J. S. Afr. Inst. Min. Metall., vol. 85, no. 11.
Nov. 1985. pp. 403-413.

Blindhole boring at Vaal Reefs South

by G.B. LUNDSTROM*

SYNOPSIS

For some time, Vaal Reefs South has operated blindhole borers successfully as an integral part of the mining cycle of operations. To date, over 13 000 m of mechanized boxholing has been completed, and from time to time impressive performances have been achieved. The paper describes the machines, the *modus operandi*, and the structure of the boring organization at the Mine, with some of the results recorded.

The Mine recently took delivery of two new machines with interesting design features. The introduction and early experiences with these two machines are also described.

SAMEVATTING

Vaal Reefs South gebruik geruime tyd reeds met sukses blindegatboorders as 'n integrerende deel van die siklus van mynbedrywighede. Daar is tot op hede 13 000 m in gemeganiseerde stortgatontsluiting voltooi en daar is van tyd tot tyd indrukwekkende prestasies behaal. Die referaat beskryf die masjiene, die werkmetode en die struktuur van die boorwerkorganisasie by die Myn, en verstrek sommige van die resultate.

Die Myn het onlangs twee nuwe masjiene met interessante ontwerpeienskappe in ontvangs geneem. Die ingebruikname van en vroeë ondervinding met hierdie twee masjiene word ook beskryf.

Introduction

Blindhole boring at Vaal Reefs South started on an experimental basis in August 1975 with the introduction of the Robbins 52 RH hydraulically driven machine equipped with a cutterhead 1,52 m in diameter. At the time, mechanized boxholing using the blindboring technique was relatively new and undeveloped, the first trials having been started only three years earlier at West Driefontein Gold Mine[1]. Predictably, the initial progress was slow, the costs high, and the teething problems many. After six months, during which the machine had drilled only 108 m, the machine was returned to the suppliers for modification and repairs. The output improved somewhat after the borer was returned four months later, but remained relatively low for several years.

In March 1979, a second borer, a Robbins 52 RE electrically driven machine equipped with a cutterhead 1,83 m in diameter was commissioned. During September of the same year, a third machine, a Calweld BH60 SP, operated by the rockboring section of Anglo American Corporation Technical Development Services†, started boring at the Mine. Between June 1980 and December 1983, additional borers were hired from time to time to supplement the output of the borers permanently based at the mine.

At present, Vaal Reefs South has four borers in full-time operation, having recently taken delivery of a Robbins 53R and a Wirth BHB 152. These two machines differ considerably in concept from the earlier machines, and are described later.

* Section Head R.D.S. No. 9 Shaft, Vaal Reefs South, P.O. Box 5010, Vaal Reefs, 2621 Transvaal.

SA ISSN 0038-233 X/$3.00 + 0.00. Paper received 28th August, 1984.

† The rockboring section of Anglo American Corporation's Technical Development Services (now Research and Development Services) is based in Welkom, and operates raise and blindhole borers on a non-profit contracting basis as a service to gold mines of the group.

Approximately 44 500 m^2 of reef are mined monthly at No. 8 Shaft. At an average dip of 18° and with main levels spaced at 90 m vertical intervals, raise connections give a stoping back between levels of about 290 m. Raises are put up at 180 m strike intervals, and each connection therefore provides about 52 500 m^2 of mineable reef. With stope panel lengths of 30 m, a raise typically requires 9 boxholes. Of the 9 boxholes, 4 are less than 40 m in length and are generally developed conventionally. The remaining 5 average 65 m in length.

When the above data are related to an ore-reserve replacement rate of 44 500 m^2 per month, it will be seen that approximately 270 m of blindhole boring is required per month. This means, in turn, that each machine must maintain an average monthly output of 67,5 m. While this may not, in the light of recent performances, appear to be a particularly difficult target to meet, it must be borne in mind that shaft moves between levels, breakdowns, etc., frequently account for up to a week of unproductive time per month.

During 1983, the three machines then in operation produced at an average rate of 65 m per month. The 100 m per month barrier was broken on several occasions, and during 1982 one crew had the distinction of maintaining this level of production for three successive months. The same crew also set up a record during July 1983 by boring 243 m in 27 days.

Although the blindhole-boring operation at Vaal Reefs South could then be regarded as being relatively successful, it had become evident that the existing machines had virtually reached the limit of their output potential, and further increases in output would be achieved only by extending their hours of operation. However, shift times are governed by blasting arrangements and re-entry restrictions in the sections where the borers are operating. As most of the borers operate in developing or producing areas, it is generally not possible to work on a round-the-clock basis. The rare cases where this is possible do not warrant a reorganization of crews, and all the boring is done on the basis of two shifts per day.

An analysis of the costs of the operation in 1983 showed that approximately 23 per cent of the total cost was accounted for by site preparation. The direction that further development would have to take clearly lay with the manufacturers in designing a machine of compact dimensions so that it would be able to operate in a haulage or crosscut of normal dimensions with little or no prior site preparation. This proposition was laid before two manufacturers: the Robbins Company of Seattle, U.S.A., and the Wirth Company of Erkelenz, West Germany. Proposals were received and orders subsequently placed for the delivery of the two machines towards the end of 1983. A third machine, the Atlas Copco Jarva BBM 1700, had also been proposed, but, as delivery could not be effected within the required time, it was not considered for this project.

Justification for Mechanized Boring

However attractive and convenient blindhole boring may appear when compared with conventional boxholing methods, it remains an extremely costly operation, and its use merely as a more convenient and safer substitute for the normal drilling and blasting method can hardly be justified.

At Vaal Reefs South, several factors led to the decision that boring should be incorporated as an integral part of the equipping–mining cycle. Foremost are the problems related to the establishment of intermediate levels. Main levels on the No. 8 Shaft system are spaced at 90 m vertical intervals. These main levels were initially supplemented with intermediate levels sited 50 m in the footwall of the reef. The inter-levels were not directly connected to the shaft, and access was via material inclines from the main level above or below.

Experience has proved that, to ensure the long-term survival of footwall strike haulages, they should be sited at least 70 m below the reef normal to the dip. Haulages sited closer to the reef are subjected to heavy stresses and, within a short period after the start of stoping operations, either fail completely or, at best, create costly support problems.

The Vaal Reef is underlain by several bands of hard quartzites (Millar Quartzites). The MBA band, at 60 to 70 m in the footwall, is hard and brittle, and becomes extremely friable when exposed. It has proved extremely difficult to support, and siting of footwall haulages on this horizon is clearly impracticable.

The many other implications of the establishment, equipping, and maintenance of inter-levels are well known, and the benefits of eliminating them entirely are considerable. Where inter-levels are eliminated, the resulting long boxholes cannot be developed productively by conventional methods. It is well known that the rate of advance decreases and development costs increase progressively with the length of the boxhole. Boxhole development is also known to be dangerous and physically arduous work, and is generally unpopular with machine and service crews.

The West Division of Vaal Reefs has experimented extensively with the 'drop raising' method of boxholing with considerable success, but the application of this technique is limited, and blindhole boring has emerged as the favoured method.

When the cost of mechanized boring is weighed against the cost of developing entire inter-levels, boring becomes a more attractive proposition. That the boring programme has been a success in this respect is clearly shown in Table I, where the ratio of waste metres developed to total square metres mined is compared from the time of commencement of the programme to the end of 1983.

TABLE I
RATIO OF REEF MINED TO WASTE DEVELOPED

Year	Reef, m^2	Waste, m	Ratio
1977	397 530	34 620	11,48:1
1978	431 489	36 330	11,88:1
1979	485 771	36 194	12,04:1
1980	495 732	37 278	13,30:1
1981	512 973	33 019	15,54:1
1982	527 900	30 992	17,03:1
1983	532 431	34 333	15,51:1

Description of the Robbins 52 RE

The Robbins 52 RE (Fig. 1) comprises the following seven basic components.

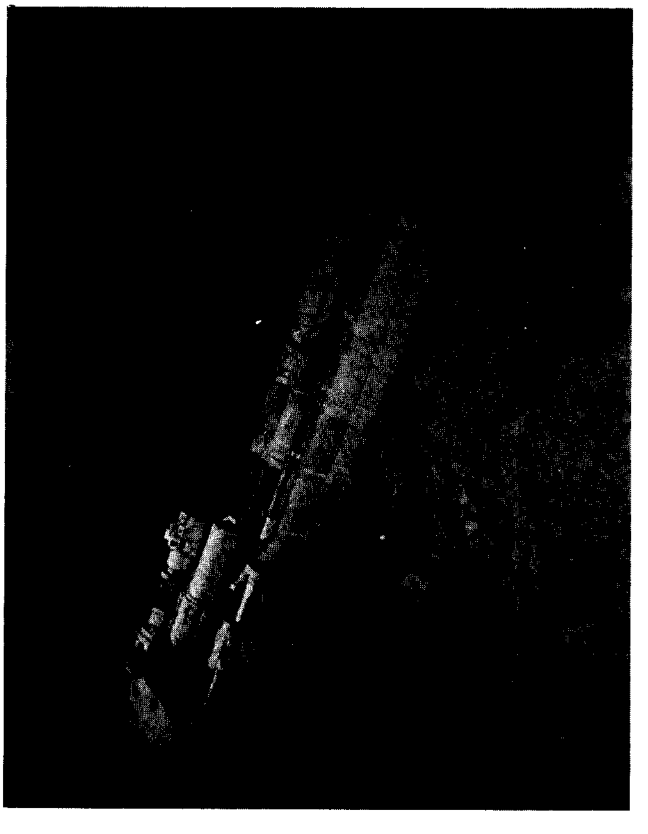

Fig. 1—The Robbins 52 RE during collaring (the muck collector has not yet been fitted)

Cutterhead

The cutterhead is a one-piece casting to which cutter saddles are welded in positions calculated to ensure correct dynamic balancing. In the centre of the head is a stabilizing stinger onto which is mounted a button tricone bit. The skirt below the cutterhead is equipped with four stabilizer rollers for added directional and dynamic stabilization. Flushing water and spray nozzles are incorporated in the cutterhead for the suppression of dust, cooling of the cutters, and the removal of cuttings from cutter saddles.

Cutterhead Drive Assembly

The cutterhead drive assembly comprises, basically, an inner stationary shaft and an outer rotating cutterhead support housing. The motor is mounted concentrically with the inner shaft, and rotation is transmitted via a planetary gear train to the outer housing. The motor is cooled by a force fan mounted in the crosshead drawing fresh air up the drill string[2].

Drill String

The drill pipes are flanged steel pipes 610 mm in diameter. The lower flange has three dowel pins that locate in corresponding holes in the following pipe. The pipes are bolted together with three bolts, which, with the dowel pins, transmit torque reaction from the rotating cutterhead to the guide columns of the machine. Stabilizing fins are attached radially at 120° intervals around the drill pipe, and take up the full diameter of the hole to provide stabilization of the drill pipe in the centre of the bored hole.

Derrick Assembly

The derrick assembly is the structure comprising the base plate, main frame, crosshead, guide columns, thrust cylinders, and headframe. The lower ends of the guide columns are attached to the main frame, and the upper ends to the headframe via bolted flanges and crown couplings. The crosshead is attached to the barrels of the thrust cylinders and moves along the guide columns when the thrust cylinders are activated.

Turntable

The derrick assembly is mounted on a rotating base, which in turn is mounted on a sub-base. After being mounted on the rotating base and raised to the vertical position, the borer can be rotated to any direction. Once the required drilling direction is attained, the rotating table is clamped to the base plate and the machine is lowered to the required dip angle.

Muck Collector

Scraper plates around the periphery of the cutterhead direct cuttings through an aperture in the adapter plate to fall down the 120° sector between the fins on the lower side of the hole. At the collar of the hole, the cuttings fall into a cylindrical box fitting into the mouth of the hole. On the lower side, a chute discharges the rock onto a conveyor, which carries the rock into a waiting hopper. The base of the muck collector is cut out to permit the drill pipe and fins to pass through. Spillage around these openings is contained by a blooie seal of conveyor belting.

Power Pack

The power pack is mounted on a car, and comprises the electric motor and pump providing power for the thrust cylinders and fast traversing of the crosshead. The oil reservoir and electrical switchgear are also mounted on this car. The operator's control console, with all the controls and instruments to operate and monitor the drilling operation, are mounted on the car, but the console can be removed and placed in a position convenient for the operator.

Description of the Robbins 52 RH

Basically similar in concept to the 52 RE, the 52 RH derives its rotational power from a hydraulic motor. Oil supplying hydraulic power from the power pack enters through the hub of the hose reel to hoses that are passed up the drill string inside one of the three stabilizing fins, which is detachable from the drill pipe. The hose is paid out from the hose reel as the hole advances.

Description of the Robbins 53 RH

The 53 RH (Figs. 2 and 3) is a compact, relatively lightweight machine designed to be transported and erected in a standard-size haulage or crosscut with no prior site preparation other than the casting of the concrete foundation. It differs in concept from the 52R in that rotational power is transmitted to the cutterhead via a rotating drill string from two heavy-duty gear-type hydraulic motors mounted in the derrick assembly.

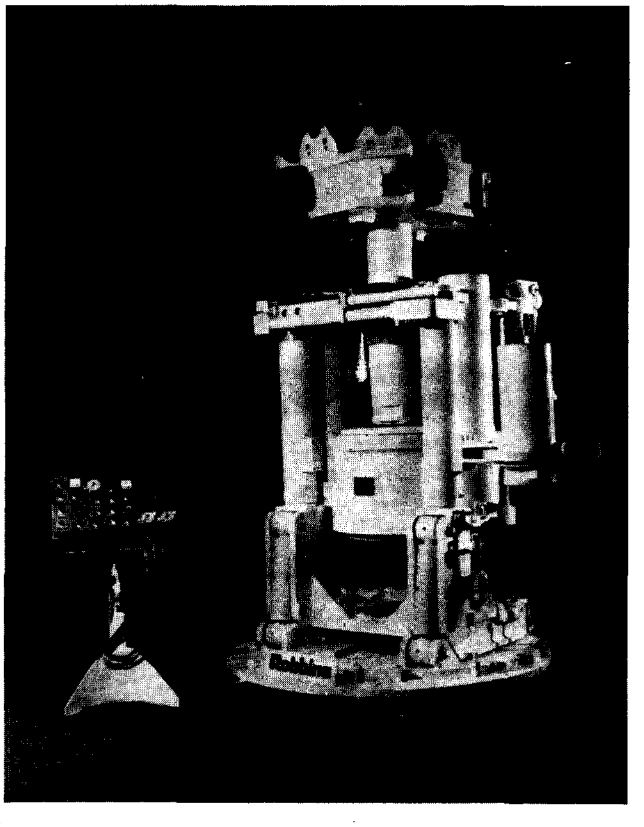

Fig. 2—The Robbins 53R in the erected position (the low profile of the machine is apparent by comparison with the height of the operator's control console)

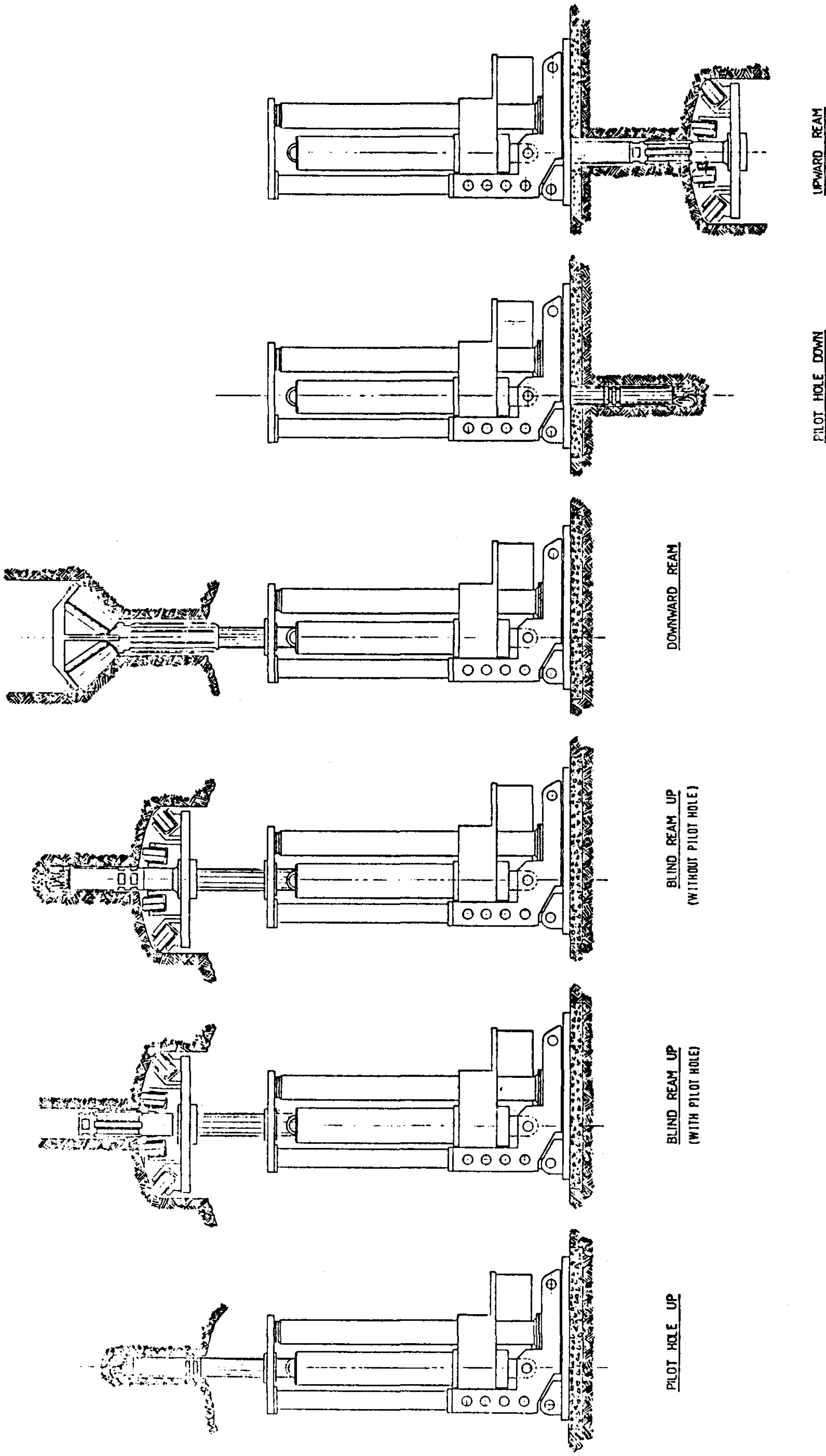

Fig. 3—The operating modes of the Robbins 53R

Two hydraulic thrust cylinders are diametrically opposed on either side of the drill string. The power head is supported between two opposed thrust bearings to enable the unit to apply upward or downward thrust. This allows the machine to be used for drilling and reaming upwards, or to be used in the same manner as a normal raise borer, i.e. piloting downwards and reaming back upwards towards the machine.

The machine has a total installed power of 172 kW, with two 75 kW electric motors for rotation. Hydraulic power for rotation is provided by three vane pumps. By the use of various flow combinations, five reaming speeds are available. Power for other derrick functions, thrust, fast traverse, and pipe loader is provided by a third 22 kW motor.

The drill string is 285 mm in diameter, and the pipe sections are 750 mm long shoulder to shoulder. Stabilization of the drill string is achieved by legs attached to a non-rotating bearing incorporated into the drill string after every sixth rod. The legs take up the full cross-section of the hole, and keep the drill string centralized in the hole (Fig. 4). At the base of each drill pipe are four pairs of wrench flats that accommodate the hydraulic spanner for making up or breaking out pipes in the drill string.

The machine has the advantage of being capable of being transported and erected, while fully assembled, in a normal 3 m high tunnel (Fig. 5).

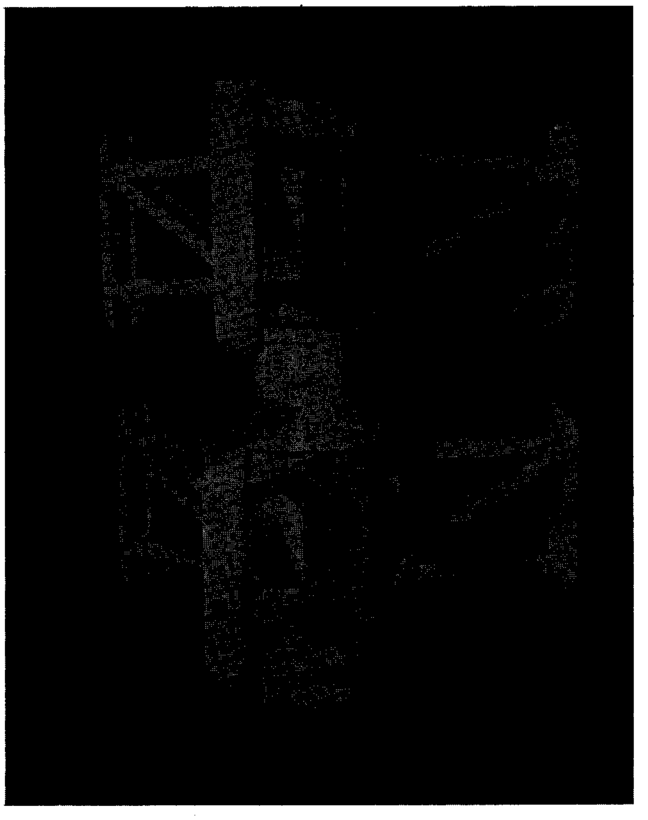

Fig. 4—Stabilizing legs fitted to non-rotating bearings in the drill string of the Robbins 53R

Description of the Wirth BHB 150

This machine (Fig. 6) also utilizes the concept of the rotating drill string, but differs from previous designs in that the thrusting mechanism is located immediately behind the cutterhead. Eight thrust cylinders 125 mm in diameter apply up to 1732 kN of thrust to the cutterhead. The thrust is reacted against four gripper pads arranged radially round the drill string and transmitted via a heavy-duty thrust bearing to the cutterhead. Four gripper cylinders each apply a gripping force of 1420 kN.

An innovation embodied in the BHB 150 is the use of water as the hydraulic medium for the up-the-hole thrusting mechanism. Water under a pressure of 180 bar is directed through ports in the drill rods to the thrust and gripper cylinders. An advantage of the application of thrust directly behind the cutterhead is that high cutter loadings can be maintained throughout the length of the hole, resulting in improved cutter life and optimizing the penetration rates.

An added advantage to this system is that the drill string, being under tension rather than compression, requires less stabilization, and in holes dipping more steeply than 60° stabilizers are installed only after every fifteenth rod section. Side loading on the stabilizer bearings is also reduced, with resultant reduced wear and tear.

Rotational power is applied from the basic machine by two 92 kW hydraulic motors through a planetary gear system giving a maximum torque to the drill string of 85 000 Nm. The speed of rotation is continuously variable from 0 to 20 r/min. The drill rods have an outside diameter of 260 mm and a length of 600 mm.

During the collaring of a hole, thrust is reacted against the four collaring booms to which the grippers are clamped.

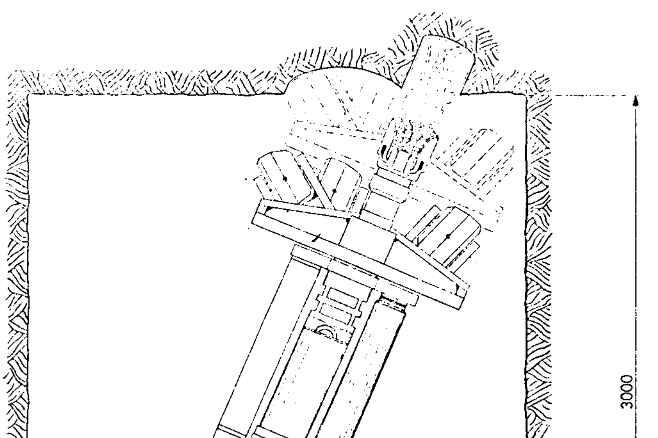

Fig. 5—The Robbins 53R erected in a 3 m high tunnel

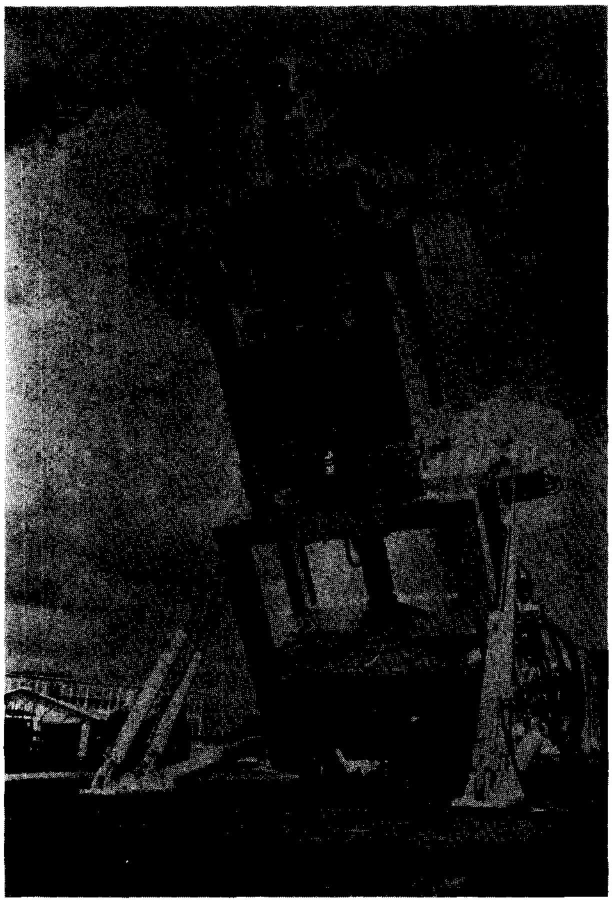

Fig. 6—The Wirth BHB 150 in the erected position (the thrust cylinders and grippers can be seen below the cutterhead)

The recycling sequence, illustrated in Fig. 7, is as follows.

(1) When the thrust cylinders reach the limit of their stroke and are fully extended, rotation is stopped and the pressure of the gripper cylinders is released.
(2) The gripper cylinders are retracted, and pressure on the thrust cylinders is reversed, drawing the outer kelly (the non-rotating component to which the gripper cylinders are attached) up until the thrust cylinders are fully retracted. During re-stroking, the weight of the head is supported by the drill string.
(3) The gripper cylinders are again pressurized to take the weight of the drill string. The crosshead is now lowered and a new rod is added.
(4) The new rod is screwed up, the thrust cylinders are pressurized, and drilling is restarted.

The time taken for the complete recycling procedure is approximately three minutes.

Drilling Procedure

The drilling procedure, which is basically similar for all the machines is as follows.

The machine is transported to the site on its transporter bogeys, and the erection cylinders are attached to clevises on the base plate. The power pack is connected and, by use of the erection cylinders, the machine is raised to the vertical position. The machine is rotated on the turntable to the required direction and lowered to the required dip angle. Turnbuckles on the erecting struts are used for fine adjustment of the dip angle.

When the alignment and dip have been checked by a surveyor, the turntable is clamped to the base plate and collaring commences. After the head has penetrated sufficiently (about 2,5 m), drilling is stopped and the muck collector fitted.

When the machine has bored the length of a rod, drilling is stopped, the drill string is supported on the slip plates on the head frame, the crosshead is lowered, and the next rod is fitted. For machines with non-rotating drill strings, fins are attached to the drill pipes while boring continues.

As the length of the drill string increases, the thrust settings are increased to counter the increased mass and maintain correct cutter loading. Typical penetration rates in the footwall quartzites at Vaal Reefs range from 80 to 120 cm/h. When holing has been effected, the head is retracted slightly, the holing is closed off, and lowering of the head is started. During retraction, the head is rotated to assist in smooth traversing along the length of the hole and prevent jamming.

After the head is out of the hole, the mouth of the hole is closed off, and the machine is lowered onto its transporters and dismantled for transporting to the next site.

A typical cycle for the drilling of a 90 m hole would be as follows:

Transport machine to site	1 shift
Erect machine and survey	1 shift
Collar 2,4 m	1 shift
Fit muck collector and load collaring spillage	2 shifts
Bore 88 m at 6,1 m per day	30 shifts
Close off holing	½ shift
Retract rods	6 shifts
Dismantle muck collector and lower machine	2 shifts
	43½ shifts
	= 22 days

Structure of the Boring Organization

A borer is manned on each shift by a crew of seven, comprising an operator, a loco driver, a loco guard, and four labourers. A supervisor takes charge of both shifts, and may be required to work on either the day or the night shift during the critical stages of the boring cycle such as erection and collaring. The supervisor reports to a foreman, who is responsible for two borers. Each foreman has a third supervisor, who acts as a leave relief and, when available, assists on the second shift during collaring and erection. An electrician serving both foremen attends to the electrical servicing of the machines and the provision of the power supply at new sites.

The two foremen report operationally to a mine overseer and on technical matters to a general engineering supervisor. The mine overseer and engineering supervisor in turn report to the section head. Both have other duties in addition to blindhole boring. The mine overseer is responsible for the scheduling of the movements of the

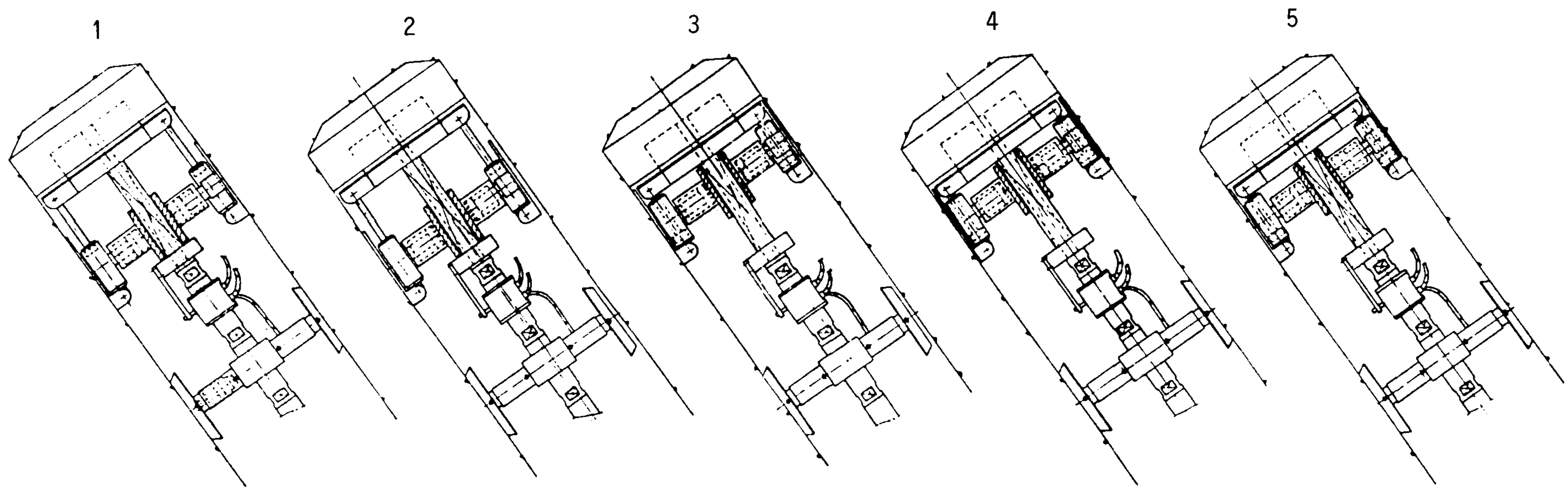

Fig. 7—The recycling procedure of the Wirth BHB 150
1 Thrust cylinders fully extended
2 Grippers released
3 Thrust cylinders retracted and outer kelly drawn forward
4 Gripper cylinders pressurized
5 Drilling restarted

borers, and is also in control of site preparation. Each of three crews of 15 members are under the supervision of a site-preparation equipper. The three equippers are supervised by a shift overseer, who is responsible solely for site preparation. A site-preparation crew comprises the following:

1 team leader
1 loader driver
2 loco crew
1 miner's assistant
6 drillers
4 labourers.

The preparation of a site for a Robbins 52R borer takes approximately three weeks. This includes the time taken for re-supporting the excavation using 6 m grouted rope loops (destranded hoist rope) and for wire-meshing the hanging and sidewalls. Site-preparation crews are also responsible for the casting of foundations and the installation of base plates for the borers. Where there are several sites in one crosscut, two or more sites may be prepared concurrently.

Results

The results of the trials conducted on the three Robbins machines are given in Tables II and III.

TABLE II
METRES BORED

Month 1983	52 RE (1255) m	52 RE (1259) m	52 RH (1202) m
January	70,2	95,8	26,8
February	53,7	36,0	61,6
March	43,3	59,2	76,9
April	Nil (overhaul)	72,6	37,8
May	Nil (overhaul)	76,7	106,1
June	18,3	76,9	52,0
July	235,5	101,3	122,5
August	40,9	59,8	75,0
September	56,1	86,0	76,3
October	92,7	77,5	2,4
November	75,1	79,8	51,2
December	81,1	50,0	9,2
Total	766,9	871,6	697,8

TABLE III
COST OF BLINDHOLE BORING (1983)

	Total cost R	Cost per metre R
Site-preparation cost		
Labour	233 813	100,13
Stores and material	136 295	58,35
Total site preparation	370 208	158,48
Boring cost		
Labour	354 296	151,67
Oils and lubricants	26 964	11,54
Stores and spares	161 740	69,24
Cutters and stabilizer rollers	430 669	184,36
Total boring	973 669	416,81
Portion of machine overhaul cost after 1500 m	269 150	115,22
Overall cost	1 613 027	690,51

Site Excavations and Boxfront Design

The cost and complexity of boxfront construction, and the time and cost involved in site preparation for the earlier generation of borers, are two major obstacles to the more general acceptance of mechanized boring. For example, the dimensions of the Robbins 52R borers require a site excavation 6,2 m high and 6 m wide (Fig. 8). Dependent on the extent to which the direction of the hole deviates from the line of the crosscut, the volume of rock to be excavated varies from 130 to 150 m^3. The size of the excavation necessitates additional support in the form of 6 m grouted rope loops, and the entire surface area must be meshed and laced.

Owing to the width of the site, the boxfront structure is large and must be sufficiently robust to withstand the impact of rock falling the full length of the boxhole. It must also be able to support virtually the full mass of the column of rock in the boxhole when full. The approximate cost of the boxfront installation as shown in Fig. 9 is R11 500. The equivalent cost of a boxfront for a conventionally developed boxhole is R3500.

The ability of the new Robbins 53R borer to be transported and erected, fully assembled, in a crosscut of standard dimensions has obvious advantages. Not only is the cost of the site excavation and support saved, but more economical variations on the boxfront installation become possible. One proposed system involves the development of a cubby 3 m wide and 4 m deep off the side of the crosscut. The hole is bored from the cubby, and the boxfront is installed by the relatively simple operation of walling off the cubby. A standard stope chute is installed in the same manner as the normal side-on boxfront.

While the dimensions of the Wirth BHB 150 borer are too large to allow it to be erected in a 3 m high tunnel, it can, by use of a special flat-profile head, drill a series of overlapping holes to form a 'slot' through which the machine, with a normal boring head attached, can be raised (Fig. 10).

Although it may be argued that it is in any event necessary to slipe 1,5 m into the hanging wall for the installation of the boxfront and loading platform, the elimination of prior site preparation allows more flexibility in that a borer can, if necessary, be moved into a site at relatively short notice.

Training of Operators

Borer operators are selected from mine employees with a minimum educational level of Standard 8. All applicants are required to undergo comprehensive aptitude testing at the Central Aptitude Testing Centre at the mine. Tests include the O.T.I.S., or general intelligence test,

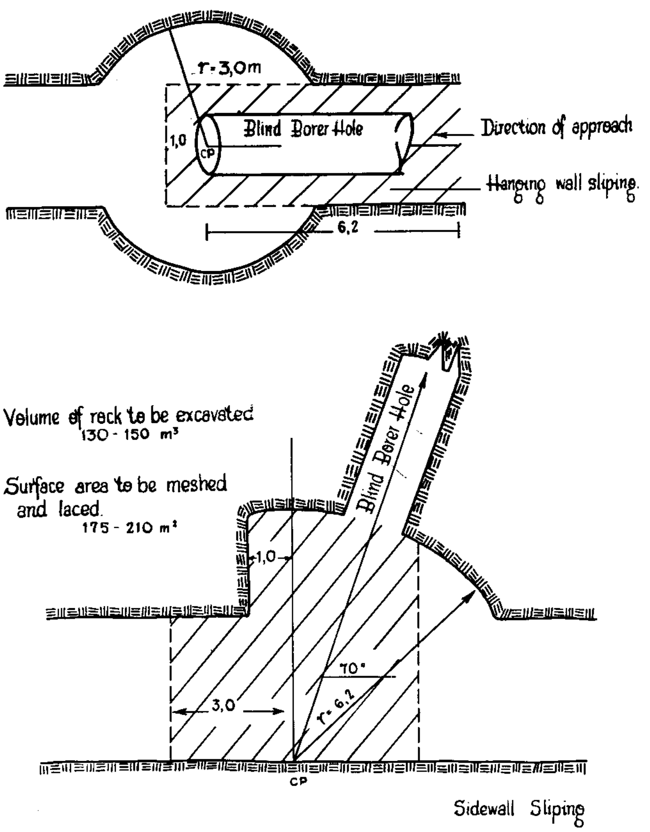

Fig. 8—Typical site excavation for the Robbins 52R blindhole borer (hole dipping at 70° and on line of the crosscut)

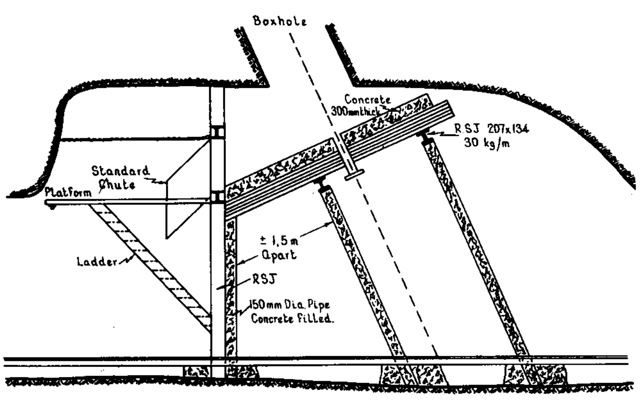

Fig. 9—Blindhole-borer boxfront

and a mechnical comprehension and computation test. Successful candidates are then interviewed by a panel consisting of two training officers, an engineering supervisor, and the section head. The candidates selected are then sent on a basic hydraulics course at the Anglo American Corporation Hydraulics Training Centre at Welkom.

After having successfully completed the hydraulics course, trainees are returned to the Mine for a period of on-the-job training, which varies from three to five months depending on the progress of the individual. He is then tested by a panel consisting of the training officer, a foreman, and an engineering supervisor, and he is either declared competent or recommended for further training on any particular aspect of the operation. At that stage of training failures are rare, and it is seldom necessary to resort to the latter course of action.

Simulator training is also available through the Central Training Organization in Welkom, but is not a prerequisite for obtaining a certificate of competency. Operators are sent on this course as and when required after having qualified. By use of the simulator, the entire cycle of operations can be reproduced at will and any element of the cycle can be repeated as often as required. This is obviously not possible in the work situation, and trainees have the opportunity of observing, for example the erecting procedure, once in probably three weeks.

The success of this selection and training procedure is evident, and operators achieve a high standard of proficiency in a relatively short period. From the commencement of training until the time an operator is placed in sole charge of a machine generally takes six months. The operators are not required to perform repair or maintenance work, but soon learn to diagnose the causes of most malfunctions and to describe the problem sufficiently accurately to enable the foreman to arrange for an artisan to be sent to the machine with the appropriate equipment or spares.

Although the selection criteria are fairly stringent and, on average, only 10 per cent of the applicants sent for aptitude testing are recommended for training, the necessity for this procedure is obvious. Delays are costly, and the potential for severe loss or damage through incorrect operating procedures is high.

Discussion

Since the introduction of the first Robbins 52R Borer at Vaal Reefs South in August 1975, over 13 000 m of blindhole boring have been completed on the Division. Four borers are currently in operation and, during the ore reserve build-up programme at the new No. 9 Shaft, it is likely that a further two machines will be acquired. The boring operation at the Mine has been relatively successful in recent years, and at times some exceptional performances have been recorded. It was generally felt, however, that the average output of the machines was unlikely to improve appreciably despite the application of improved operating techniques and various other technical advances. It was therefore necessary to look to radically new design concepts that would offer greater flexibility, more economical operation, or a significantly higher boring rate.

The high financial outlay incurred by manufacturers discourages extensive field testing of new products before they are delivered to the customer. While the designs of new machines are based on sound engineering principles, the reliability of innovative features becomes apparent only after practical application in the production situation. A considerable period of teething problems is therefore inevitable before a new borer attains its designed performance level. The two new borers at Vaal Reefs South are no exception, and it had been hoped that, by the time of writing, it would have been possible to report on considerably more progress than has, in fact, been achieved. To date the Wirth BHB 150 has completed ten holes of a total length of 672 m. The major problem has

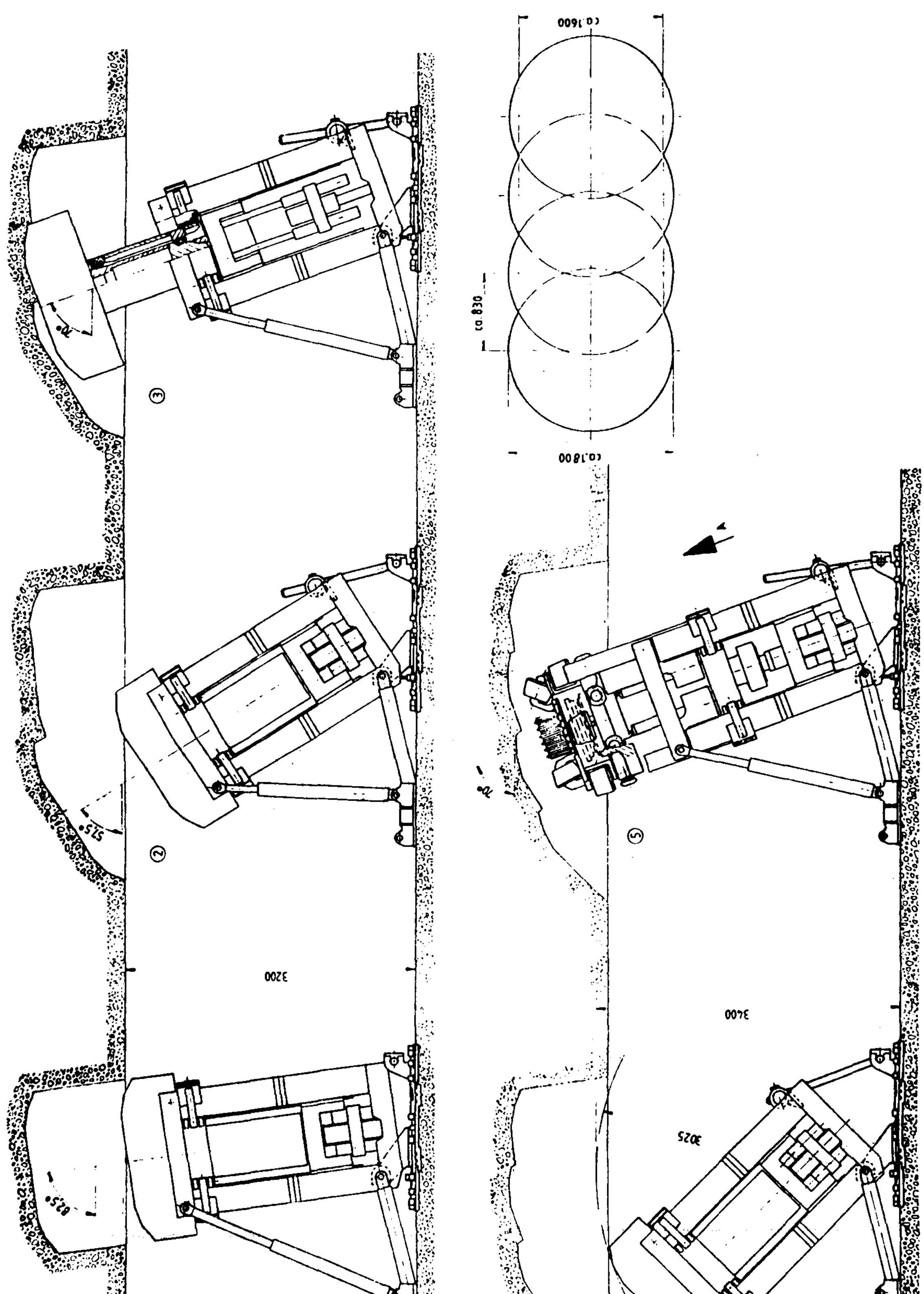

Fig. 10—The routing procedure with the Wirth BHB 150

been the inability to clear cuttings from around the outer kelly. During re-stroking, the accumulation of rock is compressed, damaging fittings on the kelly. Various modifications have been carried out, but have not yet eliminated the problem. At present the machine is undergoing further modification at the suppliers' workshops.

The Robbins 53R had performed well without significant delays due to the fault of the machine, but, after the completion of the second hole, it was noticed that welding failure had occurred around spline couplings at the upper ends of both guide columns. The slip-plate mechanism had also been damaged. The machine was brought to surface and returned to the suppliers. New guide columns and a strengthened headframe were fitted. At the time of writing, the borer had completed ten holes totalling 576 m.

To determine whether any possible benefit was to be derived from the ability of the 53R to first pre-drill a pilot hole through to the holing point and then ream the hole to its final diameter, this procedure was followed on the first hole. An average pilot drilling rate of 3,96 m/h was recorded. During the reaming of this hole, an average advance rate of 1,97 m/h was achieved. During the drilling of the second hole, which was not pre-piloted, an average penetration rate of 1,83 m/h was achieved. It is therefore apparent that the tricone bit does not have an appreciable retarding effect on the boring rate. The overall average penetration rate achieved using the prepiloting procedure was 0,95 m/h. Therefore, there is little to be gained by pre-piloting other than knowing in advance the exact position of the holing. This presupposes that the pilot hole does, in fact, hole accurately. It should also be pointed out that if, for any reason, the hole should deviate from its intended holing point, the larger diameter of the full cutterhead would increase the probability of some part of the hole intersecting the raise.

During the course of boring operations at the Mine, several instances of excessive deflection of holes have occurred. These appeared to occur more frequently during the time that steel disc cutters were in general use before the changeover to tungsten carbide button cutters, although no definite correlation can be established. Most recent cases of hole deflection can be related to geological influences. Fault planes or hard intrusive material intersecting the hole at very oblique angles are known to cause deflections. The degree of deflection is generally relatively slight and is seldom more than the diameter of the hole over a length of 90 m.

Few cases of holes failing to hit their target are caused by hole deflection and are more likely to be traceable to survey error, poor collaring procedure, or misalignment of the machine. When it is considered that an error of 1° in the alignment of the machine at collaring will result in the hole being 1,5 m off target after 90 m, it can be appreciated that a deviation tolerance from the target of 2 per cent of the length of the hole is as much as can realistically be expected from the present generation of machines. A change in the direction of dip of 1° during the alignment of the machine is a scarcely perceptible movement. The sources of error that can arise before the completion of a hole are many, and it is now standard procedure for a surveyor to re-check the alignment of the machine after collaring has been completed.

Normally, stope boxholes are put up only after ledging of the raise has been completed, and, where boxholes miss the raise, they hole into the stope ledge. Where boxholes miss an unledged raise, boring is continued until samples from the cuttings have been identified positively as reef.

The cutter market has recently become more competitive, and contract rates for button cutters are attractive. Cutter quality has also improved, and one set supplied by Dresser achieved a total of 960 drilled metres without a single cutter being changed.

Conclusion

In general, mechanized boring is becoming a progressively more attractive proposition. Advances in machine and cutter technology have combined to reduce costs and improve output. The development of borers of smaller dimensions has eliminated the necessity for elaborate site preparation. Where boring was previously warranted only on holes longer than 40 m, shorter holes can now be bored productively. While the capital outlay for the purchase of a borer remains high, the greater flexibility of the compact-design machines should lead to better utilization, and boring should thereby become more competitive with conventional methods.

Much of the input for the development and improvement of machines and techniques takes the form of feedback from the users to the manufacturers. With this in view, regular formal meetings are arranged between technical representatives of suppliers and personnel involved in boring on all the mines of the Anglo American Group. Ideas and experiences are exchanged, and problems, particularly those relating to the quality control of components and services from the suppliers, are discussed. Several of the ideas originated at these meetings have been incorporated into new machines, and the benefit of these exchanges is obvious.

Current research and development is being centred on the use of high-pressure water jets to assist cutting action and increase penetration rates. The production of a borer with a steering facility to ensure accurate holings is already under way, and the incorporation of microprocessors to automate steering is foreseen in the near future.

Acknowledgements

The author expresses his thanks to the Robbins Company and Transbor (Pty) Limited for permission to reproduce drawings of the Robbins 53R and the Wirth BHB 150, and to the Survey Department of Vaal Reefs South for their assistance in preparing the sketches used in this paper.

References

1. Bertram, R.C., and Bridgeford, M.A. Boxhole boring trials at West Driefontein Gold Mining Company Limited. Johannesburg, Association of Mine Managers of South Africa, *Papers and discussions* 1974–1975.
2. Graham, P. Environmental control for raise and blindhole boring equipment. *J. Mine Vent. Soc. S.Afr.*, Mar. 1979.