The use of continuous miners in South African coal mines

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A. Continuous miners, and their operation at Bosjesspruit Colliery

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SYNOPSIS

A brief description is given of the main types of continuous miner and their incidence of application in South Africa.

Definitions and descriptions of the design parameters and components of the main cutting head are given, together with an outline of the modifications carried out to improve machine cutting performance.

An account is given of experience with the application of water infusion to suppress airborne dust during continuous-miner operations.

SAMEVATTING

Die hooftipes delwers en die omvang van hulle aanwending in Suid-Afrika word kortliks beskryf.

Die hoofsnykopontwerp parameters en komponente tesame met 'n raamwerk van die resultate van wysigings wat aangebring is om die masjien se snyberrigting te verbeter word gedefinieer en beskryf.

Ervaring met die aanwending van infusie tegnieke met water om stof in die lug te bekamp tydens delwerwerking word beskryf.

Types of Continuous Miners

Continuous miners designed for operation in coal mines fall into four distinct types. Each type can be distinguished by the action of the cutting components, or cutting head, and a brief description of these actions is given below.

The Borer Type

With this type the main cutting components comprise rotary boring elements on which are mounted cutter picks cutting concentric paths. A conventional coal-cutter chain completes the periphery of the profile.

The Ripper Type

The main cutting components of this type of machine consist of a series of conventional coalcutter-type chains and pickboxes (usually about six chains) driven by a common sprocket shaft and having a common idler shaft. This arrangement of shafts and chains is termed the *ripper bar*; being provided with elevating hydraulic jacks and mounted on a turntable, the bar can form a roadway with a series of cutting passes as the ripper bar is raised or lowered.

The Oscillating-head Type

The cutting components of this type of machine consist of four wheels approximately 1 m in diameter, the periphery of each wheel being equipped with pick-boxes, and each pair of wheels being driven by a common gearbox situated centrally between the wheels. The two in-line combinations of motor, gearbox, and wheels are suspended from a common boom, and each combination can oscillate from side to side. Thus, a roadway can be formed by a series of cutting passes as the machine is advanced and the boom raised or lowered.

The Horizontal-drum Type

With this type of machine, a horizontal drum about 1 m in diameter equipped with an array of pickboxes is mounted on a boom that is capable of being raised and lowered. The drum is driven by gears or chain-driven sprockets. The chains may also be equipped with pickboxes. A roadway can be formed by a series of cutting passes as the machine is advanced.

Introduction to South African Coal Mines

All continuous miners designed for operation in South African coal mines are of American origin, and were designed essentially for operation in relatively soft bituminous types of coal. The introduction of such machines into the harder, more abrasive, cleat-free South African conditions has no doubt accounted for the varying degree of application of the machines. Indeed, the successful use of continuous miners in Transvaal coal seams has been demonstrated only within the last four years.

An indication of the introduction of the main types of machine is given below, and their history is summarized in Table I.

Borer Type

A machine of this type (Goodman borer) was introduced at Coalbrook Colliery in 1957, and, as a result of the acceptable productivity level (average about 800 tons per shift) and the improved strata control situation, allowing the splitting of pillars and thus improving the percentage extraction of reserves, three further machines were purchased.

The machines operated successfully until 1972. At

*Bosjesspruit Colliery, Sasol One (Proprietary) Ltd, Secunda, Transvaal.

TABLE I

HISTORY OF CONTINUOUS MINERS IN SOUTH AFRICA

Year	Machine type	Colliery	Make
1958	B	Coalbrook	Goodman
1959	B R	DNC	Joy
1960	B R		
1961	B R		
1962	B R	Sigma	
1963	B R		
1964	B R		
1965	B R		
1966	B R		
1967	B R O	Sigma	Lee Norse
1968	B R O	Usutu	Lee Norse
1969	B R O D	Coalbrook	Joy
1970	B D		
1971	B D		
1972	D		
1973	D		
1974	D		
1975	D	S. Witbank	NMS
1976	D		
1977	D		
1978	D		
1979	D		

B Borer O Oscillating head
R Ripper D Drum

that time the mine planning indicated a variable mining height in a different coal seam more suitable to other types of machine. Alternative types of machines were available, and consequently the borers were phased out.

Ripper Type

A machine of this type (Joy 6 CM) was introduced at Durban Navigation Colliery in January 1960, and in 1962 two machines were in operation at Sigma Colliery. The latter machines were withdrawn from service in 1968–1969.

Oscillating-head Type

A machine of this design (Lee Norse) underwent trials at Sigma Colliery in 1967. The machine was used primarily for the driving of development roads for longwall panels. A similar machine was subjected to extensive trials at Usutu Colliery in 1968–69. Productivity levels of 700 tons per shift were achieved, but the overall cost per ton of coal produced exceeded that of conventionally mined coal by unacceptable levels at the time of the trial, and the machine was withdrawn.

Drum Type

A horizontal-drum type of continuous miner (Joy 10 CM) was introduced at Coalbrook Colliery in 1969 and performed satisfactorily.

The first horizontal-drum machine to operate successfully in the Transvaal coalfield was on NMS Marietta miner, which was tested at South Witbank Colliery in March 1975. This machine consistently exceeded 1000 tons per shift, with a high machine availability.

Drum miners of various makes (Jeffrey, Joy, NMS, and Lee-Norse) have since been introduced into South African mines.

Operational Experience in South Africa

In a breakdown analysis report for the year 1978, the Chamber of Mines' Coal Mining Laboratory indicated that by far the largest single cause of the non-availability of continuous miners was the equipment directly associated with the cutting operation of the machine cycle. The average annual figure given for non-availability was about 40 per cent. (The non-availability of the machine as a result of conveying, tramming, grading, and cleaning-up operations never exceeded 9 per cent within these individual operational elements.)

The vast majority of continuous miners currently in operation are of the horizontal-drum, caterpillar-track mounted type, and, in view of the knowledge of breakdowns that is now available, it is of interest to look at the cutting components in more detail.

Cutting Components

Cutting Drum

This consists of a steel cylinder on which are mounted blocks, in the form of a scroll or scrolls, carrying clevis boxes or pickboxes. The drum can be caused to rotate by gears or by chain-driven sprockets. (These chains may also be equipped with pickboxes to present a continuous array of picks to the coal face.)

Clevis Boxes

These are welded or bolted to the drum and enable the pickbox to be positioned and fastened by a pin that passes through the sides of the clevis box and the pickbox. The clevis base forms the seat on which the pickbox sits.

Pickbox

This is a casting specially shaped to hold picks, and contains a slot, a hole for the pick shank, a hole for the clevis pin, and a seat.

The pick is located into the pickhole, and the base of the pick passes through the slot and rests on the seat. The slot enables fasteners to be fitted to the pick shank, which prevents the pick from being ejected from the box during operation.

Pick

The picks themselves consist of a steel body containing a recess into which a cemented carbide tip is brazed. The cemented carbide tip is the cutting portion of the pick, and consists of two materials, tungsten carbide and cobalt, sintered together to form a matrix of carbide grains within a cement of fused carbon.

The most important physical properties of the cemented carbide are hardness and toughness. The value of both these properties can be varied by the

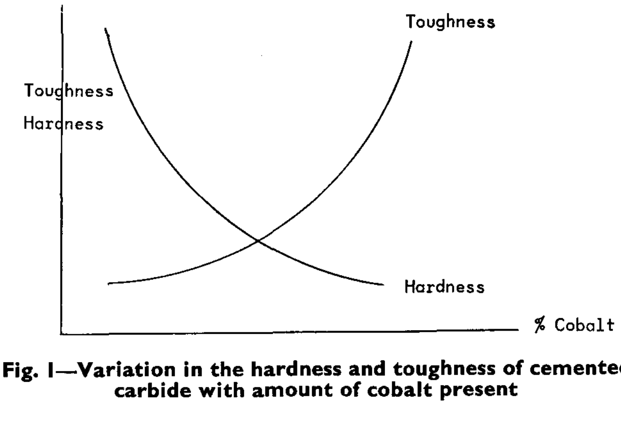

Fig. 1—Variation in the hardness and toughness of cemented carbide with amount of cobalt present

amount of cobalt present, as shown in Fig. 1. If the carbide is too hard, premature fracturing will occur, and, if it is too soft, the material will wear away too quickly. Thus, for optimum cutting performance, a balance between the two properties is necessary, dependent upon the quality of the coal being cut.

Design Definitions of Cutting Heads

Attack Angle

The angle of attack (Fig. 2) of a pick can be defined as the angle formed by a line drawn longitudinally through the shank and point of the pick and a line forming the radius of the pick point (through the centre of the drum and the point of the pick). Some manufacturers use the 'complementary angle' as their definition of attack angle.

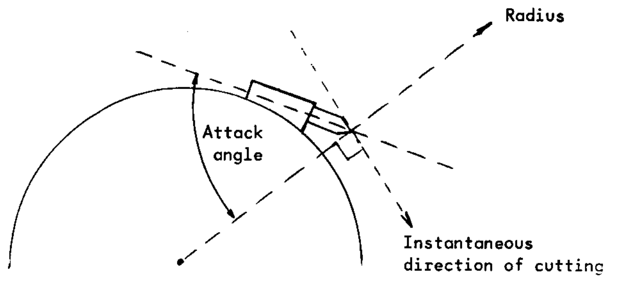

Fig. 2—Attack angle

Clearance Angle

In a point-attack pick with a point 'cone angle' of, say, 60 degrees, the sum of the back and front clearance angles will be equal to 30 degrees. The individual values of the clearance angles will depend upon the attack angle in use at the time (Fig. 3).

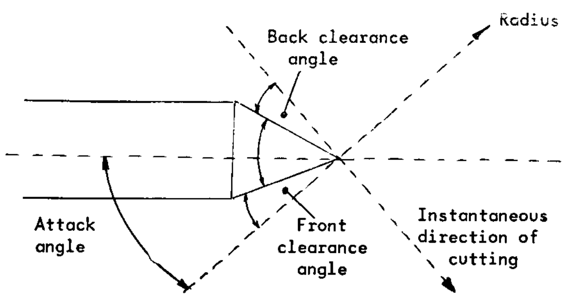

Fig. 3—Clearance angles

Pick Spacing

For a single scroll, the position of the picks on an auger is usually determined as shown in Fig. 4. Multi-scroll drums can be made by the interspersing of pick-boxes to the required pattern. Thus, more than one pick per line can be made available.

Pick 'Off-set' Angle

With point-attack picks, the self-sharpening capability of the picks, due to normal rotation, can be increased by the setting of each pickbox slightly out of line by a small amount, say 2 to 3 degrees. This induces rotation, and hence self-sharpening of the tips.

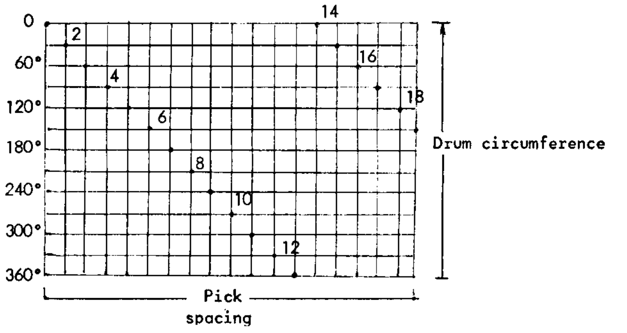

Fig. 4—Position of picks on an auger

Continuous Miners at Bosjesspruit Colliery

The continuous miners in operation at Bosjesspruit Colliery are Jeffrey 120-H2 Heliminers. The main specifications of the machines were originally as follows:

Mass (approx.)	50 000 kg
Motors	2×3300 V×205 kW
Mining height (max.)	3,66 m
Cutting width	3,30 m
Cutting-head diameter	933 mm
Cutting-head speed	67 or 50 r/min
Pick spacing	57,1 mm.

Three machines have been deployed since the completion of shaft-sinking operations in 1977 to mine primary, secondary, and tertiary development in seam heights ranging from 2,5 to 3,5 m:

Primary development. This consists of 25 or 28 m square pillars formed by 6,0 m wide roads driven as nine road sections.

Secondary development. This is mainly 25 or 28 m square pillars formed by 6,0 m wide roads driven as seven road sections.

Tertiary development. So far this has consisted of development for longwall units, being 100 m×35 m pillars (CL) formed by 5,0 m roads driven as two road sections.

Basic Geology at Bosjesspruit

The no. 4 seam at Bosjesspruit Colliery displays the normal characteristics of South African coals, being harder, more abrasive, and containing fewer cleats than the normal U.S. or European coals. In addition, patches of the seam have been encountered that contain abnormally large numbers of carbonate nodules and layers of pyritic lenses. The nodules have uniaxial compressive strengths in the region of 30 000 lb/in^2, and occur intermittently in two distinct bands approximately 1 m and 2 m from the seam floor. The patches of high incidence of nodules are apparently randomly distributed, and, so far, geological investigations have indicated no means of predicting their distribution.

The seam also contains a sandstone band occurring about 0,5 m from the seam roof and of variable thickness from 0 to 0,3 m. The planned mining height assumes the machine will mine up to the sandstone band, but in weak areas this must be cut, and, in conjunction with a high incidence of nodules, difficult cutting conditions are experienced. The floor comprises a competent sandstone.

Operational Performance at Bosjesspruit

The design of the continuous-miner cutting head originally incorporated pin-on type pickboxes with plumbob point-attack picks spaced at 57 mm on a double-scroll pattern with an attack angle of 37,5 degrees. The drum speed was 50 r/min, and the width of the cutting head 3,3 m.

During the first few months of operation, the production performances were inconsistent, and the cutting efficiency of the machines was seriously affected by the incidence of nodules. Physical evidence of the difficult cutting conditions were as follows:

- high rates of pick damage: pick shanks were snapped and bent
- high wear of pick tips: tips were ripped out of the recesses or chipped
- damage to clevis brackets: damage occurred at welded joints
- wear between pick, pickbox, and clevis pins: adjacent picks could be displaced towards each other by as much as 25 mm when grasped with the hand.

Modifications to Improve Performance

Picks

Several small-scale tests were conducted on picks supplied by various manufacturers, and it became obvious that a simple bullet-type of pick gave the best results. The picks in the pickboxes of the scrolls were changed immediately, and those in the trim chains of the machines were changed as the chains became worn and were replaced. Pick damage was reduced, but an excessive degree of wear remained in the pickbox–clevis area.

Trim Chains

After some time, the amount of wear in the pickboxes was such that as many picks were being ejected from the boxes as were being consumed by normal usage. The lines of picks were therefore increased from five to seven, i.e. the pick spacing was reduced to about 37 mm, and an improvement was effected.

Clevis Brackets

In order to reduce wear in this area, these were removed, and the pickboxes were welded direct to the drum blocks. A special jig was constructed in the mine workshops to assist with the modifications, and its use resulted in the disclosure that some of the picks of the cutting head were not describing the same concentric cutting circle. All the drums are now checked on this jig before being sent underground, and this has resulted in much reduced machine vibration during normal cutting operations.

Cutting-head Speed

Tests were conducted at two speeds: 50 and 67 r/min. At the higher speed, more dust was produced, but no appreciable difference in cutting performance could be claimed.

Pick Attack Angle

The machines were tested with picks covering a range of attack angles between 37,5 and 45 degrees. These tests are continuing.

Summary of Test Results

(1) The simple bullet type of pick has given the best results at Bosjesspruit.
(2) An increase in the number of lines of picks reduced the wear on trim chains.
(3) Improved performance was achieved by the welding of pickboxes direct to the drum blocks.
(4) At higher drum speeds, the amount of airborne dust produced increased dramatically, with only a slight increase in production rate.
(5) The tests on various pick attack angles have been inconclusive and are continuing.
(6) The use of a simple jig to check the modification has resulted in reduced machine vibration during underground operation.

Productivity

Although the output of individual shifts has been in excess of 1000 tons, the average section productivity at Bosjesspruit (on a 3-shift-per-day basis) lies between 600 and 700 tons per shift. It should be noted that, at any one time, two of the three machines have been engaged in longwall development, i.e. mining two roads with 100 m (chain) pillar centres.

Dust Suppression

The production of airborne dust by coal-cutting machines has been a problem since the development of mechanized coal mining. With continuous miners, the problem of dust production is amplified by the fact that the machine is relatively static in one roadway during normal operations, and, if it is producing coal consistently at a high rate, the local environment undergoes little variation compared with that in a conventional mechanized section. In the latter, a regular change of activities and machines in a heading can generate a variety of airborne dust levels, varying from maximum to minimum with a time interval of hours between these values. The continuous miner, however, may be engaged in non-dust-producing activities for only a few seconds.

Apart from the direct health hazards associated with the presence of dust in the working environment (pneumoconiosis, eye irritation, eye strain, spitting, etc.), the indirect effects can be just as dangerous. For example, a continuous miner, when leaving a coal roof, can cut through a slip so smoothly that the presence of slips is indicated only by a small crack. In a very dusty atmosphere, this crack can easily evade detection, and within a few minutes the crack can be directly above the area normally occupied by the driver, cable handler, supervisor, etc. and create a potentially serious situation. Reduced visibility during the manoeuvring of machines also obviously induces potential accident situations.

From a productivity point of view, the presence of a lot of airborne dust prevents the driver from steering correctly, with a consequent waste of time during realignment, and maximizes the errors associated with roof and floor control. The constant presence of airborne dust with its dimming effects on machine lights and cap lamps, and the copious amounts of water that have to be used via sprays, culminating in mud and slurry throughout the area, are bad for morale and expensive to alleviate.

Modifications to Dust-suppression Equipment

The original dust-suppression equipment supplied with the continuous miners consisted of an array of water sprays covering the cutting head and an exhaust scrubber system.

The scrubber system consisted of scrubber jets and a fan unit situated at the rear of the machine, on the side opposite to the driver's cab, and a system of steel ducting, by which air was drawn from air intakes situated on the top side of the boom. These air intakes were positioned so that the orifices faced forward towards the cutting head. The capacity of this system was 1,3 m^3/s, the air and slurry being discharged behind the fan unit and at right angles to the machine body.

After tests had been conducted on different types of sprays and spray positions, it was decided that the system should be redesigned to increase its effectiveness.

The scrubber unit, fan, and discharge point were relocated above the conveyor, in line with the hinge point of the boom, and the air intakes were repositioned to take in air vertically from the side of the boom. Additional scrubber sprays were installed, and, as a result of the reduced length of ducting, the capacity of the system was increased to 1,5 m^3/s. The system functioned approximately 20 per cent more effectively than before.

Water Infusion

Despite the improvement, dust remained a problem, and it was decided to inject water into the coal seam ahead of the continuous miners and to measure the effects on dust production. This method of injection, or water infusion, has been known in Europe for some years, but is normally practised on longwall faces in soft, broken coal.

Since the specialized equipment for this technique is normally imported and potentially expensive, it was decided to use conventional cement-grouting equipment to determine the water pressure, water flow, and drill-hole positions required for efficient infusion. A hole was drilled with a diamond drill into the centre of a 25 m square pillar, and, by use of a compressed-air pump, water was infused into the coal. Water appeared on the sides of the pillar at various horizons, and the infusion pressure was measured as approximately 3 MPa.

The results were encouraging, and it was decided to introduce the equipment into an area in which a continuous miner was operating. Again, a diamond drill was used to drill a hole compatible with the grouting equipment, and an area of about 200 m by 100 m was infused with approximately 14 000 litres of water. Dust samples were taken, according to standard procedures, as the continuous miner progressed through the area, and the results indicated a substantial reduction in airborne dust compared with that when the same machine was used in an untreated area. The results indicated reductions in dust counts of approximately 50 per cent.

The specialized drilling equipment and water-injection equipment necessary to achieve these results were replaced by an imported injection gun, which can operate in a small hole drilled by a hand-held drilling machine. An area ahead of a continuous miner was infused with water, and dust samples were taken in the driver's cab as the machine traversed the area. The results again showed a substantial reduction in airborne dust.

This technique will now be developed further and incorporated into the mine operational plan for continuous-miner sections. It is expected that the technique can also be utilized with longwall mining and conventional mechanized mining for dust suppression and as a potential aid to productivity.

Optimization of Continuous Miner Performance

The normal mining horizon at Bosjesspruit for the next few years will be between a hard sandstone band, which forms the roof, and a hard micaceous sandstone floor. Operator error in controlling roof and floor horizon can, of course, amplify poor cutting performance and pick wear in this situation. The development of indicators to assist drivers in horizon control is being pursued.

The design of the cutting heads of the continuous miners will receive constant attention in an effort to maximize the cutting efficiency of the components and reduce the downtime, and hence increase the productivity of the machines.

The various techniques of dust suppression now available will be exploited to the full in an attempt to ensure the best working environment for men and machines.

The results of recent research undertaken by the Chamber of Mines Coal Laboratory with a continuous miner at Kriel Colliery are eagerly awaited. It is obvious that the operators of the current generation of machines are feeling their way in the field of cutting technology, and the need for a knowledge of the mechanics of coal breakage and coal cutting is a prerequisite to the design of better machines and improved performance.

B. The selection and performance of continuous miners at Matla Coal

by J. D. STONE*, B.Sc. Eng. (Min.,) M.B.L. (Graduate)

SYNOPSIS

The reasons for the choice of continuous miners for the development of accesses and the winning of coal in a modern underground coal mine are discussed. It is shown that, at relatively low depths, the extraction rate as well as the costs are more favourable than those of proved total extraction methods.

The selection of a continuous miner is largely dictated by factors such as production rate, capital and running costs, imported content and the extent to which local content and manufacturing are to be increased, manpower requirements, seam thickness, expected floor and roof conditions, and maximum cutting height.

The present inherent shortcomings of continuous miners, such as inefficient continuous transportation of coal away from the miner and the lack of an infinitely variable traction to match the sumping speed with the feasible penetration speed, are pointed out.

Specific problems encountered and the methods of solving them, as well as a planned trial with a heavy-duty continuous miner, are discussed.

SAMEVATTING

Die redes vir die keuse van aaneendelwers in die ontwikkeling van toegange en die ontginning van steenkool in 'n moderne ondergrondse steenkoolmyn word bespreek.

Daar word aangedui dat die tempo van ontginning sowel as die koste op relatiewe lae dieptes meer voordelig is as die van bewese totale verhalingsmetodes.

Die keuse sowel as tipe van 'n aaneendelwer word hoofsaaklik bepaal deur faktore soos produksietempo, kapitaal en bedryfskoste, ingevoerde inhoud en die mate waarin die plaaslike inhoud en vervaardiging beplan word om te vermeerder, mannekragvereistes, laagdikte, verwagte vloer- en dakomstandighede en maksimale snyhoogte.

Die huidige inherente tekortkominge van aaneendelwers waaronder die ondoeltreffende deurlopende vervoer van steenkool weg van die delwer en die gebrek aan 'n oneindige varieerbare trekkrag sodat die delfspoed die moontlike indringspoed ewenaar, word toegelig.

Spesifieke probleme wat teëgekom word en die metodes om hulle op te los sowel as die beplande proefneming met 'n swaardienstipe aaneendelwer word ook bespreek.

Introduction

The objective in the establishment of Matla Coal Limited is to supply Escom's new 3600 MW Matla power station with coal. The colliery will consist of three mines of approximately equal capacity within a radius of 8 km from the power station. The power station and mining complex is situated almost 30 km south of Ogies in the Bethal district of the eastern Transvaal. The power station, when fully commissioned, will require around 10 Mt of coal per annum.

The coalfield from which the Matla power station will be supplied is known as block IV of the Highveld Coalfield. The area to be exploited is bounded to the east by the Anglo Power colliery, which supplies Kriel power station, to the north by the South Witbank and Tavistock collieries, and to the west by Delmas colliery, and it stretches south-west towards Leslie. The reserves contained in the three mineable seams in the mining rights area are approximately 1183 Mt. These seams, from the top down, are no. 5 with an average thickness of 1,4 m at an average depth of 48 m, no. 4 with an average thickness of 4,8 m at an average depth of 76 m, and no. 2 with an average thickness of 4,2 m at an average depth of 105 m.

Over the eastern portion of the coalfield, the roof of the no. 5 seam consists of dark-brown shale, which is very susceptible to dehydration. The resultant dehydration cracks cause the shale to fall out between the roofbolts. Over the remainder of the coalfield, the roof consists of dark-grey micaceous sandstone. Micaceous partings in this sandstone are sporadically very well developed and cause about 15 cm of sandstone to fall as soon as it is exposed.

The immediate floor of the no. 5 seam consists of soft shale underlain by very fine-grained micaceous sandstone. Heavy machinery tends to break this shale up, with the result that the floor is very uneven and covered with debris, which hinders movement and contaminates the product.

The roof of the mining excavations in the no. 4 coal seam consists of inferior-quality coal and carbonaceous shale. Under normal conditions, the roof tends to be very good. Well-developed fracture planes and the intrusion of dolerites tend to result in a deterioration of roof conditions in certain areas.

The floor of the no. 4 seam consists of fine- to medium-grained sandstone, which proves to be very stable.

The roof and floor of the no. 2 coal seam consists of a competent sandstone, and it is expected that generally excellent mining conditions will prevail. Of the three coal seams, the no. 5 seam has proven metallurgical qualities, and, from investigations, it was concluded that a market for this coal should be obtained as soon as possible. Escom stands to benefit through the economy of scale with respect to both working cost and capital requirements, and Matla will at the same time increase its profit through increased sales. The coal will be produced by means of 17 bord-and-pillar continuous-miner and two longwall sections. Of these, six continuous-miner sections and one longwall section will be operating in the relatively low no. 5 coal seam.

Choice of Continuous Miners

During the initial planning stage, a comparative cost projection was done, which indicated that by 1980, owing to the expected rapid escalation of wages, the working costs for a continuous-miner section would be

*Matla Coal Ltd, Kriel, Transvaal.

less than that of a conventional mechanized section. At a capital charge of 20 per cent, the projected working costs for a continuous-miner section would be 412 cents per ton, compared with 424 cents per ton for a conventional mechanized section. The predicted saving of approximately 12 cents per ton in 1980, which would increase to 30 cents per ton in 1983, was one of the main motivating factors for the choice of continuous miners. (See Fig. 1.)

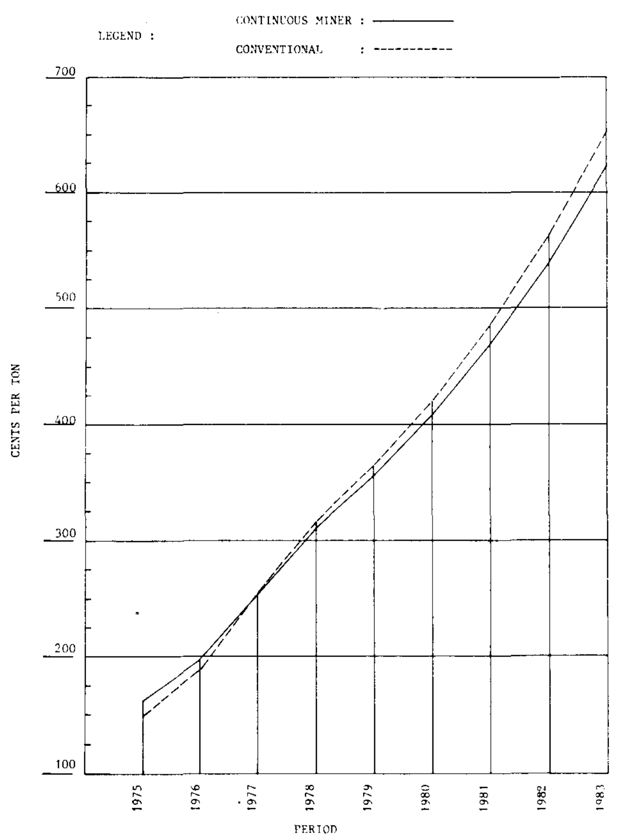

Fig. 1—Comparative cost projection for continuous-miner and conventional mechanized sections

Present-day working costs, taken from mines within the group operating under similar conditions, indicate that, by the operation of continuous-miner sections instead of conventional mechanized sections, a saving of 5,7 cents per ton in no. 4 seam and 8 cents per ton in no. 5 seam can be realized. Where the depth of no. 5 seam exceeds 50 m, a combination of longwall mining and development with continuous miners will be exploited to increase the extraction rate of the mineable reserves from 57 per cent to an expected 80 per cent for the three seams.

Until more accurate information regarding the extent of surface damage created by longwall mining is established, all reserves having a cover of less than 50 m will be mined by the bord-and-pillar method with continuous miners. From the experience that will be gained from subsidences caused by total extraction methods at no. 2 mine, further consideration will be given to the possible extraction of pillars. Until this is known, there is a danger of ventilation disruption and spontaneous combustion if severe surface subsidences are experienced.

Based on the present standard safety factors of 2,2 for main development, 1,8 for secondary development, and 1,6 for panel development, a satisfactory extraction rate of more than 80 per cent of the mineable reserves can be obtained from the no. 5 seam, which has an average cover of 40 m. The no. 4 seam, however, has an average cover of 75 m and an expected extraction rate of 57 per cent. An investigation into the introduction of ash-filling is being conducted at present; if the panel safety factor were reduced to 1,0, the extraction rate could be increased to 67 per cent at an estimated additional cost of 62 cents per ton. Judging from the poor roof conditions of the no. 4 seam in the neighbouring Kriel Colliery, it was considered that blasting operations would have to be avoided where possible.

At this stage, it appears that, from both a cost and an operational point of view, the continuous miner has definite advantages.

Selection of Machines

Tenders were received from four companies and, at the time of tender, two companies had machines operating in South Africa. Since prospective customers had the opportunity of seeing these machines operating in local conditions, as well as being able to assess the performances being achieved immediately, these companies had an advantage over the others. In the selection of the best machines, the following factors were taken into consideration.

Ability to Produce Coal

There seemed to be virtually no difference between the machines' ability to produce coal. It was decided to select the machine with the most powerful cutting head, since experience in this country with longwall shearers had indicated that it was wise to choose the most powerful machine available. American experience had also indicated that less maintenance is required for a more powerful machine doing the same job.

Cutting Height

With the no. 4 and 2 seams varying from 4 to 6 m in height, it was preferable to take the machine that could extract the most coal in one pass, especially for main and secondary development, and so avoid top coaling at a later date. The poorer-quality coal is found mainly in the upper portions of the seam.

For the no. 5 seam, a large portion of the reserves would be mined at 1,2 m. The tramming height of each machine was studied, and the lowest was selected to ensure adequate clearance for maintenance purposes. Because of the systematic support necessary and the probability of having to leave a thin layer of coal to protect the soft floor, it was essential to aim for maximum clearance.

Technical Considerations

So that maintenance costs would be kept as low as possible, it was considered that the machines should have the following:

(1) no mechanical clutches where possible,

(2) fixed cutting heads rather than those incorporating chains,
(3) electric power supply for traction rather than hydraulic,
(4) the highest sumping speed without producing slip on a soft floor,
(5) sufficient mass to avoid slip when sumping.

Financial Considerations

The least expensive machine most closely approaching the above specifications would be chosen as long as the cost and availability of spares were satisfactory.

Local Content

At the time of the selection, the amount of local content was not considered a serious problem. Since then, owing to the increasing probability of international embargoes and the consequences for the mining industry, an increased local content and manufacture of equipment become more and more important. Subsequent to the purchase of the machines, the suppliers were approached in this regard, and assurance was given that by 1981 almost all the equipment will be manufactured locally.

Final Selection

The machines required for nos. 4 and 5 seams to conform with the above specifications were considered to be the best available at the time of selection.

The average progressive machine availability and section productivity for the continuous miners in the no. 4 seam are shown in Figs. 2 and 3. Unnecessary mechanical problems are still being encountered, but it is envisaged that these will be eliminated shortly. Since mining commenced, extraction has been in main roads to provide safe access over the long term.

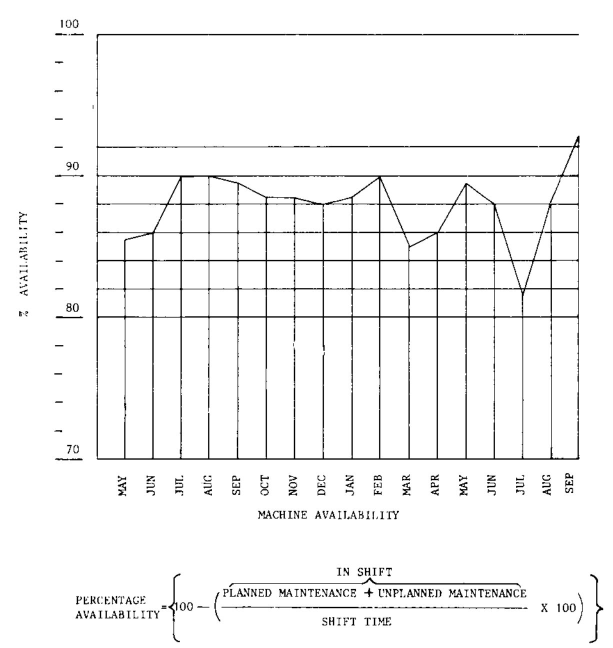

Fig. 2—Availability of continuous miners in no. 4 seam

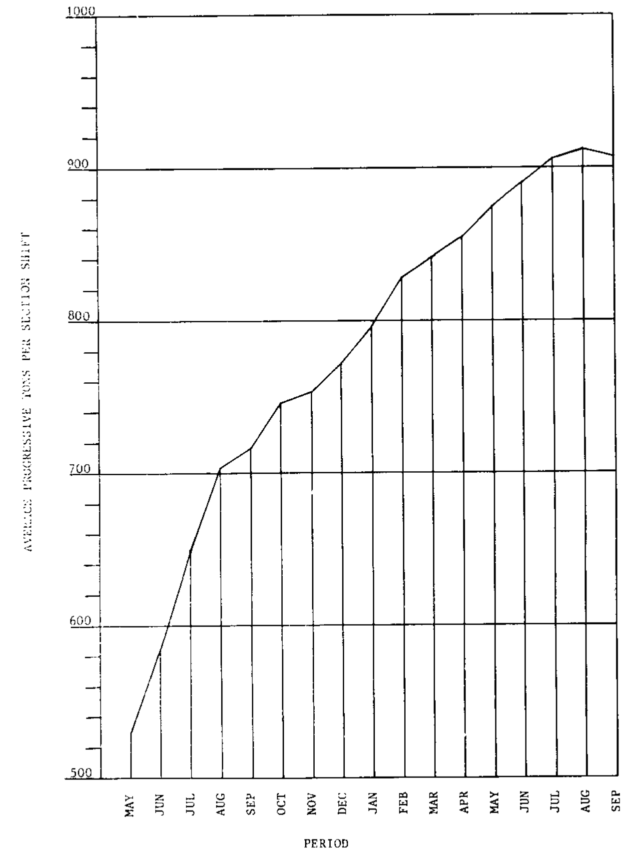

Fig. 3—Average progressive productivity of continuous-miner section in no. 4 seam

Shortcomings in Use of Continuous Miners

Because of the varying nature and hardness of the coal in South Africa, recommendations from overseas have proved to be of little value. For the optimum cutting and loading rate to be achieved by a machine, the pick spacing, drum-rotation and sumping speed, pick angle, and type of picks have to be selected so that the machine is suitable for the coal being cut.

From studies conducted at Matla in the no. 4 seam, it was found that the total utilization of the cutting time for the machine is in the region of 59 per cent. To date, no problems have been encountered in cutting coal. As a result, no experiments have been carried out to improve the production rate of the machine, and all efforts have been directed towards an improvement in the utilization of the available cutting time. The following areas have been singled out.

(a) The time lost in waiting for shuttle cars to manoeuvre into position before loading and cutting can commence accounts for approximately 10 per cent of the lost cutting time. An efficient means of continuous transportation of coal away from the miner could eliminate this lost time.

(b) So that the maximum sumping depth can be obtained, it is essential to first sump in on the floor to make room for the loading shovel. The machine is then reversed, the drum is lifted, and sumping at the desired height can commence. The possibility of shortening the shovel is being evaluated to reduce this lost time, which accounts for approximately 8 per cent.

(c) The changing and checking of picks at hourly intervals were found to be essential if the cutting capacity of 8 to 11 t/min is to be maintained. To overcome this, several experiments involving pick spacing, sumping speeds, drum-rotation speeds, and types of picks are still to be carried out to obtain maximum cutting capacity with the minimum number of pick changes. Approximately 4 per cent of the lost time can be attributed to changing of picks.

(d) Bords in the no. 4 seam are worked at 6 m widths with a cutting drum 3,3 m wide. During the first pass, the drum is fully utilized to a depth of approximately 8 m, roof conditions permitting. On the second pass, only 80 per cent of the drum capacity is used, reducing the tonnage per minute and lengthening the time taken to fill a shuttle car. By the introduction of ash-filling into the panels, it is envisaged that the bords in the panels can be widened to 6,6 m to overcome this problem.

(e) Under normal conditions with a competent roof and floor, tramming accounts for approximately 9 per cent of the lost cutting time. Where poor roof conditions are encountered, the depth of each pass is considerably reduced, increasing the amount of tramming and thus reducing the effective cutting time.

(f) Unplanned maintenance accounts for approximately 10 per cent of the planned cutting time. By a reduction in the unproductive times, it is envisaged that the present average of 1084 t per shift can be increased to 1375 t per shift at a target of 75 per cent effective cutting time.

In the no. 5 seam, a specific problem of a soft shale floor varying in thickness from 0,2 to 0,5 m was encountered. To maintain the floor while cutting was not a problem, but the traction exerted by the cat-tracks of the machine while sumping resulted in the breaking up of the floor. The slip on the cat-tracks was 72 per cent, and it was decided that experiments should be conducted on ways of eliminating this.

Planned Trial with Heavy-duty Continuous Miner

The nos. 4 and 2 seams at Matla Coal are up to 6 m thick in some areas. The present continuous miners are capable of cutting up to a height of 3,6 m, which necessitates top coaling to improve the extraction rate, with a detrimental effect on cost. For this reason, it was decided to obtain a Dosco TB.600 twin-boom miner on a trial basis so that cutting to a height of 4,5 m in one pass could be evaluated. Should the trials prove successful, the company has the option to purchase the machine.

The Dosco is designed to excavate a tunnel 6 m wide by 4,5 m high without repositioning, which will decrease the manoeuvring time experienced with the Marietta. The production rate of the machine is to be modified to achieve an average of 1400 tons per shift with a cutting capacity similar to that of the Marietta 5012 (8 to 11 tons per minute).

The dimensions and specifications of the heavy-duty miner are as follows:

Dimensions

Machine length without conveyor	11,95m
Machine length with conveyor	13,69m
Width over apron	4,0m
Width over main frame	3,2m
Discharge height of conveyor	1,5m
Cutting width (from one position)	6,0m
Cutting height	4,5m
Sumping depth	0,74m
Mass of machine	81,3t

Specifications

Voltage	1000, 3-phase 50 cycles
Cutting motors	2×187 kW
Power pack motors	1×187 kW
Tracks	Caterpillar 235

Power take off for two hydraulic drills and booms

Electric all flameproof

Steko hose fittings

The machine was due to arrive at the mine towards the end of 1979, when tests were to be carried out.

Acknowledgements

The author thanks the management of the Coal Division of General Mining and Finance Corporation for permission to publish this information, and the staff of Matla Coal Limited, for their assistance in the preparation of this paper.

C. Continuous mining within the Tavistock Group of collieries

I. D. BRUMBY*, Dip. Min. (Visitor)

SYNPOSIS

The Tavistock Group of collieries is situated some 25 km south of Witbank. The three collieries comprising the Group are Tavistock Colliery, Phoenix Colliery, and South Witbank Coal Mines.

Continuous mining is practised to some degree at all three collieries. This system of mining was introduced at Phoenix during 1976, South Witbank during 1978, and Tavistock during 1979. For the twelve months ended June 1979, continuous mining accounted for 1,7 Mt of the 4,5 Mt hauled from underground. All the continuous miners introduced to date have been of the rotary-drum type.

SAMEVATTING

Die Tavistock Groep steenkoolmyne is 25 km suid van Witbank geleë. Die drie steenkoolmyne waaruit die Groep bestaan is die Tavistock steenkoolmyn, die Phoenix steenkoolmyn en die Suid-Witbank koolmyne.

Ontginning met aaneendelwers word in 'n sekere mate deur al drie steenkoolmyne beoefen. Hierdie sisteem van ontginning was by Phoenix gedurende 1976, Suid-Witbank gedurende 1978 en Tavistock gedurende 1979 ingestel. Vir die twaalf maande geëindig Junie 1979 is ontginning deur aaneendelwers verantwoordelik vir 1,70 miljoen ton van die 4,5 miljoen ton wat ondergronds ontgin is. Al die aaneendelwers wat tot op datum verkry is, is van die roterende trom tipe.

Introduction

The Tavistock Group of Collieries is situated some 25 km south of Witbank, the three collieries comprising the Group being Tavistock Colliery, Phoenix Colliery, and South Witbank Coal Mines.

Trials with a rotary-drum continuous miner were held in the no. 4 seam at South Witbank Coal Mines during 1975. These trials, conducted by Anglo American Corporation and Dowson and Dobson Ltd, proved that this type of equipment could cut the no. 4 seam, the cutting rates being high enough to warrant consideration of the equipment for production purposes provided that fairly continuous operation could be achieved. These trials had a significant influence on Tavistock's future plans regarding mechanization programmes and the replacement of existing mechanized equipment.

Mechanization in the Tavistock Group of Collieries

Phoenix Colliery

During 1975 a programme of mechanization was commenced at Phoenix. Initially, no. 4 seam was developed on a conventional basis, but the weak roof conditions that were encountered were a contributing factor when a decision was taken to introduce a continuous miner during 1976. A Marietta 3080 model was installed in the no. 4 seam, and a second such machine was brought into use during 1977. To date, these machines have extracted some 2 Mt of run-of-mine coal.

South Witbank

South Witbank commenced production during 1946. The mine was mechanized from the beginning and was one of the first collieries in South Africa to be mechanized. The mining conditions, generally speaking, are very favourable for mechanization. During the mid-seventies, when it had become necessary to consider replacing outdated equipment, the management decided to introduce continuous mining. At the beginning of 1978, a Joy 12 CM 6 was brought into use in the no. 4 seam, and a second such machine was installed during 1979. To date, these machines have extracted some 1,25 Mt of coal.

Tavistock Colliery No. 2 Section

Until the beginning of 1979, continuous mining within the Tavistock Group had been practised only in the no. 4 seam. The no. 2 seam was considered to be a more difficult proposition for continuous mining owing to the physical characteristics of the seam and a much more undulating floor associated with stone rolls. Nevertheless, a decision was taken to do the primary development in the no. 2 seam at Tavistock no. 2 section using a narrow-head Marietta 5012 continuous miner. There were indications that weak roof conditions would be encountered initially at this new section, and it was considered that the drivages formed would be much more stable if they were machine-cut and the use of explosives eliminated. Furthermore, valuable experience would be gained. The results to date indicate, at this somewhat early stage, that an output of around 60 000 t per month can be obtained from a continuous miner operating on a treble-shift basis. This compares favourably with the 65 000 t per month currently obtained from a conventional mechanized section in the no. 2 seam at Tavistock no. 1 section.

Size Distribution of the Product

Continuous miners produce finer coal than does the conventional mechanized system that utilizes coal-cutters, drills, and explosives. The output of the Tavistock Group is marketed by the Transvaal Coal Owners' Association, all of the coal being for the inland market. The major customers are thermal power stations situated throughout the Republic and Mocambique, and the chemical and cement industries. The coal is marketed on the basis of calorific value and size. It is therefore very important that coal is produced that satisfies the customer not only in calorific value but also in percentage size distribution.

Table I compares the size distribution of coal produced from a continuous-miner section and that pro-

*Tavistock Collieries Ltd, Ogies, Transvaal.

duced from a conventional mechanized section in the same seam (no. 4) at the same colliery (South Witbank). At this particular colliery, the demand for coal above 75 mm in size is negligible, and the plus 75 mm material has to be crushed. In recent years, there has been an increased demand for smaller sizes of coal and less demand for the larger sizes. It is interesting to note that coal produced by the continuous miner at Tavistock in the no. 2 seam contains no more than 20 per cent minus 6,4 mm material after the plus 100 mm material has been crushed to 100 mm.

TABLE I

SIZE DISTRIBUTION OF COAL PRODUCED FROM A CONVENTIONAL MECHANIZED SECTION AND A CONTINUOUS-MINER SECTION OF SEAM NO. 4, TAVISTOCK

Conventional mechanized		Continuous mining	
Size, mm	Cumulative %	Size, mm	Cumulative %
+76,2	30,8	+76,0	5,0
−76,2 +38,1	47,1	−76,0 +31,5	22,4
−38,1 +25,4	54,8	−31,5 +25,0	28,1
−25,4 +6,4	79,1	−25,0 +6,3	67,2
−6,4	100,0	−6,3	100,0

Although continuous miners produce smaller coal than the conventional mechanized system, there are indications that modifications can be made to the cutting parameters so that less fine coal is produced by this type of equipment. Within the Tavistock Group, the overall effect of continuous mining on coal sizing has not proved to be a problem.

Production Potential of the Continuous Miner

Experience in the Tavistock Group indicates that cutting rates of up to 300 t/h can be achieved. In an attempt to maximize on this potential, efforts have been directed at the operation of the machines with the minimum of interruptions. Treble-shift operation is practised, with the first production shift of the week commencing at 21h00 on Sunday evening and the last shift of the week finishing at 17h00 on Saturday. The main breaks in production are caused by the following factors:

(1) scheduled daily maintenance for a period of approximately 3 hours,
(2) unscheduled downtime on the continuous miner due to breakdown,
(3) extension of the belt conveyor when necessary,
(4) replacement of the cutting tools,
(5) delays when the continuous miner is being moved from place to place, shuttle-car change-out time, and interruption of water or power supply,
(6) stoppages outbye of the section affecting the section conveyor.

Table II gives an example of the time distribution in a continuous-miner section.

TABLE II

TIME DISTRIBUTION IN A CONTINUOUS-MINER SECTION

26 Apr. to 26 May at 05h00			26 Mar. to 25 Apr. at 21h00	
Hours	%	Description	Hours	%
562,8	100	Available	594	100
162,5	29	Stoppages	203,8	34
400,3	71	Production	390,2	66
162,5	100	Stoppages	203,8	100
56,4	35	Downtime continuous miner	75,3	37
31,8	20	Picks	54,8	27
38,0	23	Maintenance	42,3	21
11,1	6	Shuttlecar	13	6
2,7	2,0	Stockpile or plant	4,8	2
4,0	2,0	Belt extension	4,0	2
—	—	Visitors filming	3	2
5,4	3,0	Water	2,5	1
9,0	6,0	Belt	1,5	
—	—	Miner absent	1	2
3,2	2,0	Mine power	0,9	
0,9	1,0	Feeder	0,5	
Reported tons 81 767 Measured tons 85 306			Reported tons 81 228 Measured tons 79 413	

Mode of Operation

Fig. 1 shows a typical geological section through South Witbank, and Fig. 2 shows the face-cutting sequence there.

Fig. 3 indicates the mining sequence in the headings and splits or cross-cuts. Headings are mined in rotation from left to right. The 60 degree split from the right barrier heading is preferred to a 90 degree split because the cutting time for this particular split is reduced.

One example of a continuous-miner panel layout is shown in Fig. 4. It is not suggested that this is the optimum layout for this particular mine, but merely that, at this stage, it has proved to be convenient.

Advantages and Disadvantages of Continuous Mining

The following are some of the more apparent advantages of this system of mining.

(a) More stable pillars and drivages are formed than when explosives are used. This could possibly lead to an improvement in percentage extraction.
(b) Reserves that would have been difficult or impossible to extract by conventional mechanized methods can possibly be exploited.
(c) Fewer people are exposed to face operations.
(d) Under normal circumstances, blasting and its associated dangers are removed from the work situation. In addition, the legal responsibility of all the persons normally involved in the storage, handling, and use of explosives is considerably reduced.
(e) Greater flexibility exists where restricted mining has to be practised.
(f) A considerable improvement in the productivity of the unskilled labour force is possible. Improvements of up to 225 per cent have been recorded in the Tavistock Group.
(g) The mined product is in a much more convenient size for handling.

The more apparent disadvantages are as follows.

(1) In the event of a breakdown on the continuous miner, production from the section ceases completely.
(2) To date these machines and a high proportion of the

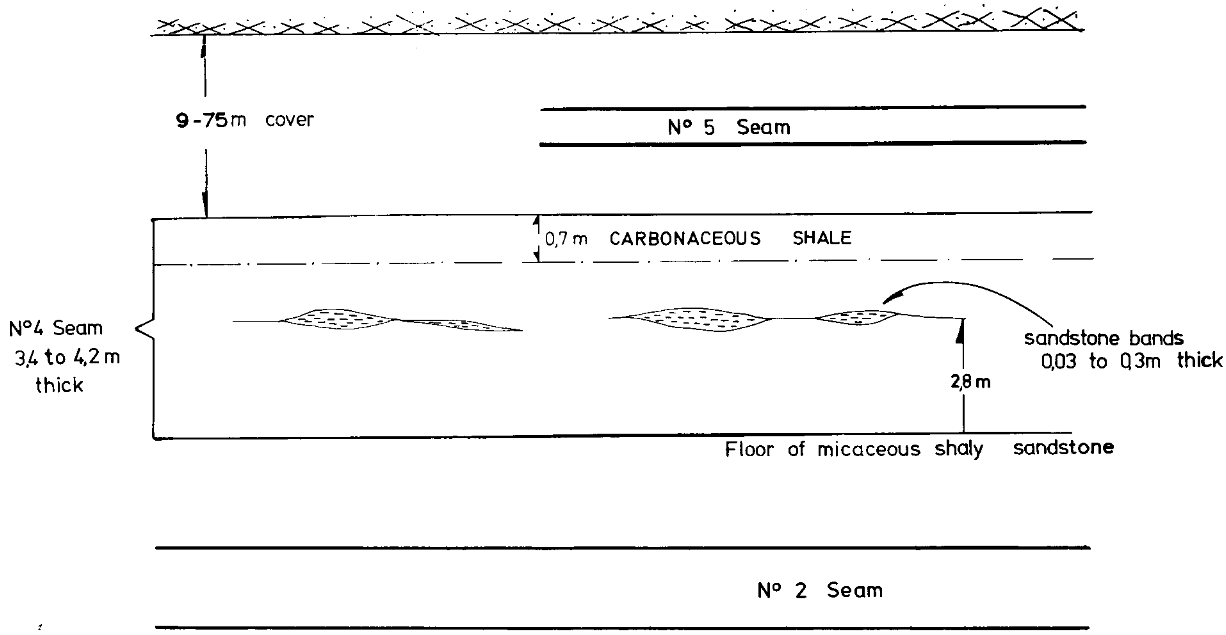

Fig. 1—Typical geological section through South Witbank

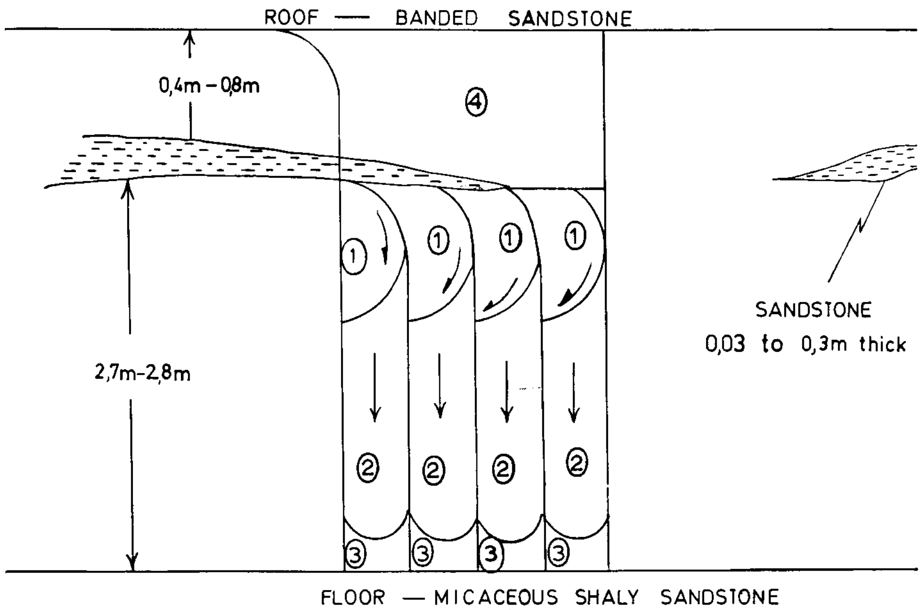

Fig. 2—Face-cutting sequence at South Witbank

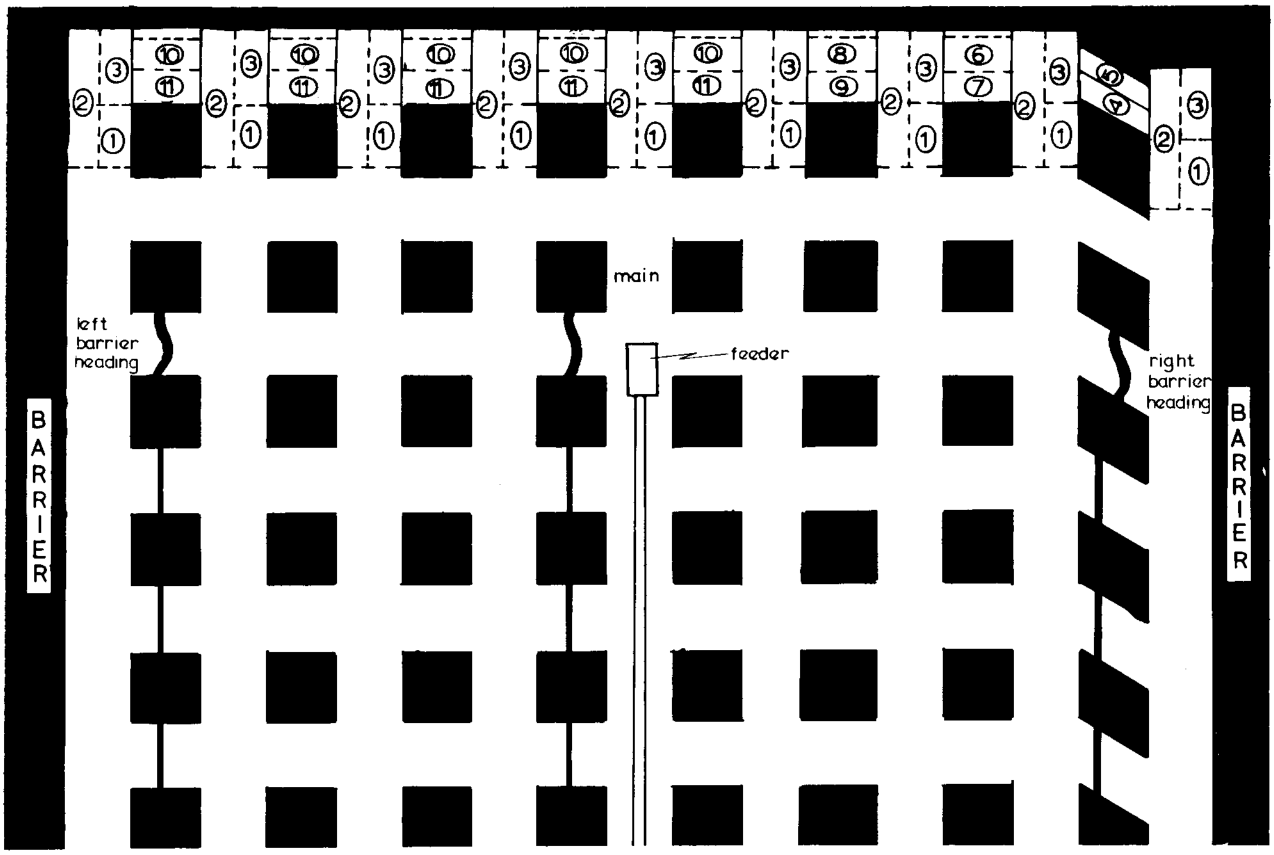

Fig. 3—Panel-mining sequence at South Witbank

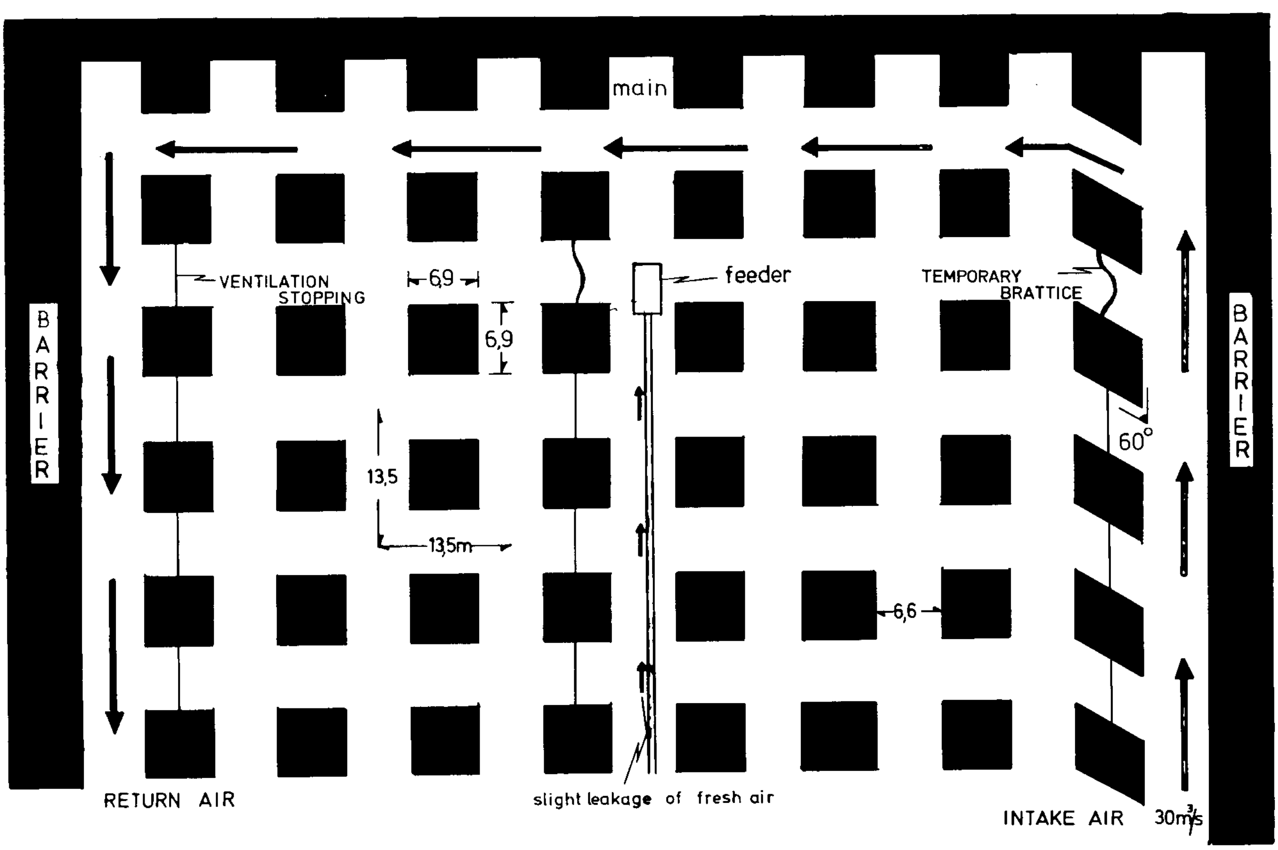

Fig. 4—Layout of a continuous-miner panel at South Witbank

spares have been imported. Local manufacture does appear to have started, but the extent is uncertain at this stage.

(3) Stone intrusions within the seam can have an adverse affect on production rates and on the machine itself.

(4) Frequent moves of the continuous miner may be necessary where systematic support is required. This can considerably reduce the time available for production.

(5) Spillage left by the continuous miner necessitates the use of hand labour or additional mechanized equipment for clean-up operations.

Conclusions

During the past three years, all the continuous miners introduced in the Tavistock Group have primarily been used for production purposes. Where special development or undermining work arose, these machines proved to be a valuable asset. The production rates achieved to date have exceeded expectations, and for the twelve months ended June 1979, continuous mining accounted for 1,7 Mt of the 4,5 Mt hauled from underground. During 1977 at Phoenix Colliery a world record was broken when one continuous miner produced more than 70 000 t in one month. Recently this record was broken when 85 000 t was produced by one machine in a single month at South Witbank.

This system of mining has proved to be very efficient and safe. It is very likely that the percentage of coal mined by continuous miners within the Group will increase at the expense of the conventional mechanized sections. This will apply in both the no. 2 and no. 4 seams.

D. Pillar extraction at Usutu Collieries using continuous miners

by C. J. BEUKES* (Visitor)

SYNOPSIS

In 1969 Usutu Collieries began pillar extraction with conventional mechanized equipment. This was very successful, but certain disadvantages could be eliminated if continuous miners were used instead. In 1976 the first continuous miner was introduced for this purpose; this proved so successful that a second unit was introduced in 1977, and pillar extraction by conventional equipment was discontinued. By the end of 1978, 1,3 Mt had been mined from pillar extraction by continuous miners.

This paper describes the method in some detail, and indicates that the operational costs are lower than for conventional bord-and-pillar mining.

SAMEVATTING

Die Usutu Steenkoolmyne het in 1969 met pilaarafbouing deur middel van konvensionele gemeganiseerde toerusting begin. Alhoewel baie suksesvol kon sekere nadele egter deur middel van die gebruik van aaneendelwers uit die weg geruim word. Die eerste aaneendelwer is in 1976 vir hierdie doel in gebruik geneem; dit was so suksesvol dat 'n tweede eenheid in 1977 verkry is en pilaarafbouing met konvensionele toerusting gestaak is. Teen die einde van 1978 was 1,3 miljoen ton van pilaarafbouing deur middel van aaneendelwers reeds ontgin.

Hierdie referaat beskryf hierdie metode en dui aan dat die bedryfskoste laer is as vir konvensionele kamer en pilaar afbou.

Introduction

Usutu Collieries is situated 20 km south of Ermelo, the mine being contracted to supply approximately 5,0 Mt per annum to Escom's Camden Power Station.

In order to increase the percentage extraction of coal reserves at Usutu, pillar extraction was introduced in 1969. This was done using available conventional mechanized equipment, i.e. coal cutter, loader, shuttle cars, and face drills. The method of extraction consisted of splitting the pillar and extracting the two fenders. This method proved very successful but had the following disadvantages.

(a) Blasting caused the immediate shale roof to deteriorate.

(b) A minimum of 5 pillars had to be mined in various stages of extraction at the same time. This caused the span of supervision to be excessive.

(c) The extraction was too slow, and resulted in a loss of pillars and created a safety hazard.

During 1976 it was decided to use a Marietta 3080 continuous miner instead of the conventional equipment and technique. This proved to be so successful that a second unit was put into operation during 1977.

Table I shows the production statistics for the years 1969 to 1978.

Geology

Fig. 1 shows a typical section through a borehole. The thickness of the overlying dolerite varies considerably (i.e. from 1 to 90 m), depending on the degree of surface erosion. In general, the overlying stratum is a very competent formation. The immediate roof above the B seam, which is being extracted at present, is predominantly shale with sandstone. This has to be supported during primary mining with roofbolts anchored in the sandstone above the B-upper seam.

The surface is fairly flat with no significant watercourses. The overlying farmland is used for grazing and maize production.

Panel Design

A minimum safety factor of 1,8 is adhered to. This may be exceeded when the pillar centres are being kept

*Usutu Collieries Ltd, Ermelo, Transvaal.

TABLE I

PRODUCTION AT USUTU COLLIERIES

Year	Average number of conventional sections on pillar extraction	Tonnage	Average number of continuous miner sections on pillar extractions	Tonnage	Total tonnage from pillar extraction	Total tonnage from pillar extraction expressed as a percentage of total mined tonnage
1969	1,0	101 468			101 468	5,82
1970	1,8	557 081			557 081	13,36
1971	2,0	629 092			629 092	13,17
1972	1,4	441 556			441 556	8,99
1973	1,0	410 331			410 331	8,79
1974	0,4	201 072			201 072	3,89
1975	0,7	177 563			177 563	3,55
1976	0,8	154 939	0,8	241 960	396 899	8,04
1977	0,4	39 321	1,5	443 773	483 094	10,20
1978			1,8	601 042	601 042	11,71
Total		2 712 423		1 286 775	3 999 198	8,84

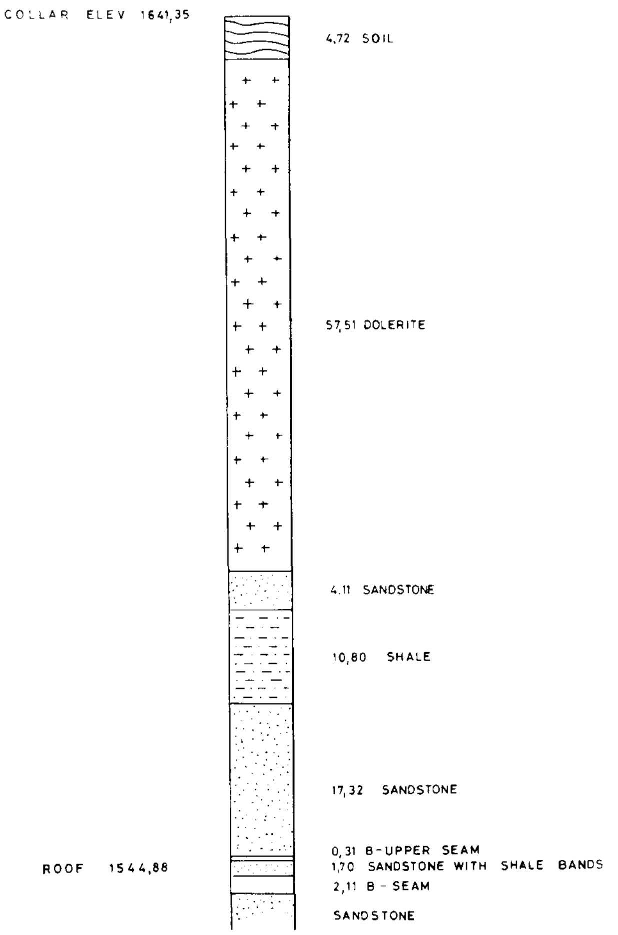

Fig. 1—Section through borehole W.10/69

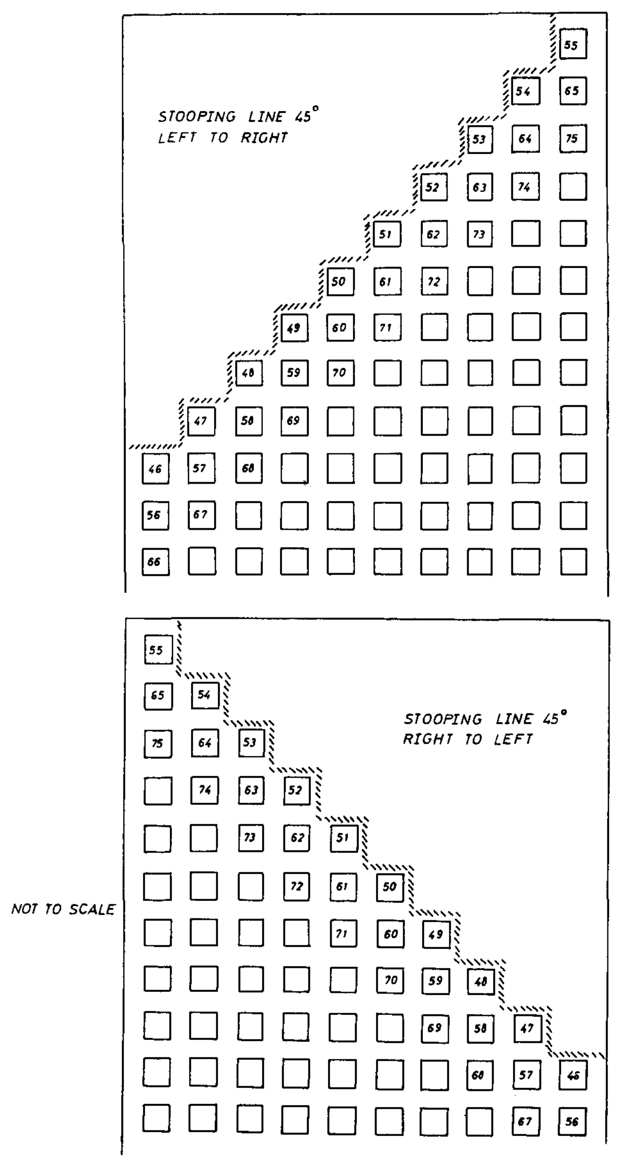

Fig. 2—Sequence of pillar extraction

to a specific pattern. The pillar centres and road widths are as follows:

Pillar centres	17 m
Road width	6 m
Pillar size	11 m.

All the panels have been developed at a width of 180 m regardless of pillar centres, no exception being made for panels that are to be stooped. However, investigations are being conducted to attempt to relate the design width of the panels to the thickness of the overlying dolerite, the depth below surface, etc.

A panel normally consists of 10 rows of pillars at 17 m centres.

Roofbolting is done in all the roadways on a standard pattern of 3 rows of roofbolts 1,5 m apart and 2 m spacing between rows. No roofbolts are used during pillar-extraction operations. Only timber supports of minimum 100 mm diameter are used for roof support.

Pillar Extraction

The stooping line is kept at 45 degrees to the panel direction. Various stooping lines were tried, but the 45 degree line remains the most suitable approach for Usutu's conditions. The sequence of pillar extraction is shown in Fig. 2. Pillar-extraction operations are confined to one pillar at a time.

The sequence of cutting and support installation is indicated in Fig. 3. The sequence of activities is as follows:

Stage 1

Breakerlines BL 1 and BL 2 as well as fingerlines FL 1 and FL 2 are installed.

Stage 2

Cut C 1 is completed up to the goaf (i.e., a single pass). The machine is moved back, and cut C 2 is taken. The machine is now moved back to position BL 4 for pick inspection. Fingerline FL 3 is installed during this period. In the event of poor roof conditions, fingerline FL 3 is installed between the split and goaf before cut C 2 commences.

Stage 3

Cut C 3 is taken, followed by cut C 4. The machine is now moved back to BL 4 position for pick inspection. Fingerline FL 4 is installed during this period.

Stage 4

Finally, cut C 5 is taken, after which the machine is moved to the next pillar on the 45 degree line, (i.e., Pillar B). Breakerlines BL 3 and BL 4 are installed.

Stage 5

A long sling is put around BL 1, BL 2, FL 1, FL 2, FL 3, and FL 4 and hooked on to a shuttle car in one operation. About 50 per cent of the timbers are reclaimed for re-use.

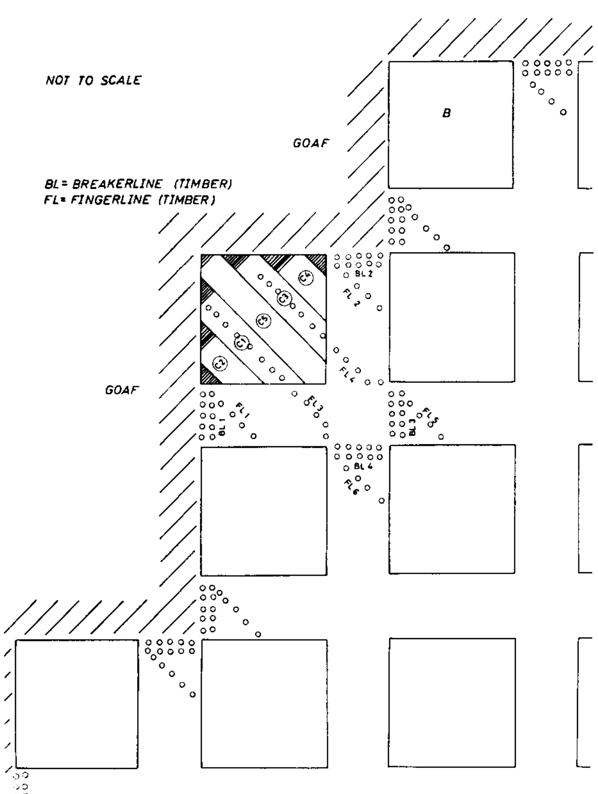

Fig. 3—Pillar extraction by continuous miner

Problems Encountered in Pillar Extraction

The machine must move in a straight line. Serious cat-track problems were encountered in the experimental stages when direction changes were attempted within the pillar while cutting. A cat-track break during the final stages of a pillar-extraction operation can cause serious problems.

The first stage of goafing normally occurs within 30 minutes after the timbers have been drawn. On two occasions, the continuous miner was totally covered when unscheduled goafing occurred, fortunately without injury or loss of life. In both instances the machine was recovered.

A breakdown, especially in the tramming mechanism, can be hazardous in pillar extraction. This is overcome by a proper maintenance programme.

At the start of every shift the machine is checked and lubricated. A fitter and electrician are on shift in the section as part of the production team.

Monthly maintenance is done over a full shift. This normally includes welding, for which permission must be obtained from the Inspector of Mines.

Minor sub-assemblies are kept underground. Major sub-assemblies, i.e. traction motor, cutting motor, etc., are kept in a sub-assembly store on surface. When required, any sub-assembly unit is normally delivered to the section at short notice.

Equipment and Personnel

The equipment consists of 1 Marietta 3080 continuous miner and 3 Torkar Model 48 AC transshuttle cars.

The section personnel employed are as follows (per shift):

Shiftboss	½
Miner	1
Fitter	1
Electrician	1
	3½
Team Leader	1
Continuous Miner Operator	2
Cable Handling	2
Shuttle Car Drivers	3
Discharge Point	1
Support	6
	15

Electrician Aides	2
Fitter Aides	2
Lubrication	2
	6
Total	$24\frac{1}{2}$

Costs and Efficiencies

The average stores costs are as follows (section only):

Picks	8,7 c/t
Support	9,5 c/t
Miscellaneous (Mining)	1,9 c/t
Continuous Miner Maintenance	48,3 c/t
Lubrication	1,7 c/t
Shuttle Car Maintenance	24,2 c/t
Total Stores	94,3 c/t

Ignoring the added cost advantage of reduced geographic expansion and excluding capital charges, the operating cost compared with that of conventional bord-and-pillar mining is approximately 10 per cent lower.

The efficiencies are as follows:

Tons per pick	33,3
Tons per shift	730
Tons per hour	105
Tons per month	$\approx$30 000 average

Average cutting time per shift (drum-turning time) =4 hours.

Average continuous miner availablity=82%.

Average section availability=65%.

N.B. Continuous miner availability is calculated on the machine's downtime only. Section availability is calculated on the total time available and the total downtime, which includes external downtime.

The section extraction rate is 95 per cent.

Conclusion

The continuous miner as a pillar-extraction unit has come to stay at Usutu. The advantages of the machine in terms of greater recovery of coal reserves, costs, productivity, and safety have assured its continued application for this purpose.

Acknowledgements

The author thanks the management of the Coal Division of General Mining and Finance Corporation for permission to publish this information, and the staff of Usutu Collieries for their assistance in the preparation of this paper.

Defect solid state

A one-day multidisciplinary symposium entitled 'The Defect Solid State '80' will be held under the auspices of the Solid State Physics and Materials Science Subcommittee of the South African Institute of Physics at the University of the Witwatersrand on Monday, 14th July, 1980, following the Twenty-fifth Annual Conference of the South African Institute of Physics. The Symposium is the second in a series (the first having been held under the auspices of the NCRL/CSIR and the South African Chemical Institute in 1978) and is intended to provide a forum for scientists and engineers of various disciplines and backgrounds interested in the field of microscopic defects and defect-controlled processes in materials. Eminent overseas speakers will be taking part.

There will be both invited and contributed papers. Those providing a broad perspective of recent developments and techniques with a description of their future scientific and industrial potential will be particularly welcome. In order to provide a suitably balanced programme within the limited period of the symposium, papers will be selected both on scientific merit and for their general appeal to a multidisciplinary audience.

Areas of interest would include

- Point and extended defects, their production, properties, and interactions.
- Materials modification and development — ion implantation, chemical defects, and doping, etc.
- Surface defects, catalysis, etc.
- Materials with device potential that use defect properties — semiconductors, solid electrolytes, etc.
- Instrumental methods and techniques of production and observation of defects.

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