.
15 feet	134 hours	210	10,000
15 ,,	73 ,,	156½	Slight flow.
20 ,,	82 ,,	143½	200
20 ,,	82 ,,	223¾	5,000
20 ,,	—	No cementation	No water.
20 ,,	85 ,,	74¾	Slight flow.
20 ,,	34 ,,	62¾	Slight flow.
20 ,,	49 ,,	69¾	800
20 ,,	47 ,,	51¼	1,600
20 ,,	43 ,,	64¼	Nil.
20 ,,	35½ ,,	41½	Nil.
20 ,,	54 ,,	72½	4,000
20 ,,	28½ ,,	59¾	2,000
20 ,,	24¾ ,,	41½	Slight flow.
20 ,,	32½ ,,	41¼	Slight flow.
20 ,,	36 ,,	51¼	Slight flow.
30 ,,	59½ ,,	69¼	Slight flow.
30 ,,	48 ,,	90½	2,400
30 ,,	46½ ,,	77¼	1,200
30 ,,	39½ ,,	72¼	Slight flow.
30 ,,	30½ ,,	38½	Slight flow.
30 ,,	32½ ,,	47½	1,000
30 ,,	77¼ ,,	168½	11,300
30 ,,	59 ,,	50	No water.
30 ,,	—	No cementation.	No water.

Introductory Remarks by the Author: I have endeavoured not to elaborate all details but to outline briefly what was done at Vogelstruisbult. There are one or two points, however, to which I wish to draw attention.

(1) We were sinking very close to our cemented zone, viz., with a plug of 3 ft. Though this may appear risky in practice when drilling holes for cementation, we only once encountered water at 5 ft., once at 10 ft., twice at 15 ft. and on all other occasions water was met at a depth of over 20 ft. This suggests that the cement was giving us cover well below the depths of our holes.

(2) From our experience it would appear that, unless very big fissures are met, it should be possible to count on sinking 150 to 175 ft. per month and that a bigger footage should be obtained if deeper holes are drilled and cemented in the same time as 30 ft. holes.

(3) That probably the fastest sinking would be done by partial cementation, *i.e.*, to drill deep holes for cementation and only cement when water is encountered. This method, in my opinion, should not be tried in a known heavily watered zone, and in any event, the necessary pumping plant should be installed.

(4) The only pumps at Vogelstruitbult were two No. 7 Cameron, so no risks could be taken.

(5) All water was fairly easily shut off except the volume met near the bottom of the dolomite, which proved troublesome, and more holes than the usual series had to be drilled.

(6) It was also our custom to drill another hole in the neighbourhood of a hole that had encountered fairly heavy water, after the initial hole had been sealed.

(7) On numerous occasions when pumping a hole that had intersected water, cement would show in a dry hole, showing that these holes were connected, but pressure was needed to clear the fissure.

(8) On many occasions dry holes took more cement than wet holes.

(9) Since this work was done an experimental hole was drilled at Vogelstruisbult No. 2 Shaft in an endeavour to drill a 40 ft. hole. An N.75 machine was used with no front-head release ports, so that air passing through the steel was assisting the sludging.

The first six lengths to a depth of 15 ft. were $1\frac{1}{4}$ in., the gauge difference being $\frac{1}{16}$ of an inch. The next eight lengths to a depth of 35 ft. were 1 in. hexagon. The last two lengths were $\frac{7}{8}$ in. to depth of 40 ft. Unfortunately the bit of the 37 ft. 6 in. drill broke off so that the hole was drilled to a depth of only 36 ft. 6 in. The overall drilling time was $4\frac{1}{4}$ hours and the average drilling speed 5·15 in. per minute.

(10) The greatest quantity of water encountered in any one hole was 5,000 gallons per hour—the neighbouring hole had only slight flow, but the water was sealed from this second hole.

(11) The cementation crew were employees of the Francois Cementation Company (Africa) Limited, and I desire to express my appreciation of the co-operation of Dr. Voskule and Mr. Willcox—the latter was directly supervising the cementation work. Also I wish to express appreciation of the able assistance of Mr. C. H. Davis of Ingersoll-Rand Company in the drilling of the deep holes.

A. L. James : Mr. MacWilliam in his valuable paper has described what is, I think, the first case in which the dolomite formation on these fields has been penetrated without the use of pumps. One of the most interesting features of the method adopted is the use of ordinary rock drills instead of diamond drills to drill the cementation holes.

This contribution will be confined to a few remarks on the subsequent history of No. 1 Shaft and a description of the sinking of No. 2. Shaft through the dolomite, in which the same method was used.

No. 1. *Shaft.*—No increase in the quantity of water entering the shaft has occurred since cementation stopped.

The shaft entered quartzite at 799 ft. and at 856 ft. a dolomite pump station was cut and a pump installed. The cost of installing this pump, including chamber and sump, was £850. The quantity of water handled is 28,000 gallons per 24 hours, or 840,000 gallons per month. Ten thousand gallons of water per 24 hours are bailed from the shaft bottom, which is now over 3,000 ft. in depth.

No. 2. *Shaft.*—This is a six-compartment broad rectangular shaft identical in size and timbering with No. 1. Shaft.

From known geological sections in the district it was estimated that the dolomite series extended to a depth of approximately 450 ft., and judging by the high ground water level and the waterlogged nature of the surface strata, it was anticipated that fairly large volumes of water would be met with in the dolomite.

It was decided to carry on sinking with a temporary headgear and four temporary winches—three 35 h.p. electric and one 40 h.p. air—until the arrival of the permanent electric winders from England. These winches operated 1-ton buckets in Nos. 2, 3, 4 and 5 compartments.

The permanent steel headgear was erected while sinking proceeded.

The Black Reef quartzite was actually entered at 483 ft., and the first of the permanent winders was placed in commission when the shaft had reached a depth of 470 ft., hence, practically the whole of the dolomite and the whole of the water-bearing strata were penetrated with the temporary hoisting equipment described above and a pumping plant consisting of two No. 7. Cameron pumps.

The actual cementation work was carried out by the Francois Cementation Company.

Systematic cementation began at 132 ft. in chert breccia, and at 172 ft. the permanent toe was cut in dolomite and the reinforced concrete collar completed to this depth.

Heavy water, amounting to 680,000 gallons per 24 hours, was struck in this section, principally in a 12 in. seam of wad between the chert breccia and the dolomite. Cementation was difficult here, for while large quantities of cement were taken by the wad seam, penetration of the chert breccia was poor, and hence residual water was high, amounting to 60,000 gallons per 24 hours. As there was some danger of this water washing the cement out of the concrete collar as it was being built and thus weakening the collar, the following method was used to deal with it :—

Rubble walls were built against the sides of the shaft and drain pipes were led from these walls to the inside of the shaft. These walls were insulated from the general mass of concrete by bags of wet concrete, and after the collar had been completed the cementation pumps were used to pump cement into the drain pipes and thus consolidate the rubble walls. The quantity of water reaching the shaft bottom after the operation had been completed was 1,000 gallons per 24 hours.

There followed 49 ft. of dolomite containing comparatively little water, and then a band of green dyke 67 ft. in thickness. This green dyke was very much decomposed, especially the last 30 ft., and gave the usual trouble due to the sides of the shaft scaling away during sinking. Timbering precautions taken in the green dyke included doubling up the setts and carrying them to within 8 ft. to 12 ft. of the face, also close lagging of the shaft and staging over the blocks. Eighty feet of concrete lining was installed in this section making 252 ft. of concrete lining in the first 300 ft. of shaft.

Below the green dyke was a band of syenite dyke 36 ft. thick, and then dolomite containing large volumes of water, 32,000 gallons, 150,000 gallons, 125,000 gallons and 540,000 gallons per 24 hours being accounted for in successive cementations, the last being at a pressure of 60 to 80 lb. per square inch.

Below this was 100 ft. of dolomite containing moderate quantities of water, and Black Reef quartzite was entered at 483 ft. Cementation was stopped at this depth as the quartzite was free from water, but pilot holes were continued for some distance.

The following tabulation gives the time taken, the quantity of cement used, and the quantity of water encountered for each cementation :—

Depth of Shaft.	Length of Holes.	Time taken from beginning drilling to end of cementation.	Cement Used (Bags).	Gallons per hour of water encountered.
Feet.	*Feet.*	*Hours.*		
132	20	74½	60	3,200
149	26	228	1,090	25,260
172	30	72	59	Slight.
199	30	56	118	Slight.
313	28	59	109	1,350
337	30	53	94	6,500
351	15	42	145	5,200
362	25	106	454	22,550
378	28	48	134	1,350
404	28½	41	110	200
434	29	36	52	1,700
459	29½	43	35	Nil.
Totals	319	858½	2,460	67,310 = 1,615,440 gallons per 24 hours.

The total quantity of water passed through was 1,615,000 gallons per 24 hours. The residual water after cementation amounted to 40,000 gallons per 24 hours or 2·5 per cent. of the total water met with. A dolomite pumping station similar to that at No. 1. Shaft has now been installed which handles the majority of this water, and about 10,000 gallons per 24 hours are being bailed from the shaft bottom.

It should perhaps be explained that the method of arriving at the quantity of water passed through consisted of measuring the flow from all the cementation holes. As all the holes of a round were not measured simultaneously, the flow from each hole being measured as soon as it was drilled, it may be contended that the quantity of water measured was greater than the actual quantity present. This, however, in my opinion, is not the case, for on many occasions holes which had drilled into water were shut off without having any effect on the flow from neighbouring holes. Furthermore, it must be remembered that many of the later holes in a round were drilled after cementation had proceeded some distance, and hence the water that they might have tapped had already been partly sealed off.

On the whole, I think the evidence goes to show that considerably larger quantities of water than those recorded would have been met with had sinking proceeded without cementation.

Method of Drilling.—The method of drilling described by Mr. MacWilliam was used throughout, the only modification being that 20 ft. holes were reverted to in some of the later rounds where heavy water was encountered in broken ground.

The reason for this was that, with 30 ft. holes under these conditions, the residual water was found to be higher in the last 12 ft. of sinking than in the first 15 ft., due to cementation being less efficient in the bottom half of the hole.

This was ascribed partly to the taper of the hole giving less area for the cement to penetrate and partly to cement gravitating to the bottom of the hole and clogging the crevices in this section of the hole before pressure had time to build up, and thus preventing the subsequent spread of the cement.

Casings.—To overcome the loss of time due to casings breaking away, various new types of casings were tried.

In the first, the casing pipe was made to fit fairly neatly into the hole and was expanded from the inside after being placed in position by a boiler tube expander. This was defeated by the fact that the holes, being drilled with cross-bits, were rifled internally instead of being truly circular in section.

Rose bits were used with the second type of casing which consisted of a pipe somewhat smaller in diameter than the hole, so that an annular space was left between the hole and the pipe. Rings of copper and lead were threaded over the pipe and driven down into this space by a driving sleeve from the top. This was very successful where the holes were dead straight, but it was found that, the machines being hand-held, small variations of direction occurred in collaring which caused the rings to stick. This method could, however, be used with rigid machines.

The third type of casing, which was ultimately adopted, consisted of an inner and an outer tube. The inner tube was threaded and worked in a nut at the bottom of the outer tube. The bottom of each tube was fitted with a flange and packing was placed between these flanges in such a way that, by tightening up the inner tube, the packing could be made to expand against the side of the hole. This method, when used in conjunction with Sika cement and wedges, gave a very reliable casing.

A telephone was installed from the bottom of the shaft to the pumps.

Machines.—In the later cementations two C.D.V. 3½ in. machines were used with improved results.

Jumper Extractors.—Quick and efficient extraction of the jumper is essential in drilling the long holes, in fact, if the jumper is not extracted within the first few moments of stopping drilling the hole is usually lost. To meet this difficulty, a big two-handled jumper extractor with toggle jaws to grip the jumper was designed on the mine, and proved very useful.

Cementation.—The largest accumulations of water were met with in the bed of wad at the top of the dolomite and at a point 100 ft. from the bottom of the dolomite where a steeply dipping fissure carried water at a considerable pressure.

For the rest, the water was carried in a network of small fissures, sometimes interconnected, but more usually not so. At times one hole would seal off the whole of one side of the shaft, and at other times, particularly in the chert breccia, the cement would hardly travel at all. It frequently happened that after a hole, which had struck a considerable column of water, had been sealed off, another hole drilled 12 in. from it would strike an equal quantity of water and even after this hole had been sealed, a third hole would occasionally give the same flow.

On one occasion an attempt was made to use inert material mixed with cement. This was in the wad seam where one hole took 10 days to seal and required 784 bags of cement. A mixture of one part of slime with two parts of cement was tried, but on subsequent sinking the slime was found to have separated out from the cement.

The following shows the monthly advance :—

Month.	Footage Advanced.	Total Depth.	Remarks.
May	42	132	Concreting and cementing Collar. (May–July)
June	17	149	
July	23	172	
August	120	292	
September ...	59	351	Concreting green dyke.
October	108	459	
November ...	113	572	Cementation stopped at 483 ft

COSTS.

Cementation No. 2 Shaft (from 172 ft. to 483 ft.), 311 ft. sunk.

		Amount.	Cost per ft. cemented.
Cementation Company's accounts for Labour, Material and Supervision		£3,213 6 8	£10 6 8
Mine Charges:	White Wages	387 15 5	1 14 11
	Native Wages	532 6 8	1 14 3
	Compound Expenses	187 6 5	0 12 0
	Cement and Stores	454 13 3	1 9 3
	Workshop Charges	34 14 9	0 2 3
	Ventilation and Lighting	7 0 1	0 0 6
	Air Power	103 17 6	0 6 8
	Rock Drill Maintenance	128 9 11	0 8 3
	Drill Sharpening	55 6 2	0 3 6
	Hoisting	482 1 0	1 11 0
		£5,586 17 10	£17 19 3
		Total	Cost per ft. sunk.
Cost during cementation period		£22,120 9 3	£71 2 6

E. P. Cowles: Mr. MacWilliam deserves great credit for having successfully pioneered a new sinking practice and the thanks of members for having placed on record the results of his work. His paper describes the various stages passed through in perfecting the system from the original plan of depending on diamond drill holes to the satisfactory drilling of 30 ft. holes with the sinking machnies, and the cementation details.

There are two points on which Mr. MacWilliam may be able to give further information. No mention is made of the static pressure of the water intersected in any of the holes. Presumably, any hole that struck water was stopped, cemented and thereafter drilled to its full depth to complete the fan of holes. It seems from the figures on page 80, that the average time taken to drill a 30 ft. hole was about six hours, and it would be interesting to know the comparative drilling speeds for 20 and 30 ft. holes under the same conditions. The drilling technique appears to have so improved towards the end of the operations that the comparison of 48¾ hours for a 20 ft. series and 49 hours and 6 minutes for a 30 ft. series is hardly fair. Finally, will Mr. MacWilliam tell why the pilot hole machines were limited to four instead of using all the drills available ?

It may be remembered that No. 1. Shaft, East Geduld, had to pump and bail 2,000,000 gallons per day at one time, half of this quantity from above three intermediate pump stations and the remainder from the bottom at nearly 1,000 ft. below the surface. The sinking of this shaft progressed satisfactorily to a depth of 460 ft. in 8½ months, during which period all surface construction was completed; the shaft was concreted to dolomite at 54 ft. and the "green" dyke was also lined with concrete from 290 to 407 ft. A small pump station was cut above the

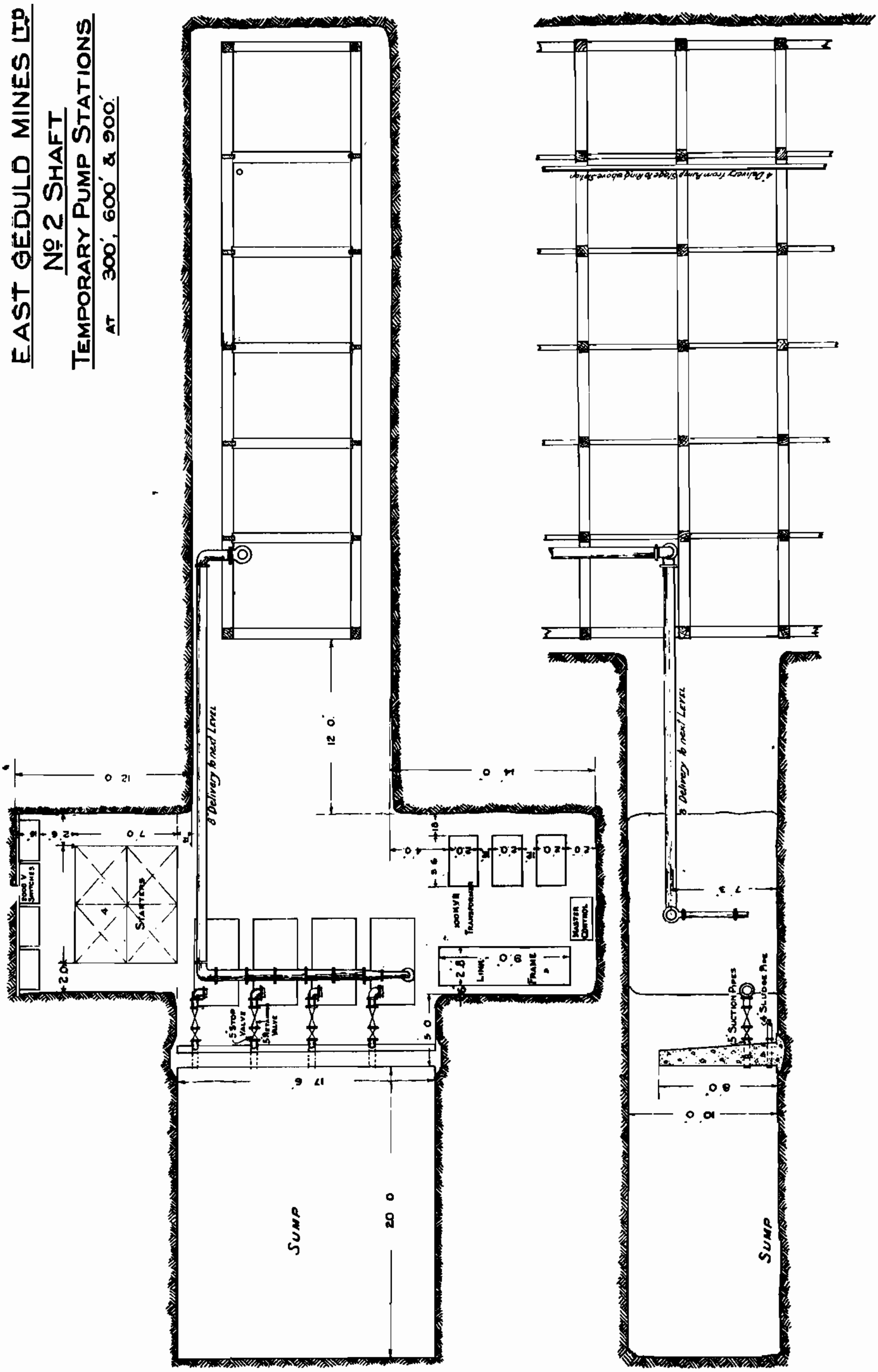

EAST GEDULD MINES LTD
No 2 SHAFT
TEMPORARY PUMP STATIONS
AT 300', 600' & 900'
8" Delivery to next Level
Starters
Sump
Sump
Master Control
100 KVA Transformer
Frame
5" Suction Pipes
4" Sludge Pipe
5" Stop Valve
8" Delivery to next Level

Fig. 23.

dyke. The bottom of the dolomite at 1,021 ft. was reached in 6½ months or at an average sinking rate of 85 ft. per month including the cutting of two intermediate stations.

This experience influenced the incorporation at No. 2. Shaft of a sixth compartment to below the bottom of the dolomite, in which a pump stage, operated by a powerful single-drum geared hoist, was installed. The stage was designed to hold four electric centrifugal pumps of 30,000 gallons per hour capacity against 375 ft. head. Intermediate pump stations at 300, 600, and 900 ft. were cut and equipped, each with three centrifugal pumps of 30,000 gallons capacity, see Fig. 23. The stations were equivalent to about 80 ft. of driving (14 ft. by 10 ft.) and the last one was cut with a loss of 12 sinking shifts. The object of the pump stage was to be able to lower large capacity pumping plant into the shaft bottom immediately after the blast and to pump from there to a temporary pump station. Our thanks are due to Mr. Richardson of Randfontein Estates for the proposal to use electric centrifugal pumps in the shaft bottom, as described in his paper. It was later decided to continue the sixth compartment to the bottom and to use it as a ventilation upcast.

Contractors sank and lined the shaft to 17 ft., completed the mat, a portion of the headgear, and had started on boilers, winding engines and transformer house, etc., in 3½ months. The shaft was sunk 205 ft. in the following five months with two winches. It was necessary to stop for concreting on five occasions to a total lined depth of 209 ft. on account of cavities in the dolomite and the " green " dyke. The two steam rock hoists, headgear and skips were available before this depth of concrete lining was completed.

The shaft was then sunk 804 ft. in 4¼ months to the bottom of the dolomite at 1,026 ft. The three intermediate pump stations were cut during this period. The pump stage was equipped with two No. 7. Cameron air pumps which delivered to the pump station above or to another air pump at an intermediate ring when the head exceeded 150 ft. The quantity of water in the shaft bottom did not necessitate the use of electric pumps on the stage.

The sinking of this 804 ft. was carried out with what one might term partial cementation together with the pumping plant described above. The cementation pump was operated on the surface through a 1 in. steam pipe carried to the shaft bottom. Four 17 ft. pilot holes were drilled on each shift at the start. The length was reduced to 12 ft. and then to 10 ft. When the presence of water was suspected or it had been struck and sealed with cement, a number of 17 ft. holes were drilled dry before sinking was resumed. The rock drills used were N.75 sinkers with hexagon round shanks on 1 in. diameter steel.

Sinking was stopped for cementation on five occasions, at 222, 405, 715, 865 and 890 ft., and water fissures were also cemented in the 300 ft. pump station. The first three stoppages caused a loss of 13 sinking shifts and a total of 90 bags of cement were used. The fissure at 860 ft. was more troublesome. Twice, after sealing and blasting, water was again struck by pilot holes. The lost shifts were 13 and 35 bags of cement were pumped. Forty 17 ft. pilot holes were drilled in the bottom at this point. The last water intersection took 13 shifts to seal with 65 bags of cement. The total shifts spent on cementation were 39.

The security of adequate pumping plant for emergencies, and to deal with such residual water as may remain after cementation, combined with comparatively short pilot holes as a precaution and the sealing by cementation of any water that may be intersected, appears to me to give facilities for rapid sinking through the dolomite occurring on the Far East Rand. The cost of cutting the stations is not great ; the temporary pumping plant can be recovered and a sufficient number of short pilot holes can be drilled while blasting three times per 24 hours. The advance in two successive months was 210 ft. A pump station was cut during the first month and, in the second, the shaft was twice stopped for cementation.

The water fissures encountered were not serious as regards number, width or static pressure as was the case at No. 1. Shaft. The relative sinking rates were 190 and 85 ft. per month and, while the conditions were not comparable, there is no question that the use of cementation made the former speed possible.

25th January, 1935.