WEST DRIEFONTEIN -ORDEAL BY WATER

A. P. CARTWRIGHT

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Foreword by the Chairman

This book was commissioned with the express purpose of endeavouring to place in true perspective the efforts which led to the successful outcome of the struggle against an unprecedented and completely unexpected inflow of water into the mine in October and November, 1968.

The burden of the technical planning and the responsibility for decision could be borne only by the technical advisers and the senior members of the mine's management. This burden was made significantly lighter by the magnificent and voluntary response of all employees who took up the challenge. Obviously it has been impossible to record every individual's contribution in courage and endurance.

It is my sincere wish that all employees who have been presented with a copy of this book will accept it and treasure it as an acknowledgement of the admiration and esteem engendered in the people of the Republic of South Africa, and those of many places in the Western World, for their response to the challenge which nature had set them.

Finally, I wish to pay tribute to the author for the enthusiasm, speed and zest with which he tackled this assignment.

Author's Note

This is the full, unvarnished story of how some 4,000 men at the West Driefontein mine battled against an inflow of water that must have totalled at least 2,000-million gallons between October 26 and November 18, 1968. It was written in the fortnight that followed the announcement that the mine had been saved. While this had disadvantages for the author they were outweighed by the fact that all the incidents recorded were described to me while the details were fresh in the minds of those who had been involved. I have written it in the simplest language so that even those who have no knowledge of the processes of mining will be able to read and understand it. It was impossible to include all the stories the men told me. However, since this was above everything else a magnificent effort by a team who fought to save *their* mine, those who do speak may be said to speak for all.

I am convinced that in all the long history of mining there has never been a finer story than this. It is a wonderful record of courage, endurance and great engineering skill. But you must choose your own heroes once you have read the narrative. To make it quite clear where I think the honour lies I dedicate this book to

> the Consulting Engineers of Gold Fields of South Africa and the Managers and Men of the West Driefontein Mine.

WEST DRIEFONTEIN -ORDEAL BY WATER

The near-disaster that descended upon the West Driefontein gold mine out of a clear sky on a sunny Saturday morning in October, 1968, bears some resemblance to that moment of horror at sea when, on a calm day, a liner strikes an uncharted reef.

Here was a great gold mine carrying out its normal Saturday routine. The morning shift had gone underground at 7 o'clock. Hoists, ventilation fans and such pumps as were on duty, lifting water from the bottom of the mine, were working smoothly. Everything seemed in apple-pie order.

The first written record of the disaster: the note that was sent to surface to inform the management of the mine that stope 46B on 6 Level west of No. 4 Shaft had broken open and that water was running six inches deep into the shaft.

There was nothing at all unusual in any of the reports the sectional managers had received. Officials not on the duty roster were planning to play golf that afternoon. The miners were looking forward to the usual diversions of the week-end which they believe they enjoy more than ordinary human beings who don't work underground.

Let it be said that West Driefontein is not only incomparably the most profitable gold mine the world has ever known but that it is also one of the best equipped and most efficient mines in the South African industry, which is saying a good deal. In the course of the sixteen years that have elapsed since it first began to produce—and to shatter all existing output records—it has had to bear its share of misfortunes. The worst of these was the disaster in 1962 when a vast sinkhole opened on the surface and swallowed up the crushing plant, which took 29 men down with it.

As the result of the trials and tribulations of its early years and its unceasing battle with the water-bearing fissures of the Far West Rand the mine's early-warning system is a highly developed one. Mr. Ray Buley, the general manager, or Mr. Allen Pole, the manager, has merely to make one short telephone call to bring all five shafts to action stations and to set a huge battery of pumps to work.

But there were no indications of trouble to come, no warnings and no alarm bells that morning. At 9.40 a.m. the banksman at No. 4 Shaft received a message from the onsetter to say that "a great deal of water" was coming down the shaft. The man below sounded worried.

Now "a great deal of water" at West Driefontein, depending on who uses the phrase, can mean anything from a trickle to a million-gallon shower of mud and water coughed out by a small fissure. The mine has dealt with many such occurrences so this report caused no alarm on the surface. But there were nearly 1,200 men in the workings from 4 Level to a pump station at the bottom of the shaft, 4,600 feet down. It sounded as though the water coming down the shaft might be making things "uncomfortable" for them—as indeed it was. So an underground manager, L. R. Alexander, accompanied by Jack Cuthbertson, a mine overseer, went down in the rock hoist to find out what was going on.

By this time the report "inflow of water at No. 4 Shaft" had reached the general manager's office and these two were followed down by sectional manager H. R. K. (Harry) Wheeler. They all went down the shaft to deal with what they regarded as a minor emergency. The inflow of water would have to be diverted . . . there might be a fissure to be plugged . . . it was a damned nuisance on a Saturday morning. But it could be dealt with in a matter of half an hour, perhaps an hour at the outside.

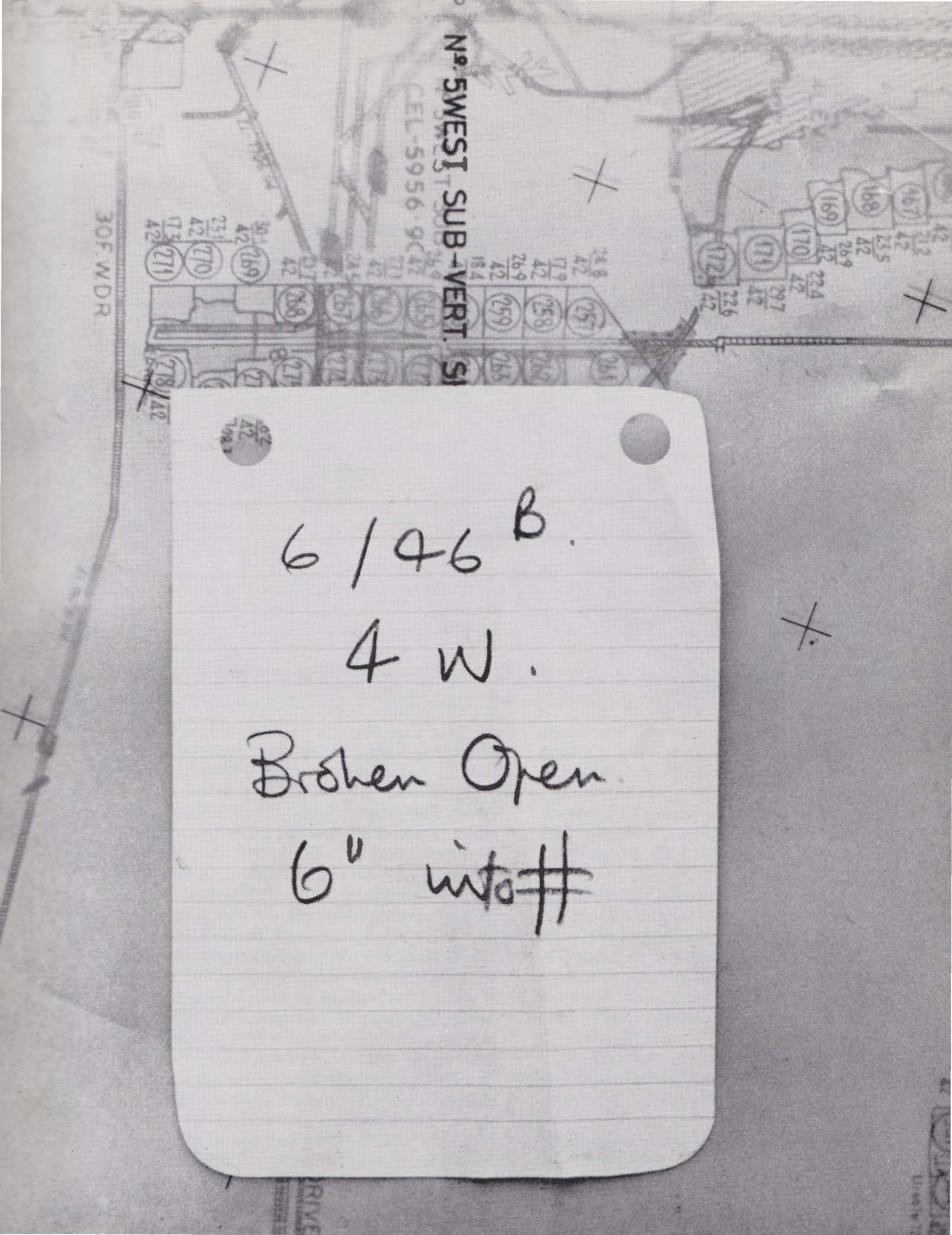
What they saw—and heard—once the cage was below 4 Level soon changed their minds. "A great deal of water" was the understatement of the year. It was a cascade, a torrent, that pounded on the roof of the cage and roared as it poured down the 4,000 feet to the bottom of the shaft. This was no ordinary "inflow". Water coming down at this rate meant trouble.

Their first thought was: "We must get the men out".

No one at that hour had time to make calculations and no one really knew what had happened. There was a job of the utmost urgency to be tackled.

But at this point, using our hindsight, it is possible to explain to the reader how grave the situation was though no one on the mine, from the general manager downwards, as yet had an inkling of what was in store for him. Perhaps it was as well they hadn't . . .

This was no ordinary fissure that had opened in the upper reaches of the mine. Somewhere, up above the workings, the rock formation had parted to produce an aperture—a "leak" if you prefer it—that led directly or indirectly, not to



6/46 B.

4 W.

Broken Open

6" into ##

a mere "pocket" containing 100-million gallons more or less, but to the great underground reservoir that lies below the surface of the Wonderfontein Valley and is known as the "Bank Compartment".

Water in the dolomite

Here some simplified geology is required to explain the formations beneath which the workings of the mines of the Far West Rand lie. West of Randfontein, as far as the Mooi River, there is a vast bank of dolomite that extends from almost immediately below the surface to a depth of 2,000 to 4,000 feet. Through countless thousands of years this slightly porous formation has acted as a vast receptacle for the natural water of the district—seepage of rain and underground springs.

This water, working ceaselessly to erode the dolomite through the centuries, has carved itself reservoirs, some big, some small. In these it lies peacefully until it is rudely disturbed by the collapse of a dolomite layer that forms a wall or the bottom of its particular reservoir. Then it either flows into another cavern at a lower level or occasionally finds a fissure that takes it down.

This natural process, continued for millions of years, tends to produce bigger and bigger reservoirs. It is these bigger compartments with which we are concerned at the moment. The best way to picture them is to have in your mind's eye something like a gigantic model of the ice tray in your refrigerator. If you imagine this tray slightly tilted so that the water from one compartment flows into the next, constantly replenishing it, you have a rough idea of the underground water system in the dolomite beds.

Many millions of years ago intrusions of molten material from the core of the Earth formed massive dykes in the district that extend up through the dolomite and form the dividing walls of those compartments.

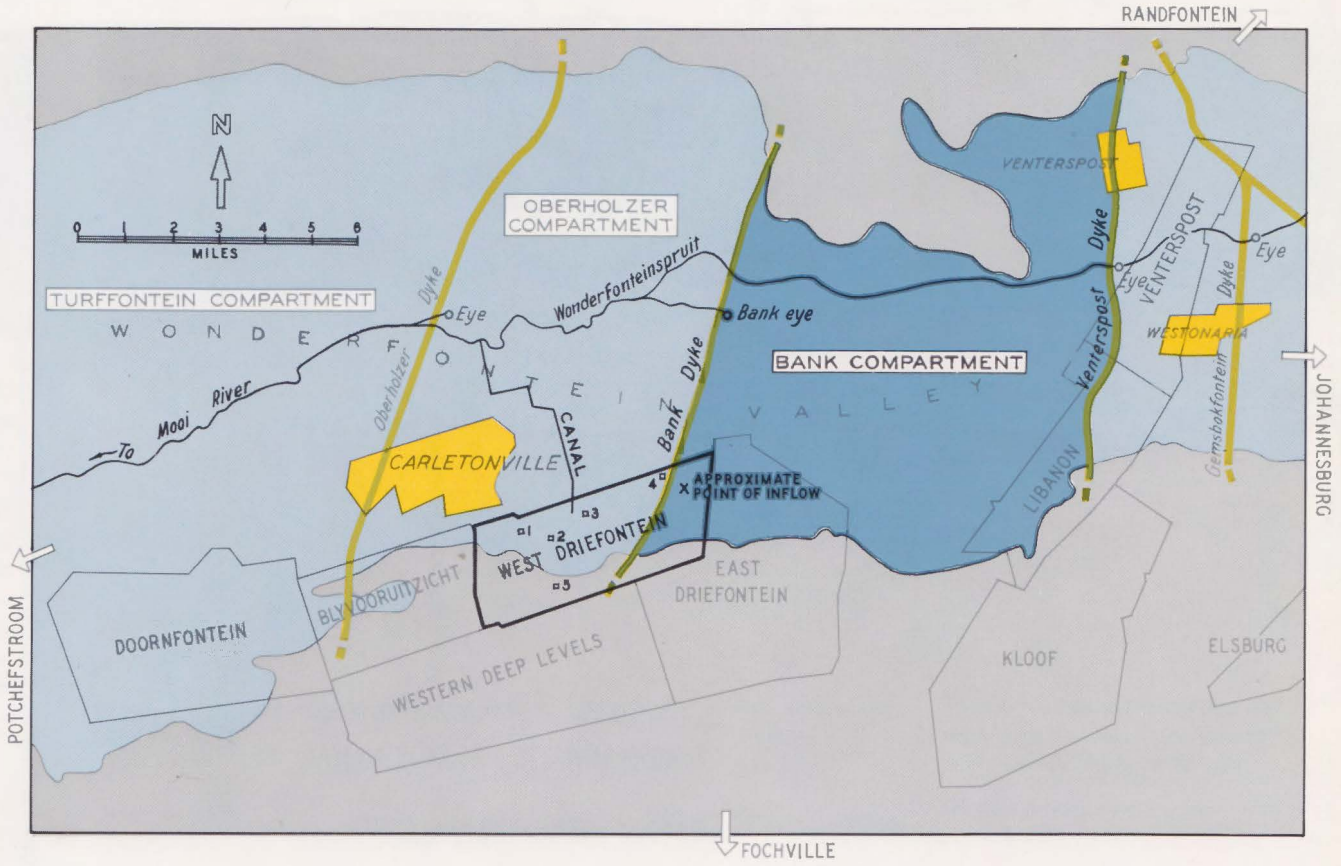
The firmly established belief in the Wonderfontein Valley that a great underground river flows through the dolomite, constantly filling up the reservoirs and their satellites, the fissures, is decried by the geologists. But there are innumerable underground springs that feed the compartments and many of these natural reservoirs are connected so that as water is drawn off more flows in.

The "eyes" that have provided the farms in the district with a perpetual water supply are to be compared to the overflow pipe in the cistern in the small room next to your bathroom. They are outlets at the top of the compartments which, fed by gravity, have always overflowed—that is until the mine pumps went to work in earnest.

Blyvooruitzicht, Western Deep Levels and the greater portion of West Driefontein lie under the Oberholzer Compartment. The fissures in this area have been the cause of endless trouble in shaft sinking and an expenditure over the past 25 years of more than R200-million on pumping costs.

West Driefontein, from 1955 onwards, has never pumped out less than 7 million gallons of water a day and from 1962 to 1964 was obliged to take out more than 30 million gallons a day. This was to lead to the installation of pumps on a scale that exceeded anything that had ever been attempted in South Africa. The mine was eventually equipped with pumps capable of handling 63 million gallons of water a day. And as an additional precaution water-tight doors were installed to protect the pumping shafts up to 16 Level. These doors had been installed progressively over the previous twelve years and provided a unique and ever-increasing storage capacity which was about 1,000 million gallons by the end of October, 1968. So there was reason to suppose that it would be able to cope with any conceivable emergency.

The water compartments in the dolomite area of the Far West Rand.



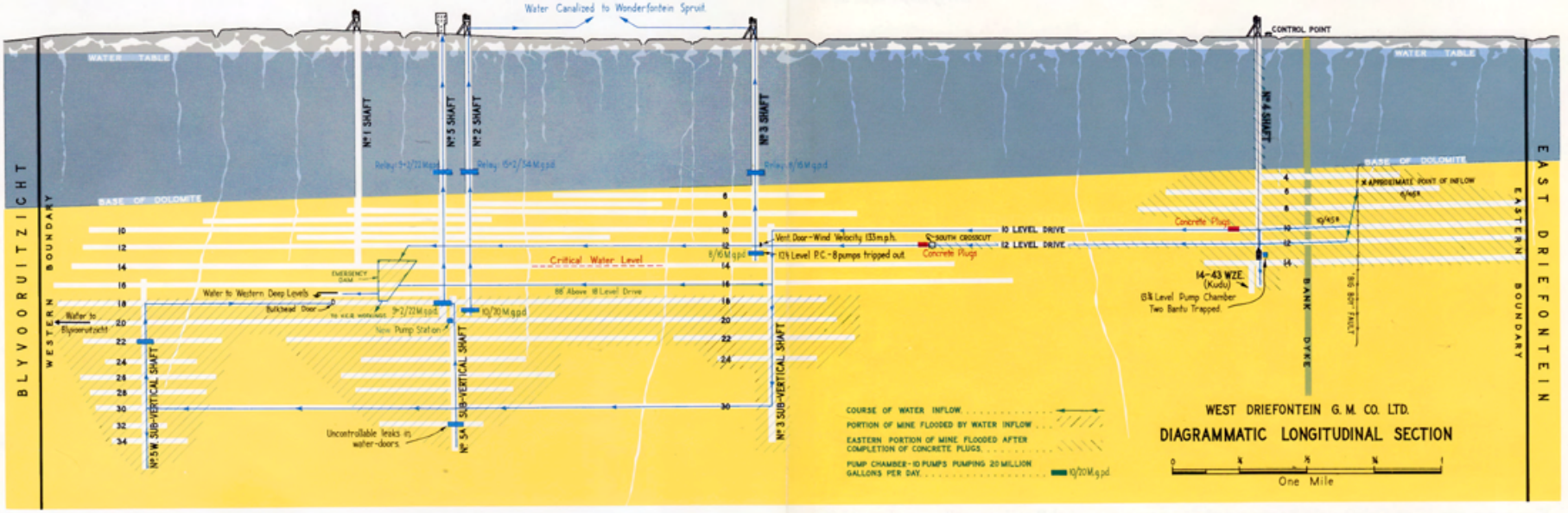
Five years ago West Driefontein began development of the far eastern section of its lease area to mine the Ventersdorp Contact Reef there. No. 4 Shaft, which had been sunk for this purpose was deepened and work began. Mining here meant driving through a particularly big fault, irreverently known as "Big Boy" by everyone on the mine. This fault extends up to the base of the dolomite under the Bank Compartment so that in the stopes to the east of it West Driefontein reached out for the first time to work beneath this other great compartment, estimated to extend over sixty square miles and to hold perhaps 100,000 million gallons of water or more.

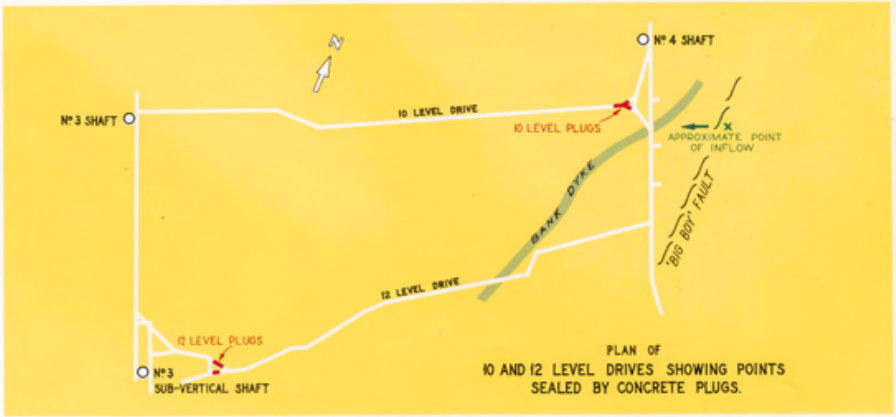
But the Bank Compartment and its satellites had given comparatively little trouble to Libanon, the mine further east. True, Venterspost had suffered tremendous inrushes of water while shaft-sinking, but that mine had never been obliged to pump more than 12 million gallons a day while at Libanon the total has never exceeded 3 million gallons a day. These were fleabites compared to West Driefontein's battle with Oberholzer's water.

However, these were not considerations that could be taken into account in planning development. It was safe mining all the way. There were thousands of feet of rock between the bottom of the dolomite and the workings except where Big Boy intervened. The pilot drills released no more than the usual amount of water. For more than two years work went on round Big Boy and beyond him in a perfectly normal manner. 10 Level was planned as a haulage that would eventually extend to the boundary and into the East Driefontein mine where the sinking of the first shaft had begun. Both 10 Level and 12 Level connected No. 4 Shaft with No. 3, the distance between the shafts being some 12,000 feet.

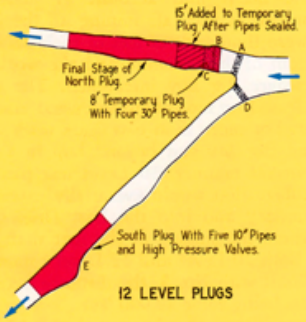
What was it then that happened at 9.15 a.m. on Saturday, October 26?

All that can be said with certainty is that a

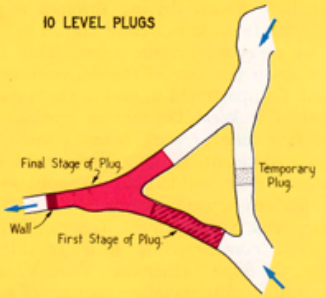




PLAN OF
10 AND 12 LEVEL DRIVES SHOWING POINTS SEALED BY CONCRETE PLUGS.



12 LEVEL PLUGS



fissure opened somewhere between 4 and 6 Levels. The exact spot and the size of the gap remain the subject of surmise. No one succeeded in getting near the source of the torrent. The force of the water made a survey impossible and until the day comes when the Bank Compartment is pumped dry, whenever that may be, no geologist will be able to inspect the orifice through which the water flowed. But to those who have followed the story of West Driefontein's fight for its life it may be of interest to know that this could have been as small as 140 square inches. It has been estimated that it required only a crack 140 inches long by one inch wide, given the pressure overhead, to pour 82 million gallons a day into the mine.

One theory is that a slight tremor on Friday night may have started a movement of rock that would have been sufficient to cause this fracture. Another theory is that the apex of the fracture was at a point where the Big Boy fault intersects another fault that extends across the whole strike of the mine much higher up, that the water found a weakness here and forced its way down to burst into the workings.

Whatever the ultimate finding may be, the hard fact is that the "leak" had some 2,800 feet of standing water above it exerting fearful pressure. It is possible that, after the initial burst, the force of the water slightly enlarged the vent. Some of the men who were on the spot are convinced that the inflow increased considerably during the first fifteen minutes. But in the confusion, the shattering noise in the shaft and the almost complete lack of visibility these were "guesstimates".

Whether they were right or wrong—what does it matter? The results, as far as the men and the mine were concerned, could scarcely have been worse had a drill tapped the bottom of the Mediterranean.

But remember that this is an account of a battle written after it had been won. Neither the managers on the surface nor the men in No. 4 Shaft on that Saturday morning knew what was happening or could estimate how much water was coming in. Most of them thought that a small fissure had been breached and that the inflow would soon diminish. They were confident that the water that was flowing into the stopes could be diverted down a series of water raises designed for that purpose. They were sure that the pumps, once they got going, could cope with the water.

Getting out the men

In the meantime the roar of the torrent rushing down the shaft had risen to a crescendo. Some bells and telephones ceased to function and the cages, in the expressive phrase that miners use, were "yo-yoing" up and down (rising and falling) as the downpour hit them. The immediate decision was taken that it would be dangerous, if not impossible, to try to get out men working below 4 Level by way of No. 4 Shaft. Shift bosses were sent down to warn all men that they would have to make their way to 10 Level and then walk to No. 3 Shaft where they would be taken to the surface.

Informed by Mr. Buley and Mr. Pole that there was water in No. 4 Shaft and that he'd better investigate Harry Wheeler, sectional manager, replied: "That's a piece of cake. We'll have that fixed in half an hour".

He's never likely to forget those words.

"I went underground at 10.10", he said. "I went to 6 Level where the water had formed a stream flowing down the shaft. When I saw that stream three feet deep rushing down the shaft I realised that the shaft would be out of commission below 6 Level and that we'd better start evacuating the men.

"I then tried to walk in on 6 Level against this fast flowing stream. When I got to the ventilation door the rush of air was so strong that

Jack Cuthbertson, mine overseer, in the flooded No. 4 Shaft, near the surface of the water. This picture was taken before the valves were closed. The white marks are drops of water coming down the shaft.

I just couldn't get through the door. And so I came back, went up to the surface and reported to the manager that the water was much more than any of us had expected and that we had already sent messages down to the men to make their way to No. 3 Shaft."

An underground manager, Leon Alexander, gave me this version of the beginning of the deluge: "On the morning of the 26th it was reported to me that the ground in 6/46B (6 Level) had 'bumped' during the night. I brought it up at the meeting. Mr. Wheeler asked me whether it was making any water but at that stage no water was reported, or nothing more than usual, coming from that stope.

"During the morning Van Heerden, the stoper, reported that the stope was 'talking' and bumping and that he had drawn all his men out to await the arrival of Andries Taljaard, the shift boss. When Taljaard came he, accompanied by Van Heerden, examined the working place and decided to pull out all the men from this stope. He instructed Van Heerden to take his boys to the development end.

"He realised that the stope had started to make more water than was usual and he walked to the station to report the fact. He wasn't unduly concerned because the water was being contained in the drains.

"As he lifted the telephone to phone the office he happened to look up and saw that the water was coming six inches deep and into the shaft.

"The mine captains and I were having a meeting in the office of Mr. Cuthbertson, the mine overseer. Taljaard phoned at 9.40 and he reported to me that water had broken away at 6/46B and was running down the shaft in a six-inch stream. Mr. Cuthbertson immediately telephoned the shaft bottom boys who reported that parts of the shaft bottom were already under water. He instructed them to pull out.

"We then went and changed and went down to 6 Level at 9.47. The water at this stage had increased to about 12 to 15 inches and was running freely into the shaft carrying with it timber that was floating on the water. Mr. Cuthbertson immediately phoned Kudu (this is the new sub-incline shaft that was being sunk at 14 Level) and told them to pull out all the men and instruct them to make their way to the station where we would try to pick them up with the cage. After putting a barricade across the shaft to try to stop any timber going down it we came back to the surface.

"The water was running as I said at 12 to 15 inches but at this stage I thought—or I hoped—that it was merely a deluge that had broken away and wouldn't continue very long. I was concerned about the men working down at the dead-end level which had no outlet (that is below 14 Level where they were in what was to become the Kudu sub-incline shaft). Ryan, the banksman phoned and said they had all come back to the station on 14 Level.

"At 11 a.m. the water rose and started flooding 14 Level and most of the chaps, realising from the amount of water coming down the shaft that we could not come down in the cage to fetch them, climbed up to 12 Level to work their way back to No. 3 Shaft".

However, there was no escape route for the two Bantu pump men in their small pump chamber just above 14 Level. They had to wait there until the cage could be sent down to get them—and if the cage could not get to them there was only one chance in a thousand that they would get out alive.

Alexander, still worried about the safety of the men in his section, then made a reconnaisance, accompanied by C. J. N. van Rensburg, the shaft foreman. It was fortunate that they did for on 10 Level (actually 10/45B) they found a stoper named Louis La Butte, a Frenchman, still at work. The drilling machines had drowned all other sounds and La Butte and his men had no idea that anything was amiss.

They and various other men who were found were told to "leg it" for No. 3 Shaft.

All were safe

All told some 1,500 Bantu mineworkers and 20 odd white miners made that two-mile journey to No. 3 Shaft and safety with the water lapping round their knees. It would be untrue to say that there were no signs of fear but certainly there was no panic. It was a slow but disciplined march.

There was the danger that men might lose their way and wander into dead ends. But thanks to the shift bosses, led by Bruce Bailey, who had been sent down to organise the retreat and who actually wired off some drives into which stragglers might have strayed, all went well.

By 5.30 all the men had reached the surface—all that is except the two unfortunate Bantu pump men marooned in their "cave" at 13¾ Level.

When the final count was made and it was realised that not a man had been lost there was general rejoicing for the risk had been great. "Looking back now on the evacuation of these men from the working places through water that was running very strongly by then it seems to me close to a miracle that we managed to get them out without a single loss", said Alexander to me afterwards. "This I think was one of the most amazing and outstanding achievements of the whole operation.

"There was only one minor mishap when a boy tripped and fell while running away from the water."

One of the last men out was Jim Ryan, the banksman on 14 Level, whose task it had been to recall the men working in the Kudu shaft. Jim Ryan's "climb" is now one of the legends of the mine. If I was asked "Have you heard about Jim Ryan?" once I was asked it a hundred times.

Ryan was telephoned and told to pull out because the water was rising. He was to make his way up to 12 Level (from 14) and then walk to No. 3 Shaft.

"Hell, man," he said "I can't do that. Don't you know I've had a coronary thrombosis?"

Then everyone became worried about Ryan and how he was to get out. The last telephone call down the shaft was made to him just before the line failed. Mr. Pole, the manager, who spoke to him wondered why Ryan, having heard what he had to say, slammed down the instrument without so much as a word of acknowledgement. He found out afterwards that it was because the water was up to Ryan's waist and he had no time to say: "Well cheerio, hey".

"Poor Ryan, he'll never be able to climb that far," they said. So two shift bosses were sent down to find him and help him up. But when they got down to where he ought to have been there was no sign of him.

"Ryan's missing", they reported.

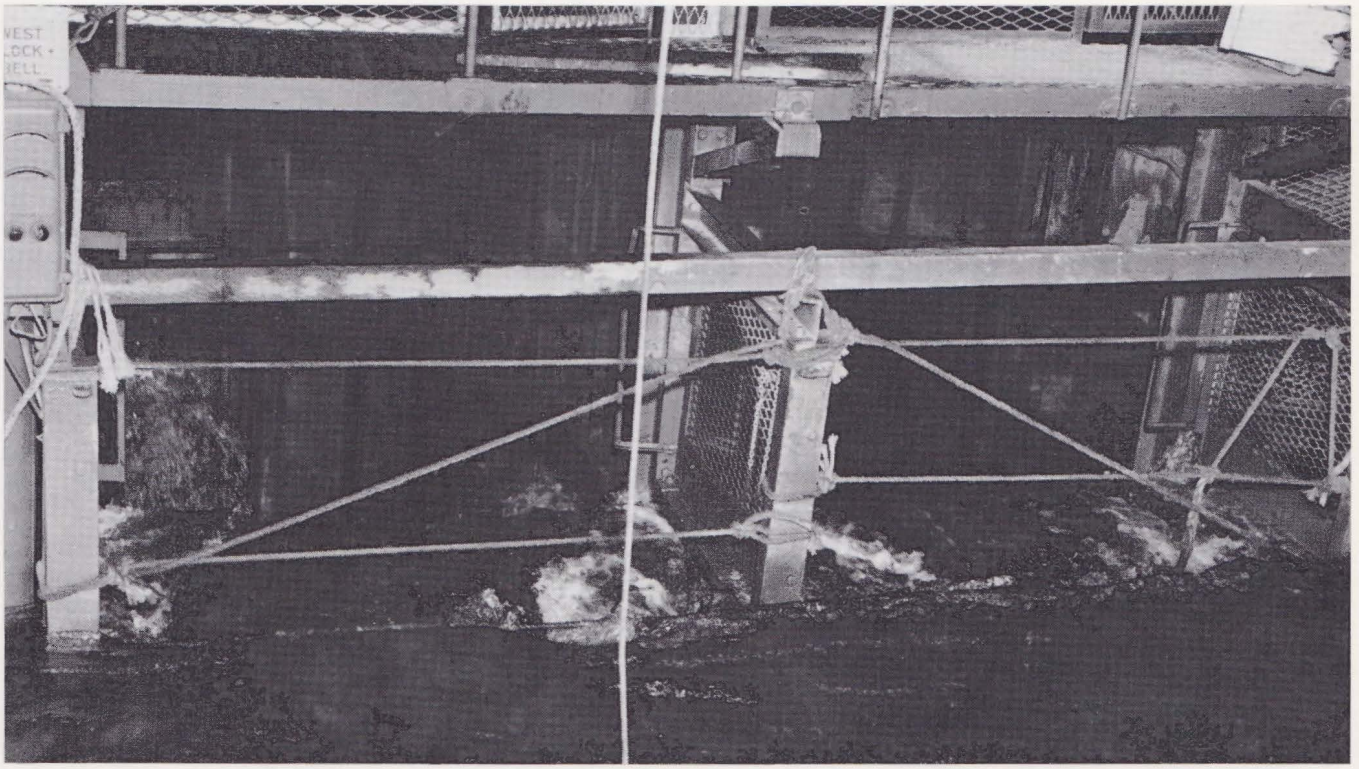
But Ryan wasn't missing. Coronary or no coronary he had climbed, not merely to 12 Level, but all the way up to 10 Level, a distance of 2,000 feet, and then walked to No. 3 Shaft and reached the surface.

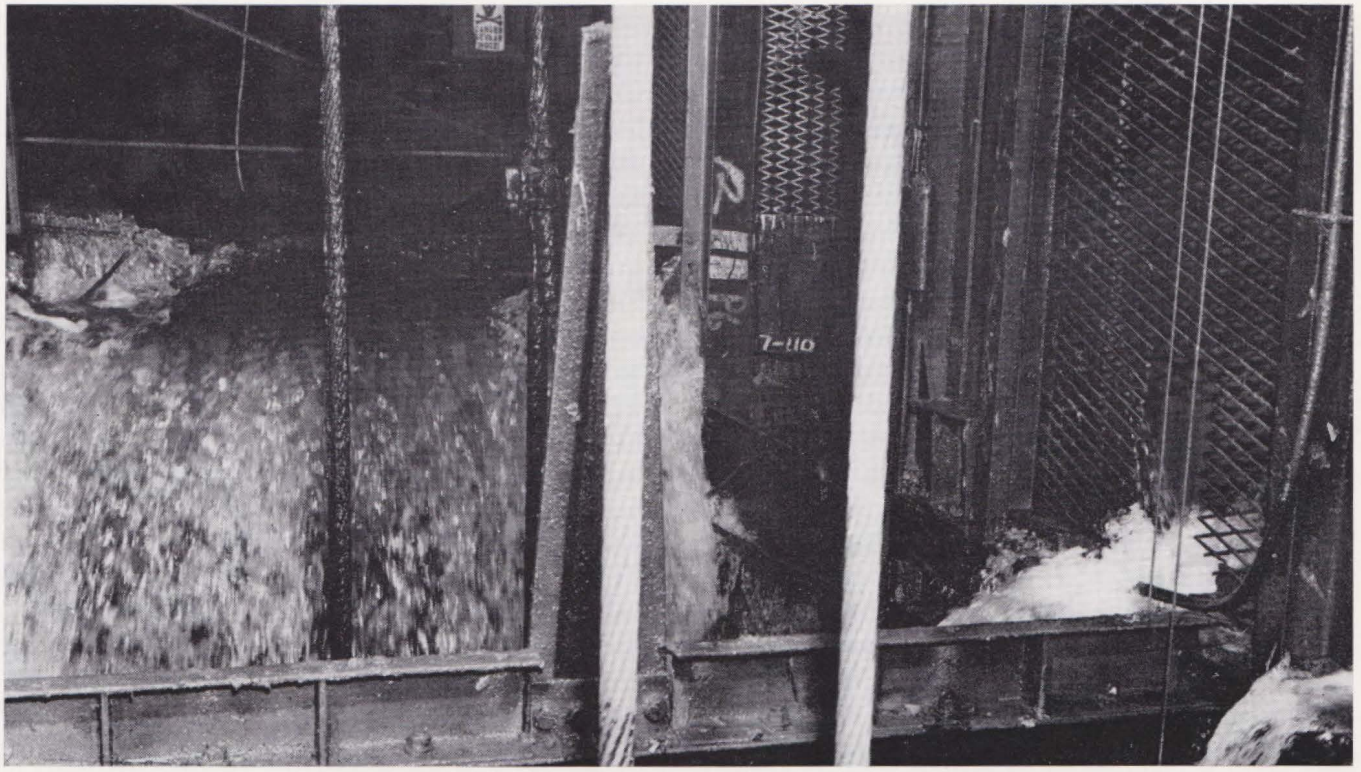
In the meantime the two Bantu pump men at 13¾ Level had been there most of the day, cut off from all communication with the outside world. Their only light was that provided by their cap lamps. A solid sheet of water was roaring down the shaft outside the pump chamber where they were cowering.

There cannot have been two more unhappy, frightened men in the world that day than these two Shangaans.

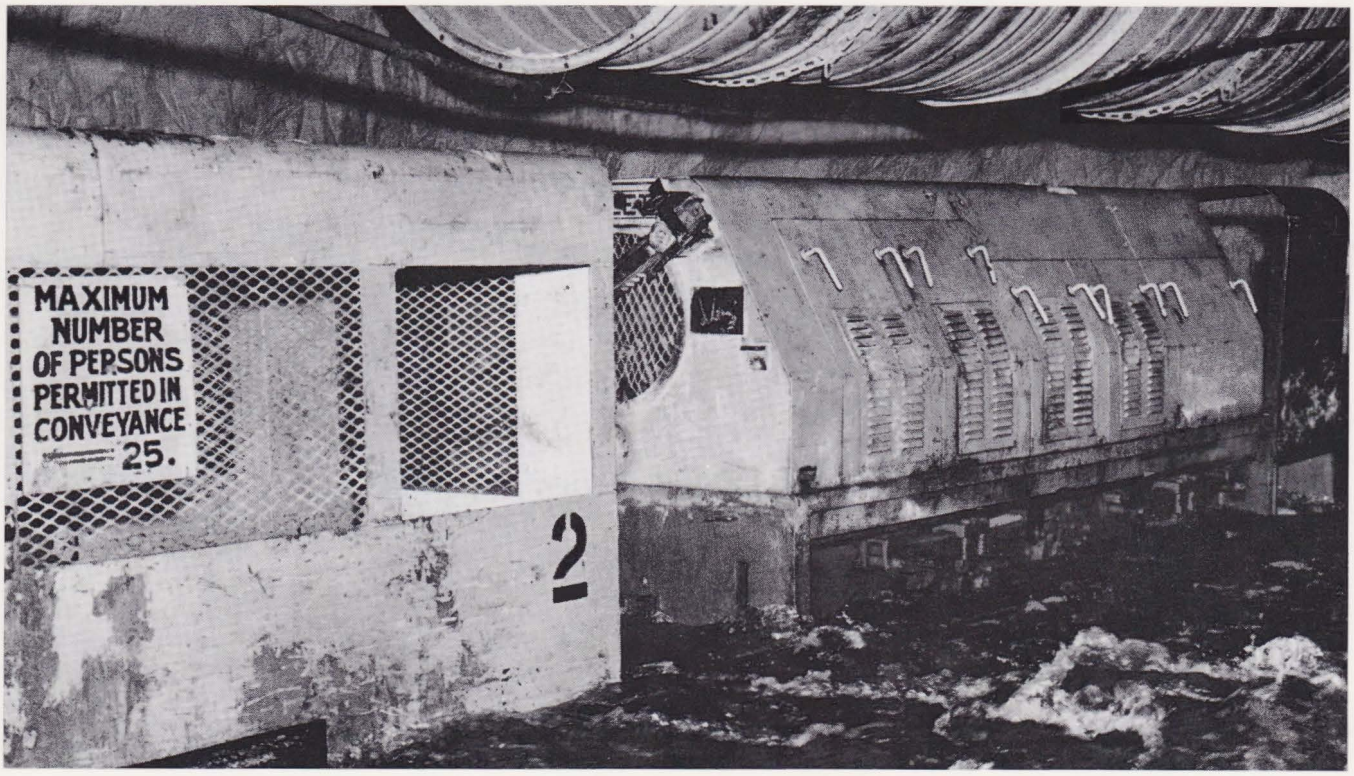
They had not been forgotten but it had been estimated that they were safe for at least twelve hours, provided they sat where they were, since the pump chamber provided them with shelter. But how was the cage to reach them? All the bells in the shaft were "out" and the force of the water falling to the bottom of the shaft would make the cage rise and fall at the end of the winding rope. If they were to be rescued it would have to stop precisely opposite their station.

Two views of the water that poured down No. 3 Sub-vertical Shaft at a rate of 30 million gallons per day on its way to the storage areas of the mine. All water that could not be pumped out was diverted down this shaft. The picture was taken on 12 Level.





A partly submerged underground locomotive and passenger conveyance in a drive on 12 Level near No. 3 Sub-vertical shaft.



Let Jack Cuthbertson, mine overseer, describe how it was done.

"One of the problems was the yo-yoing of the cage under the weight of water falling on it," he said. "We had to put a metal canopy on top of it to deflect the water—it took about three-quarters of an hour to make this. Then we put a polythene ball on a rod inside the cage."

The purpose of this polythene ball was to indicate, on a trial run, whether the water had risen higher in the shaft than had been calculated. It was part of Cuthbertson's brilliant improvisation in an emergency.

"Assuming the level was under water and the men in the pump chamber were already drowned there was no sense in anyone taking a risk", he said.

Hence the polythene ball, with a patch of wet red paint on it was to serve as an indicator. If the water had already risen above the level it would push the ball up to the top of the cage and thus show that it was too late.

"With the canopy on the cage and the polythene ball inside it we tried a dummy run," Cuthbertson continued. "The canopy deflected the water all right but there was still a good deal of yo-yoing. However it seemed reasonably safe to try it".

"But how could you operate the cage without bells?"

"When the bells went we got walkie-talkie equipment, that is two-way radio. I still had a telephone line open from the engine driver on the hoist as far as No. 4 Level (that was above the point where the water was flowing in). Then I had a man to ring the bells on 4 Level and I had two-way radio communication with the men in the cage.

"In the cage they couldn't see or hear anything because of the noise of falling water, so that they had to be told that they'd arrived at their destination and get out. They then had to step out blind from a cage that was yo-yoing as much as three feet and hope for the best,

though, of course, once they were through the curtain of water they could see what they were doing.

"We had also fitted big lights, loco lights, to the cage in the hope that the men in the pump chamber would see these and jump into the cage, but the cascade of water down there was so solid that they did not see them".

The man who volunteered to carry out this blindfold rescue was shaft timberman W. C. Theron, who was accompanied by Vascoe, a boss boy. He was told to keep in constant communication with Cuthbertson on the walkie-talkie. If communication ceased it would be a sign of trouble and the cage would be hauled up again. On arrival at the pump station he would be allowed exactly three minutes silence. If he was not back, with or without the pump men, at the end of that time limit the cage would be hauled up anyway.

So down went Theron and his aide-de-camp, talking all the way. When the cage came to a halt they jumped for it, hoping for the best, and landed in the pump chamber.

There were the two pump men, stark naked. They had stripped off their clothes in readiness for stepping into the water and swimming for it if they were forced to leave their refuge. They had climbed up some steel sets that were stored in the chamber and were perched under the roof.

Theron and Vascoe got them out and into the cage in exactly 90 seconds, well inside the time limit. They reached the surface at 7.20 p.m. having been underground for twelve hours and cut off for nine.

Both were sent to hospital but, apart from treatment for cold and slight shock, were none the worse for what they had endured. Both were at work again on Monday.

Alberto Noife summed up their thoughts on their experience for me very succinctly.

"Baas, we thought we were dead", he said.

You will find the full story of their hours of darkness on page 80.

The rescue of these two men was the most dramatic incident of the day but it was only one of a number of events that now began to pile up as the water, still pouring from the fracture that nobody had seen, flowed through 10 and 12 Levels towards No. 3 Shaft despite all attempts to divert it to lower levels through water raises provided for this purpose.

This is the appropriate point at which to explain that, in the West Driefontein mine, water that flows down to 14 Level and the levels below it, goes to the bottom of the mine where the pumps can deal with it. But on October 26 and the days that were to follow the flow was so strong that it was overrunning this drainage scheme and the urgent task became the protection of No. 3 Shaft, the only means of egress left in the eastern section of the mine.

Control point

Mr. Buley and Mr. Pole, once they had received Harry Wheeler's report and various other calls from the "front", set out to plan their campaign in what they thought was going to be a short, though sharp, battle against an ugly inrush. Mr. Buley decided that a control point should be set up in the offices at No. 4 Shaft, to which all calls from underground, as well as those that mattered from outside, were to be directed. It was then intended that this operations centre should control all developments for the next 48 hours. In fact it was to remain in action day and night for the next three weeks and also became the headquarters of Mr. R. R. M. Cousens, the Technical Director of the Gold Fields group, who from October 26 onwards was to spend up to sixteen hours a day at the mine.

To begin with the general manager and the manager were continuously on duty for the

The control office at No. 4 Shaft. Messrs. A. Pole, R. Buley and J. Rose-Innes in characteristic attitudes during the crisis.

first 36 hours and then had eight hours on and eight hours off. But on Tuesday, Mr. J. Rose-Innes, sectional manager (planning) who had come hurrying back to the mine from leave, joined the fray and thereafter there was always at least one of the three most senior officials on duty. As often as not all three of them were there and one of the sectional managers as well. The volume of telephone calls from various parts of the mine was to rise to a crescendo of three a minute at times. This system of having a direct link between the top brass and the men below was of very great importance as the situation grew more and more serious. What counted was that when a worried man telephoned from underground there was always someone in authority to answer his call whether it was vital and urgent or comparatively trivial. In this way there was no passing on of messages and getting a reply twenty minutes later on the "I'll-ring-you-back" principle. Instant decisions were made and instructions given. Demands for men and more materials—sandbags, pipes and cement—were met with the minimum delay. Since on most jobs the men were attempting to carry out in a matter of hours work for which, in normal circumstances, they would have allowed weeks, this was a great advantage.

It may have been just a little alarming to be about to say: "Why the — — haven't you . . " and then find the general manager on the other end of the line, but it was heartening too.

The "war diary" that was compiled recording the more important calls and the instructions that were given, though much of it is incomprehensible to anyone who was not involved, deserves a place in a mining museum, dog-eared as it is.

Among the first day's entries I found these recordings of the supposed inflow of water into the mine, illustrating the difficulty of estimating the volume of the torrent.

They read: "5 p.m. . . . 43 million; 5.45 p.m. . . . 46.8 million; 8 p.m. . . . 45 million."

In fact at that time the volume must have been at least 70 million gallons a day which, with the normal quantity that was being pumped, as it was pumped every day—say 16 million gallons—made the total inflow with which the pumps were required to cope 90 million a day —roughly 30 per cent more than their capacity.

There is also this note, in the handwriting of Mr. Pole, written at 10.30 p.m. on October 26:

"1. No further water must be sent to No. 3 Shaft pumps.
   (*a*) Every pump is working.
   (*b*) Any further water would flood No. 3 Shaft and the pumps would be lost.
   (*c*) There is also a possibility of losing the shaft bottom at No. 2 Shaft.
2. If the water builds up to 12 Level No. 3 sub-shaft would have to be flooded and this would inevitably lead to the flooding of 5 sub-shaft.

Note: Between 5 p.m. and 10 p.m. there was only 5 million gallons per day spare pumping capacity in the mine. In our opinion the policy is to play for time, hoping that the inflow will decrease considerably."

This shows that the position was still obscure. There was *no* spare pumping capacity. Actually the pumps were being outgunned by some 30-40 million gallons a day.

Underground the men grappling with the situation were beginning to get some idea of how serious it was. But they still thought that the mine pumps could cope with the flood and they still hoped that the flood would subside.

"We knew we had a pretty big problem on our hands," said Harry Wheeler. "It wasn't just a case of losing one shaft. With that flow of water on 10 Level you had the problem of protecting No. 3 Shaft. With the water overshooting your waterways and going down No. 3 Shaft itself and down the ore passes steps had to be taken immediately to safeguard the shaft otherwise we wouldn't have a working shaft below 10 Level to evacuate the men in that area.

"That meant that we had immediately to start putting up barricades on 10 Level to protect the shaft but we also had to be very careful in making these barricades not to make them too high or the water would have been too deep for the people coming out of the No. 4 Shaft area and they would have been drowned.

"I'd lost count of time by then. I suppose it was approaching 5 p.m. But up to that time I still don't think we had appreciated exactly what the position was. We had felt on the surface—and I had felt until I went underground just after 10 a.m.—that the reports coming up were grossly exaggerated.

"I'd had experience of an inrush of 2½ million gallons before this. I recalled the concern and near-panic that arose from this and I thought I had a similar job on my hands with everybody getting into a flat spin, not knowing what to do and people feeling that the inrush was much less than the men in the water said it was.

"I didn't change my opinion until I went down to 6 Level and saw that river running in. Then I realised that we had something really big on our hands."

Mr. R. S. MacNaughton, another of the sectional managers of the mine, had this experience on what is now referred to as "the first day".

"On that particular Saturday when the water broke out I had a few visitors underground. They were visitors from overseas connected with Ingersoll-Rand. Just about at the time when the water was breaking out we were in the pump chamber on 18 Level at No. 5 Shaft.

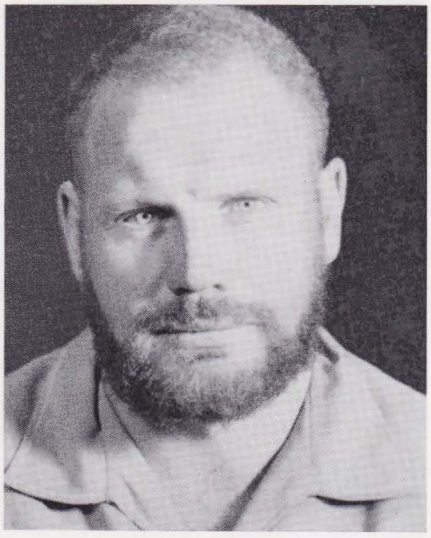
"One of the questions put to me by one of these visitors was: 'Why do you have so many pumps when you are only pumping 15 million gallons a day?'

"I replied that we had a capacity for pumping 65 million gallons or more a day so that we

Sectional manager Harry Wheeler

Sectional manager Ray. MacNaughton

Sectional engineer Terence Stirling



The Blyvooruitzicht and West Driefontein cementation teams

Back row (left to right): J. H. Pieters; J. D. Behr; G. A. P. Andreasen; J. L. van Staden; H. L. Jansen; W. S. Garrett; J. J. Theron; F. J. Stassen; J. H. P. le Clus; G. P. Labuschagne; R. W. Royston; M. M. van der Berg; J. H. Boets; F. H. Guise Brown; J. J. Redelinghuys

Middle row (left to right): N. C. Willemse; P. A. Olivier; H. G. Raubenheimer; W. D. Brinkworth; H. G. Palmer; J. M. Liebenberg; H. J. Venter; D. A. Reyneke; J. A. van Niekerk; A. G. Borrageiro; B. J. F. Schutte; B. Reyneke; D. A. Reineke

Front row: P. Meyer; P. du Plessis; J. H. Opperman; C. F. Opperman; H. S. Lange; L. T. MacDonald; C. F. Lombard; A. R. Collings; D. M. J. J. van Rensburg; A. J. Douglas; C. J. J. Harmse; J. H. Pieterse.

would never lose the mine because of flooding. "When I got to the surface the message came through that we had had this outbreak in No. 4 Shaft . . . !"

Later Mr. MacNaughton, accompanied by Koos Stroebel, a mine captain, was to make a "recce" in a vain attempt to find the fracture which was the source of the inflow. They fought their way into the stope on 4 Level in water up to their necks. Soon the velocity of the water convinced them it was a hopeless mission. But they probably got nearer to the seat of the trouble than anyone else—not that they, or a team two hundred strong, could have done anything about the "leak" then.

Thus began the first stage of the fortnight-long battle to protect the pumping shafts for it was on these pumps that the life of the mine depended, so they thought.

The layman who studies sectional diagrams of the mine is apt to be misled by the fact that in these both the 10 and 12 Level haulages appear to connect directly with No. 4 Shaft. Surely, therefore (he says) water coming from the far eastern section of the mine and flowing down to these levels would pour itself into the shaft, leaving the western section of the mine more or less unaffected until the water level in the shaft rose to, say, 14 Level?

If only that had been true the situation would have been much less critical. There would have been time to build the necessary barriers before the water rose in No. 4 Shaft to the point where it endangered the whole mine.

But the diagrams are misleading in this respect. The 10 Level haulage actually by-passes the shaft and 12 Level does not lead directly into it. Therefore, though a vast quantity of water was pouring into the shaft from the workings east of it, an equally vast quantity was finding its way along these two main thoroughfares towards the heart of the mine. Had there been water doors on these two levels they could not have been closed without drowning the men in the working areas. Had there been other haulages connecting No. 4 Shaft with No. 3 down which the water could have found its way the mine would certainly have been lost.

The main battle front was to be on these two levels which became waterways soon after the inflow started.

On Sunday, October 27, Mr. Adriaan Louw, chairman of the West Driefontein company and of Gold Fields of South Africa issued a statement which said that "The inflow had increased very considerably" and the flow of water into the mine (in excess of the sixteen to eighteen millions of gallons a day that was the normal pumping rate) was estimated to be more than 40 million gallons a day.

The statement added that it was hoped that the inflow would decrease as the reservoirs in the dolomite were drained. But it added "should this not occur owing to the fissure being freely connected to overlying water in a large portion of the Bank Compartment the situation at the mine would become extremely grave once the underground storage capacity has been filled".

It will be realised from this that, owing to the very great difficulty of measuring an enormous flow of water such as this in the initial stages it had not yet been realised what the mine had to face.

It was not until Friday, November 1 that it was announced that the inflow was 86 million gallons a day (68 plus the normal 18). On November 5 this estimate was increased to 100 million gallons per day (80 million plus 18). By that time the men in the mine were too tired to read newspapers or to care much what was said. They knew it was going to be a touch-and-go struggle for the life of "West Drie"—their mine.

The first plug

The first attempt to hold back the water began on Saturday night when Mr. Cousens, the

The emergency pump station on 20 Level, 5A Sub-vertical Shaft. Here six months' work was done in less than a fortnight to get the pumps installed to beat the rising tide in the flooded shaft.

consulting engineer, decided that a plug should be constructed as quickly as possible on 12 Level. He had been called to the mine that morning and arrived at 1.30 p.m. Mr. Adriaan Louw, the Chairman, followed him.

Here a word about "plugs" in general is necessary. The word "plug", as used in mining, is hopelessly inadequate. A plug is a solid concrete wall that may be anything from 10 to 100 feet in length and sometimes even longer. It is made by filling the drive that is to be plugged with packed rock—if there is time—and then injecting quick-setting cement until a solid block of concrete seals the entire space between the shuttering at either end ("seal" is actually a better word than plug).

A great deal of the effectiveness of a plug depends on how much time the concrete has to set. A "green" plug (i.e. one that has not set properly before pressure is brought to bear on it) can cause a worse disaster than that which it was designed to prevent. In an emergency—and all the plugs at West Driefontein were emergency cases—pipes are laid and the plug constructed round them. The water then flows through the pipes while the concrete is setting and there is very little pressure on it.

Then, as soon as the cement is tough enough to stand the coming strain, blank flanges (caps) are clamped on to the projecting ends of the valves and through smaller valves in these flanges more cement is pumped in under tremendous pressure until the pipes themselves become solid tubes of cement. Simultaneously, or very shortly afterwards, vast quantities of cement are pumped through cementation pipes to the far end (the "wet end") of the plug where it sets and adds its support to the wall that now holds back the water. Finally the plug is "tightened" by forcing more cement, again under great pressure, through cementation pipes so that any tiny gaps that may exist are filled and the whole concrete barrier is a solid wall of cement that would require high explosives for its demolition.

In the end the cementation pipes are sealed—and there's your plug.

This brief description of a highly scientific process, carried out according to a well-established formula*, makes it sound a comparatively simple business. It is anything but that. In the first place, before anything else can be done the footwall in the drive has to be washed and brushed and blown by air hose until, as the miners say, "you could eat your breakfast off it". The hanging wall gets similar treatment lest some tiny loose, fragment of rock should weaken the whole structure. This must be a madly irritating job when you are working against the clock to get your plug in, but it has to be done.

At West Driefontein, as on most mines in South Africa, most cementation work is carried out by the world-renowned specialists in this job, the Cementation Company (Africa) Limited, the South African branch of the firm that was founded in 1920 to exploit the patents of Albert Francois. Francois, a Belgian engineer, was the first man to prove that cement could be injected under pressure into cavities in a shaft under water. Improved and refined, the process he devised has done more to assist mining engineers in all parts of the world than any other single invention this century. Without this process by which inrushes of water can be controlled it is highly unlikely that it would have been possible to sink shafts through the dolomite on the Far West Rand. The mining companies freely admit that they owe an incalculable debt to Francois, the man who first explored the cementation field, for having enabled them to get at new sources of gold, including the Carbon Leader Reef which today produces a very substantial percentage of the state's revenue.

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*The formula:

$$\text{Length} = \frac{\text{Perimeter of Drive} \times \text{Shear Factor}}{\text{Area of Drive} \times \text{Static Head}}$$

The Cementation Company has a team of 40 men permanently employed at West Driefontein. Of this team, and of Harold Palmer who leads it, you are going to hear a great deal more before this narrative is finished for they were the shock troops in the battle that was to come. Wherever there was trouble the cry went up: "Get the cementation men".

And now back to that first attempt to seal 12 Level against the advancing flood. Work began late on Saturday night under the supervision of Harry Wheeler who was later relieved by Ray MacNaughton. Underground managers Leon Leask and Terry Gouws and some 60 men worked in shifts while a sandbag barrier, aided by an upward incline in the drive called the "Hump" helped to divert and delay the advance of the water.

They thought they had until Monday morning to get the pipes into position and complete the plug but that was a miscalculation. The pipes were sent down from the surface and were being manhandled into position when the water arrived—and that was the end of that plug.

"We believed we had until about 4 a.m. on Monday to get the plug in", says Harry Wheeler. "I thought that if we got it in, with six 10 inch pipes in position, before the rush of water hit us and just let the water run through the pipes we could tighten it up later.

"The pipes arrived down the mine at 11.30 and the water arrived at 12.30. There were two pipes in position when it came—and that was tickets!"

This was the first of many setbacks that were to come. Hours of hard labour had been put into preparing the site for the plug and it had all been wasted.

But there was no time to be despondent for a new emergency had risen. The water that had made its way along 12 Level was now heading for No. 3 sub-vertical shaft and was soon pouring down the shaft to the bottom of the mine.

The men who had been working on the plug under Ray MacNaughton, sectional manager, and Terry Gouws, an underground manager, now had a terrifying experience. The water pouring down the sub-vertical shaft, drawing the air to the shaft after it, created a semi-vacuum with the result that air from the workings above was sucked down to 12 Level and into the shaft.

This meant that a gale of wind now rushed at the tired men who were waiting to go to the surface and forced them to lie flat on their faces in whatever shelter they could find.

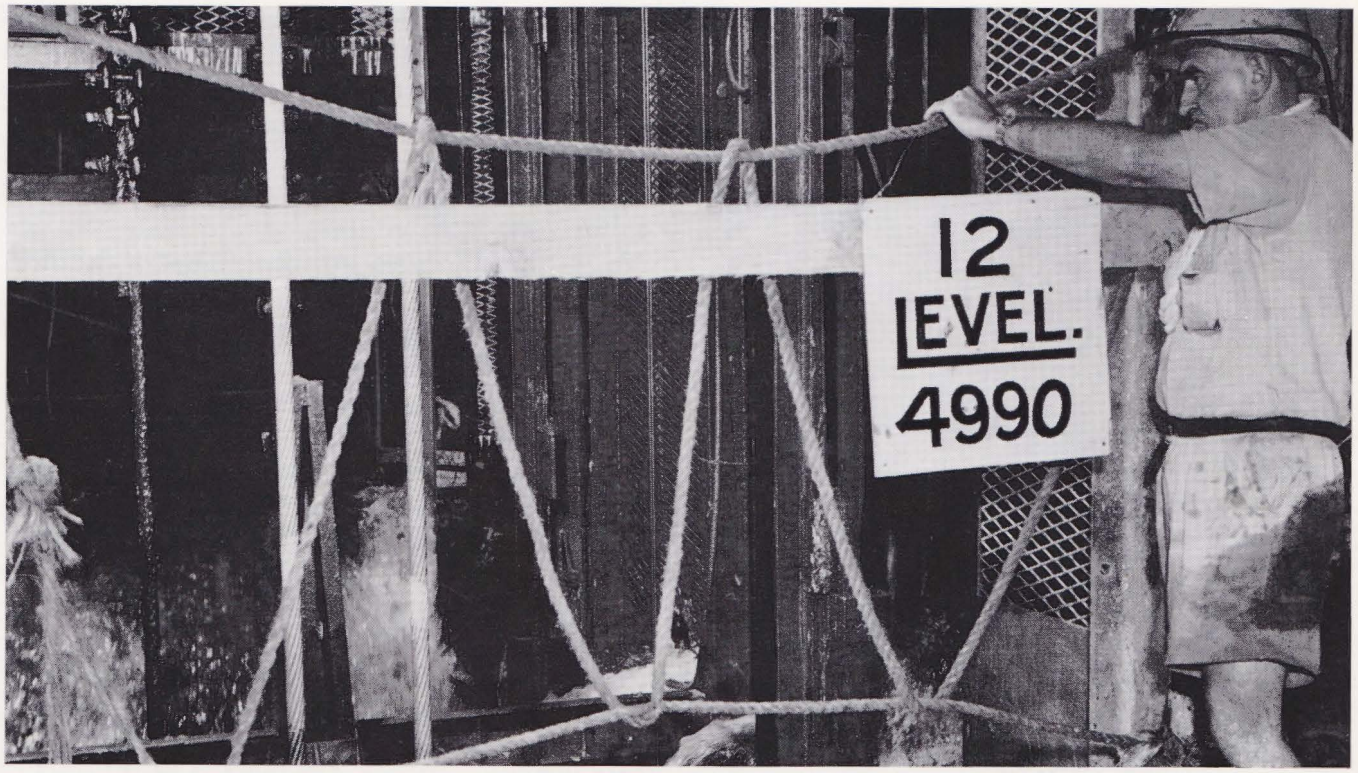
I have called it a "gale" but it was much more than that. The force of this terrific draught has since been measured at 133 miles per hour and at points where ventilation doors narrowed the drives it was so strong that nothing could stand against it. What had happened was that the rush of water down the shaft had created what is technically known as a "venturi", a sort of circulating whirlwind, that was chasing its tail round 10 and 12 Levels to 18 and 20 Levels and rushing down every passage in this section of the mine.

Imagine the plight of these men, 15 white officials and miners and 80 Bantu, pinned to this drive with no escape route open to them. The cage in No. 3 Shaft could not descend below 10 Level and they could not get through the ventilation doors to make their way to higher levels. The wind sweeping past them carried a fine spray with it that kept them damp. The water in the shaft was rising—and they could not move.

Two men, who were prepared to face anything rather than stay in this trap, clawed their way along the drain and, tearing the flesh on their hands to pieces, managed to make their way through the ventilation door and to safety. One of them on reaching the surface drew his pay and has not been seen on the mine since that day.

Fortunately there was a small compartment in the footwall into which the Bantu mineworkers

A miner standing on the opposite side of No. 3 Sub-vertical Shaft where water rushed down the shaft at a rate of 30 million gallons per day.



were directed. Terry Gouws spoke to them and explained the situation, assuring them that, if they did not panic, all would be well. The fact that they had some shelter from the wind comforted them a little.

The white men found what shelter they could. The whole party were round a slight bend in the drive which saved them from being subjected to the full force of the *venturi* but just round the corner was the frame of the ventilation door which narrowed the drive considerably and it was here that the blast was at its worst.

MacNaughton says: "I was still not convinced that we could not get through and I attempted to do it by crawling up the drain. But after moving slowly forward for about 20 feet I realised it was utterly impossible. No one could get through."

All the men were frightened. The thought uppermost in their minds was: "How are we to get out?" Ray MacNaughton had done some calculations and he was able to assure them that they were "pretty safe" as far as drowning was concerned. It would be at least seven to ten days before the water could get to them. All they had to do was to sit still—there wasn't anything else they could do—and they would be rescued. But that was the worst part of it all—the waiting.

One man dropped to his knees and continued to pray for the next three hours. His prayers were answered.

The telephone rang. MacNaughton crawled to it and heard the cheerful voice of Mr. Jack Tinkler, the resident electrical engineer. He said that he was going to send one of his foremen down to 10 Level to turn on the power there. If that could be done it might be possible to send down to them the small lift that operated between 10 and 12 Levels and bring them out that way.

That was what happened in the end. After an hour's work on 10 Level the lift was put into

commission and it brought them up from 12 Level six at a time (5 Bantu and 1 European). Even then their troubles were not over. The draught was almost as strong on 10 Level and they had to fight their way against it.

"As we approached the ventilation door we had to be pulled by chains while lying flat on our stomachs", says MacNaughton. "The people on the other side would pull us along for about 15 to 20 feet until an arm or a foot could be grabbed. Then they pulled us through a ventilation door frame. We simply could not stand up in that wind.

"Once you got through the frame and walked down to the station you walked leaning forward at an angle of 45 degrees. If the wind had stopped suddenly we would have fallen flat on our faces".

Thus at length this exhausted band of men reached the surface at 4 p.m. on Sunday, October 27. They had been trapped for about four hours.

"It felt like a lifetime", they say.

Mr. Cousens and Mr. Louw were both at the mine early that day. Both men had been general managers of West Driefontein in their time. Mr. Louw had been there for nearly ten years having risen in that time from underground manager to general manager. Mr. Cousens had been consulting engineer to the mine for 12 years. So both were "West Driefontein men" and proud of it.

At this time the total inflow of water into the mine was estimated at a maximum of 58 million gallons a day which was well within the capacity of West Driefontein's pumps (68 million gallons per day). It was still hoped that the inflow would decrease and as the mine had a storage capacity of 1,000 million gallons it looked as though time was on the side of the management.

Nevertheless, as exact estimates of the rate at which the water was flowing in would not be available until it reached 24 Level in the storage area it was decided to increase the pumping capacity of the mine. The first step was to be the installation of a pump at No. 4 Shaft and it was hoped to procure other pumps that would increase the total pumping capacity by 15 million gallons.

The difficult problem of plugging 10 and 12 Levels and thus containing the water in the No. 4 Shaft area was discussed but a decision deferred for the time being as it was still considered possible to beat the inflow by pumping faster than the rate of inflow.

The first official announcements about the flooding, issued by Mr. Louw on October 26, brought West Driefontein right into the news and the steady flow of enquiries begun and was to continue for the next three weeks.

"They also serve . . . "

All underground development, that is to say all normal mining, ceased as from Sunday night. It was then announced that the emergency work that had to be done in the area where the water was flowing in would be on a voluntary basis.

The normal working strength of the mine is approximately 17,000 men—1,550 white men and 15,500 Bantu. Of the Bantu some 12,500 go underground every day. The balance are employed on the surface. The stoppage of normal work presented the managers with a problem. Allowing for the fact that the mine would probably need anything from 1,000 to 5,000 men to cope with essential measures to control the water underground, they could expect to have some 12,000 idle men on their hands with no way of estimating how long it would be before they could all be usefully employed again.

The problem was dealt with by sending off all white employees who were due for leave except those who were regarded as key men and by sending home the time-expired men in the compounds.

The notice beside the road at the training school, put up to encourage those men who could not be actively employed on the various tasks during the crisis.

Special training courses with lectures were organised for white miners who were on standby.

The Bantu employees were told that, for as long as there was no work for them, they would be paid the equivalent of a full shift every day and receive their usual meals in the compounds. Those of them who volunteered for work underground would be paid at treble the normal rate.

After this, when there was work to be done underground, there were calls for volunteers. The response to these calls from the white miners was magnificent. They stepped forward in a body and pleaded to be given a job to do. Indeed the voluntary system made no difference to them at all. They all turned up for work every day in the hope that they would be called and when the crisis was at its height there actually were 1,200 of them at work. The contract men were among the volunteers and many of them did general miners' work, anything that came to hand, to meet the emergency.

One of the most moving sights at the mine when things were going badly was a large notice erected beside the road at the training school. It read: "They also serve who stand and wait."

Unfortunately the same spirit was not found among all the Bantu mine workers. Admittedly many of them had been badly frightened by the sight of water flowing along the drives and down the shafts and hearing it falling on the cages. And the stories told by the men who were evacuated from No. 4 Shaft area soon spread round the compounds and helped to make the conditions sound even more unpleasant than they were. So there was every excuse for the fact that there were few volunteers at first. Nevertheless, however gently one judges them, it must be said that among some groups the reluctance to go underground lasted too long.

The African tribes from which the men who work on the mines come, all have their mining traditions. They remember and repeat the stories their fathers told them of what happened to them on the mines.

When the story of "the big flood" and the rushing waters at "West Drie" comes to be told it will be counted a lasting disgrace that there were young men of certain tribes who unashamedly sat in the compounds drawing their pay and eating heartily while their comrades went below to battle with the water. However, it would be wrong to tar all the men with the same brush. Most of the Bantu, when they had recovered from their initial shock and saw the white miners doing *their* work, rallied and then worked like heroes. The boss boys were steady and courageous throughout.

Mr. W. L. Dinkelmann, chief compound manager of the mine, told me that he heard a Xhosa boss boy addressing the men in his compound. "This is our mine and it is in trouble," he said "Let us go out and help."

And there is, too, the story of the two Shangaans rescued from No. 4 Shaft that I have already told. They were sent to hospital on Saturday night and volunteered for work again on Monday.

My impression was that in the years to come the Bantu mineworkers will say, in their own words, that this was an affair that sorted out the men from the boys.

From this point on there is so much to describe that it is difficult to present all the major happenings in their correct order. As for the minor incidents, I can but record those of which I have the details. What you have to realise is that there was no man who was underground at this time who hadn't a story to tell.

By Monday everyone was beginning to be worried by the very rapid rise of the water in the lower levels of the mine. On Friday, October 25, the pumps had lifted out 17.5 million gallons. On October 26 this rose to 41.5 million gallons and on Sunday to 50.5 million (with the certainty that it would be more than 60 million thereafter).

Since the estimated inflow was still said to be 72 million gallons per day the pumps ought to have been making a considerable impression and the water level in the mine should have been rising slowly. But, in fact, it was rising very rapidly indeed.

If you had been a mining engineer you would then have begun to wonder whether the inflow figures were correct. It was a very difficult job assessing the rate of inflow in the first three days. The surveyors could really only make an accurate assessment when the water in the storage area of the mine reached 24 Level. Then they would have known quantities to deal with.

But the water had not yet reached 24 Level. Suppose that it was flowing in greater volume than had been estimated? (By Friday they knew that it *was*—at 100 million gallons per day.)

The engineers that Monday were on the horns of a dilemma. They knew that the mine's pumping capacity could be rapidly augmented, to pump out more than 70 million gallons per day. They also knew that their neighbours, Blyvooruitzicht and Western Deep Levels—neither of whom relished the prospect of having a "drowned" mine containing perhaps 2,000 million gallons of water on their boundaries—were coming to their rescue. But would they be there in time? Could West Driefontein put its trust entirely in its own pumps and the draw-off that its neighbours would provide?

Mr. R. R. M. Cousens, the consulting engineer, thought it was a case of "try anything that may work". He was in favour of another attempt to plug the 10 and 12 Level drives and thus seal off the No. 4 Shaft area—and the "leak"—from the rest of the mine. He asked Mr. W. S. Garrett, managing director of the Cementation Company, to come out to the mine on Sunday and discuss the possibility.

Cousens at that time had already decided that the neighbouring mines, Blyvooruitzicht and Western Deep Levels, must be asked to join the fight. His thought was that, if they could drill through the boundary pillars and draw water from West Driefontein's storage areas before they filled, there would be time to construct plugs and he believed that in these plugs lay the main chance of saving the mine.

But not many of those present that day thought that the plan had much chance of success. Remember what had happened—the first plug had been washed out, the 133-mile-an-hour gale was sweeping through the workings above 3 Sub-Vertical Shaft and some 95 men were trapped there. The water was flowing in what seemed greater volume than ever.

Mr. Garrett was given all these depressing details and told that there appeared to be little hope of diverting the water and that it would be difficult to get in on either 10 or 12 Level. Nothing could be done that day.

He returned to Johannesburg to ponder over

the problem. It sounded as though it would be virtually impossible to divert the immense stream of water that was flowing through the workings at these levels. And it would take at least three weeks, perhaps a month, to get the plugs in position anyway if it was found possible to do a diversion. According to his estimates that would almost certainly be too late.

But what alternative was there for the mine? If the pumps failed, or if the inflow was greater than had been estimated, they would lose the pumping shafts and that meant losing the mine. The one sure method of saving it would be to put in the plugs. It might be a hundred to one chance that they could be completed in time. But, if men could get into the level and plan a diversion it must be tried. Cousens said: "Go ahead. It must be done."

Mr. Garrett, who is one of the world's foremost authorities on mine plugs, went home to work out the possibilities. In his mind was the thought that, if he could possibly divert the water at some point where there were alternative routes for it, he might succeed.

He returned to the mine on Monday to explain his ideas on the subject and to find that the feeling still was that a diversion was impossible, but if he wanted to try it—well good luck to him. His first problem would be to get into the levels where the "venturi" was still producing a draught of gale force and where the flow of water seemed as strong as ever.

Back he went to Johannesburg to spend most of the night drawing tentative plans for a diversion on 12 Level at a point where a south cross-cut formed an apex with the main drive. It was further west, and closer to No. 3 Sub-shaft, than the site of the plug-that-never-was, washed out on Sunday.

His thoughts at that time were that, if he could use this apex to divert the water while a plug containing large diameter pressure pipes was rapidly constructed in the other heading it might be possible to switch the water through these pipes and build another plug in the cross-cut—a 60 footer in which there would be sufficient pipes to tackle the whole flow. And then . . . but I am running ahead of events that are to come.

Garrett returned to the mine early on Tuesday morning to go underground and see whether he could get into 12 Level and do a reconnaissance. At 9 o'clock he and Mr. F. H. Guise-Brown, a mining engineer who is the company's manager in the Far West, went down at No. 3 Shaft.

They were accompanied by Harold Palmer, who has been at West Driefontein for 17 years and, as they say, "knows the mine like the back of his hand".

They went down to 10 Level, which was the best starting point for their "recce" and then, battling against the water and the terrific draught, made their way to the lift—the same lift that had rescued the trapped men—in which the power was still on. This took them down to 12 Level. They then had a long wade, through water that was up to their waists, to No. 3 Sub-shaft and beyond it to the apex where the cross-cut and the main drive parted. As they got further in they found that there was rather less water than they had expected. But in the mental calculations he was making Garrett added 20 million gallons per day to the estimated inflow. This meant that such time as he thought he had in hand diminished.

They returned to the surface at about 1 o'clock and immediately held a conference attended by Messrs. Cousens, Buley and Pole. There were two vital questions to be answered: Could the water be diverted? Was it worth attempting to put in plugs?

To both questions Garrett's answers were: "Yes". The water could be diverted. The plugs could be built. The company was prepared to tackle the job.

Let it be remembered to the eternal credit of Mr. Garrett that there was no equivocation at this hour. He made his decision calmly and

staked his reputation on it, committing his company and his men to the labours of Hercules for the next three weeks.

What was more he said that, if it could be done on 12 Level he was sure it could be done on 10 Level, too, though he had not had time to make a survey there. This survey was carried out that afternoon by Mr. L. R. Robinson, consulting mechanical engineer to the Gold Fields group and Mr. W. W. Malan, a consulting engineer and a former manager of Doornfontein. They found a site that met the requirements of Mr. Garrett's plans.

In the meantime that man of iron had returned to Johannesburg to work through the night turning his tentative plans into fully detailed ones which, considering what they were to accomplish, were surprisingly simple and understandable to all.

The mine began assembling the material that would be required that night. It all had to be taken down to 10 Level, manhandled to the lift (capacity 6 men) and then manhandled to the site on 12 Level.

So, early on Wednesday morning, the work of preparing the sites for the plugs began. I have before me a report by an underground manager which reads:

"Wednesday, October 30: First stage 12 Level plug: Removed pipes of abandoned plug from plug position. Installed deflection barricade of planks and sandbags. Water deflected to South cross-cut. Transported sandbags and cement for second wall."

Behind these laconic words lies the story of the beginning of the battle in which two teams, each of some 50 white men (a sectional manager, underground managers, four mine overseers and 19 shift bosses formed the 12 Level team) and 80 Bantu were to be involved, working in 6 hour shifts, for the next 17 days.

Elsewhere in the mine these things were happening:

An additional pump was being installed at No. 2 Shaft relay pump station to pump an additional 2 million gallons per day. Preparations were being made for installing six pumps in the No. 5 Shaft complex (later this was to be increased to 10 pumps). This involved laying the foundations on which the pumps were to stand and bringing 28,000 feet of cable to No. 5 Shaft and down it to supply the extra power that would be required.

A 14 inch pump column was being installed at No. 4 Shaft to which it was planned to harness pumps borrowed from the Elsburg and Virginia mines—to increase the pumping capacity of the mine by 7 million gallons per day within a month.

Diamond drilling by Blyvooruitzicht and Western Deep Levels was about to begin on the other side of boundaries of the lease area and West Driefontein was planning drives that would connect up when the drills holed through on 18 Level and 20 Level.

Water doors in No. 2 Shaft area and 5A Subvertical shaft area were being closed—a long job, this. All told there are 16 doors protecting the pumping shafts.

Meanwhile blank flanges for pipes in the plugs and elsewhere were being prepared in the engineering shops and the chief storekeeper, Mr. N. J. Raaff, was making desperate telephone calls trying to order vast quantities of quick-setting cement to augment the mine's stock.

He also needed thousands upon thousands of bags to be filled with sand for the barricades and walls below. And where does one find large quantities of bags at dead of night?

Mr. Raaff was in a quandary until, in a moment of inspiration he thought of telephoning Mr. Jack Waks of Carletonville. Mr. Waks got in touch with the manager of the Sentraal Westelike farmers' co-operative.

Co-operative was the right word in this case. From them the chief storekeeper obtained some 40,000 bags in his hour of need. Thus bags that had once held farmers' mealies helped to save the mine.

The importance of the sandbag walls that protected the pump stations and were used to divert water cannot be over-emphasised. On the first day when the flood poured along the drives water made its way into 12½ Level pump station at No. 3 Shaft and doused the cooling water pump motors. All eight pumps tripped out at a time when they were desperately needed. Two of Jack Tinkler's men, Dick Cottrell and R. Wermer, electricians, went down and managed to get all the pumps started again by manually operating the contactors.

"This was done just in time because the water was actually touching the stators", said Mr. Tinkler. "At that stage failure to get these eight pumps away could quite easily have caused the loss of the mine."

Whatever else was happening in the mine there was always a desperate struggle going on to protect the pumps. You must have in your mind's eye a picture of teams of men working round the clock to build sandbag barricades to hold back the water and divert it from the pump stations. It was touch and go most of the time.

On Tuesday came ominous news. The flow from the Bank Eye, the unfailing water supply of the district had fallen suddenly from eight or ten millions a day to a quarter of that quantity. The following day it dried up altogether—and at once the loud laments of the farmers were heard in the land.

Measurements taken in old boreholes that had been put down from surface beyond the Bank Dyke now indicated a drop of some 32 feet in the water level.

This was all the evidence that was needed to prove that the worst had happened—the water from the vast Bank Compartment was pouring into the mine. It put paid to the hope that the flow would diminish and eventually cease. Estimates of the quantity of water in this great natural sponge vary but most put it at more than 100,000 million gallons. And it was now certain that a considerable proportion of this water was flowing into the mine.

On Friday, November 1, Mr. Louw announced in a statement to the Press that a revised estimate of the inflow put the daily figure at 86 million gallons. This meant that the water was defeating the mine's pumps and, unless the pumping capacity could be increased, and very rapidly augmented by the efforts of its neighbours, there was very little hope of saving the mine. There would have to be an increase of at least 24 million gallons per day in the quantity of water pumped by November 17, the critical date. At that stage it did not look as though this could be achieved.

Mr. Louw's comment was: "The position at the mine continues to be extremely serious and the possibility of having to withdraw all personnel completely during the next several weeks remains."

There was worse news to follow. On Monday, November 4, it was announced that "uncontrollable leaks" in the water-doors on 32 Level, No. 5A sub-vertical shaft, had caused the evacuation of this shaft and the loss of its pumps. This was a very serious blow to the pumping plans for it complicated the problem of getting at the water at the bottom of the mine. Accordingly it was decided to install additional pumps on 20 Level to protect No. 5 and No. 2 Shafts.

In a statement prepared for the annual general meeting of the West Driefontein Gold Mining Company, held on November 5, Mr. Louw told the shareholders that the total inflow was "about 100 million gallons per day, or approximately 40 million gallons per day more than the mine's previously installed capacity." It was hoped that within a week the pumping capacity would be increased to 70 million gallons and that within three weeks the holing through from Western Deep Levels and Blyvooruitzicht would draw off an additional 25 million gallons per day.

Then for the first time he mentioned the forlorn hope (my words, not his)—the plugs.

A Bantu miner working waistdeep in the water at one of the sandbag barricades.

"An effort to install two plugs on each level connecting No. 4 Shaft to the rest of the mine has been in progress since the first inrush occurred", he said. "In order to install four suitable plugs, to allow time for the setting of the sand-cement grout and to take up possible leaks with the cementation process, it is estimated that approximately four weeks will be required.

"On the presently available figures of storage, pumping capacity and rate of inflow, this effort will unfortunately not succeed. However, work will continue unabated in the hope that changing circumstances will give some chance of success."

In his anxiety to give shareholders precise information about the serious position at the mine Mr. Louw was telling them exactly what he thought at that time. There were no grounds for optimism then.

His words might have had a depressing effect on the men at work on the plugs—had they read them. But I doubt whether any of them found time to study the news about the mine at that time, and certainly in all the talks I had with them I could find no one who could recall this rather gloomy forecast.

All the senior officials had been working at fever pitch since Saturday. When they came up to the surface they stripped off their soaked garments, showered, had something to eat and then fell asleep. They woke only when it was time to go underground again. The miners, too, were disregarding the length of their shifts and staying on to complete a particular job. They had often to work up to their waists in water and this left them cold and dog-tired. Every job was twice as difficult as it ought to have been because of the water in the drives.

Building the barricades

The job of "throwing" (mining jargon for "constructing") the plugs began on the morning

of Wednesday, October 30, with an early meeting at No. 4 Shafthead, the control point. At this the various tasks were allocated and the shifts arranged.

It fell to Ray McNaughton and Peter Tress, an underground manager, to take the first shift down to 12 Level and set the ball rolling. Their's was the toughest job of all for they were to begin building a barricade in the apex that would hold back the water that was flowing along the main drive and push it into the South cross-cut. Let me add that the job was no less difficult on 10 Level where work began at the same time.

To build these all-important barricades the men had to work in water that was up to their necks. To get the material they needed—timber, sandbags and cement pockets—into position they had to manhandle them to the site through water and a high-velocity draught (though it was not as bad as it had been when the venturi was at full force).

"The problem of building this wall lay in the business of having to bring the material at 10 Level down the lift and then transferring it to site", says McNaughton. "Everything was carried in by hand. When we got to the ventilation door we would drop the bag or whatever we were carrying and the air blew it in for us. It would stop about 50 feet on the other side of the door.

"You can imagine what happened as the bags of cement broke open in this high-velocity wind. We were covered in sand and cement. It was in our mouths, our eyes, our noses and our ears. We were plastered in the most literal sense of the word.

"I feel that this was the toughest job of all. We really did work up to neck level, as the water rose."

Mine captain Harry Mills, who worked on the 10 Level plug had this to say: "Both the boys and the miners were magnificent. They all worked really hard.

"The white miners did exactly what the Bantu were doing. They took up shovels and lashed which is normally the Bantu's job. The walls were built by white men and on this job, once you dammed the flow, it would come up to your neck.

"We had a former Royal Navy man with us—his name was Glynn. He would pick up a sandbag, hold his breath and allow the sandbag to pull him down right under the water. There he would feel around finding out where to put it. All you saw was one foot, and occasionally his backside, sticking out of the water.

"At times I was a bit worried, thinking that the wall could come down on him and he'd be drowned. But up he'd come and give us the thumbs up sign.

"I've never encountered anything like it, except in the war—and then it wasn't water but mortar fire. There were times when things did not go smoothly but we never had any doubt in our minds that we would succeed in getting the plugs in."

A very simplified explanation of what was to happen, which the diagrams will illustrate and which was roughly the same process on both levels, is as follows (Diagram on page 6):

1. Build wall A to deflect all the water from the main drive on 12 Level to the South cross-cut.
2. Build a second wall B behind this wall to establish a sump from which the inevitable leakages from barricade A could be pumped back.
3. In the dry conditions beyond wall B lay four 30 inch ventilation pipes (the capacity of these pipes being important) and then build round them an 8 foot plug of solid concrete C.

If all these operations succeeded the first round would have been won. The time would then be at hand to carry out the first "switch"—in other words to divert the water that was flowing unhindered down the South cross-cut back to the main heading. This would mean that it would build up behind your "mini-plug"

This is how material was transported to the various places where it was needed. It had to be manhandled by men who worked waistdeep in the fast-flowing water.

and flow through the 30 inch pipes provided for that purpose. The cement would still be setting in the mini-plug but would have to stand very little pressure as long as the water was flowing through the 30 inch pipes, which incidentally would be fitted with flaps that would be wide open at that stage of the proceedings.

The second stage of the operation would then begin and called for:

4. Building a barricade D across the mouth of the cross-cut and almost simultaneously removing wall A (wall B having by this time been incorporated in the mini-plug). It would be no easy job demolishing this wall of quick-setting cement and sandbags. But once it had gone the new barricade would push the water back into the main drive and through the 30 inch pipes in the mini-plug.
5. Then, with all the water flowing through the pipes in the plug C (it was to be hoped), dry conditions would be established in the South cross-cut and the wash-and-polish of the footwall would begin for building a real plug (E), 60 feet in length and containing five 10 inch pipes fitted with valves. This would be a maxi-plug that, under normal conditions, would take you a fortnight to three weeks to build. You would have to have it ready in four days. This would call for 60 feet of packed rock and the pumping in of about 25,000 bags of cement mixed with sand to form a solid wall. To form the five 60 foot pipes that would run through the plug you would have to join 30 ten foot lengths of pipe and test the joints by applying a pressure of 1,500 lbs per square inch—for a leak could be disastrous.

Now you ought to be beginning to grasp the ingenuity of the plan. In one arm of these forked tunnels you have all the water flowing through four 30-inch pipes. In the other tunnel you have five 10-inch pipes set in a solid concrete seal 60 feet long. You have to give the concrete twenty-four hours to set. Then comes the time for the third switch. Once again the barricades would be reversed, diverting the water back to the South cross-cut E. But now instead of flowing freely it would be forced through the five 10-inch pipes.

You now have the torrent bridled but it has yet to feel the bit.

Once again there are dry conditions in the other arm of the apex and the 30 inch pipes no longer carry water. Stage three of the operation begins and calls for:

6. Closing the flaps on the 30 inch pipes, filling them with packed rock and pumping in grout under high pressure, thus converting them into tubes of solid concrete. Immediately after this 15 feet of concrete are to be added to the mini-plug and, at a later stage, a further 60 feet to make the plug 83 feet long.

That describes the procedure that Garrett had planned for 12 Level. But, remember, a similar procedure was to be carried out simultaneously "upstairs" on 10 Level though it was made somewhat easier once all the water that was flowing into the mine was diverted to pass through the 10 inch pipes in the 12 Level plug. That plug, very early in its life, was expected to take the full flow of 85 million gallons a day. It did.

That was the procedure and that, with some cutting of the corners, was what was carried out in a never-to-be-forgotten achievement by miners and cementation teams.

I asked some of the cementation engineers how long it would have taken to construct those plugs in normal circumstance. Their estimates varied from three months to six months.

West Driefontein, fighting for its life, completed the whole operation in 17 days.

And today the broad shoulders of these plugs, considerably strengthened since the first frantic rush, are bearing the pressure of more than 100,000 million gallons of water while the rest of the mine is pumped dry.

Let Bill Garrett, who planned the whole operation, describe it as calmly as he thought it out.

"There is one cardinal difference between making a dam on surface and one in an underground tunnel (he said) in that, as soon as you block the underground tunnel, the water builds up to a high pressure immediately and destroys your dam or plug.

"It is, however, possible to follow the same process as dam builders and that is to divert the river so that part of the dam may be built in dry conditions with suitable passages in it for the river to flow through when it is diverted back to its old course.

"In the case of West Driefontein the flood was so big that it presented a serious problem to provide pipes large enough to carry the flow through a dam or plug and therefore the only hope was to provide smaller pipes and valves, but to build the plugs in such a way that the water could be put under pressure to force it through the pipes."

He listed for me the vital questions that had to be answered:

1. Could suitable places be found to divert the flood while plugs were being built and were hardening?
2. Was it humanly possible, working in fast running water and extremely difficult conditions, for men to make the diversions?
3. Was it possible to get materials to the right spots for building the dams or plugs?
4. Would there be enough time to complete the work?

We know that all these questions were answered satisfactorily. If the answer to any one of them had been "no" West Driefontein would have drowned. But let's see what actually happened.

The pluggers at work

The greatest problem of all was working space. The miners and the cementation teams had to construct their small Karibas in tunnels roughly 9 feet high and 9 feet wide, while working at break-neck speed. A hundred men working in such a confined space, even though the rear ranks are strung out, is quite a crowd. They had to have ventilation laid on and, believe it or not, a water supply as well. Here it may be added that most of the men drank the mine water when they were thirsty. No one was any the worse for this though gallons must have been consumed in the fortnight they worked there.

First the miners removed all loose rock in the footwall and the hanging wall, washed the surfaces down and brushed them. Then everybody carried "plums", the rocks with which the space was to be packed. Meanwhile the pipes, which had to come down to the site in single sections, were being joined up, the joints pressure tested and then arranged in carefully spaced positions. When that was finished the carpenters moved in to build the shuttering.

When all that was done the cementation teams moved forward with their high-pressure pumps and began injecting the grout. For the layman it should be explained that in these days some mines have their cementation ranges (delivery pipes) which run down every shaft and serve every level. The sand-cement mixture, called grout, is prepared on the surface and pumped to wherever it is required thousands of feet below so that the cementation men have a constant supply of fast-setting cement—hundreds of tons of it—on tap. By pressing a lever on the nozzles of their pumps they inject it into any cavity that may require plugging. In this case the cavities were the drives and the amount of grout used ran into thousands of tons.

What everybody feared most was a blockage in one of the cementation ranges while a plug was being built. That would have meant a disastrous delay. Such blockages are not uncommon. In fact they occur on an average once every ten days. Throughout the whole

of this operation not one range failed. All cementation gear behaved "like angels" and the grout was pumped in in a never-failing series of jets.

The men on the surface who mixed the astronomical quantities of grout that were required worked until they were dropping with exhaustion. They may have been only the back-room boys of Harold Palmer's team but they did a wonderful job in keeping the front line supplied.

There were no photographers there to record the scene on the plug sites where the work went on day and night. So you have to imagine these determined men, carrying in everything they needed, scrambling over all sorts of debris that lay in the mud in the drive and taking their turns to get to the front rank to carry out their allotted tasks. They were wet to the waist when they got to the job and sweat-soaked by the time they were finished.

All the you-do-this-I-do-that conventions of mining went by the board in the scramble. Mine captains were seen carrying rocks and helping to clean up the footwall. Underground managers passed planks to carpenters. Everybody lent a hand when it came to getting the cementation pumps into position.

Sectional manager Harry Wheeler's description of the scene will help you to picture it.

"There were cementation chaps standing on trestles being supported by Bantu while they tied off pipes against the high spots in the hanging . . . There were carpenters working like men possessed. There were Bantu mineworkers passing rocks the size of footballs.

"All you saw was a mass of moving humanity. Funnily enough there was very little shouting and very little sound of human voices. Everybody knew what he was doing. It was an impressive sight to see a white miner take over from a Bantu when it was necessary and to see a white man light up a cigarette, take a few draws and then push it into the mouth of a sweating Bantu whose hands were occupied. How they worked!"

That was on 10 Level. Let Leon Leask, an underground manager, describe the same scene on 12 Level.

"On Sunday, November 3, I was withdrawn from the job I was doing to take over the 12 Level plug construction from Peter Tress (who had to leave the job and fly to Britain where his father was gravely ill).

"By that time the coffer dam was installed and we started the South "valve plug" excavation.

"My four crews, all working 6 hour shifts, shared the feeling of urgency that I had. There was not much talking or shouting during the next few days but the atmosphere was electrifying. Every man, and every one of the Bantu, who really pushed themselves to their maximum of endurance, was intensely aware of the situation. The whole area was seething with steaming human bodies as approximately 80 men in two lines lashed the ballast from one to another with shovels and pinch bars flashing as they bent to the job. They were magnificent in those hours of stress.

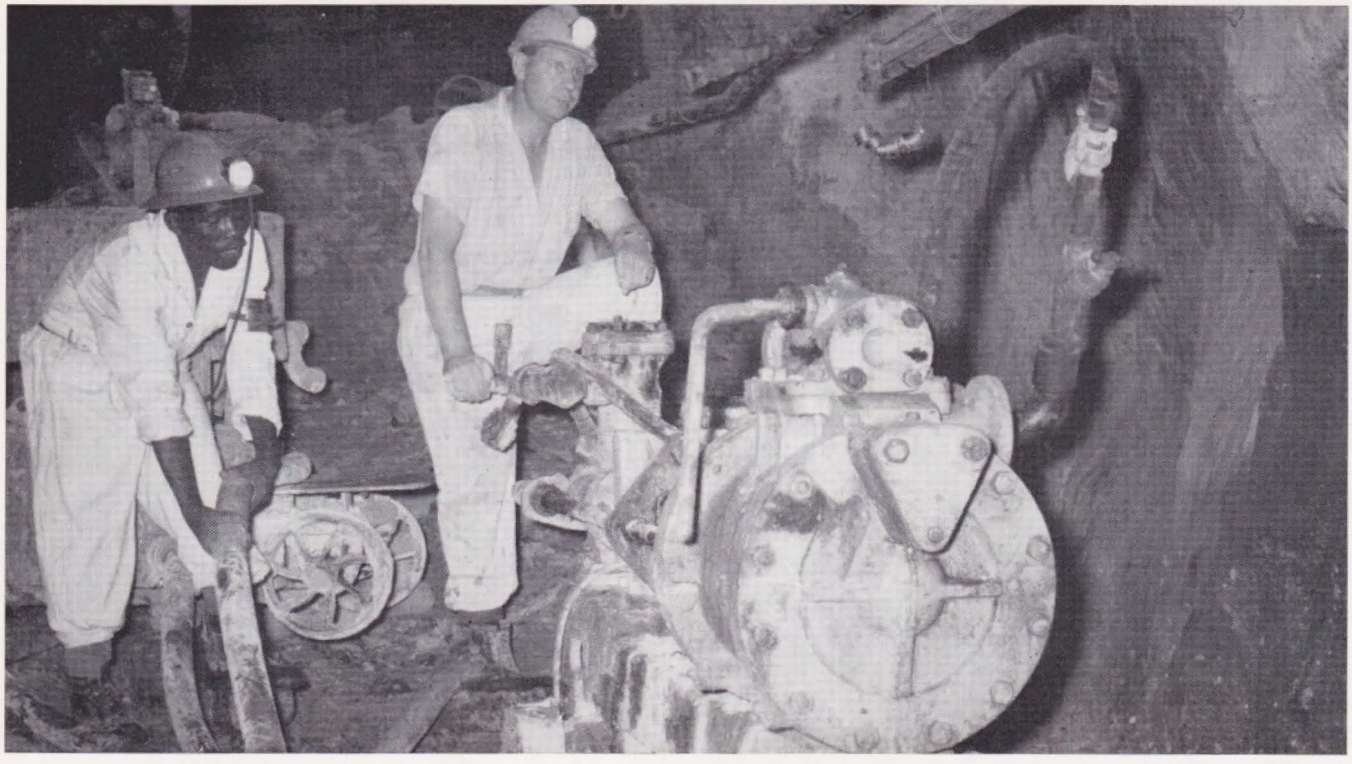
"By Sunday night the shuttering was started by the carpenters and the heavy, high-pressure pipes were manhandled into position and the valves installed. Then the cementation of the plug began.

"The water was then diverted, the flaps on the 30 inch pipes closed and the 15 foot addition to the mini-plug begun. By Saturday—that is six days later—this plug and the main 60 foot plug were complete and I think all the members of my crews had a terrific sense of silence at this stage as the clangour of the job died down. We knew we had done our best and the prospects of saving the mine were very good.

"The various difficulties and snags encountered are too numerous to mention. Once they were overcome they were forgotten."

Peter Tress had a similar story to tell of the first stage of the job, the building of the barricades with men diving into the water with bags of cement and clay to carry out the

A cementation pump underground.



diversion, on the success of which the whole operation depended. This was desperate work while it lasted and it was not until the walls, four feet thick, were completed and the pumps took over in the sumps behind them that the men knew they had won. There were times when they thought they were in a losing battle and the water would never be diverted—but it was.

There must be at least a hundred men on the mine who have a story to tell of the shifts they worked on the plugs. For all of them it was a nightmare, the grimmer details of which have been forgotten. But they all remember the incidents that made them laugh. So the whole mine knows the story of how Johannes Fourie lost his trousers.

He is a carpenter who was working on the 12 Level plugs. After he had waded through the water to No. 3 Sub-vertical shaft two or three times, and thereafter worked in dripping garments, he decided to end this irritation. One night as he came on shift he took his trousers off, folded them and put them over his arm meaning to keep them dry as he waded to the job.

However, during his battle with the water, he raised his arms to keep his balance and away went his trousers, never to be seen again. He had to work throughout the shift, trouserless. He will never live the story down.

And what of the cementation men who worked on the plugs? The company's team of 40 men at West Driefontein was augmented by reinforcements brought in from other mines and other jobs. However, the original team's knowledge of the mine workings, and the liaison they had established with underground managers and mine captains, was perhaps the biggest single factor in getting the job done in time.

Mr. G. A. P. Andreasen was the Cementation Company's manager on the spot and Frank Guise-Brown and Harold Palmer commanded the shock troops down below. What hours

these men kept, and when they slept and ate, no one will ever know. They were constantly on call. The mine's "war diary" is studded with entries that read: "Get Guise-Brown on the phone . . . " "Ask Palmer to send some men to . . . " "Where's Guise-Brown now . . . ?"

For the greater part of three weeks Harold Palmer, who is not as young as he used to be (he's been with the Cementation Company for 40 years), lived like a very active mole darting, as far as it was possible to dart in knee-high water, from one point to another wherever he was wanted. By the time it was all over his weight had dropped by 20 lbs.

In the years to come I think the abiding memory of everyone who took part in the great plug scramble will be a mental snapshot of either Guise-Brown or Palmer, haggard and cement-stained, standing on trestles as they "tightened up" the plugs, concentrating like sculptors putting the finishing touches to a masterpiece.

If there were medals to be awarded I should put these two right at the head of the line.

This narrative has now carried you forward to November 16 when all four plugs were in position and the entire inflow of water was rushing through the five 10 inch pipes in the South plug. The final act in the drama, the closing of the valves on these pipes and the bottling up the 80-million-a-day torrent, has yet to come. It makes a fitting climax to the whole story.

"*Fond hearts and coronets*"

But the battles that were being fought on 10 and 12 Levels were being duplicated in other parts of the mine for it followed that, as the water was diverted from one channel to another, critical situations arose at other points. The control centre was thus kept busy, not only with constant telephone calls from the plug builders, but also with S.O.S. messages from both the No. 5 Shaft area and the No. 2 Shaft area. Water doors were leaking, walls needed raising as water threatened pump chambers and there were constant calls for more men, more sandbags, more timber and more advice.

There was no lack of sympathy and kind thoughts for the men who were fighting for the life of their mine. Messages came from all over the country. Early in the struggle the Minister of Mines, Dr. C. de Wet, personally visited the stricken mine to encourage the men.

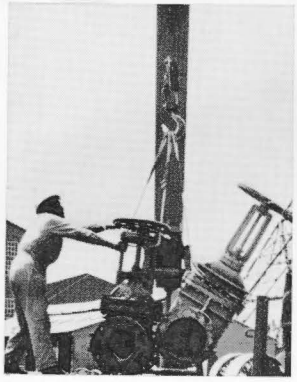
In paging through the diary afterwards and trying to reconstruct the order of events I was baffled to find an entry (sandwiched between "water rising at 16 Level" . . . "Guise-Brown going to inspect water door at 30 Level") which read "Fond Hearts and Coronets". What, I asked myself, had this to do with the hour of crisis in the mine?

A certain amount of detective work produced the answer. A kindly female voice had come on the telephone and asked to be put on to the manager. As both the general manager and the manager were at the control point at that time answering a telephone call a minute she was switched through to "control".

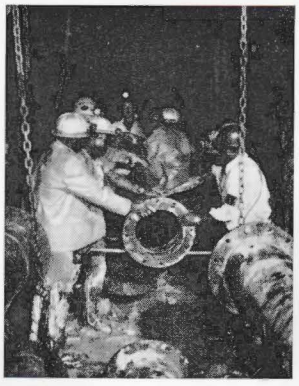
Sympathetically she explained that everybody in Johannesburg was terribly worried about the "trouble" they were having and, as a gesture of goodwill, the management of the ——— Theatre would make available 30 seats for men who wanted to see "Fond Hearts and Coronets".

It was a kind thought but, coming at that hour, it could not but raise a laugh. The mere idea of the men coming up from the flood exhausted and then changing, getting into their cars and driving to Johannesburg to see "Fond Hearts and Coronets" was funnier than anything in the show.

At about this time Mr. Allen Pole, on night duty, received a call, also from Johannesburg, from a merchant who launched into a long statement about nuts and bolts that he either

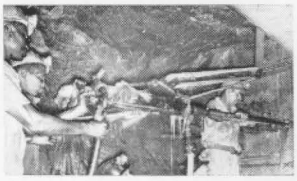


High-pressure, 10 inch valves being offloaded at the mine during the crisis.

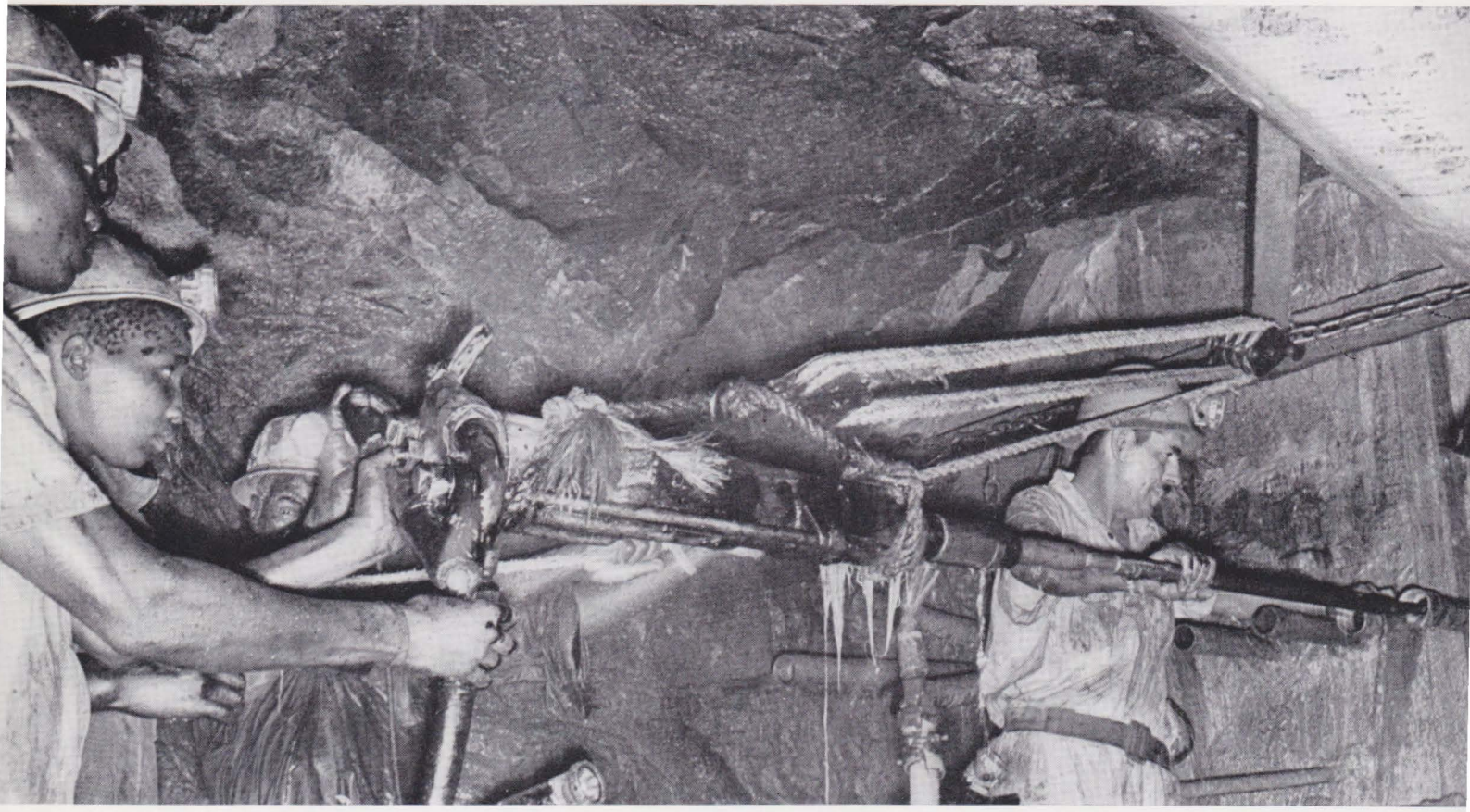


Cleaning up after the valves were closed: the extension pipes on the valves being removed prior to the blank flanges being bolted on.

A small pump being installed to pump dry a sump behind a barricade.



A cementation pipe in a plug being drilled open to allow tightening of the plug.



was or wasn't delivering. He had apparently wanted to get in touch with someone in the chief storekeeper's department whose name sounded something like Mr. Pole's.

Mr. Pole listened to him until other telephones began to ring and then cut him short.

"I suggest you telephone this number (giving it to him) and get in touch with Mr. . . . . ", he said. He'll know all about your problem. I can't help you . . . I know *nothing* about nuts and bolts. I'm only the bloody manager!"

Mr. George De Lacy, the mine secretary, took most of the calls from outside sympathisers and gave them such news as he could.

Among them was one from a well-known Johannesburg man who said that he so admired the heroic battle the miners were putting up that he would like to stand every man "on the job" a bottle of beer. How many were involved? Told that there were over 1,000 men who would qualify he said: "Right, I'll send out the beer." But it was decided to wait until the struggle was over and a celebration justified.

A shareholder in West Wits sent Mr. Louw, the chairman of the company a cheque for R100 to be spent on the men "in any way you wish." That, too, helped to swell the celebration fund.

But it was too early to talk of celebrations yet. The mine was still fighting for its life and, though the early confusion had now given way to disciplined action, there was no certainty as to the outcome.

Though the water being pumped to the surface was averaging 62 million gallons per day by November 4 it was still rising rapidly in the mine and at that date was 180 feet above 22 Level. The storage capacity of the mine, including stoped-out areas and emergency dams below 14 Level and extending to the bottom of the mine, was 1,000 million gallons and this was very rapidly filling up. Once these reserve areas were full the flood would rise at a greatly accelerated rate. Theoretically the ultimate disaster would not come until it climbed to 14 Level and drowned the shafts. But long before that happened it would be necessary to abandon the pumps on 18 Level in No. 5 and No. 2 Shafts and that inevitably would mean the end.

Fortunately, very early in the crisis Mr. C. R. Anderson, the resident mechanical engineer, had decided to augment the pumping capacity in No. 5 Shaft both at the relay station near the top of the shaft and on 18 Level. He had already begun to formulate the theory that the main pumping battle might have to be fought on 20 Level by installing pumps there to check any inflow of water that might threaten the main pumping station above. He had ordered new pumps and motors from the makers, had borrowed every pump on which he could lay his hands and resuscitated the one spare pump on the mine.

It must be remembered that, at this stage, the plugging operations I have described were still a forlorn hope. By November 4 they had reached only the first point at which the temporary plugs had been installed. There were still grave doubts whether they could be completed at all, let alone whether they could be completed in time. Thus the main hope still lay in the straight battle between an immense battery of pumps and the volume of water flowing into the mine.

However, by this time it was realised that the inflow was of the order of 100 million gallons a day and that the pumps were fighting a losing battle. The only good news lay in the fact that the drilling through from Blyvooruitzicht and Western Deep Levels was going ahead much more quickly than had been anticipated and that within a week Western Deep Levels might be taking 10 million gallons per day and that three days later Blyvooruitzicht could probably take 15 million gallons per day.

You then had a sum like this: West Driefontein (with five additional pumps installed) 75 m.g.p.d. + Western Deep Levels 10 m.g.p.d. + Blyvooruitzicht 15 m.g.p.d. = 100 m.g.p.d.

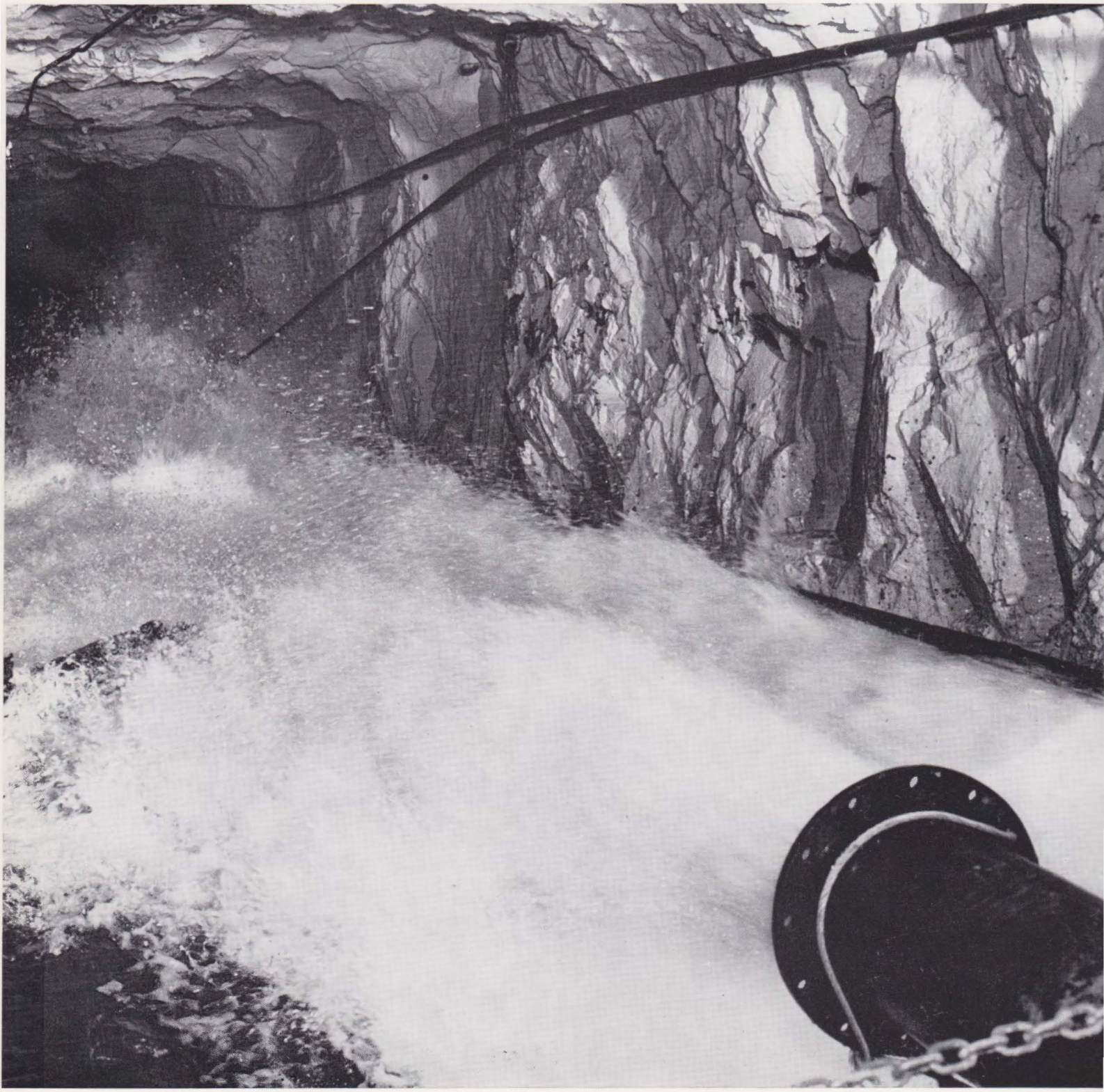
That would bring the position into balance just before the storage areas filled—provided there were no power failures and that none of the pumps "packed up".
To show what a close call it was going to be it may be added that, as from November 4, it was estimated that the pumping capacity and the inflow must be brought into balance within 13 days. If everything worked according to plan that might just be accomplished.

Loss of a shaft

But everything did not work according to plan. At 9 a.m. on November 4, Mr. Adriaan Louw issued the urgent statement to which I have already referred. It said:
"I have just been informed that uncontrollable leaks through two 4-inch pipes in the water doors on 32 Level, No. 5A Sub-vertical shaft, have caused the evacuation of this shaft. An attempt is being made to install pumps on 20 Level station at this shaft with sufficient capacity to control the inflow to this shaft.
"If this attempt is unsuccessful on 20 Level the lower pump stations on 18 Level at both No. 5 and No. 2 Shafts will have to be abandoned in the next few days."
That was the worst possible news and the chairman underlined its gravity by adding that plans were under consideration for the installation of major shaft plugs in Nos. 2, 3 and 5 Shafts below the relay pumping stations. This is a procedure used in flooded mines to protect what is left when all the lower levels have been drowned and all the men withdrawn. Had it ever begun it would have meant the writing on the wall for West Driefontein for at least two years.
Behind this grim announcement lay the story of the struggle that had been going on in the lower levels of the mine to protect the pumping shafts. It was a struggle in which almost everybody in the mine who was not engaged in constructing the four main plugs was involved —engineers, pumpmen, electricians, cementation teams, mine overseers and miners, they were all at work. And it was not the sort of job that could be tackled in shifts. Men who went underground to deal with leaks in a watertight door had to stay there until the job was finished.
The main diagram in this book (Page 6) explains the emergency water plan at West Driefontein better than I can do it in words. This plan was devised in 1957/58 by Mr. S. B. Gibbs, at that time manager of the mine, and Mr. C. R. Anderson, at that time and today resident Mechanical Engineer, whose special pride it was. It was designed to cope with the inrushes of water that were to be expected in workings below the Oberholzer Compartment of which the mining engineers had considerable experience before West Driefontein began producing. It was subsequently extended and improved by the engineers who succeeded Gibbs. In recent years it has been stoutly defended by Mr. Anderson whose cry has always been: "More pumps . . . give us more pumps." As a result West Driefontein has roughly three times the pumping capacity of any other mine on the Far West Rand and probably a greater capacity than any mine in Africa. It's pumps, its emergency dams and the constantly increasing storage areas as sections of the mine were stoped out seemed sufficient to deal with any inrush. You would have thought that its ability to hold 1,000 million gallons in its stomach would be enough!
The cardinal principles of dealing with a water emergency in a mine are to divert the inrush to the settlers of the pumps as soon as possible so that pumping can be accelerated at once and to play for time by erecting barriers and diverting the water down to the lower levels to such emergency storage space as may be available.
The layman never ceases to be amazed by miners' skill in handling the floods that burst

The "mini" plug on 12 Level, showing the four 30-inch ventilation pipes through it.

Water coming through the pipes in the main plug on 12 Level at the rate of 85 million gallons per day.



in on them from time to time. They divert it here and push it there and even appear to make it run "uphill". It is chivvied about just as though it were a flock of sheep. The trouble at West Driefontein was that they were trying to pen a herd of buffaloes.

Soon after the inrush began on Saturday, October 26, and the men had all been evacuated from No. 4 Shaft area, the emergency plan was put into operation. At 11.55 p.m. the instruction was given: "Close all water doors on 5A Sub-shaft."

This was to be followed next day by the closing of virtually every water door in the lower levels of the mine. Once this was done the pumps and the men in charge of them at the bottom of the mine were theoretically safe for at least a week, though they would be working below the water level outside the shafts which might rise 3,000 feet above the level of the pump stations they were manning. The effect of the closing of the water doors was to convert the sub-vertical shafts into sealed tubes from which the water could be pumped to 18 Level and hence out of the mine.

It was, of course, a somewhat nerve-racking job keeping the pumps going at 32 Level in 5A Sub-vertical shaft, knowing that you were surrounded by a rising tide of millions of gallons of water outside the water-tight doors and that if they gave way you would be drowned. But it was a job that had to be done and the cages were still operating in the shaft. Higher up the shaft there were eerie noises as the water doors began to creak under the pressure of the rising water but the pumpmen could not hear those above the noise of the engines.

All pumps were now working full out but the water was rising more rapidly than had been expected and the emergency dam was filling fast.

All went well in No. 5A Sub-vertical shaft until Monday when the first report of a leak in the water doors on 32 Level was received. Thereafter the entries in the diary ran:

8.50 a.m.: 32 Level leaking slightly.
9.05 a.m.: checked that 32 Level water door leaking slightly.
9.25 a.m.: Guise-Brown told to tighten door.

Then at 2.45 a.m. on the following day it was again reported that there was another leak on 32 Level and again Guise-Brown went down to seal it.

Later there is a note in Mr. Buley's handwriting: "Peter Tress phones from 30 Level 3 Shaft and complains of cracking noises near the pressure door . . . The pressure on door at 3 p.m. can only be 100 lbs per square inch and thus is negligible. Any pressure or cracking must be normal ground movement and not a result of the pressure of water but rather the weight of water in the stopes."

However, one cannot blame the men inside the water doors on 32 Level, with the water level outside some 600 feet above their heads, for being slightly apprehensive.

On October 31 that wretched leak on 32 Level appeared again. Diary note: "10.40 water door on 32 Level leaking 10,000 gallons an hour. Inspection to be made of 5A water doors every eight hours."

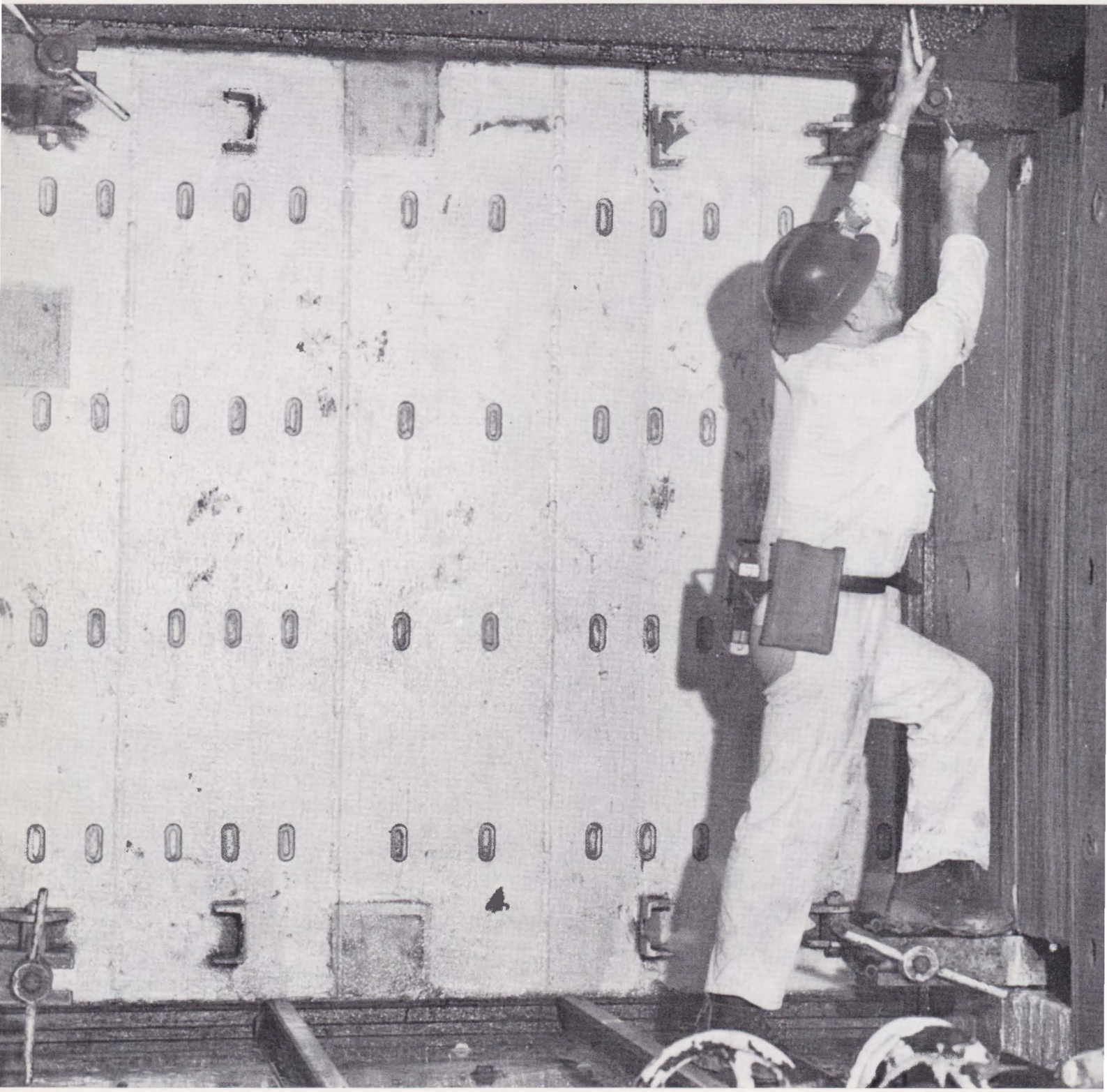
Terry Gouws gives a vivid word picture of his team's effort to plug the leaks.

"Well, we got the report that the 32 Level flanges had started blowing and our first reaction when we saw the water spraying out at such force was panic", he says. "When the engineers could not seal the leaks by tightening up the bolts with a hole in the centre which were bolted to the valves they began pumping pieces of sacking and gland packing through this hole, thus sealing the leaks at the flanges, and then pumping cement into these pipes. But we were still doubtful as to the success of this method.

"They were no sooner finished with the first one than another flange on the West side door blew up and no sooner was this sealed when the East door started leaking again.

"Eventually Mr. Pole decided that we could

A watertight door on 16 Level, No. 5 Shaft. This is a low-pressure door designed to withstand pressures of up to 150 lbs per square inch only.



A makeshift raft used at No. 5A Sub-vertical shaft during the crisis.

not continue sealing the flanges by this method. So we decided to throw a plug at the East door."

But in the middle of their preparations for the plugs that might have sealed the leaking doors they were rudely interrupted. The water cut the bolts on the 4 inch pipe.

"The flange must have opened and it sprayed out water over the whole working area. The Bantu nearly drowned themselves in trying to get out of the place", he adds. "We then had to build up the walls in the cross-cut leading to the shaft to stop it from pouring down the shaft."

But, as fast as they laboured to build their walls, the water topped them and overflowed. They saw there was no hope of getting in the plugs. And that was the beginning of the end. As the pressure mounted the doors on 32 Level began to give further trouble and there were leaks on other levels as well. At one time there must have been 50 men, including an underground manager equipped with goggles and fins, struggling to tighten up the doors on various levels.

On November 2 the pressure of the water cut through two bolts on the valve in a 4 inch pipe on one of the 32 Level doors as though it were a hacksaw and then the flange on another door blew and the water flowed into the shaft causing quite a scare. All labour except the pumpmen was withdrawn at that stage.

The valves were repaired and blank flanges fitted where that was possible, but it was all in vain. Other leaks were pouring water into the shaft. This fight had been lost and at 4.48 a.m. on November 4 the evacuation of the shaft was ordered.

"The loss of 5A Sub-vertical shaft was one of our spinal shivers," said Mr. Rose-Innes. "We held our own for about 24 hours at the bottom of the shaft with the water building up on either side and the men trying to stem what started off as minor leaks on either side.

"The leaks got stronger and the men became more and more doubtful whether they could beat them. Eventually I went down, not so much to give advice and assistance, but to make the men feel that the control point was not quite remote and just looking down from outside. I spent two periods down there and the last time the decision to stop pumping was initiated by me. I could see that we would not make the grade as the water was then rising fast from the shaft bottom.

"I phoned Mr. Pole and told him that we were fighting a losing battle. We could only keep going for as long as we could keep the water away from 32 Level itself which gave us a limited period with no hope of stopping the water."

At 5.10 a.m. that morning sectional manager Harry Wheeler went down to 32 Level to arrange the evacuation of the last of the pumpmen.

"At that stage the water was 10 feet below 32 Level," he said. "I told them all that we had half an hour which was plenty of time. I had the cages waiting. It was a very orderly retreat but a sad one. When the pumps were tripped there was an eerie silence. The last pumpman came out with his logbook and his ruler in his hand. There were tears in his eyes as he took a last look at his pumps."

So the flood had chalked up another victory and it must be confessed that the news of the loss of the pumps on 32 Level had a depressing effect on all who heard it.

Mr. Rose-Innes told me that . . .

"Down on 32 Level I had said to myself: 'If we lose this do we lose the mine or have we still some form of defence?' It was then that we started thinking about having a separate station on 20 Level at which we could try to beat the influx.

"The only doubts that I ever had in my mind about saving the mine were whether we could divert the main stream of the water sufficiently to build secure plugs on 10 and 12 Levels and how we could make up for the loss of 5A Sub-

vertical shaft. Once 20 Level was established as a subsidiary pumping station I had complete confidence that we would win."

Once the 32 Level pumps had been drowned the water in 5A Shaft began to rise at an alarming rate, some 80 feet an hour. So there was another crisis at hand and the question now to be answered was: Could the new pump station on 20 Level be built and equipped to mount at least eight pumps in time? And the time was seven days.

Pumps require solid concrete foundations if they are to act properly. They also require power lines, pipes and sumps. These particular pumps needed protective walls and pipes to the 18 Level sumps above them. There was also the problem that, though new pumps had been ordered, they were still being assembled by their makers in Johannesburg.

Normally the installation of a pump chamber of this size and all the necessary fittings would require at least two to three months. West Driefontein, in its hour of need, had to have some pumps to hold back the rising water within four days and if there weren't eight of them in action within a week the whole station would be washed out as the first plug on 12 Level had been washed out. Then the 18 Level station would go and with it nearly half the pumping capacity of the mine—and that would be the end.

Thus there began one of the most hair-raising races between pumps and water in the history of mining in South Africa. Mine teams prepared the site and the mechanical engineering staff threw the concrete floor while the electricians brought in cables and laid on a main power supply and an auxiliary one as well (as a precaution against power failure or electrical breakdown).

While this was going on the Sulzer pumps were being assembled and tested in Johannesburg with some of the castings still hot from the moulds.

The pumps, when they were ready, had then to be delivered to West Driefontein from Johannesburg and one by one they went there over the next week. But, though the manufacturers had thoroughly entered into the spirit of the struggle and were working day and night, that wasn't enough for the engineers on the mine. Mr. Anderson, I was told, "was on the telephone morning, noon and night."

By 9 a.m. on November 5, the day after the retreat from 32 Level, two foundations had been poured in the new pump station and the walls of the dam had only three feet to go. Two pumps and motors borrowed from neighbouring mines were waiting for the concrete to set.

At 6 a.m. on November 6, the diary in the control room recorded: "Water 12 sets below 20 Level. Come up 165 feet in two hours."

At 7.45 that evening the first two pumps began their running in and some water was lifted to 18 Level but not enough to make much difference to the rising tide. Meanwhile of course, the foundations were being rapidly extended for the reinforcements that were to come. On November 7 the diary, doing its best to cheer everybody up, recorded: "20 Level—almost two pumps."

A close call

Then, on the following day, the new pump station began to show what it could do. Three pumps were running and a fourth arrived on the station at 6.05 a.m. At 11.20 a.m. an entry in the diary recorded: "Fourth pump ready to run." To anyone who knows the difficulties of installing pumps of this size (they were Sulzers), and the cossetting they need before they are ready to go "full out", this sounds incredible but the record is there. And, of course, the water was still gaining and threatening the pump station and the mine.

Material being offloaded during the emergency period.

A fifth pump came in on November 10. At 6.15 a.m. the next day there was cheering news for everybody on the mine: "Report from Blyvoor that they have holed through"—though this did not mean that they could begin pumping immediately.

The news from 20 Level was that the water was still rising but that a sixth and a seventh pump were being installed.

At 9.15 that night someone made a gloomy calculation and recorded it in the diary. In fact it was an estimate of how much time was available to get 18 Level pump chamber ready in case 20 Level was lost.

It read: "Capacity from 20 Level 5A to 18 Level pumps in 5 Shaft at inflow of ± 10 million gallons a day is 14 hours if seven pumps running when swamped."

And how very nearly the 20 Level pumps *were* swamped the next day, November 12! That day, and the day that followed, brought West Driefontein to the very edge of disaster despite the fact that Blyvooruitzicht and Western Deep Levels, having completely outstripped all forecasts, were on the point of giving aid.

The diary entries tell the story better than any words of mine. They run like this:

November 12

a.m. 6th pump, 20 Level running and due to be started at 4.30 a.m.

5.40 a.m.: 6th pump was running for 1¼ hours. Dropped water by 18 inches.

That evening—

10.10 p.m.: Water 9 inches below wall A, 20 Level. 3rd pump to be put back.

10.30 p.m.: Balancing disc in 6th pump giving trouble. Water 6½ inches to go at wall A. Cement bags to be put on top of wall. T. Gouws going down to get water to 5 Shaft bottom. He says this gives 1,000,000 gallons per day.

11.07 p.m.: Water 5 inches from top of wall. Fifteen minutes needed to fix balancing disc. Bags thrown to extend wall by 18 inches.

11.15 p.m.: 6th pump running.

11.55 p.m.: No. 7 pump running.

12.05 a.m.: Motor burns out on No. 7 pump.

What this means is that for most of the day five pumps just managed to hold the water at bay. The sixth pump was being repaired and the seventh pump just about to be installed. The sixth pump was restored to action just before the seventh pump started but the latter's motor and transformer blew up just as it began to pump. Before anything could be done the water rose to within three inches of the top of the wall. Another ten minutes and all seven pumps would have been lost.

November 13

4 a.m.: Six pumps running. Water level dropping.

5.30 a.m.: Six pumps in working order, 5½ running. No. 7 ready by 7 a.m. Motor wet.

8 a.m.: Blyvoor reported taking 1.2 million gallons.

11 a.m.: No. 7 pump O.K.

12.15 p.m.: Western Deep Levels. Today 3 million gallons ex 17 Level.

8.50 p.m.: Carswell reports from 5 Shaft seven pumps running.

12 midnight: Inflow appears to have remained steady at 5 Shaft. Seven pumps going over past 24 hours i.e. 570,000 gallons per hour.

Even though all these entries are written in mine managers' shorthand they must convey to you what a close shave it was. There was a period round midnight on November 12 when the mine was within 10 minutes of losing the pumping battle on 20 Level—and that would have been the end. Even after those hair-raising moments on November 12 the situation was still critical until ten pumps were installed and running smoothly as they were to run for the next six days, lifting 20 million gallons every twenty-four hours.

Nº2
CABLES
HYSTER

A new pump column being installed at the main pump station on 18 Level, No. 2 Shaft.

And what is one to say of the men who performed the unheard of feat of installing a new pump station and seven pumps and motors in seven days? All of them—Mr. Anderson's men, the electricians, the miners, the pump foremen and their teams—worked like men possessed. They have established a record that will certainly find its place in the annals of mining and is never likely to be eclipsed. In what was essentially a team effort, made possible by brilliant planning and backed by superhuman effort, they all must share the glory. But everybody on the mine agrees that one man must be singled out as having made the greatest contribution of all. He is Terence Stirling, sectional engineer (pumping).

Stirling had been working on 32 Level throughout the crisis there while it was still thought it might be possible to augment the pumps in the sub-vertical shaft. He came straight to the job on 20 Level and took charge, working as only a skilled engineer, whose speciality is pumps, can work. He is reputed to have worked for ten days with only twelve hours sleep snatched at intervals between installing new pumps. He lost all count of time or of what day of the week it was. But he does recall the terrible period when the water was within inches of the top of the dam. That he will remember to the end of his life.

Nothing could have been accomplished without an adequate and unfailing source of power and of the hundred and one miracles performed by the electricians on the mine this was perhaps the most impressive of them all. To make certain that nothing should interrupt the smooth running of the pumps they provided not only a main supply but also an auxiliary supply which would have come on if there had been a power failure.

"The possibility of a power failure became a nightmare", said Mr. Jack Tinkler, the resident electrical engineer. "To guard against it shifts were organised round the clock both on 20 Level and at all power supply points.

"The amount of work done on the installation, operation and maintenance of these pumps during this vital period was exceptional and no praise is too high for the men who did it under the most trying and nerve-racking conditions."

November 13, 1968 was West Driefontein's lucky day—or perhaps it would be better to say the day when the graph of its misfortunes levelled out and the tide began to turn. It was just as well, for the men had been working—with a minimum of sleep and constant calls for one more superhuman effort—for 17 days. The strain was beginning to tell on the senior officials who had borne the heavy burden of anxiety for all that time.

It was on that day that both Blyvooruitzicht and Western Deep Levels set their pumps going to draw water from West Driefontein and between them began taking about 6 million gallons a day. Information which was received (after the diary entry quoted above) put the amount pumped by Blyvooruitzicht at just less than 3 million gallons.

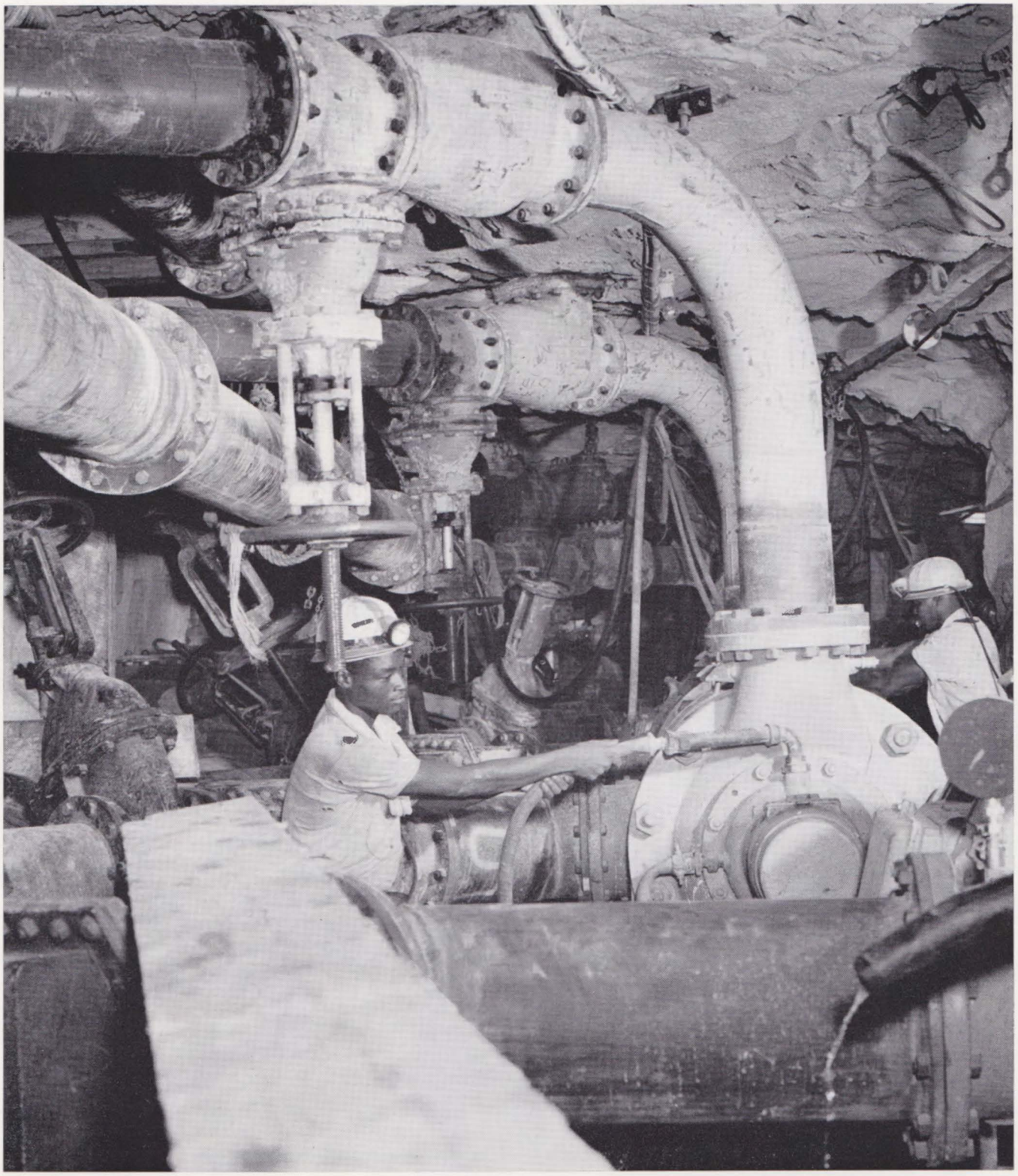
The chairman's Press statement that morning struck a distinctly cheerful note. The progress on the four plugs on 10 and 12 Levels had exceeded all expectations. The grouting of the 10 Level plug had been completed during the night. At the 12 Level plug all that remained to be done was the final tightening-up. Work that had been expected to take three weeks had been completed in 12 days.

Mr. Louw announced that it was expected that both plugs would be ready to take full pressure on Saturday, November 16 or the following day. This meant that the hour was approaching when the five valves in the 12 Level plug would be closed and then, by all the laws of mathematics and cementation, the inflow would be shut off and the whole eastern section of the mine sealed. That was if the plugs held . . .

This was almost the first bit of really good news the men had heard since October 26. A wave of optimism swept through the mine. The end

A view of the partly-completed emergency pump station on 20 Level, No. 5A Sub-vertical Shaft.

Another pump ready to run at the emergency pump station on 20 Level, No. 5A Sub-vertical Shaft.



of what had seemed a never-ending struggle was now in sight. There was a definite date on which they could pin their hopes.

"Have you heard? They'll be closing off the valves on Saturday or perhaps on Sunday," the word went round. "It looks as though we've won . . . if the plugs hold."

It was an announcement that gave the morale of everyone on the property the lift it needed. Meanwhile some 85 million gallons of water a day were pouring through the five 10 inch pipes in the 12 Level plug and with all West Driefontein's pumps going and the assistance its neighbours were giving, water was still coming in at an average of more than 15 million gallons a day faster than it was being pumped out. The 20 Level pumping station was still the crisis point. For the next four days it must continue to pump at its maximum capacity.

All this time, and regardless of what was happening in the rest of the mine, the work on the plugs in 10 and 12 Level drives had gone on round the clock. The plug on 12 Level, which I have described as a "mini" plug, had had a further fifteen feet of concrete added to it when the 30 inch pipes were sealed. In the final stage of its construction it was extended another 60 feet. Thus the heading in the end was blocked by 83 feet of concrete calculated, when it had hardened, to stand virtually any pressure.

Then, with the whole inflow passing through the pipes in the South cross-cut, the apex on 10 Level, in which two plugs adjoined, was turned into a solid block by adding 70 feet of concrete as the tail of the "Y". Thus the two plugs became one and the diverging arms of the haulage were completely blocked.

These "thickening" operations on the four plugs (now three) were completed by Wednesday, November 13. Thereafter there was no outlet for the water pouring into the mine save through the pipes in the South plug.

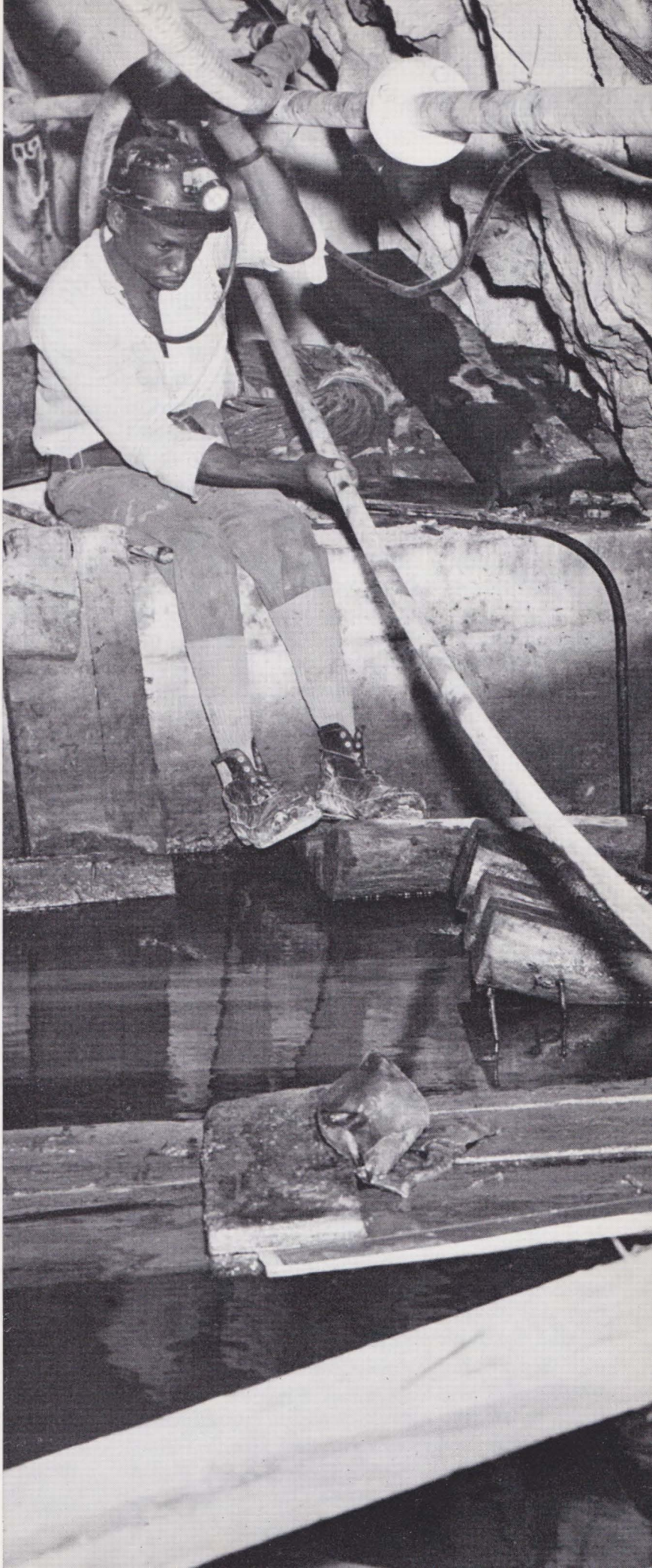
The next step was the "tightening up" of the plugs through the cementation pipes provided for the purpose. These pipes were then injected and sealed off. All that remained after that was the important business of allowing the plugs to harden before being subjected to high pressure. For this four days were the minimum. Therefore the earliest time for the closing of the valves was Sunday, November 17, or possibly, at a squeeze, midnight on Saturday. That would be the great climax of all the endeavour that the men had put into the fight to save the mine—but it could not be hurried.

Closing the valves

The events I have described so far—the last-ditch stand on 20 Level, the construction of the plugs and the loss of the 32 Level pumps—were not isolated incidents in which only three groups of men were involved while the rest looked on. They formed part of the pattern of the whole battle that was under way throughout the mine. The picture is not complete unless you can see, not only these main battle fronts, but also the other levels from 14 upwards where bands of sweating men toiled night and day to build barricades and open diversion channels that would keep the water away from the working shafts and guide it, as far as that was possible, to the storage areas. (I mention "working shafts" because No. 1 Shaft plays no part in this story. It has been out of commission since the working areas that it once served were completely stoped out).

Everything that happened in the eastern area had its effect on the western area. Thus when all the water was diverted through the pipes of the 12 Level plug a minor tidal wave swept along 14 Level and rose behind the water doors that protected Nos. 5 and 2 Shafts. Similarly, when all the water was sent flowing along 10 Level the men at No. 3 Shaft had to fight like tigers to protect the shaft and the pumps.

The water level at the emergency pump station on 20 Level at 5A Sub-vertical Shaft. A power failure of five minutes would have brought the water flooding over the wall on which the Bantu mineworker is sitting, the emergency pumps would have been flooded.



Desmond Patterson, the underground manager at No. 3 Shaft, and Nick van Niekerk, underground manager at No. 2, both have a little extra grey hair to remind them of the sleepless nights and the anxiety they endured during the period when they were told: "If your pumps go: we're finished"—not that they needed to be told this.

One of Patterson's hair-raising moments came on that first day when the pumps on 12½ Level in 3 Shaft, then lifting 16 million gallons a day, tripped out and he thought the worst was about to happen.

"We had them going again in 25 minutes", he said "But they were the longest 25 minutes I ever remember."

The defenders of the shaft handled a flow that was never much less than 50 million gallons a day, and at times rose to more than 80 million, over a period of 23 days. All that really matters is that they won.

Van Niekerk's team at No. 2 Shaft, of course, received what might be described as the "backwash" from No. 3 Shaft, a tremendous torrent. There was a time when they thought that their barricades on 14 Level, designed to push the water down to the bottom of the mine and protect the pumps, were going to be overwhelmed. By the time they were sure they had won their battle these barricades were 30 feet thick.

There was another crisis on 14 Level when a hydraulic plug on this level, which normally serves as a regulator of the flow of water from 14 Level to the pump chambers on 18½ Level in No. 2 Shaft, chose an awkward moment to jam. This happened at a time when it was essential that the outlet the plug provided should be wide open to feed water to the pumps and save the barricades that were protecting the shaft. Normally the raising and lowering of this plug was accomplished easily enough by hauling on a chain block. But at this moment, when 14 Level was flooding, the slings holding it broke. Down went the plug, effectively shutting off the water from the pumps that ought to have been hurling it out of the mine.

The situation called for desperate measures because, if the plug were not coaxed out of its anchorage, the water on 14 Level would rise very rapidly, climb the barricades and pour down the shaft to drown the pumps.

The men on the spot, led by the ubiquitous Harry Wheeler, dived into ten feet of water and fixed slings to the plug. But when they tried to haul it up it refused to budge. It was being held in position by the vacuum created by the drawing off of water by the pumps. Manpower would not suffice to move it.

What could they do? I think it was Harry Wheeler who had the inspiration that saved the pumps. Next to the plug there was an inspection plate which consisted of a 30 inch diameter steel pipe, the steel being a quarter of an inch thick. They sent for an oxy-acetylene burner, burned off the top of the plate and then went down into the pipe in an attempt to burn through it.

"The burning was done by boilermaker Britz and to start with he did not think he could do it", says Wheeler. "But, to his and my amazement, when he heated the pipe and blew through with the oxygen in his torch the flame came right through the pipe. He could look down two feet under the water and see the flame coming through the pipe and burning under water."

In that way they burnt away the pipe until at length they had made a new channel through which the water could flow to the pumps and thus lowered the level before it topped the barricades and went into the shaft.

Having warded off this crisis Wheeler, John Botha, the pump foreman, and a rigger then dived down to the recalcitrant plug and, by sheer persistence and courage, managed to get lashings on to it. They then rigged a block and tackle and hauled it out by main force.

No sooner had they done this than they had a

frantic telephone call from the 18½ Level pump chamber in No. 2 Shaft.

"We're getting too much water now", said the voice. "You're drowning us."

So down went what everyone on the mine calls "the bath plug" again, and the flow of water was controlled. Thereafter the plug behaved obediently.

The incident serves to illustrate some of the hundreds of problems that faced the water controllers as they pushed a flow of more than 80 million gallons a day down to the pumps and the storage areas of the mine.

All this time, of course, these storage areas were filling up with the surplus that the mine pumps could not handle. Towards the end it became an hourly calculation as to how long it would be before they were filled to capacity and water would rise above 18 Level.

West Driefontein then was in much the same position as Bluebeard's wife, leaning from her window and wondering whether her rescuers would be in time.

Blyvooruitzicht and Western Deep Levels were fairly galloping to her aid and, running neck and neck with them, were the four plugs, constructed more quickly than plugs had ever been constructed before.

In the end it was virtually a dead heat. On Thursday, November 14, the neighbouring mines lightened West Driefontein's burden by 7.8 million gallons so that the total quantity pumped out of the mine was 80.3 million gallons.

On the same day, with 72 hours to go before it was estimated that the storage areas would be filled to overflowing, it was announced that the plugs would be ready to take full pressure on Sunday, November 17. That would be in the nick of time.

On the following day West Driefontein and its neighbours pumped out 80.3 million gallons. This colossal "lift" of water now began to have a perceptible effect on the rising tide in the western section of the mine. Hourly measurements showed that, where once the rise on the critical levels had been measured in feet, it could now be measured in inches though it was still coming up.

This meant that, almost for the first time since October 26, there was a little breathing space for the cementation engineers—though not for the men who were watching the barricades. There was not quite the same urgency about the decision as to when the valves should be closed and the plugs be allowed to take the strain. The pumps had won them a little time—perhaps 24 hours. They used it to thicken the solid plug on 12 Level.

Now the hour of decision was at hand. Seven very weary men—Cousens, Buley, Garrett, Andreasen, Anderson, Robinson and Guise-Brown—had to make up their minds whether they should give the plugs a little more time to harden or whether they should give the order: "Close them off."

"There was really no guess work about this decision", says Garrett. "The strength of the plugs could be calculated from test samples of the material used to make them and careful experiments had been carried out on the strength of plugs under the aegis of a Chamber of Mines research panel. On the other hand the rise of the water in the storage area of the mine and the pumping conditions were exactly known."

He was the man who had made the calculations and, now that they were to be tested and his head was on the block, he was completely confident. But you cannot blame the mining engineers if, at that hour, when the richest gold mine in the world was about to be saved or lost, they showed some signs of nervous strain.

They all met at the mine on Saturday together with Mr. Louw, chairman of the West Driefontein Company, and Mr. R. Hope, a director of that company, and decided to take advantage of the improved storage position and give the plugs a little more time to harden.

A close-up of one of the five high-pressure valves used in the main plug. The blank flange, fitted with a cementation cock, can be seen bottom left. The pipes sticking out of the wall in the background go into the plug and were used for "tightening" the plug.

Accordingly, at 8 a.m. on Monday, November 18, Mr. Louw announced that "it is planned to close off the valves and isolate the No. 4 Shaft area some time on Tuesday, November 19."

But at 4 p.m. that day he announced that there had been a change of plan.

He said: "A meeting of the technical advisers to the company was held at the mine this morning. The tests on the concrete of the plugs conducted earlier today proved it to be more than adequate. It was therefore decided at 11 a.m. to make an immediate start on the closing of all five valves . . ."

One of the reasons why this great moment for which everyone on the mine had been waiting was put forward was because the pumps on 20 Level 5 Shaft were still having a desperate battle to keep the water at bay and there seemed no point in prolonging the agony.

Everything was ready. The tools required for the job had been assembled, checked and tested and sent down to 12 Level two days earlier. The blank flanges (fitted with cementation cocks) had been selected and tested. A spare set was ready in case anything went wrong and there was a third set ready in the workshops. The men who were to do the job had been through the drill at least a hundred times.

Thus when the order "close" was given they went down to wade to their job, briefed to the last detail.

Let Barry Mathews, assistant mechanical engineer, leader of the team of eleven men who did the job, tell the story.

"We were entrusted with the finale of the whole emergency—closing the valves and blanking them off", he said. "The actual closing took only two minutes. All valves were closed simultaneously, the blanks were fitted and then the water was harnessed behind the plug. The total time taken from start to finish was 55 minutes.

"The crew who did the job were a bit nervous to begin with. But after it had been explained to them that the pressure behind the plug would not build up immediately they were quite happy about it.

"It was not the greatest feat of the whole emergency. Nevertheless it was an exciting moment, this closing off of the water after thousands of people had been battling day and night for more than three weeks, planning and preparing for this final act."

I have presented the closing of the valves as the dramatic climax to the whole of this most moving and exciting story. And this indeed it was because soon afterwards something approaching peace came to the mine that had suffered so much.

But, in fact, the closing of the valves and the bolting of the flanges was a comparatively simple act that took 55 minutes. Though this shut off a flow of 85 million gallons a day there was no great danger at that moment for the pressure had yet to build up. The testing time for the plugs was to come later as the water filled up the workings behind them and began climbing in No. 4 Shaft. Probably the real moment of danger came when it rose above 1,000 lbs per square inch.

If there had been a fault in any of the plugs, or if serious leaks had developed, that would have been the moment when they might have given way, releasing an angry torrent that would have carried all before it as it swept right through the mine.

As it was the cementation men, who know all there is to know about water pressures, went calmly on with the work of pumping 4,200 cubic foot of grout behind the 12 Level plug, injecting the pipes so that they became concrete tubes and finally sealing off the cementation pipes.

A point about the final operation on the plug that may baffle readers who have followed this description of the various processes is the question of how the men who were to put on the flanges and screw them up got close up to

An auxiliary plug being taken out, after the valves were closed. The method for the construction of the plug—cement with big rocks in it—can be seen.

the five pipes through which the torrent was flowing at 30 to 40 miles an hour. It should be explained that extension pipes had been fitted earlier to carry the water a considerable distance away from the plug and thus avoid "break-back" waves that might otherwise have kept the working area under water. These extensions were removed once the valves were closed.

The control point "war diary" recorded the operation thus:

10 a.m. Decision to close off valves as from 11 a.m. by Messrs. Cousens, Buley, Pole etc. Mr. Louw informed.

12.47: Starting to close off 10 inch valves at 12 Level.

12.50: Closing off completed. No leaks apparent on any of the valves. Blank flanges to be put on now.

1.45: All blank flanges secured on 10 inch valves.

And that was all the diary said.

There were no exclamation marks, no cheerful comments—nothing in fact to indicate that after three weeks of intense anxiety and ceaseless toil the end was in sight.

The truth is that, for Mr. Buley, Mr. Pole and the sectional managers, the closing of the valves was not the end of all anxiety. The well-greased valves had turned smoothly. The flanges had fitted perfectly and the injecting of the pipes and the tightening up that followed had gone according to plan. But these men had in their mind's eye a mental picture of what was going on behind the plugs as the water hurled itself against the concrete that now barred its way.

They saw the torrent building up behind these barriers, filling the stopes and the shaft. They saw a vertical column of water rising at the rate of ten feet an hour until it filled almost the entire capacity of the lost shaft.

Within a few days it would be only 200 feet from the surface and, somewhere about that point, the level in the shaft would balance with the water level in the dolomite. Then, for all practical purposes, the shaft and the workings it had served would be part of the Bank Compartment. At that point the plugs, so rapidly constructed, would be holding back a very considerable proportion of the 100,000 million gallons in that compartment.

They had all done their calculations and they knew that at that stage the pressure on the plugs would be of the order of 2,000 lbs per square inch. Within the memory of all of them was the tragedy caused by a plug that had failed in a South African mine some years earlier.

If they tell you they weren't worried for the next few days—don't believe them.

On the other hand if the Cementation Company's officials ever worry about the plugs they have constructed they never show it. Their attitude is: "This plug will still be here 100 years from now."

Frank Guise-Brown now became the surgeon reporting on the condition of a patient to the anxious relatives after an operation. He'd already had 21 very busy days and nights. The diary tells you what he did on November 20:

10.05 a.m.: F. Guise-Brown reports that he feels both 12 level plugs are in order. He feels plugs are just becoming saturated, hence oozing of droplets of water. Going up to check 10 Level plug.

12.10 p.m.: F. Guise-Brown reported 10 Level plug 100 per cent order.

7.10 p.m.: Guise-Brown down to 12 Level to inspect the plug where an increase of water is reported.

8.30 p.m.: Guise-Brown reported from 12 Level plugs that seepage on plug has not increased. He is placing drilling equipment ready in case it is necessary to seal up some leaks.

2.30 a.m.: Guise-Brown reported from 12

A long view of the main plug on 12 Level, illustrating the cramped space in which the men had to work when they "threw" the plug. The television camera can be seen in the top right-hand corner.

Level plugs that, although quantity has increased, it was clear water. (*This was important because water carrying traces of cement might have indicated a fault in the plug.*) He said he would later on re-drill the pipes and tighten up.

3.40 a.m.: Guise-Brown on the way up.

One begins to feel sorry for Mrs. Guise-Brown! The next morning (pressure 800 lbs per square inch) a little tightening up was done.

A television camera

Soon after the water had been diverted through the valves a television camera was brought down to 12 Level, fixed to the hanging wall and focused on the plugs. The receiving set was installed in an office at No. 3 Shafthead. Thereafter this silent watchdog kept its eye on the five valves.

This, of course, was the show of the year. Everyone on the mine who could possibly do so trooped into the offices at No. 3 Shaft to see the "telly". But it turned out to be the dullest show on earth. The camera stared at the valves and the valves stared back—and nothing happened. It was even suggested that a girl in a bikini should be sent down to liven up the scene.

The alternative was to watch mine captain Hans Kellendonk gazing in admiration at the valves. Kellendonk is a Hollander. He had fought as valiantly in the mine's battle as he once fought with the paratroopers during the war. The valves were his pets and he spent a great deal of time watching them.

"Tell Kellendonk I want to speak to him", said a managerial voice on the 12 Level telephone one morning.

There was a pause and then the reply: "Mr. Kellendonk says he's busy. He can't come to the phone."

"Tell Mr. Kellendonk that he's not busy", said the voice on the surface. "I am sitting in front of the television screen and I can see him leaning against the valves smoking a cigarette."

So the television camera had its uses after all. It turned out that the valves scarcely needed this private eye. There was hardly a moment, day or night, when someone wasn't visiting them, patting them on the head and gazing in awe at the little trickle of water that was flowing from the left-hand corner—all that was left of the great flood.

Photographers came and went and many photographs were taken for the record. And that was just as well, too, for soon the valves were to disappear altogether, buried in the 30 feet of concrete that were added to the plug to strengthen it. Today all you will see if you go down to 12 Level, 4,000 feet below the surface, is a blank concrete wall behind which are entombed the valves and the pipes that were once world-famous.

And that ends the story of the plugs and of how they saved the mine.

"It's over . . . "

I said earlier that peace came to the mine once the valves were shut. This was not because of the cessation of noise. Curiously enough the torrent that poured into the mine was almost completely silent except at the points where it fell to the bottom of a shaft or roared out of the mouths of the pipes in a plug. The great difference came when the level of water in the drives fell suddenly and it was no longer necessary to defend the barricades. Then an almost audible sigh of relief rose from all those hundreds of men who had endlessly filled sandbags and hauled them into place.

Throughout the mine the cry went up: "It's over." Men shook hands, smiled and slapped one another on the back. It had been a long, hard fight but they'd won. Then it was that

the tension ended and peace descended not only on the mine but on the town of Carletonville.

Most of the limelight in this story so far has shone on the men who worked on the plugs and saved the pumps. But it must be remembered that, at the height of the struggle, there were approximately 1,200 white men and 8,300 Bantu at work (of the latter some 4,300 volunteered to work underground). Every man who went underground had his hours of anxiety and discomfort. They began from the moment the cage in which he was going down reached the levels that were flooding and the water splashed into it.

In a mine the size of West Driefontein a flood, even when it is coming in at more than 80 million gallons a day, does not completely fill the drives but pours along them at varying levels. However, the man who is wading thigh-high in water, always has the feeling that at any moment a tidal wave may bear down upon him and knock him off his feet. So that, in addition to the muscular strain imposed upon him by the effort of pushing against the water, there is nervous tension, too. If you can picture yourself working up to your waist in water in a narrow passage thousands of feet underground with the shaft more than a mile away and the cages as your only means of escape you will have some idea of what they felt.

However, as the days went by, familiarity with the conditions underground began to breed, not contempt for the flood, but a sort of "well-here-I-go" attitude. Some men went down in bathing trunks and boots topped by a waterproof jacket.

One underground manager, Leon Alexander, who is no swimmer, took an inflated inner tube to work with him and found that, when he was going with the tide, he could float smoothly down the drives with his feet off the ground.

Mine captains Hans Kellendonk and Harry de Wet, who volunteered to conduct a recconnaisance in the No. 4 Shaft area on the second day of the flood found themselves on the outward journey climbing up a series of waterfalls in the deserted workings beyond 4 Shaft. On the return journey to 3 Shaft they swam for about a quarter of a mile.

Everybody had adventures and escapes of one sort or another but their injuries never amounted to more than cuts, bruises and sprains.

And, of course, grim as it was, the situation produced its jokes, some of which have been immortalised by electrician Paddy Ryan in a series of Heath Robinson type drawings on the notice-board at No. 4 Shaft. I don't know who it was who put up the notice that said: "This has been declared a dust-free mine", or who launched all the Van der Merwe jokes (example: "Why is Van der Merwe a shift boss at West Driefontein? Because he drank Canada Dry.") But I do know that the exciting story of how a cementation man was washed through a 30 inch pipe and emerged unscarred on the other side is a figment of someone's imagination. It would have required a pretty slim kêrel to get away with that.

Of all the individual achievements during the days of crisis I single out that of Wynand Breytenbach, a member of the executive of the Mineworkers Union and a shaft steward at West Driefontein. He earned the respect of everyone on the mine by the way he flung all his energy and organising ability into the struggle.

Mr. Breytenbach, who is a developer, saw the underground manager at No. 3 Shaft on the first day of the crisis, October 26, and offered his services in any capacity that would be useful. He was asked to get together his own team and erect a barricade at 12/28 to help divert the water that was going down No. 3 Sub-vertical shaft.

Then began an almost indescribable struggle that lasted from Saturday night to Monday morning to get bags of cement into position and build a wall. Twice the water topped the barricade and washed it away. Once all the Bantu

on the job ran for their lives when they saw the water coming over the wall. Bags of cement were literally torn from the men's hands in the struggle.

Breytenbach himself was almost continuously underground until 11.30 a.m. on Sunday when at last he was satisfied with his diversion scheme.

His next job was to organise shifts of miners who volunteered to work underground.

"They were all there at 6 a.m. on Monday and they all wanted to go underground," he told me. "I tried to choose only the younger men. But the older chaps would have none of this. They all stepped forward and asked to be chosen."

He found this a most moving scene and had to use all the tact at his command in organising the shifts which it was agreed should be of six hours duration, because men working waist-deep in water felt the cold.

His next job was to organise, at the request of Mr. Buley, a team of developers to go across to Blyvooruitzicht to lend a hand in the work that would be done on that mine behind the drills on 10 Level that were to hole through on 20 Level West Driefontein and in due course take up to 15 million gallons a day.

So swiftly did Mr. Breytenbach get his men and all their equipment together that they arrived at No. 4 Shaft, Blyvooruitzicht before the officials there were quite ready for them.

In the days that followed the Blyvooruitzicht men and the West Driefontein men worked side by side in one of the fastest mining jobs ever done in South Africa. Work began on Wednesday, October 30 and on Monday, November 11, the first pilot hole came through. Two days later Blyvooruitzicht was taking 3 million gallons.

Mr. Breytenbach says that the co-operation between the men of the two mines in this operation was something that he will never forget.

Meanwhile, of course, a similar operation was being carried out at Western Deep Levels. There work that it had been estimated would take two to three weeks to complete was accomplished in eight days and by Wednesday, November 14, the mine was taking 3 million gallons a day from West Driefontein.

For five days these two mines helped to hold their neighbour's flood at bay until the plugs were ready.

No power failures

As for the resident electrical engineer's staff, it is only possible to say that they virtually re-equipped the mine in the space of 20 days. Indeed when you show them a list of all the jobs they tackled during the emergency they can't believe that it was humanly possible that they did all this in the time. But the increase of West Driefontein's power intake from 78 megawatts to more than 125 megawatts speaks for itself.

The 28,000 feet of cable they laid across the mine from No. 2 Shaft to No. 5, down the shafts and into the workings was in position and "alive" within 32 hours. In this they had the assistance of electricians from Doornfontein, Kloof, Libanon and Venterspost. The latter mine also supplied a nine-panel switchboard that was installed very rapidly.

But that only solved half the power problem. Mr. Tinkler got in touch with the Electricity Supply Commission and a temporary sub-station was established at No. 5 Shaft to augment the capacity of the existing sub-station there. However, no Escom low tension switchgear was available so this additional power had to be fed back through two of the mine's circuit breakers on to the bars.

That operation, and the installation of the first six pumps and their motors on 20 Level, proceeded simultaneously but the electricians beat the pump engineers in getting power to the station. Then came the time when a power

failure that lasted as long as ten minutes would have spelled disaster. There was no power failure and all went well.

In addition to these main jobs there was a constant stream of calls for help from all parts of the mine. Telephones, signals and many other services were installed and maintained.

"On many occasions vital decisions were made by the man on the spot and troubles averted in this way", says Mr. Tinkler. Undoubtedly he can look back with pride on what he and his staff accomplished.

Let it be added that in all these operations the mine staff was assisted by a team of five electricians and 10 fitters from the English Electric Company of South Africa. This team, led by M. E. Moyes, C. Leyland, M. Spencer and L. Grobler worked like Trojans throughout.

I found this entry among more than 300 others in the electrical department's diary of events: "Electrical fire in fitting shop reported by Mr. Brear who put out fire and isolated supply to overhead crane."

After all what was a little difficulty like a fire in the fitting shop when everyone was busy?

The hurricane of urgent orders that swept through the mine stores and kept Mr. Raaff, the chief storekeeper, and his assistants busy night and day is best illustrated by a list of some of the demands that were met during the crisis. An army could hardly have asked for more.

This is Mr. Raaff's list of the things he was asked to supply:

	Quantity	*Value*
Bolts and Nuts	60,400 lbs	R7,853
Bricks	190,000	R2,853
Cement	81,400 pockets	R42,256
Bags	46,000	R10,828
Pump spares		R63,104
Pipes, tubing		R47,000
Cocks, valves		R27,473
Sand (approx.)	4,000 cu. yds.	R7,000
Timber		R12,093
Shovels	1,800	R1,801
Tools		R11,078

To this may be added a total of eight pumps that cost R32,000 each. The cost to the mine of other pumps, bought and borrowed has not yet been worked out but it will be high.

Obviously the stocks in the mine's stores were rapidly depleted. It was Mr. Raaff's job to sit at his telephone until the small hours getting the suppliers out of bed and telling them that his demands must be met at once. The response was magnificent. Stores were opened up in the middle of the night and trucks carrying cement, timber and pipes set out before dawn. For twenty-four hours at a stretch convoys passed through the mine gates and in some cases the materials had scarcely been unloaded before they were whisked away to be taken underground.

You have already heard how Mr. Raaff found the sandbags that were needed for the barricades. But that was not the only problem he had to solve. At 2.45 one morning No. 3 Shaft telephoned to say they must have a particular type of big spanner and would he get them at least a dozen. There was only one such spanner on the mine.

Telephone calls roused the motor dealers and engineers' suppliers of Carletonville and they obligingly opened up their shops. Eighteen of these spanners were obtained in remarkably quick time by taking them out of sets that were for sale. It was a case of: "Anything the men on the job want they must have" and no one grumbled.

Lesser statistics than these are no less interesting. There was, for example, the business of feeding the men at the shaftheads when they came up for a "breather", often to go underground again almost immediately. All snacks were "on the house" with the result that the mine paid R1,700 for 7,393 packets of sandwiches to say nothing of 1,652 fish cakes and 24 gallons of soup. During the period of the emergency the mine stores supplied 308 lbs of coffee, 584 lbs of tea and 7,500 lbs of sugar.

"The co-operation we received from the merchants of Johannesburg and Carletonville was magnificent", says Mr. Raaff. "They spared no effort to make our task as light as possible. There were deliveries both day and night and at no time was there any unwillingness on the part of any supplier to make the goods available at the shortest of notice.

"There were several awkward moments when we thought we were not going to be in time with supplies. I remember on one occasion we had just enough cement to last perhaps half an hour. Then, in the nick of time, a consignment I had ordered the previous night arrived by road. Two lorries containing a total of 1,000 pockets turned up with about 25 minutes to spare.

"I am pleased to be able to say we got through everything we were asked to do. It was very strenuous and very worrying but I wouldn't have missed it for anything."

Mr. De Lacy, the mine secretary, pays a high tribute to the Carletonville telephone department which went out of its way, even to sending a special team of engineers to the mine, to see that the telephone service functioned efficiently night and day.

He also praised the girls in the mine offices for working at all hours day and night to keep the mine records up-to-date, to man the switchboard and, in fact, to do anything they could to help. The whole office rallied round and the abnormal demands that were made upon them were handled with calmness and efficiency.

Offers of help

There were men and women in all parts of South Africa who worried about the mine and the men working in it. Letters and telegrams offering advice and assistance poured in from unexpected sources. However, they revealed that most people had no conception of what a daily inflow of more than 80 million gallons involved. They came in some cases from men who were used to handling water in thousands of gallons and thought that it should be a comparatively simple matter to divert the flood or get at it with pumps before it entered the mine. The general manager and his assistants would have welcomed with open arms any plan that might have checked or reduced the flood but there was no one among their would-be helpers who really understood what they were up against.

Some of the suggestions that were received called for the exercise of supernatural powers. Here, for example, is one letter that tells its own story:

"To the Managing Director, Gold Fields of South Africa: I have enclosed a small packet of Sacred Ash which, together with a whole coconut (that can be obtained from any Indian fruiterer in President Street) and 51 cents (one 50c piece and one 1c piece) is to be placed into the water that flows into the West Driefontein mine by a girl who was born on December 1, 1962, and whose name starts with a "J". Then the inflow of water will start to drop within 48 hours . . . Believe in God and have faith in Him. He does wonders."

The general manager, while appreciating the help and sympathy that was offered to him in the hours of crisis, thought that it would be better to stick to well-tried methods—and cement.

I doubt whether the public—even those who knew something about mining—ever grasped the tremendous problem that the men of West Driefontein faced. The newspapers did their best to explain what was happening and how it might end. But nothing short of a full-scale model, erected outside the Stock Exchange and incorporating a series of U-tubes filled with water, could really have brought home to the man-in-the-street what it means to deal with 100 million gallons a day. The most apt analogy I heard was the phrase: "Imagine the entire

water supply of the Johannesburg Municipality flowing into your house. What would you do?" The man who was asked this thought for a moment and then said "Take to the boats."
Certainly it was not the fault of Mr. Adriaan Louw, Chairman of Gold Fields of South Africa and of the West Driefontein company, if the public failed to grasp the significance of what was happening underground. He added to the burdens he bore by compiling and issuing a series of the fullest, frankest statements ever put out by a South African mining company. If you read these as they were published they gave you a very clear idea of how at times his hopes of saving the mine, the brightest jewel in Gold Fields' crown, sank very low indeed and then rose when it began to look as though the battle would be won.
When at last it was clear that the flood had been brought under control and that all was well the messages of congratulation began to pour in. They came from the Minister of Mines and his department, from the shareholders and from ordinary men and women throughout South Africa who wanted to express their appreciation of what the men of West Driefontein had done. Perhaps the most heartwarming of all these were the tributes that came from the managers of other mines who understood what they had been through. "Bravo. Only West Drie could have done it", said one.
"We send you our unstinted admiration and congratulations. Wonderful performance", said another.
Sir George Harvie-Watt, Chairman of Consolidated Gold Fields, London, cabled his board's "very great appreciation of the magnificent and unrelenting efforts which have been made in the West Driefontein situation.
"We are very conscious of the debt owed to you all", he added.
To Mr. Reg Cousens, the Technical Director of the Group, he wrote a letter which contained this well-deserved tribute:
"You have done a remarkable job and when the full story of the flooding at this mine is written I hope that the magnificent part which you played will be spelled out. The whole group is grateful to you and I, in particular, as an old friend, have watched your struggle with anxiety, with confidence and with pride . . . My warmest congratulations on a superb piece of work."
That was some reward for three of the most agonising weeks of Mr. Cousens's whole career as a mining engineer. He has been associated with West Driefontein since the first shaft was sunk. The mine and its production records have been his pride and joy. Had disaster overtaken it at this stage of its career I think it would have broken his heart. In three weeks I doubt whether he ever had more than four hours sleep at night and he was on the spot from the first day to the last.

The great miracle

Ultimately, when all was over, there was a thanksgiving service at the mine's recreation club at which hymns were sung and prayers offered. Two things struck me about this service. The first was that it ought to have been a much more joyful celebration than it was. The other was that, for reasons that I cannot explain, the people of Carletonville weren't there. Perhaps they had not been told that it was taking place, but the fact remains that, where I had expected to see the entire population of the town, there were at most 400 people present.
Yet there was much for which they ought to have been thankful. The men on the mine had bent to their task on the principle that God helps those who help themselves. And Providence looked after them. It was miraculous that there were no electric storms at a time of year when they are to be expected. There was

one day when a power failure blacked out the Far West Rand from Randfontein to Libanon for an hour. Yet West Driefontein, for whom five minutes without power would have meant disaster, was not affected.

And surely the greatest miracle of all was that, in all that period of 23 days when all work was difficult and dangerous, not one man was killed or drowned or injured. For that the mine may well give thanks to God.

Asked by the South African Broadcasting Corporation to comment on what had been accomplished Mr. Buley wrote out one sentence and handed it to the announcer to read it for him since, at that moment, he felt too deeply moved to trust himself to speak. His words were:

"No feat in the history of mining endeavour can surpass the work and the devotion of the men of West Driefontein, who successfully subdued the forces of Nature in the twenty-six days, October 26 to November 20, 1968."

Their laurels

So ends the West Driefontein story—a record of courage, determination and endurance that will be told and re-told throughout the world and is destined to become one of the great stories of mining history.

The men who took part in the battle to save the mine are justifiably proud of their achievement. They have emerged from this ordeal with that spirit of comradeship that comes to men who have stood shoulder to shoulder in the hour of danger. They are better men for this.

They earned their laurels the hard way. And I have little doubt that, when this story has been read, all South Africans will turn to them and say: "Well done, men of West Driefontein. We are proud of you."

Mr. R. R. M. Cousens, Technical Director, Gold Fields of South Africa Limited, and Consulting Engineer to the West Driefontein Gold Mining Company.

This very full account of what happened during those nineteen days fighting the flood leaves little more for me to add. When reports of the flood reached me on that memorable Saturday afternoon, I realized immediately that we had a major disaster on our hands. But I also knew that Gold Fields had the technical ability and the resources to overcome this situation. Lack of time was the vital factor necessitating snap decisions and instant action if the mine were to be saved; and all this fell on the shoulders of those officials who carried the full responsibility of the task. To my mind there was always only one decision that mattered—to install concrete plugs, large and strong enough to stem the gigantic inflow—but how to do this and how to keep them in place was another matter. Meanwhile pumps would have to be installed and the flood waters diverted. The strain of the job weighed heavily on all of us and there were times when sheer exhaustion, physical and mental, appeared to be gaining the upper hand, but the work had to go on and the most anxious hours were to come towards the end. It required only a power failure of no more than five minutes, the failure of a team of men, or even one man, to carry out a task, or perhaps the intrusion of defeatism, to bring about ultimate disaster. Our story is one of individual courage and endurance and no praise is *too* high for the sense of responsibility displayed by those involved in the fight, and for the support so unstintingly given by the neighbouring mines on our boundaries. It was the willing co-operation of all these people which made the ultimate recovery of West Drie possible.

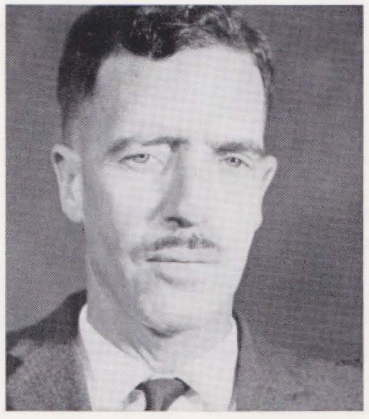
Mr. R. Buley, the General Manager

It was a miracle that we could switch the water from 10 Level to 12 Level and back again to 10 Level. If there was anything miraculous to me, knowing what I did at the time, it was this because to this day I don't quite understand how it happened. However, once it did happen our chances of success for getting in the plugs rose from 20 per cent to 80 per cent.

I started my training on September 23, 1928, which means that I have been working on mines, and underground, for 40 years. Not only have I never met anything like this before but I have never even heard of anything like it before . . . As to what I thought of the men—well read what I said in my broadcast (Page 71). It is just a few words but I don't think I need say more.

Mr. W. S. Garrett, Managing Director, The Cementation Company (Africa) Ltd.

I'd say that this was the most critical underground job that I have ever had anything to do with and without doubt the most exciting. I think that the information that will come to us, and to the mining industry, through the circumstances of this job will be of value for years to come. Once I had decided that we could divert the water I was always confident that we would get the plugs in. My only worry was the time factor. Would there be time to complete the job? I knew it would be a race against time—and it was. I cannot praise too highly the work of our men and that of the mine teams who tackled the preparations for the plugs.



Mr. Frank Guise-Brown, The Cementation Company's Manager on the Far West Rand

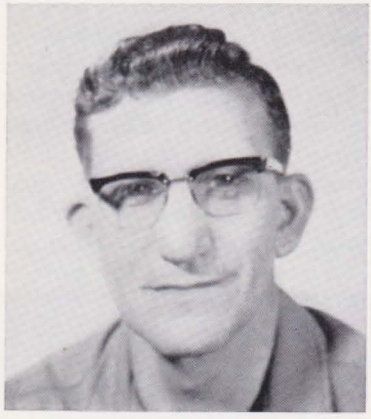
I think the reasons why it was possible to put in these enormous plugs in a matter of 11 days were, firstly, because we happen to have the set-up for doing this. We have the surface pump sheds which are used almost every day on the mine for normal construction work but of course, not used quite as extensively as they have been over the last eleven days. We were also particularly fortunate in this case because we had in our head office the brains to plan this operation in detail and perhaps even more fortunate in having a cementation crew on the mine of whom half have been there for almost 15 years. It was a crew that knew the mine inside out and who, with the minimum amount of fuss and bother, could be sent from level to level, from plug to plug or wherever they had to go. I would like to say a particular word of thanks to Harold Palmer, who has been on West Driefontein more or less since it started and who was actually the chap in charge of all the underground operations.

I would also like to thank the mining department. Our initial schedule did not allow for the turning-off of the valves on the day that it was done but because the mining department did all the dirty work of cleaning out the plugs, the barring and all the rest of it they actually managed to save something like four days, which meant that we did have the time to put these plugs in. Finally I would be failing in my duty if I did not pay a tribute to the top management of West Driefontein. They were always accessible and to my knowledge nobody ever, at any stage, became rattled. Any one of them was always available for discussion and no one ever gave the impression of panic or "flapping". I consider that made a tremendous difference to the success of this operation.

Mr. Leon Leask, Underground Manager

On Monday, November 18, we closed the valves, blanked them off and injected the 10 inch pipes with cement. The flow of water stopped. This was the climax for which we had worked so hard. One could almost see the lines of worry and fatigue fade from the faces of those present although there was still the nagging thought: "Will the plugs hold?" They did! In all the jobs in which I was involved the outstanding aspect that impressed me most was the extreme willingness of the men, both black and white, to give of their utmost—their unstinted physical effort and their devotion to duty. The co-operation between all departments was wonderful and the patience, approachability and tirelessness of the managers in control was marvellous.

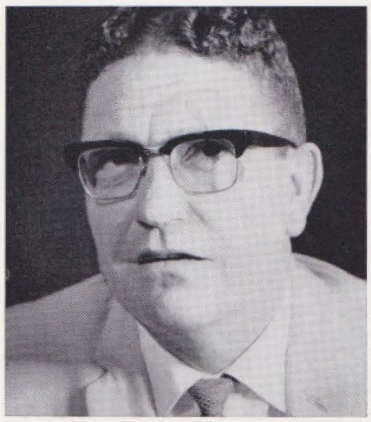
I had no hair-raising experiences though I was more than a bit nervous when we had to seal off a hole on 30 Level. This was an old development drive cover hole, close to the 30 Level East bulkhead door, which had suddenly made some 5,000 gallons an hour when the water built up behind the door. The middling between the hole and the drive was about eight feet and when the hole was sealed off under pressure this middling could have fractured, causing an even greater flow of water. Fortunately it did not.



Mr. W. C. Theron, Shaft Timberman, who rescued the men stranded at 13¾ Level No. 4 Shaft.

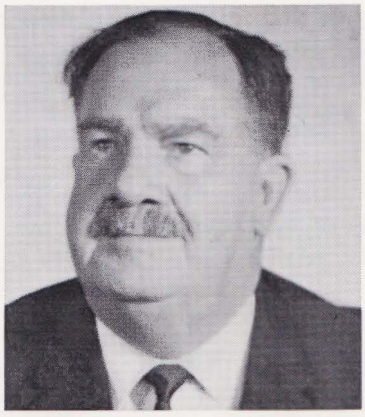
My real trouble was that after we got below 8 Level I could not hear Mr. Cuthbertson on the walkie-talkie because there was so much noise from the water falling down the shaft. The result was that I did not know when we had reached the station on 13¾ Level. I couldn't really tell whether we were going up or down. However when we seemed to have stopped I put my hand out and felt the screening so I knew we were there. Naturally I was nervous because I knew the cage would be pulled up after three minutes so I kept talking all the time. When I got out the first time and shouted for the boys and they did not reply I got back into the cage and went on talking into the walkie-talkie. Then I got them to lower the cage about three feet so it would be opposite the station. Vasco then took the rope and went round to the other side of the shaft where he found the pump boys. We then tied them to the rope and hauled them into the cage. I wasn't really nervous because I knew Mr. Cuthbertson had made this plan and would get us out all right. I would do it again if I knew that Mr. Cuthbertson was at the other end of the line . . .

The Chamber of Mines of South Africa has awarded its Bronze Medal for outstanding bravery—known as "the miner's V.C."—to Mr. Theron and Vascoe for their brave action.



Mr. Nick van Niekerk, Underground Manager

I have been mining for 23 years and I have never experienced anything like this. We had a constant battle to protect 2 Shaft because we all realised that losing it would mean losing the mine. Throughout this period—and I want to put this on record—the men who worked under me never had to be asked to do anything. They were always willing for anything and their morale was very high. The courage that some of them displayed was absolutely fantastic. I would like to record my thanks to them and to the officials for their assistance.



Mr. Les Thompson, Underground Manager

The most hair-raising job that I had to do during this trouble we had with the water, was to go down No. 4 Shaft with a "walkie-talkie". Jack Cuthbertson was on one end and I was in the cage with a mine captain and a shift boss and we had to go down and deflect the water from the one ore pass into another. The noise was terrific. The water falling on to the cage and the ventilation and so on, made it very difficult to hear what was going on. The fact that we could have lost all contact with 6 Level was what worried me most. As it happened, the job was comparatively easy once we tackled it. But never in my experience on the mines have I ever encountered anything like this. What impressed me most was the wonderful co-operation that we got from everybody, both Bantu and Europeans.

Mr. Wynand Breytenbach, Senior Shaft Steward

The most outstanding feature of this operation was the fact that when we called for volunteers for this work, each and every man was willing to step forward and help. It did not matter what the work was. Even if it was pick-and-shovel work, they were still willing. This I shall always remember. I shall remember, too, the co-operation that we received from the managers and men of the Blyvooruitzicht Mine. It was wonderful seeing these men work for us in the manner they did.

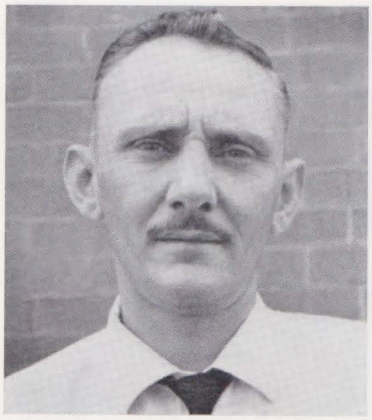
Mr. James Stevens, Mine Overseer

On October 27 the manager allocated me a job, which was to put through a drive from 2 Shaft on 16 Level to the Blyvoor boundary. I had to go down at 1 a.m. in the morning and get the boys together and explain to them what was happening on the mine and the importance of the job. The co-operation of everyone was terrific. All were willing to do their share and they really worked for it was all hand or manual labour. We worked 6-hour shifts and we managed to blast three times in six hours. We cleaned up all this dirt by hand into one-ton cars and they were taken away manually. We had to lash the dirt out again by hand (there were no tips available). This went on continuously until the job was done. The work went on day and night. The gangs changed over and immediately carried on with the work. The most vivid impression I had was of the last shift. We went down as normal, got to 16 Level and found that the water doors were closed. We came up to 14 Level and found that they had already constructed a dam wall to keep the water from the shaft. We could not get through the water because of the terrific force of the ventilation. We were told to abandon this job. The boys left this job and we had to pull the other shift out. This was the hard part. We had to go back to 12 Level and walk a long distance along the haulage and then go down some very steep inclinations. Eventually we found the crew, whom we told to go back to surface. After that we were allocated jobs of water control.

There was a most amusing incident at this stage. One night during my routine visits, I found, on 14 Level, a shift boss named Horak, who had built himself a canoe and was sailing along the dam as though he was on a picnic.

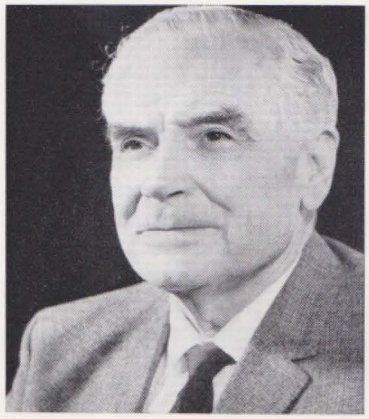
Mr. R. J. Crowther, Mine Overseer

It was the task of my team to divert the flow of water down to 10 Level from 6 and 8 so that No. 4 Shaft could be used to lower men and material. The signalling system below 6 Level was damaged. To get down to 8 Level from 6 we had to make use of the "walkie-talkie". As we were lowered below 6 Level water cascaded onto the cage and the "walkie-talkie" failed. For 10 minutes we remained stationary with a stream of water cascading down on to the cage. After 10 minutes the cage was hoisted back to 6 Level. This 10 minutes seemed like a day. Back on 6 Level we managed to divert the water down the ore pass system down to 8 Level, using sandbags as a wall. Then we proceeded to 8 Level where the performance was repeated and all the water was removed from the shaft down to 10 Level.



Mr. Norman Sellwood, Electrical Foreman.

At one stage I was sent by Mr. Tinkler to 18 Level pump station at 5 Shaft to give a hand, taking charge of two electricians. The pump fitter was having trouble regulating the water to the dam by opening and closing the emergency valves at the top of the dam. We had telephones in but they were useless because the noise of the water discharging and the pumps drowned the voices. I therefore installed some lights at the discharge point at the valves and a pull bell at the pumps. When the bell was pulled the lights at the valves flashed. A code of signals was drawn up and we had no more trouble regulating the water until the end of the emergency. During the first week (I forget which day) I decided to open up the cable trench for the installation of the cables for the new pumps on 18 Level. I instructed my electricians not to use any sharp instrument on this job as that might damage the main cables feeding the pumps. I was called away to check one of the pumps which was overheating. Suddenly the lights went out. I rushed to the trench area and found that they had put a jumper through the cable feeding the main pumps. We immediately pulled the cable out of the water with the help of the electrician on the relay pumps. I isolated the damaged cable which fed four pumps, and put the power back on to the other pumps. By then the level in the low-lift sump had about 3 inches to go before the pump motors would have been flooded. We got the power back just in time and managed to hold the water there. I then tackled the repair job on the damaged cable. Altogether, from the time the jumper went through the cable until it was repaired, it was a matter of just over an hour. But it was certainly a close call.



Mr. Norman Raaff, Chief Storekeeper

This happens to be my 43rd year of service in the Gold Fields Group and during all those years I have never experienced anything like this. I am being honest in saying that, had I been on leave, I should have hated not having been able to serve the company during this emergency. I have already said something about the co-operation we had from the merchants of Johannesburg and Carletonville. Now I want to pay tribute to my own staff. They were magnificent. They did not begrudge a single minute of the long and awkward hours they served and for that I am extremely grateful because, without them, I do not think that the store could have played the part that it did. I am proud of them and what they accomplished.

Mr. J. M. Backman, Shift Boss

Of all the incidents in which I was involved during the emergency, I remember, and always will remember, one morning at 1.30 a.m. on 32 Level, 5A Sub-shaft. We were working on the leaking bulkhead doors which were at that time approximately 1,500 feet below the water level. (The shaft, it should be explained, was isolated from the water by the bulkhead doors). There were two cages on standby on 32 Level to raise us to a safe level at any sign of danger. All of a sudden a 2 inch rubber compressed air hose burst with a tremendous "bang". All the men, whose nerves naturally were on edge, dashed into the waiting cages. When they were all in they shouted to the onsetter to "Ring away". From the cage, right at the back, came a sheepish voice saying "Hier is ek". In the panic the onsetter had been the first to dash into a cage, leaving nobody to ring it to a safe level. When we realised there was no danger we all had a good laugh on the poor old onsetter, who took the teasing with good humour and now has the nickname of "Hiersek".

Mr. Peter Tress, Underground Manager

The general impression of all of us, I think, is of the terrific fight that we have had against the elements. I do not think that, in the history of mining, anyone has ever before had to cope with an inflow such as this. The most amazing feature of it all was the way everybody worked such fantastically long hours—not only the officials. There were many pump fitters who I know worked 48 hours at a stretch under very trying and frightening conditions. The conditions at 5A from 32 Level upwards, were always nerve-racking and the chaps who worked down there deserve medals. Once we had the meeting with the General Manager on the first Wednesday morning everybody began to feel that we were going to win. But until that time, I don't think we felt we had much hope. Once jobs were delegated to each and every man a great fight was put up and every man worked ten times harder than he had ever worked before.

Mr. Jim Ryan, Banksman

On October 26, 1968, I was the Banksman at Kudu Shaft. On arriving at 14 station we found that there was water coming into the shaft which we thought was from a burst pipe. The shift boss phoned someone on surface and they told us about the breakout of water and advised us to get back and to bring everybody out from the Kudu Shaft and the stoping area, and take them up to 12 Level. The shift boss instructed me to stay behind in order to take telephone messages. I waited and at various intervals rang up the bank and they said they were coming to fetch us. Eventually, round about 11 o'clock the last boy came up from the bottom and everybody was then out. I then rang again and told them that the water was increasing and asked what I was supposed to do. I was then told officially that they could not come and fetch me, but that I should take the boys and work my way up to 12 Level. I said that I did not know the way, and was then put on to Mr. Pole, who started talking to me. Suddenly I looked up and saw the water coming in a 4-foot wave towards us. I dropped the phone and decided it was time to get out. The boys were running about in all directions trying to find a way out.

I decided to continue walking with the boys, not knowing where I was going. I stopped in the cross-cut and was bowled over by the rush of water. I picked myself up and made my way across to the Kudu Shaft. I noticed that the Bantu were running ahead of me and I shouted to them to come back and asked them if any of them knew the way out. They did not. I then knew that it was up to me to get these men out so we started to walk and halfway between Kudu and the place we had left, the lights went out, leaving us in darkness. We took a turning left—why I don't know—and found a notice which read "V.C.R. cross-cut". I knew it was the V.C.R. being mined between 14 and 12 Levels. After going a short distance we came upon a stope. There we stopped to check our party and found that everyone was still with us. Then we started to make our way up and after climbing for quite a considerable distance, it became obvious that we had missed 12 Level. It was too late to turn back so we just followed the ventilation and found ourselves in a raise with a terrific amount of ventilation coming through it. I thought that this area must lead somewhere and, after a lot of crawling through small places, we continued until we came to a level and were more than relieved to see lights in the distance. We found a miner there who told us that we were on 10 Level. We then went to the station and a mine captain told us that we had to go through to 3 Shaft. Once again I did not know the way so the mine captain gave us a guide. On the way we were walking in water waist high, filled with timber, sacking and other debris and the going was tough. We arrived at 3 Shaft, looking dreadful, and came to surface where I found my wife waiting for me.

When it was all over—a number of the men who took part in the struggle against the flood.

Alberto Noife and Luiz Sandela, Pump Boys

We are the men who were rescued from the pump chamber on 13¾ Level, No. 4 Shaft. We are both Shangaans from Portuguese territory. Our kraal is near Masinga. We really did not know what was happening on that day when all the water came down the shaft except that there was a big noise. At first we had the telephone and we tried to get the boss boys at the bottom of the shaft but there was no one there. Then we rang the banksman and he said to stay where we were till the cage came to get us. But no cage came. Then the lights went out. Then the telephone was no good and still the water was coming down. When the lights were gone we used one of the lights on our hats and kept the other one for later. We were very frightened. It was cold and we thought we were going to die. Much time went by and no one came for us. We climbed up on the sets and sat there. When the cage came we saw no lights and could hear nothing until suddenly the boss boy came with a rope and they pulled us into the cage. We were very frightened when we had to go through the water. (*This was the curtain of water falling outside the pump chamber*). But we were very, very happy when we got to the top. We felt bad afterwards and we were sneezing but soon we were well again . . . Alberto has sent a letter to the chief and to his wife telling them about it.

Vascoe, Boss-boy No. 4 Shaft

At 6.30 p.m. Mr. Cuthbertson told me that two pump boys had been left underground at 13¾ Level, and he asked me if I was prepared to go down with Mr. Theron to fetch them. I replied that I would. He asked if I was not afraid and I replied that I was not. On surface I had not been afraid, but I must admit that when I saw the amount of water, and the noise it was making, I was afraid, but felt something must be done to save the pump boys. When the cage stopped, Mr. Theron was informed through the walkie-talkie that we were at 13¾ Level. We could not see the station, as the water was pouring down past the cage. I left the cage and went to find the pump-boys. They had removed their boots and hard hats, and they were very scared. I made them put their boots and hard hats on, and we returned to the station. They were afraid to climb through the water into the cage, so I climbed back into the cage, collected a rope and climbed back onto the station again. I tied the rope to the first Bantu, and whilst Mr. Theron held the rope, I made him climb through the water into the cage. I did the same with the second Bantu, and I then returned to the cage and we were pulled to surface.

The Chamber of Mines of South Africa has awarded its Bronze Medal for outstanding bravery—known as "the miner's V.C."—to Vascoe and Mr. Theron for their bravery.

Glossary of mining terms used

Banksman
The person on surface who controls the routine working of a shaft. He gives the signals to the engine-driver indicating to which level the conveyances must be sent.

Bells
A signalling device used by the Banksman and Onsetter to communicate with the Hoist Driver. Depending on the number of rings on the bell the Driver knows to which level he must raise or lower the conveyance.

Bumping (in stopes)
See **Talking**.

Cage
A conveyance which travels up and down in the shaft (similar to a lift).

Cross-Cut
A tunnel which heads at right angles towards the reef body.

Develop, Developer
A miner who works at blasting a tunnel through the rock is known as a developer, and he is said to develop a tunnel.

Development End
The end of a tunnel which is being advanced.

Dolomite
A soft sedimentary rock overlying the reef formations on the Far West Rand, consisting mainly of calcium and magnesium carbonate.

Drain
A curved concrete furrow running in the floor of a tunnel through which the water flows from the workings to a position near the shaft where it enters a waterway.

Drive
A horizontal tunnel.

Driving (Mining)
The process of excavating a tunnel.

Dyke
See intrusion.

Fault
A fracture in the earth's crust, accompanied by movement of the rock formations on either side of the fracture.

Fissures
Fractures or cracks in the rocks of the earth through which water may be forced if the underground workings intersect them.

Flange
Blank flange: A solid circular piece of metal bolted onto the open end of a pipe or valve to close it off.
Blowing flange: Caused by the pressure of the water breaking the seal between the flange and the valve face. Water is then forced through this aperture and the flange is said to blow.

Footwall
The floor of a tunnel or a stope.

Grout
A fluid mixture of cement, sand and water which can be pumped through pipes by using special cementation pumps.

Hanging Wall
The rock above ones head in a tunnel or stope.

Haulage
A tunnel (one which usually connects with the shaft and through which the ore broken in the stopes is taken to the shaft for transportation to surface).

Hoist (Rock-, Man-)
The mechanism comprising the motor and the hoist drums round which the ropes are wound for raising and lowering the rock skips or man cages.

Intrusion (Geological)
Originally molten rock (lava) from the depths of the earth which forced its way into cracks and fissures in the earth's crust before solidifying.

Jumper
A steel rod, tipped with a tungsten steel bit, used to drill holes in rock.

Lease Area
The area of ground over which the Government allows a mining company to extract minerals.

Lash (with shovels)
Load broken rock with shovels.

Levels
These are access points in a shaft from which tunnels are driven to the workings of a mine. Usually spaced at regular intervals of about 200 feet in the shaft.

Miner
The person responsible for directly controlling the Bantu mineworkers in a stope or development end.

Official
A person (Shift Boss, Mine Overseer, Underground Manager) who assists the Mine Manager to maintain a good standard of workmanship in and on the mine.

Onsetter
The Banksman's assistant who travels up and down the shaft in the cages.

Ore Pass
A very steep tunnel (approx. 60° inclination) through which broken rock mined on the upper levels can be passed all the way down to the shaft bottom from whence it can be hoisted to surface.

Plug
Long concrete block constructed in a drive or tunnel underground to completely seal it.

Plug (hydraulic-)
A remote-controlled plug used to divert the water (similar to bath plug).

Plum (in cementation)
When constructing an underground plug a box is made which is filled with large rocks (plums). This box is then pumped full of a cement, sand and water mixture (grout) which hardens. The final result is similar to concrete, the plums taking the place of the aggregate.

Pump Chamber
A large underground room, usually near the bottom of a shaft, in which the pumps are mounted.

Reef
In this book, a bed or layer of gold-bearing rock—a good analogy being a sandwich with the butter being regarded as the goldbearing reef and the bread as the layers of rock above and beneath.

Sets
Wooden or steel beams used to support shaft walls or loose rocks in underground tunnels. Usually installed at regular intervals in a shaft.

Settlers (pumps)
Underground water is mixed with fine particles of rock and mud, and if this mixture is pumped directly to surface, the pumps will be damaged. The water is first taken to settlers where the mud and sediment is removed through settling. The clear water then goes to the sumps.

Shaft

Vertical Shaft: A connection from surface, usually circular and of diameter 18 to 30 feet, which allows access to the mine's underground workings.

Sub-Vertical Shaft: A shaft which is sunk from the underground workings to a greater depth.

Incline Shaft and Sub-incline: Similar to the above, but at an angle which usually is similar to the dip of the reef—say 30°.

Shaft Timberman
A person whose job it is to maintain all the equipment in a shaft. The word stems from early days when most of the shafts were equipped with wooden beams. Modern practice is to use steel.

Station
A shaft station is found on each level immediately adjacent to the shaft. It is a place where material and equipment which is lowered in the conveyances can be temporarily stored until taken into the workings.

Stope
A working place in which the gold-bearing rock is mined or excavated.

Stoper
The man who controls the work carried out in a stope.

Sump
An underground chamber which is used to store clean water prior to pumping it out.

Talking (in stopes)
When a tunnel is driven or reef removed from a stope, stresses and strains develop in the rock near the opening. At great depth this stress releases itself slowly by deforming the rock in the vicinity of the excavation. The rock is said to talk when small cracking noises are heard. If the stress is suddenly released it makes a loud noise or "bump", often causing much damage through collapse of rock in the workings.

Tighten (a plug)
Holes are drilled through the concrete of a plug at angles so that they intersect the rock on all sides. Through these holes a cement/water mixture is forced at high pressure by a cementation pump, filling up any small cracks in the concrete or the rock in which the plug is situated.

Ventilation Door
Wooden doors placed in tunnels to force the air used for ventilation to travel through the working places and to prevent it from coming back to the shaft.

V.C.R.
Ventersdorp Contact Reef.

Waterway
Special tunnels, usually steeply inclined, to take any underground water from the higher levels progressively downwards to storage chambers (sumps) from whence it can be pumped to surface.

Water Raise
See waterway.

Winding Rope
A steel cable which is coiled on the drum of a hoist. It passes over a wheel in the shaft headgear and is attached to the conveyance in the shaft. The hoist driver, by winding the rope on and off the drum, can raise or lower the cage in the shaft.