

# The presinking of Harmony No. 4 shaft by use of the MATLA headgear

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## SYNOPSIS

A new shaft system was required to replace stope face for the North Section of Harmony Mine and to allow for systematic opening up of the North Eastern Section. Owing to the economic circumstances at the time the project started, it became vital to alter the original planning and to sink the service shaft first.

The MATLA coal-sinking headgear, a novel presinking arrangement, allowed sinking to continue to 108 m concurrently with the erection of the permanent sinking headgear and sinking winders. It is estimated that this arrangement resulted in a saving of two months on the overall project.

## SAMEVATTING

Met die doel om 'vervangings'-afboufront vir die Noord Seksie beskikbaar te stel, asook die ontsluiting van die Noord-oostelike seksie moontlik te maak, is die noodsaaklikheid van 'n addisionele skagsisteem ondersoek. In die lig van die ekonomiese toestande met die aanvang van die projek, was dit noodsaaklik om die beplanning te hersien en voorkeur aan die graving van die H4 diensskag te verleen.

Die MATLA skagtoring, tot op hierdie stadium uitsluitlik ontwerp en gebruik op 'n koolmyn, het toegelaat dat die graving tot op 'n diepte van 108 m voltooi is, terwyl die permanente skagtoring en hysers opgerig is. Hierdie metode het 'n tydbesparing van twee maande tot gevolg gehad.

## Introduction

### History

Harmony Gold Mining Company is situated in the Orange Free State (O.F.S.) Goldfields at the town of Virginia. The mine was formed in 1952, and the first bar of gold was poured in 1954, the extraction of uranium following shortly afterwards in 1955. In June 1973, the Supreme Court of South Africa sanctioned a scheme in which Harmony Gold Mining Company acquired the entire share capital of the Virginia Orange Free State Gold Mining Company Limited and Merriespruit (Orange Free State) Gold Mining Company Limited. After the amalgamation, an expansion programme was undertaken to increase the milling capacity from 480 kt to 620 kt per month.

The mine is divided into four sections: the North and West being centred on the original Harmony Gold Mine, the East being the old Virginia Mine, and the South being the old Merriespruit Mine.

### General Geology

The gold-bearing conglomerates of the O.F.S. Goldfields are overlain by a blanket of younger rocks of the Karoo System. The typical geological succession is shown in Fig. 1. The economically viable gold-bearing conglomerates are in the Basal and Leader Reefs.

The Basal Reef has accounted for most of the gold extracted from the goldfields. The reef band consists of one or more pebble bands and varies in thickness from a few centimetres to approximately 1 m. The total channel rarely exceeds 1 m, although channels of up to 2 m have been found. The pebbles vary from 12 to 50 mm in diameter and can consist of quartz, shale, and chert with minor lava and jasper. The primary sulphide mineralization consists of modular crystalline and finely disseminated pyrite. Carbon is usually present in the form of

scattered granules or as seams between bedding planes. The gold mineralization is concentrated on the lowest contact with sporadic values higher up in the channel.

The Leader Reef is much lower in gold mineralization and is distinguished from the Basal Reef by differences in the relative abundance of the different types of pebbles. In general, this reef has very pronounced pay shoots, indicative of the transport direction at the time of deposition, and the mineralization is far more evenly distributed within the channel. The channel can vary from a few centimetres to more than 3 m.

### North Section — Harmony Gold Mine

This section of the mine is centred on Harmony 2 Shaft and 2 Sub Vertical Shaft. Production for the financial year 1981-1982 amounted to 1642 kt (136 kt per month) and 9000 m of development.

By far the majority of the production is derived from the Basal Reef. Prospecting and mining on the Leader Reef this far has shown the gold ore in the Leader Reef to be very patchy and of a lower average grade than in the Basal Reef. The strike of the reef in this section of the mine varies from north-south to east-west, and the dip varies from flat to approximately 12°. This area of the mine is heavily block-faulted, north-south trending faults being cut off against east-west trending faults. Displacements vary from 3 to 30 m with a maximum of 100 m. In general, the Basal Reef channel is immediately overlain by a khaki shale, which can vary from a few centimetres to 2 m. This shale has caused considerable mining problems.

The complexity of the faulting and the dip of the reef have largely dictated the mining configuration, and have resulted in a system of scattered mining with severe rock mechanics problems on predeveloped off-reef excavations. The very scattered mining system results in a number of logistical problems in terms of the travelling times for the shift. Thus, shorter times are available for production if a bank-to-bank time of 8 hours 45 minutes is observed.

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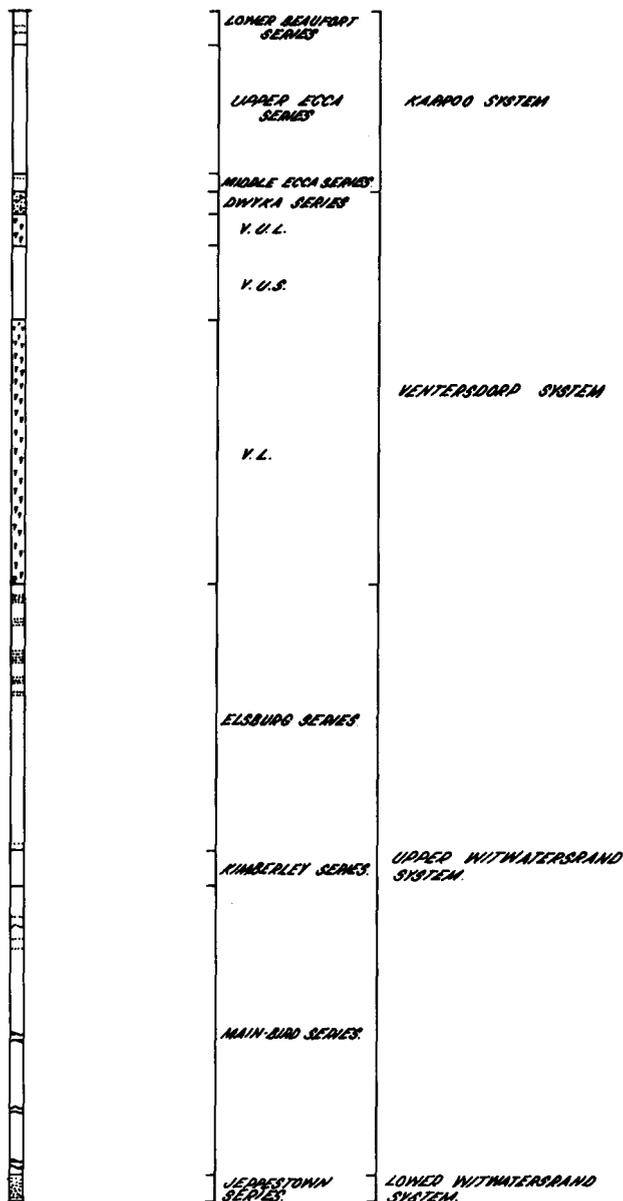


Fig. 1—Idealized section of geological formations encountered at Harmony Gold Mine  
 V.U.L.=Ventersdorp Upper Lava  
 V.U.S.=Ventersdorp Upper Sediments  
 V.L.=Ventersdorp Lava

In addition, there are severe ventilation problems in this section of the mine, and face temperatures (with cooling installed) vary from 29,5 to 32,0 °C wet bulb.

### Motivation for a New Shaft System

In the determination of a life-of-mine plan for Harmony it became apparent that the north-eastern corner of the mine would be serviced from Harmony 2 shaft and Virginia 1 shaft. Both these shafts are far from this area, and it was evident that the transportation of men and material and the ventilation would not be satisfactory without a major development programme and substantial additional refrigeration units.

Furthermore, it was estimated that, with a sustained high gold price, a large new block of lower-grade ore

would be available for mining long after the rest of the mine was worked out. In more-detailed scheduling for the North Section of the mine it was evident that stope-face availability would diminish to the extent that, unless the face advance could be dramatically increased from 4 m to approximately 7 m per month, the flow of ore to the Harmony mill would be significantly decreased (Fig. 2).

A new shaft system to serve the north-eastern corner (areas A, D, and E in Fig. 3) would have the following advantages.

- Rapid travelling times for personnel in areas A, D, and E would lead to higher productivity.
- These areas could become an independent ventilation district not requiring any refrigeration.
- Waste rock from the north could be diverted to the new shaft, thus enhancing the reef-hoisting capability at 2 shaft.
- Men, material, and ventilation facilities previously provided from H2 shaft for this area would become available for area C, the north-west corner of the mine.
- Some rerouting of downcast air would also be possible for the Western Section of the mine, enhancing the environmental conditions — area K. In the longer term, the Virginia lease areas F, G, and H would be better exploited via the new shaft system than through the present Virginia 1 and 2 shafts.
- Finally, the provision of a new hostel complex would allow the existing hostel facilities at Harmony 2 and 3 shafts and at Virginia 1 shaft to be upgraded.

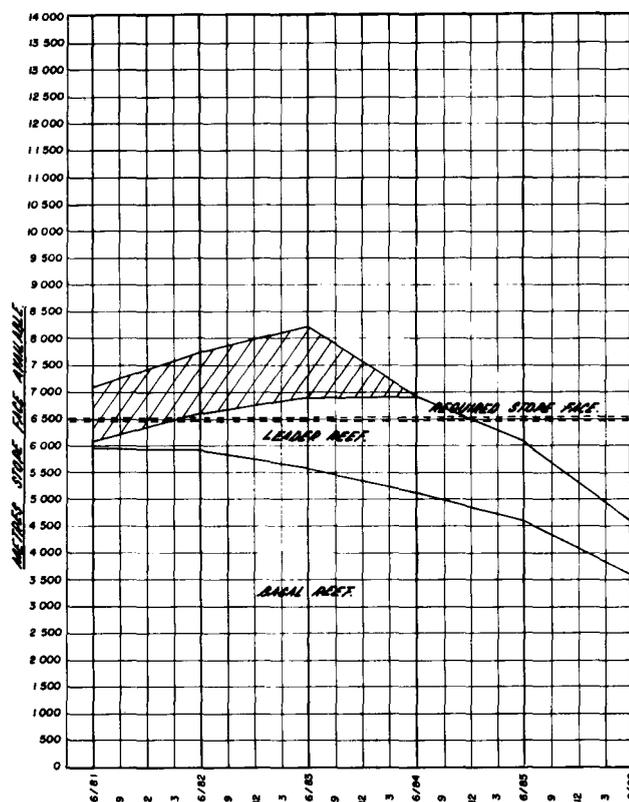
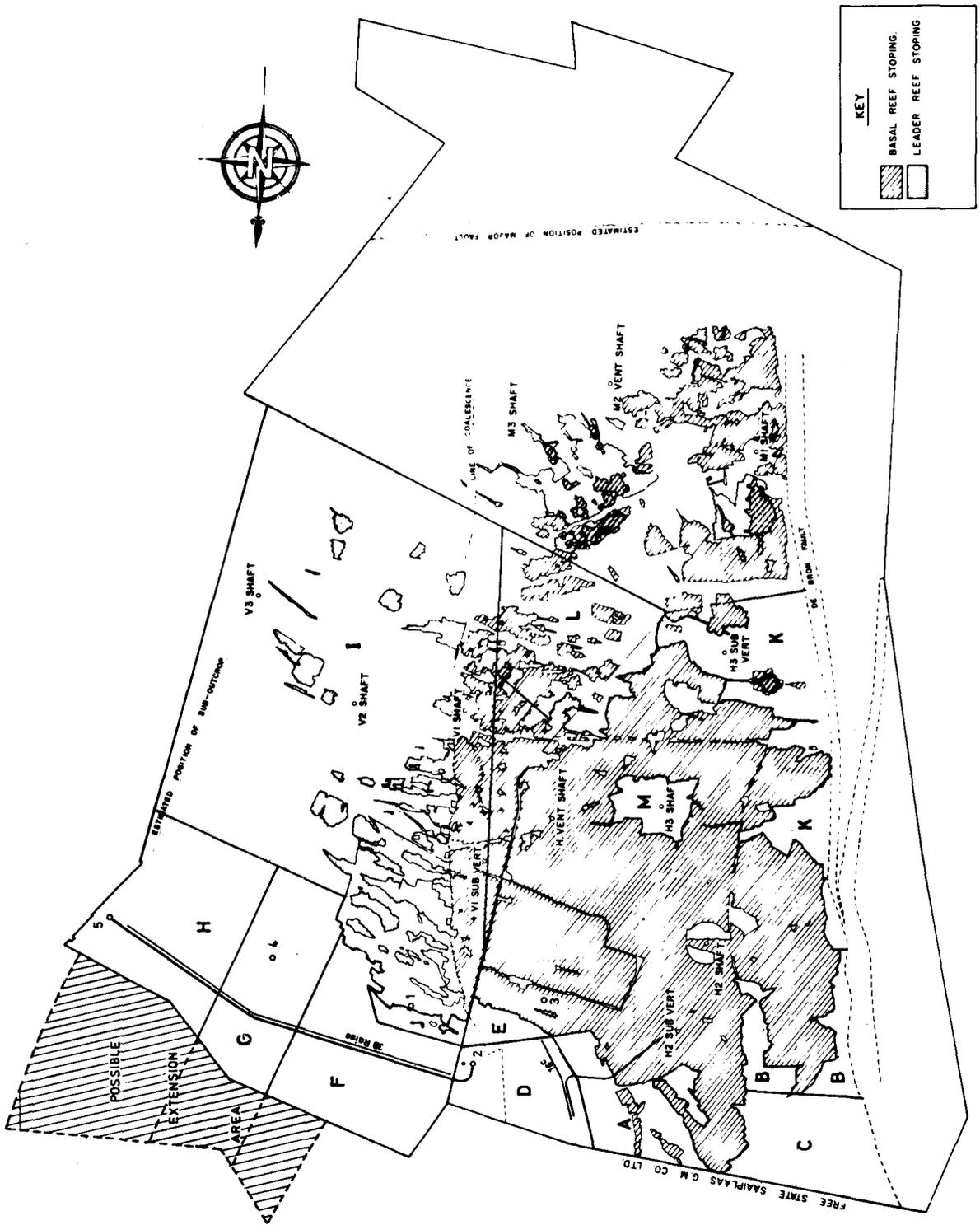


Fig. 2—Face available at Harmony Gold Mine in the Basal and Leader Reefs



SCALE 1:40,000

Fig. 3—Plan of Harmony Gold Mine showing the allocation of the various areas

An analysis of various shaft systems (i.e. a bratticed wall shaft, a twin-shaft system, and a downcast shaft plus extensive underground return-airway development) showed that a twin-shaft system would best cater for the immediate and long-term facilities required in the total mine plan. In the analysis use was made of calculations of present value for all the alternatives, and the twin-shaft system was found to be the most cost-efficient solution to the problem (Table I).

TABLE I  
COST\* COMPARISON OF SHAFT SYSTEMS FOR HARMONY

Proposed System	
H4 twin-shaft system (Phase 1)	47 761 500
10 Level twin haulages (Phase 2)	3 600 000
V4 Upcast-ventilation shaft (Phase 3)	5 000 000
TOTAL	56 361 500
Alternative 1	
H4 multipurpose bratticed shaft (Phase 1)	44 900 000
V4 service shaft to 10 Level elevation (Phase 2)	29 300 000
V5 upcast-ventilation shaft (Phase 3)	5 000 000
TOTAL	79 200 000
Alternative 2	
H4 multipurpose bratticed shaft (Phase 1)	44 900 000
V4 multipurpose bratticed shaft (Phase 2)†	17 200 000
Main return airway on 1 Level (Phase 3)	900 000
TOTAL	63 000 000

\* All costs calculated at present values

† Assumes no hostel at V4 shaft

The final siting of the twin-shaft system was influenced by the need to establish mineable reef for the North Section in as short a time as possible, as well as to fit into the longer-term strategy of systematically opening up the remainder of the lease area (Fig. 3).

At the time the decision was made to proceed with the project, a sinking crew was available from ERPM (East Rand Proprietary Mine) and, because little detailed planning had been completed, it was decided that the ventilation shaft should be sunk first and the service shaft later.

#### Harmony 4A Ventilation Shaft

This shaft is 6 m in diameter and 1280 m deep. It will be equipped with two centrifugal fans to allow for a duty of 400 m<sup>3</sup>/s at 7,5 kPa water gauge.

As time did not permit precementation of the shaft barrel, it was decided to preceementate to only 60 m. Thereafter, a 36 m 8-hole spiral cover would be completed every 30 m to a depth of 200 m. Below that depth, an 8-hole pilot cover would be carried. The preceementation started on 23rd December, 1981, and was completed on 12th February, 1982.

During the preceementation, it was found that the surface elevations in the immediate shaft surroundings moved upwards by 80 mm, even though a low-pressure (1,4 MPa) grouting technique was used.

Civil contractors constructed the collar, which was toed in at 10,3 m below surface. Extensive reinforcing of the collar was necessary because of the shale bands,

which crumble and deteriorate on being exposed to the atmosphere. The same contractors constructed the foundations for the kibble winder, stage winder, headgear, and compressor. This work started on 15th February, 1982, and was completed by the end of March.

At that time, in view of the prevailing gold price, the whole project was re-evaluated in terms of what capital could be delayed and what portion of the lease area would be mined if a low gold price were to prevail during the remainder of the life of the mine. In this sensitivity analysis, it was determined that the highest priority was for a service shaft — not a ventilation shaft — and alternative sinking arrangements were obviously required.

The following alternatives were investigated.

- (1) Stop the ventilation shaft, erect the permanent service-shaft headgear at its original site, and then sink the service shaft.
- (2) Continue to sink the ventilation shaft, but incorporate bunton boxes so that it could be equipped if work did not proceed on the service shaft.
- (3) Blast out the ventilation-shaft collar, slip to a service shaft of 8 m diameter, continue sinking, and erect the permanent headgear on completion of the sinking.
- (4) Continue sinking the ventilation shaft while preparing the service shaft for sinking, erect a temporary sinking headgear, sink the service shaft, and erect the permanent headgear only after completion of the shaft.

When these alternatives were costed and considered in terms of the short-term and long-term strategy, it was decided that alternative (4) was the most acceptable. The H4A ventilation shaft was therefore presunk to only 48 m to allow for the permanent sinking arrangements to be installed when the sinking and equipping of the service shaft had been completed.

#### Harmony 4 Service Shaft

Once the decision had been taken that the service shaft was to be sunk first, the following problems arose.

- (a) The sinking crew was already on site.
- (b) If the permanent headgear was to be erected before the sinking commenced, there would be a delay of approximately ten months before the sinkers could recommence work.
- (c) As was the case for the ventilation shaft, it was felt that civil contractors should be used for the construction of the collar, which would require extensive reinforcement in order to cater for the loads that would apply when the permanent concrete headgear was erected.
- (d) The Inspector of Mines will give exemption for unguided travel to a maximum depth of six times the diameter of the shaft (48 m in the case of the service shaft).

At that time the sinking contractor came up with the idea of making use of their MATLA headgear, which had been developed by Gold Fields Cementation and Mining Co. Ltd to sink a major shaft for a colliery. The advantage of this headgear is that it provides guided

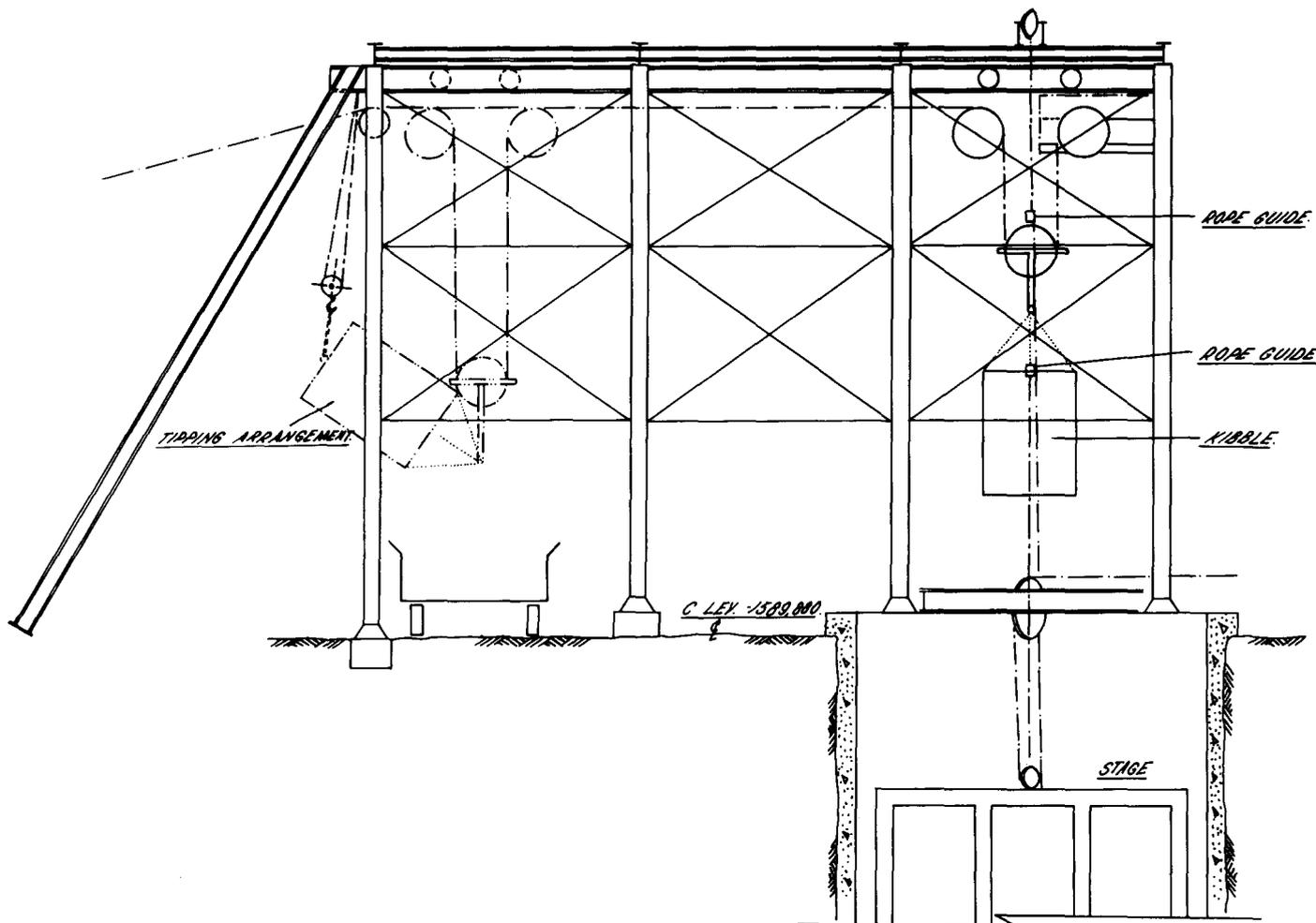


Fig. 4—General arrangement of the MATLA headgear

travel for the kibble, and therefore a complete shaft can be theoretically sunk by use of this facility.

### The MATLA Headgear

As stated previously, this headgear was designed to provide the guided travel requirement of the Department of Mines. As can be seen from Fig. 4 the stage winch ropes pass over temporary sheaves incorporated on the bank level down to a two-deck stage back-up and through sheaves incorporated in the MATLA headgear back down through the sheaves on the temporary stage, and are anchored in the stage.

The single-drum kibble winder operates one skip, which can traverse horizontally from the tipping position to the centre of the shaft, from where the cross-head attaches onto the two-stage ropes to provide the guided travel. This horizontal travel is accomplished by means of a system of pulleys as shown in Fig. 4. The detachment and re-attachment of the cross-head are shown in Figs. 5 and 6.

In the tipping position the kibble is traversed to the limit of the horizontal travel and lowered sufficiently for a tipping winch rope to be attached to the bottom of the kibble. The kibble is raised to the top of the travel

and the tipping rope is tensioned. The kibble is then lowered, causing it to overturn and shed the load of rock.

The lashing in the shaft bottom takes place using an EIMCO 630 Loader, which is raised and lowered in the shaft by the MATLA kibble winder. An effective lashing cycle of twelve 6 t kibles per hour has been achieved by use of this system, which has resulted in an average rate of 3 m of sinking and concurrent lining of 3 m per day.

The typical daily cycle of operations achieved during the presink and slow sink from 18 to 108 m below surface is shown in Table II.

The temporary sinking stage is a two-deck stage with a central kibble opening through which a single 6 t kibble passes as well as the EIMCO 630 loader used for lashing the round. All concreting operations are carried out from the two decks of this stage, as is normally the situation where a conventional sinking stage is used. However, the stage has to be raised and lowered into position for each concrete pour of the curb, barrel, and tiller. These operations cannot take place from a single-stage setup.

### The Sinking of Harmony 4 Service Shaft

The site layout is shown in Figs. 7 to 10. From this it can be seen that the MATLA headgear straddles the

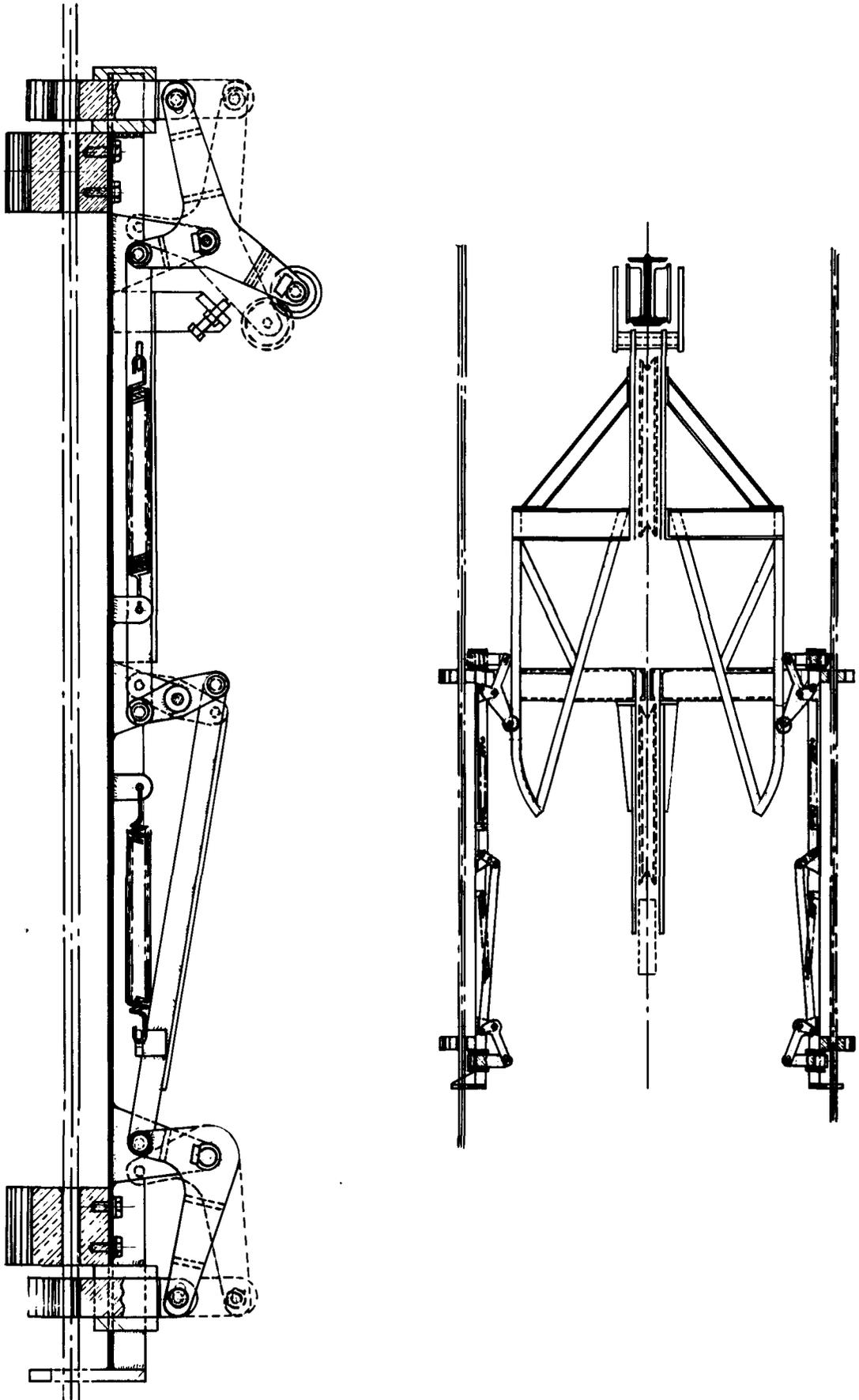


Fig. 5—Sketch showing arrangement for cross-head detachment on the MATLA headgear

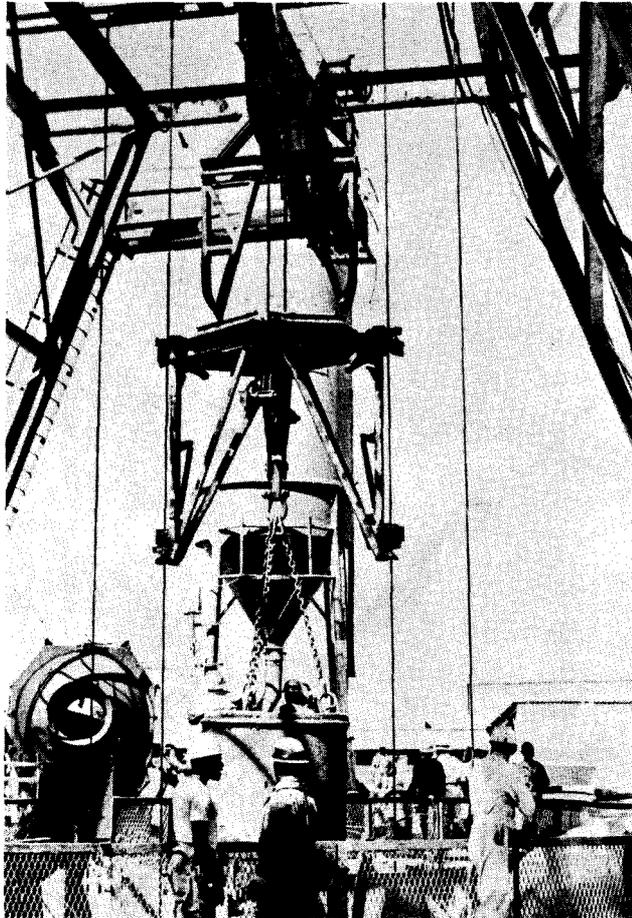


Fig. 6—Photograph showing arrangement for cross-head detachment on the MATLA headgear

shaft so that the A frame of the sinking headgear can be erected over it.

The permanent sinking winder was used in conjunction with the temporary sinking stage, although this is not essential. The MATLA kibble winder is situated some distance from the shaft collar and could in fact be moved even further from the shaft if required. This would be accomplished by the installation of additional legs to the MATLA headgear and an extension to the kibble's range of travel to its tipping point.

The A frame was erected over the MATLA with heavy lifts, being done on Sundays, when no work was carried out in the service shaft. At the same time as the erection of the A frame, the permanent sinking stage was erected alongside the headgears. As can be seen from Fig. 11, this stage was erected completely except for the lashing unit while the shaft was being sunk.

When the kibble winder was fully erected, sinking operations stopped and the MATLA headgear was dismantled, transported, and re-erected on the site of 4A ventilation shaft. Two girders were then placed over the collar of the service shaft so that the sinking stage could be slid over the shaft.

The permanent stage and kibble winder ropes were wound onto the respective winders, and the stage ropes were threaded through the headgear and stage sheaves.

TABLE II  
DAILY CYCLE DURING PRESINK AND SLOW SINK

Time	Activity	Comments	Kibbles of rock
07h01-08h00	Shift down and other up Continue to brow over Surveyor down	Month end measure	3
08h01-09h00	Completed brow over Machine workers down and started drilling Send loader out No. 1 Send 1 × concrete pipes down Send concrete kettle out for examination		2
09h01-10h00	Drilling completed Send explosives down Charged Raise stage for blasting	Drilling 6 c/s Dynagel, charging time 22 min, advance of previous round 1,7 m	
10h01-11h00	Blasted round at 10h05 Re-entry 15 min and lock stage for pipe work Shift down Water pipe down Air pipe down Concrete pipe down		
11h01-12h00	Lower stage for ventilation pipe extension Lower ventilation pipe Lower machine workers for lashing		
12h01-13h00	Lower stage to prepare curb ring Loader No. 3 down		
13h01-14h00	Lash muck		9
14h01-15h00	Lash muck Send shift up and other down		7
15h01-16h00	Lash muck		7
16h01-17h00	Lash muck		10
17h01-18h00	Lash muck		11
18h01-19h00	Lash muck		11
19h01-20h00	Lash muck Started to brow over		5
20h01-21h00	Completed brow over Machine workers down Started drilling		4
21h01-22h00	Completed drilling	Drilling time 30 min, 6 c/s Dynagel advance of previous round 1,5 m	
22h01-23h00	Raise stage for blasting Blasted at 22h27 Re-entry Lower next shift		
23h01-24h00	Lower shift Send curb-ring material down Lower stage - loosen curb ring		
00h01-01h00	Lower curb ring Install and line up curb ring		
01h01-02h00	Complete lining up curb ring		
02h01-03h00	Start to pour concrete to curb ring Lower loader no. 1		
03h01-04h00	Complete pouring concrete Start to lash muck	21 batches	8
04h01-05h00	Raise stage to lower barrel Lash muck		9
05h01-06h00	Line up barrel Pour concrete Lash muck		10
06h01-07h00	Continue pouring concrete to barrel Lash muck End of shift	50 batches	8

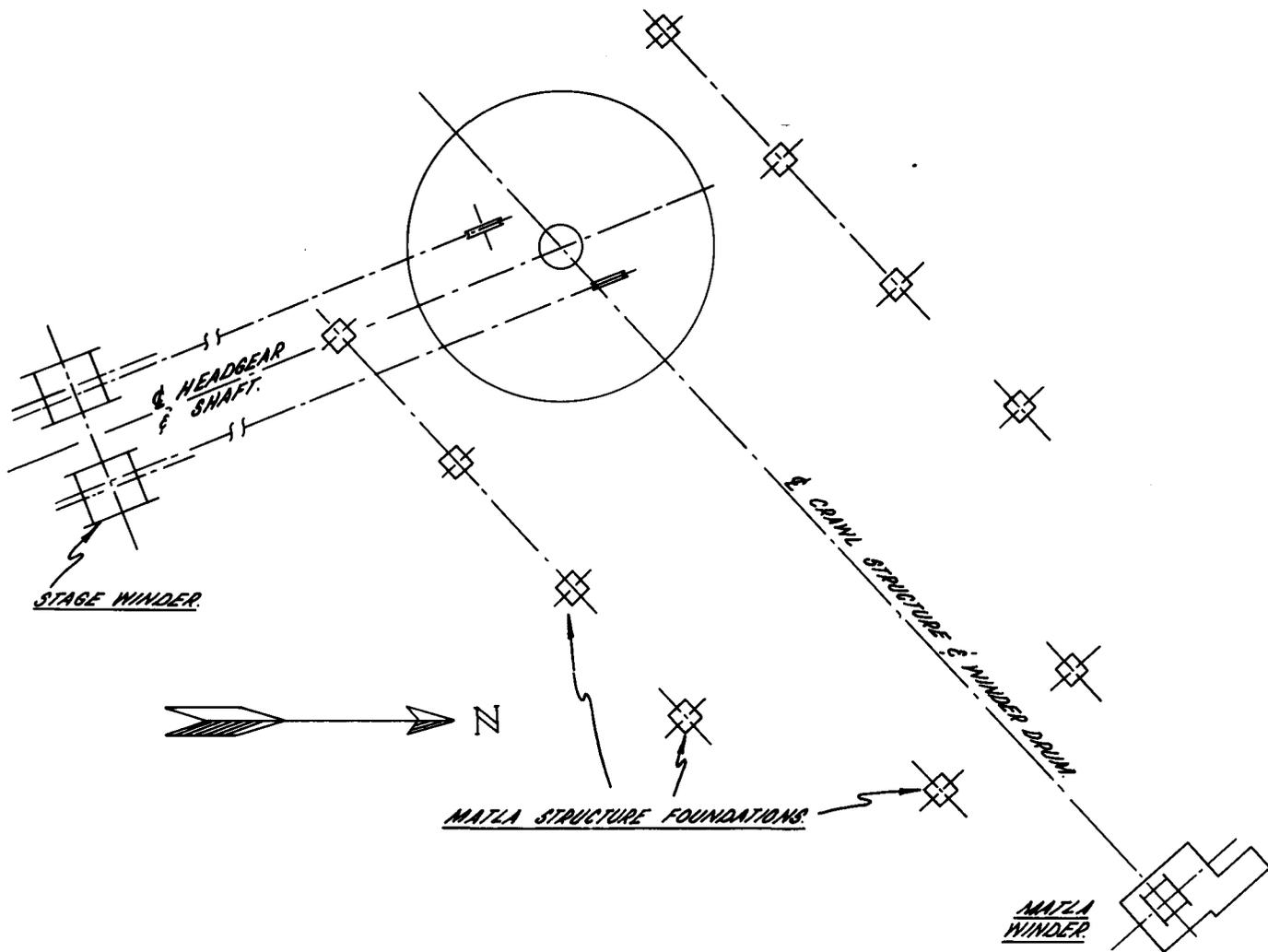


Fig. 7—Site layout showing the MATLA headgear and winder in relation to the shaft excavations

A 120 t crane was then used to slide the stage into position. The stage was lowered down to the shaft bottom so that the lashing unit could be installed and commissioned. The complete collar was then decked over, and the lowest deck of the headgear together with the tipping steelwork was installed.

While the sub-contractor was completing the headgear, the sinking contractor commissioned the various safety devices in the headgear and the two winders. Once the Inspector of Machinery had passed the winders and headgear, the main sink commenced and has progressed to date to 200 m.

#### Time Schedule

The critical path schedule for all the activities from the start of the collar excavation to the start of the permanent sinking is shown in Fig. 12. The project was 26 days ahead of schedule at the time of the change-over and, after the change-over had been completed, was 22 days ahead.

#### Legal Requirements

Exemption was required from regulation 16.57 — Use of spring keps or jack catches. This was granted by the

Inspector of Machinery subject to the following conditions.

- (1) An overwind limit switch — electrical switch, cam operated, mounted behind indicator.
- (2) Headgear ultimate-limit switch — trip-wire operated.
- (3) Winding speed limited to 0,88 m/s.
- (4) Conveyance attached to a doubling-down arrangement with the free end of rope attached to a hydraulic load cell fitted with two pressure cutout switches. The cutout switches incorporated in the brake safety circuit. Setting of high-limit cutout switch recommended as follows:

Breaking force of rope	455 kN
For 2 falls of rope	910 kN
Maximum load attached to rope	7740 kg
Force exerted by attached load	75,85 kN
For suddenly applied loads (i.e. trip-out while down going)	
Force exerted = $2 \times 75,85$	151,7 kN
For practical purposes the cutout switches could be set at 151,7 kN, which is equivalent to a mass of 15 480 kg attached to the ropes.	
A force of 151,7 kN would be equivalent to	

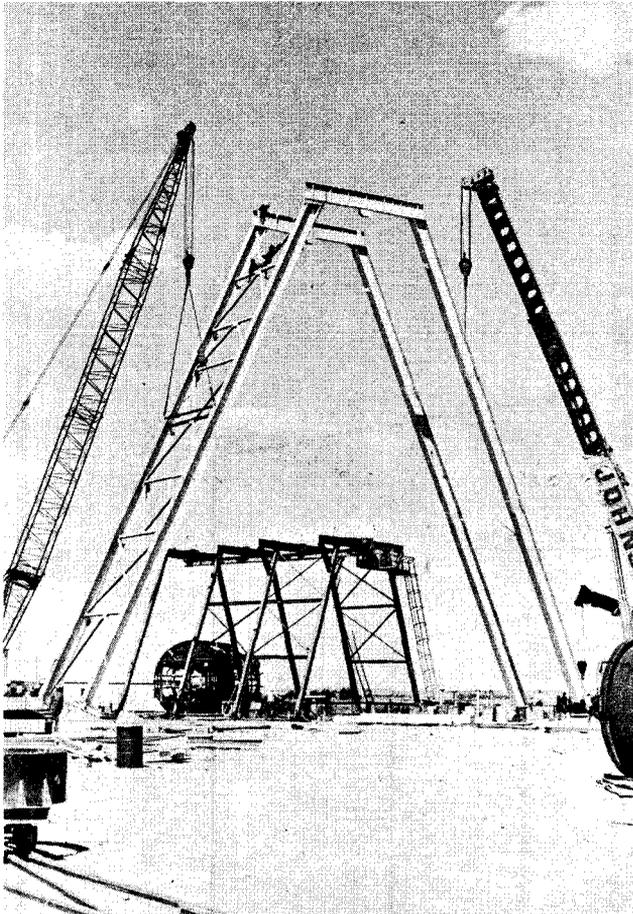


Fig. 8—Erection of A frame over MATLA headgear (1)

16,67 per cent of the breaking load of the rope. The low-limit pressure switch would be set so that a loss of fluid would be detected. A complete loss of fluid would result in the load cell becoming ineffective.

#### Future Considerations

As a result of the success achieved by the use of the MATLA headgear for the slow sink and of a far more satisfactory gold price, it was decided that work should

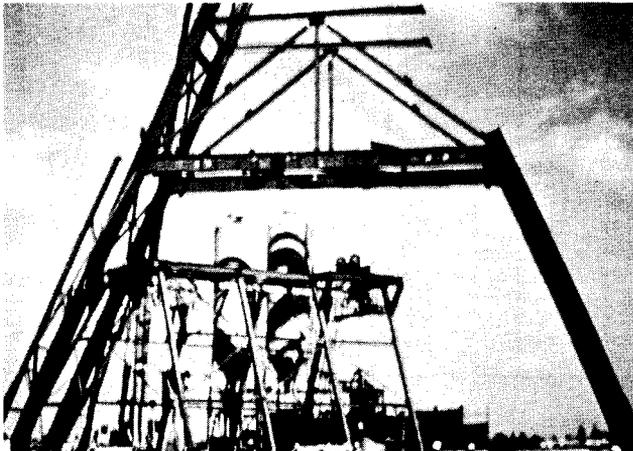


Fig. 9—Erection of A frame over MATLA headgear (2)



Fig. 10—Erection of A frame over MATLA headgear (3)

recommence on the sinking of the ventilation shaft. In view of the time required for the erection of the necessary permanent sinking equipment at the ventilation shaft, it was again decided that the MATLA arrangement should be erected at the ventilation shaft. It is expected that the slow sink at this shaft will continue to a depth of 250 m before the change-over to permanent sinking conditions is established.



Fig. 11—Erection of the sinking stage



### Conclusions

The use of the MATLA headgear, which was necessitated by the particular circumstances prevailing at the H4 shaft complex, had certain beneficial side effects in that the sinking stage was erected outside the shaft and sinking could continue concurrently during this time. It

is estimated that a saving of approximately two months resulted from the adoption of this method of presinking.

### Acknowledgements

This paper is published by permission of the General Manager of Harmony Gold Mining Company Limited and the Directors of Rand Mines Limited.

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## INTERKAMA 83

The Ninth International Fair for Instrumentation and Automation is to be held at the Trade Fair Centre in Düsseldorf, West Germany, in November 1983. The Interkama Exhibition runs from 9th to 15th November, while the Congress is to be held on 8th and 9th November and again on 14th and 15th November.

Altogether, 65 papers are to be presented by 96 specialists from 8 countries. INTERKAMA will combine four main divisions: an international trade fair on the application of measurement and automation techniques, an international congress concerning science and research embracing practical applications, a special show with the theme of 'Applied Research' where institutions will show

new ways and solutions to problems, and exhibitors' seminars, which concentrate on practical applications of measurement and control techniques.

The high rate of innovation in instrumentation and automation calls for ongoing dialogue between manufacturers and operators, researchers and consumers. INTERKAMA 83 should provide an excellent opportunity for such dialogue.

Further information can be obtained from the Düsseldorf Messegesellschaft mbH-NOWEA-INTERKAMA 83, Postfach 32 02 03, D-4000 Düsseldorf 30, West Germany.