A follow-up report on longwall coal mining at Durban Navigation Collieries (Pty.) Limited

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INTRODUCTION

To prepare the reader adequately, reference should be made to the paper 'The Pioneering of Fully Mechanized Longwall Coal Mining in South Africa' by R. T. Naude and M. J. Deats, published in the February, 1967, edition of the Journal. At the time mechanized longwalling had been proved operationally feasible with encouraging results since its inception in South Africa in mid 1965. Subsequently, further top seam panels were successfully extracted with improved productivity and with some modification to equipment.

In 1968, after an overseas visit by mine officials, equipment specific to suit local conditions was acquired and lower seam trials commenced. Despite initial obstacles and difficulties the first panel was successfully mined. Modification and improvements to equipment and techniques resulted in the second lower seam panel being extracted economically during 1969-1970 and with productivity exceeding even that of top seam faces.

During extraction of the second lower seam panel, gradual and complete surface subsidence occurred over the panel without affecting face operations. Rock mechanics investigations had originally indicated some uncertainty regarding adverse dolerite sill behaviour which could have caused longwall mining to be hazardous. All such doubts have now been removed.

RESUMÉ AS AT FEBRUARY, 1967

Mechanized longwalling was introduced in 1965 on an experimental basis in an effort to improve productivity in the newer area of the mine and to increase the quality of the comparatively dirty run of mine feed to the washing plant. In addition advantages could be predicted in the long term by better utilizing reserves of straight coking coal and increasing the life of the mine.

The top seam unit was obtained on a rental basis and by the beginning of 1967, two panels, the first having a face length of 215 m, a panel length of 345 m, seam section of 1 219 mm, and the second the same face length, a panel length of 453 m and a seam section of 1 067 mm had been successfully longwalled. At this stage a best month of 24 602 metric tons with an average of 17 364 metric tons per full working month could be reported.

Results were sufficiently encouraging for the company to exercise its right to acquire the equipment as its own asset and from 1967 onward, the unit has operated on this basis.

From the point of view of rock mechanics, the dolerite sill over the first two panels was known to have 'bridged', only the material below the base of the sill having truly 'goafed'. No adverse pressure effects had significantly affected face operations except for two 'bumps' towards the end of operations in each panel. Gate road maintenance presented no problem.

The strong inflows of water experienced on the first face were now known to be associated with an isolated water bearing fault plane and were not experienced on the second face.

TOP SEAM EXPERIENCE — MAY, 1966, TO DATE

Panel 2 (February, 1966, to November, 1966)

The operations in panel 2 (see Fig. 1 for location of panels) continued uneventfully until the final month in this panel. At this stage, the chocks behaved most inconsistently, often lowering under the weight of the canopies alone. Roof trouble became so severe that the unit was unable to produce adequately and blasting of chocks became a daily occurrence. Finally 24 m short of the planned limit it was decided that a complete overhaul was the only solution and the extraction operations commenced. At this time, the only fatal accident associated with longwalling occurred when a Non-White inadvertently fell into the panzer conveyor transfer point at the main gate.

Some gate road difficulties in this panel were overcome by bolting tapes to the roof as decking and allowing them to pass over the gate chocks and collapse into the goaf. Two cribbed roof falls were also negotiated by the gate chocks at the face ends without undue difficulties.

It was decided in the light of maintenance problems encountered on this face that the best solution would be to appoint a foreman solely in charge of face maintenance crews. This step has to a large extent contributed to success achieved subsequently.

Panel 2 – face length 213 m
panel length 456 m
cutting height 1 092 mm
average monthly output 16 443 t
best month 19 130 t

Panel 3 (December, 1966, to June, 1967)

By the end of 1966 results were sufficiently encouraging for the company to exercise its right to acquire the equipment. This was negotiated and the unit has operated as such to the present date.

Prior to installation in panel 3, all face equipment was thoroughly overhauled underground and the chocks boost-tested to yield-load. The costs of overhauling, including almost complete hose replacement, were much higher than anticipated. Advice had been received that complete hose replacement was common practice after ± 18 months' operation.

Shortly after commencement of operations in panel 3 the chocks again failed as they had towards the end of panel 2. At this stage, the suppliers advised that the valve gear should have been repaired during the overhaul as the needle and seat seals could no longer be relied upon.

This operation was impossible to carry out on the face and would have been extremely time consuming. Fortunately a new type of valve gear was then available from the suppliers, termed the capsule-type valve, and a complete change over could be made on the face. The encapsulated valve has a delrin pad sealing over a raised

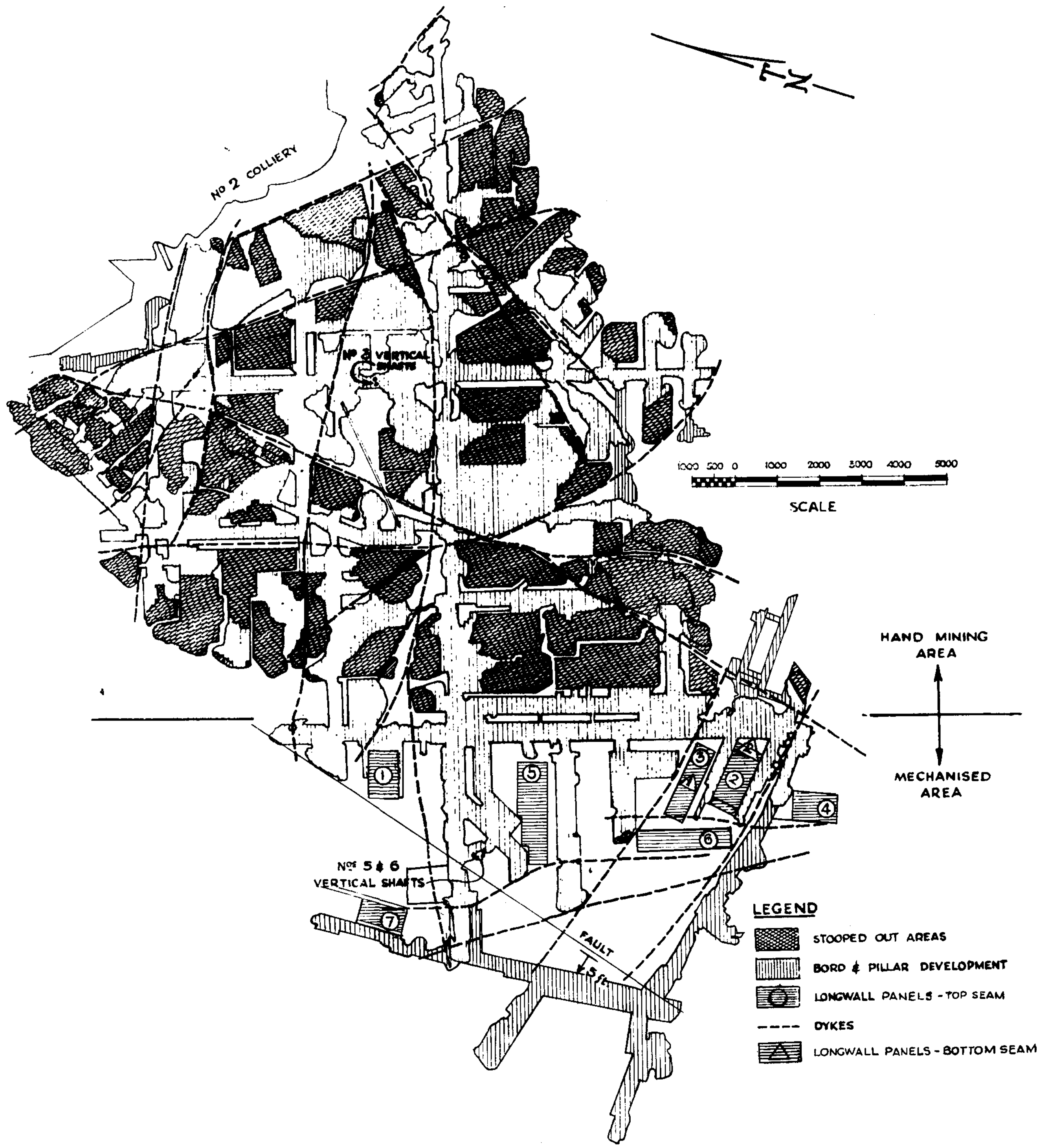

Fig. 1 — Disposition of longwall panels. The D.N.C. (Pty.) Ltd. No. 3 Colliery, underground workings.

brass bush. This type of valve gear has been in use in the top seam unit ever since.

Panel 3 – face length 144 m
panel length 543 m
cutting height 1 092 mm
average monthly output 21 127 t
best month 26 884 t

Panel 4 (June, 1967, to November, 1967)

This panel was equipped after another substantial overhaul and boost test. Due to geological disturbance the panel was very short and was intended to serve as a stop gap while another longer panel was being prepared. It was not realised that the geological disturbance penetrated the periphery of the panel at the start of operations. The seam was appreciably thinned out and could not be cut with a 1 092 mm diameter drum.

A spare drum was cut down in the mine workshops and fitted with pick holders to cut 991 mm. This was an extremely make-shift drum but proved to be the first of many mine fabricated drums – this operation now being routine.

By the end of July the seam section was once again normal and good results were obtained from here on.

In panel 4 a bleeder road was maintained in the goaf by cogging the tail gate immediately behind the chocks to allow an airway to remain open.

Panel 4 – face length 202 m
panel length 300 m
cutting heights 1 092 mm, 991 mm
average monthly output 24 625 t
best month 28 368 t

Panel 5 (November, 1967, to August, 1968)

This panel was the first laid out as an advance-retreat panel (see Fig. 2 to clarify the term). Advance-retreat layouts have the advantage of almost halving the peripheral development requirements for a unit to be able to commence mining.

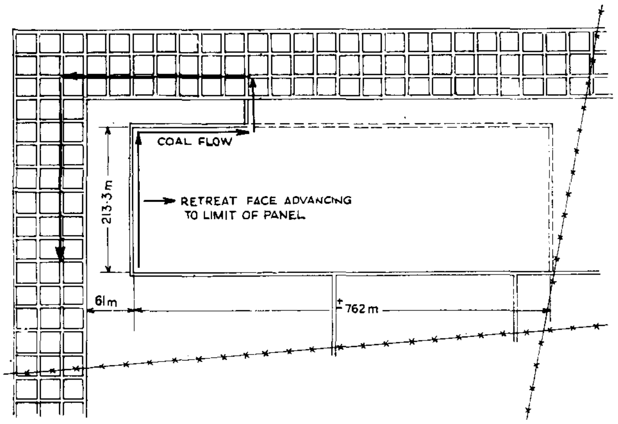

Fig. 2 — Representation of an advance-retreat layout.

In addition this panel incorporated the first deviation from the previous standard rectangular pattern (see Fig. 1 – panel 5). The face was shortened twice during its life – an operation which presents little difficulty.

The seam section of 1 m was rather neat for the chock range 813 mm to 1 245 mm and this working height persisted for the life of the panel. Floating stone was also encountered but this was fortunately over a limited area. This stone could not be cut and blasting on the face had to be resorted to.

The stage loader for this panel was rail mounted and comprised a 50 m straddle over the gate belt to reduce belt retreats to a minimum. By having the stage loader on rails, it could not misalign when being moved so that the light belt structure was not fouled or knocked over.

On this panel the armoured conveyor had to be completely replaced on the face. This operation was completed within 3 days.

Panel 5 – face lengths 210 m, 186 m, 155 m,
panel length 752 m
cutting height 991 mm
best monthly output 27 925 t
average monthly output 23 118 t

Panel 6 (January, 1969, to September, 1969)

This panel commenced operating as the first lower seam panel became exhausted, thus obviating the usual rush to overhaul and install equipment. In this panel the tail gate development was planned to advance concurrently with face advance.

Face operations were practically stereotyped by now, although a large patch of floating stone at the end of the panel's life severely hampered output. This stone required to be blasted and a dummy stable was carried in the affected area.

The planned concurrent tail gate, face advance concept failed due to ventilation difficulties as the cogged bleeder road collapsed and complete peripheral development had to be hastily resorted to.

Panel 6 – face length 149 m
panel length 672 m
cutting height 1 118 mm
best monthly output 25 471 t
average monthly output 21 241 t

Panel 7 (March, 1970, to mid-November, 1970)

This panel was another advance-retreat layout. Methane was reported on this face for the first time in longwall history on the mine, probably due to the inadequacy of long cogged bleeders. Gas release boreholes from surface may obviate such problems in future.

Valve failure occurred on this face after some years of complete freedom from this problem. The reason for this was probably faulty reconditioning technique of valve gear together with constant blasting of stuck chocks. Valve gear is not particularly resistant to the shock loading resulting from blasting, however light this may be.

This was the first top seam face to be equipped with 191 mm high heavy duty manganese cast end pans, which proved far superior to the previously used 178 mm high welded lug pans in respect of conveyor life, down time, etc.

Panel 7 – face lengths 181 m, 162 m
panel length 675 m
cutting heights 1 219 mm, 1 188 mm
best monthly output 30 339 t
average monthly output 24 370 t

SELECTION OF LOWER SEAM EQUIPMENT

By 1967 fairly considerable tonnages of lower seam were locked up below top seam goafs and the mine management and its consultants had now to tackle the problem of specifying a unit to exploit this coal.

The top seam unit could not be used for this purpose as it was now no longer experimental but an integral production unit which could not be risked in trials.

Consortium experts had indicated that similar chocks fitted with servo-lowering and adjacent control would be suitable with a similar conveyor and cutting machine. Mine officials were not optimistic that this was so and two senior maintenance and one senior production official were sent overseas in July-August, 1967, to inspect installations in the U.K., Germany and the U.S.A.

The attention of these officials was to be concentrated on:

1. Specifying modified equipment after studying techniques that would be required for exploitation of the ± 450 000 tons locked up in the bottom seam after top seam extraction by longwall methods.
2. Obtaining first hand knowledge of reconditioning and maintenance procedure after several extensive and costly production losses on longwall faces.

The objectives of the trip were therefore twofold in the main and required site investigation in countries where longwall was either the accepted basic underground coal mining method (England and Germany) or where it was achieving great success after recent introduction (U.S.A.). Wherever seams worked in close proximity could be observed, this was aimed at to enable a sound feasibility prediction for lower seam exploitation to be made.

After observation of workings under goafs in close proximity to the seam worked, it was considered that initial exploitation of the lower seam could be undertaken with a reasonable chance of success provided large unsupported roof exposures were avoided.

With this in mind preparation of a panel, 125 m face length, was put in hand and installation of equipment was aimed at for late 1968.

SUMMARY OF OVERSEAS OBSERVATIONS

(Longwall and related operations)

Operation under weak roof. Several longwall faces were seen operating under weak roof approaching the nature of the Durban Navigation Colliery black shales with a fair measure of success.

Elimination of stable holes. Large exposures of roof at face entries where roadway widths are restricted were wholly or partially eliminated using various techniques or combinations of techniques. These comprise flat top panzer conveyor drives, short driven or non-driven panzer conveyor return ends, panzer conveyors driven from one end only and sumping drums on shearers. Another technique is to use more than one shearer on a face (see Fig. 3).

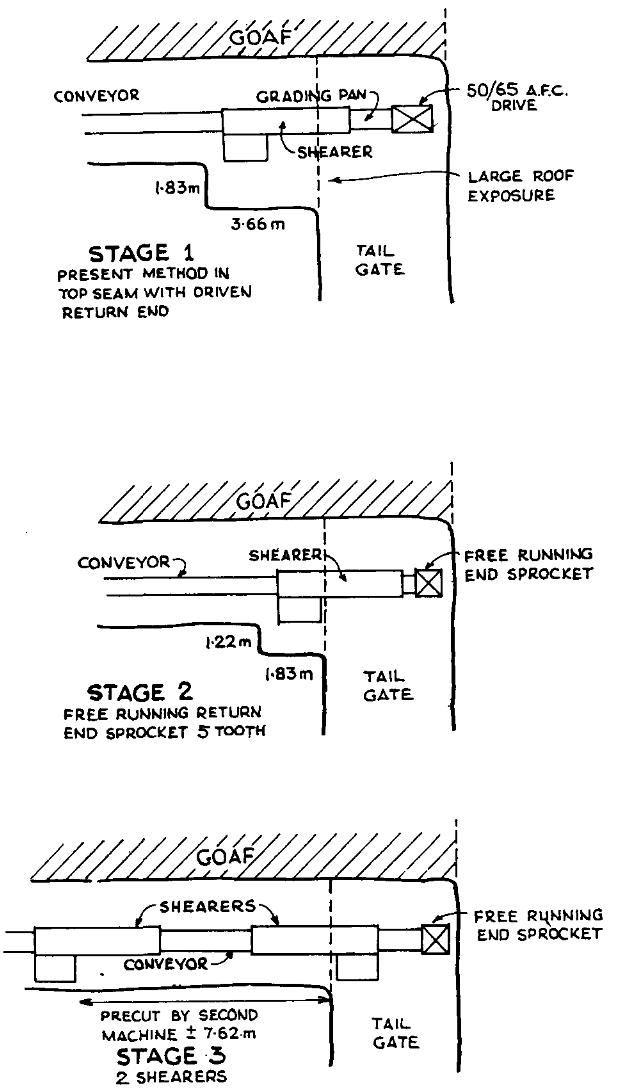

Fig. 3 — Progressive reduction of tail gate stable to avoid weak roof exposure.

Operation without face cleaners. These men were dispensed with by using ramp plates or trailing ploughs.

Multiple seam workings. Several faces were operating below goafs, but in the majority of instances the inter-seam parting was greater than that at D.N.C. or alternatively of stronger material.

Face maintenance. Almost no fresh knowledge was gained on this aspect.

Overhaul facilities. A great deal of useful data on workshop procedure was obtained.

Equipment transfer organisation. No pit visited had similar equipment transfer problems viz. the combination of distance involved and the necessity of speed of transfer. Some useful information was, however, obtained on this aspect.

Face communication systems. Sophisticated systems were generally condemned by operators and the most efficient systems seen were basically simple.

Updating of top seam equipment. Proposals for updating the already obsolete top seam equipment were requested, but it was indicated that this was not general policy. Developments in hydraulics are so rapid that support systems very quickly become obsolete.

ASPECTS AFFECTING SPECIFICATION

Elimination of Stable Holes

Main Gate Entry. For lower seam operations the provision of a dinted (floor excavated) roadway and flat topped conveyor drive allows the shearer, with drum leading to come right out into the entry. This enables the conveyor to be advanced without stable provision for drum and cowl (see Fig. 4).

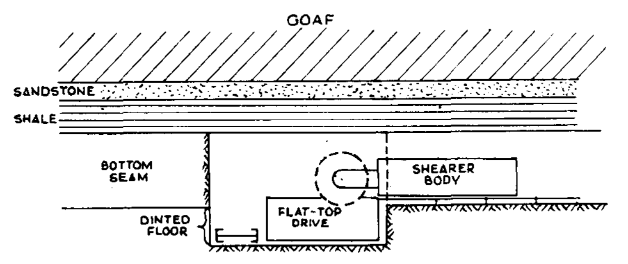

Fig. 4 — Use of flat-top drive and ranging head shearer to eliminate main gate stable.

Tail Gate Entry. This entry is not usually brushed or dinted and presents a more complex problem. The first stage of stable elimination is to dispense with the bulky armoured conveyor return chain drive and its inclined grading pan (refer to Fig. 5).

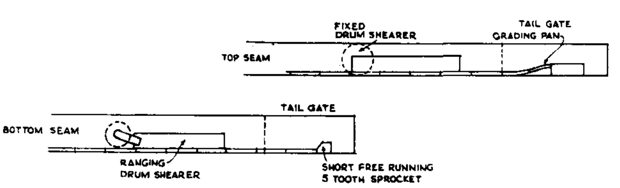

Fig. 5 — Reduction of tail gate stable.

The return end is replaced with a short free-running tooth sprocket which allows the shearer body to come out into the tail gate itself. However, the stable cannot be completely eliminated but the roof exposure is reduced (see Fig. 3). For bottom seam work on the first relatively short face, the driven tail end was dispensed with to reduce stable work to a minimum.

Operation without face-cleaners

The dangerous practice of having to allow men to clean up behind the shearer after its cutting run so that the conveyor can be adequately pushed over, can be obviated.

The most attractive solution is the provision of ramp plates, which are angled plates attached on the face side of the armoured conveyor.

When the conveyor is pushed across to the new track, these plates doze into any spalled coal lifting this material up and onto the conveyor. More powerful rams with stronger push rods are required and with the new strengthened pan designs available, the maximum advantage from ramp plates could be gained.

It must be mentioned that ramp plates do not normally enable a full push-over to be attained. On a 610 mm web, up to 60 mm can be lost if the coal face spalls heavily. Ramp plates are generally used in conjunction with tilting underframes or ranging drum shearers for horizon control.

LOWER SEAM EQUIPMENT

Cutting equipment (see Fig. 6 to compare shearers).

Lower Seam	Top Seam	Remarks
AB 16/200 Bi-di ranging drum shearer – goaf side trapped.	AB 16/125 Bi-di shearer	Extra 75 h.p. for hard cutting. Ranging head for horizon control and possible 2-pass cutting system.

Fig. 6(a)—AB 16/125 Bi-directional shearer used with fixed diameter drum and tilting underframe. (Swinging arm cowl in tail to main cutting position)

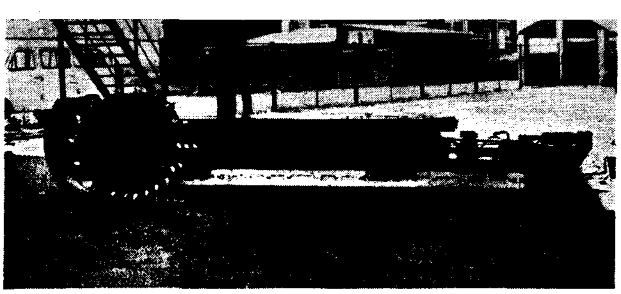

Fig. 6(b)—AB 16/125 Bi-directional shearer used with fixed diameter drum and tilting underframe. (Swinging arm cowl in main to tail cutting position).

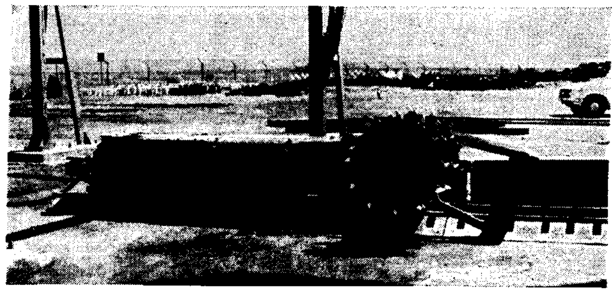

Fig. 6(c)—AB 16/200 bidirectional ranging drum shearer, goaf side trapped. 914mm dia. drum in top cut position.

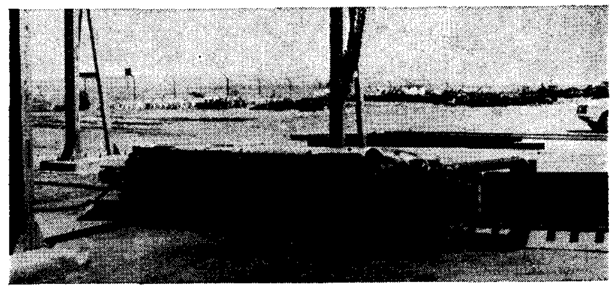

Fig. 6(d)—AB 16/200 bi-directional ranging drum shearer, goaf side trapped. 914mm dia. drum in bottom cut position

Conveyor (see Fig. 7 to compare armoured face conveyors).

Lower Seam	Top Seam	Remarks
191 mm heavy duty manganese alloy cast ends.	178 mm welded lugs.	Heavy duty to reduce face maintenance, withstand hard pushing with ramp plates.
Ramp plates – full pan height 37½°/45°	—	To eliminate face cleaners.
Heavy duty spill plates – deep trough.	Light duty spill plates.	To accommodate Bretby cable handler.
120 h.p. – Flat top AFC drive head.	120 h.p. – AFC drive head with ramp pans.	To operate within dinted gate road and eliminate stable.
Non-driven 5-tooth sprocket return end.	50 h.p. – AFC drive head with ramp pans.	To reduce size of tail gate stable.

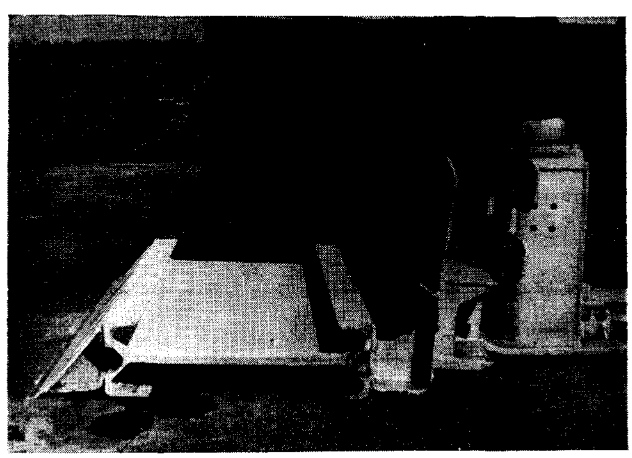

Fig. 7(a)—191mm heavy duty manganese alloy cast end pan, ramp plate on face side, heavy duty spill plate.

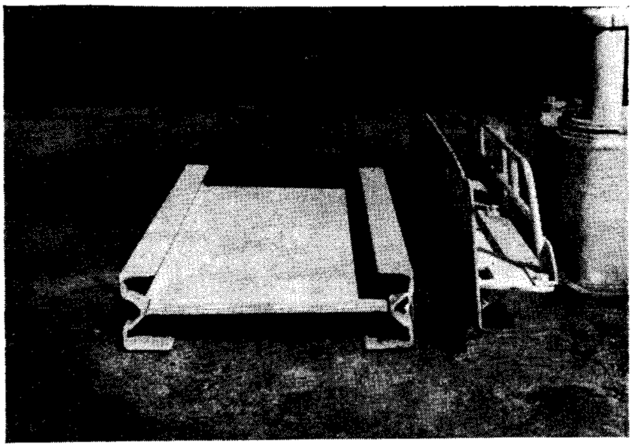

Fig. 7(b)—178mm pan with light spillplate.

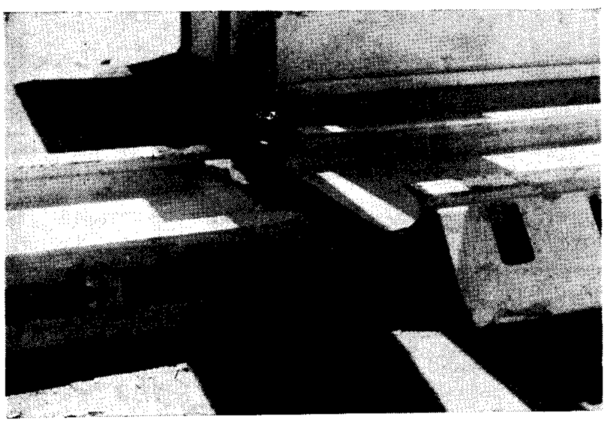

Fig. 7(c)—Left—light pan with welded connecting lugs. Right—heavy duty pan with cast end.

Supports (see Fig. 8 to compare chocks).

Lower Seam	Top Seam	Remarks
Gullick – 6 leg chocks. 50 ton yield/leg. Top feed slave legs. Heavy duty rams.	Gullick – 6 leg chocks. 30 ton yield/leg. Bottom feed slave legs.	
Adjacent control, servo lowering. Staple-lock 'O' ring hose connections. Separate ram, leg circuits. Flush nets. Ram housings – sloped on goaf side.	Manually operated valve gear – per pair of legs. Hose connections – cone faced. One circuit.	Improvements based on local experience and overseas visit recommendations. Minimum on-face maintenance aimed at.
Sledge bases – fore and aft. Individual chock filters.	Sledge bases – fore only.	
Support power packs. T25 – High capacity pumps.	Support power packs. Mark 2 – Low capacity pumps.	Improved line filters.

Signalling.

Lower Seam	Top Seam	Remarks
Winster – separate 'fone, signal, lockout, protected cables.	Davis-Derby plug in 'fones – one multi-core unprotected cable.	Based on local experience.

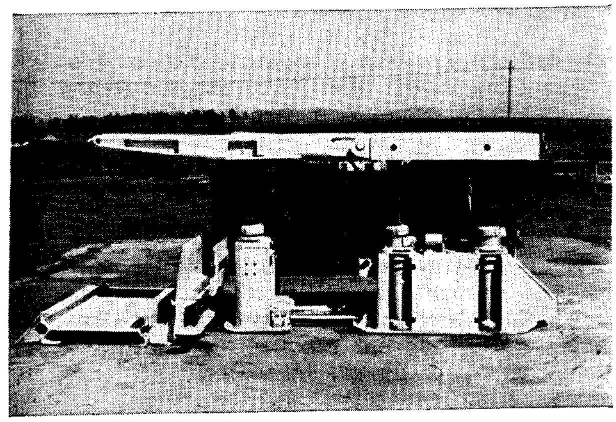

Fig. 8(a)—Heavy duty chock for lower seam operation 6×50 ton legs.

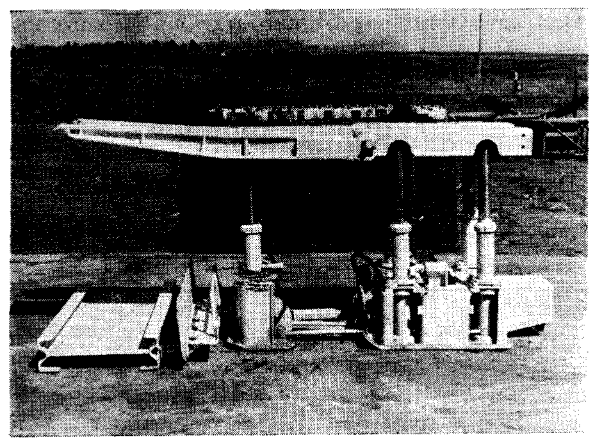

Fig. 8(b)—Top seam chock 6×30 ton legs.

BRIEF COMPARISON OF EQUIPMENT

The U.S.A. overseas visit indicated a trend towards more robust equipment which would require a minimum of on-face maintenance. Lower seam equipment was therefore specified with this aspect in mind.

More robust 300 ton chocks were specified in comparison with 180 ton units on the top seam. Powerful rams were included on a separate feed circuit so that leg setting pressure could be varied at will. Staple lock hose fittings, easy to replace on the face, were required. Remotely controlled valve gear comprising the MRE valve block powered from adjacent chocks was specified. Complete goaf flushing protection behind and between chocks was required.

The AFC pans were the more robust 191 mm manganese alloy cast end type to withstand strong thrusts involved in ramp plate use. Heavy spill plates for these pans and the Bretby cable handler were included. The flat top drive for the main gate end was essential for stable elimination and to work in a dinted gate road (see typical lower seam panel layout – Fig. 4). To permit the shearer to travel as far as possible into the tail gate and reduce stable size, a short non-driven return end was specified (see Fig. 5). The top seam unit pans were light 178 mm units having rather weak welded connecting lugs and both AFC drives required ramp pans to connect to the face line pans – this in turn resulted in large stables at both ends of top seam faces (see Fig. 9).

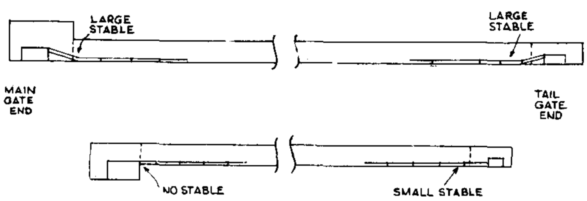

Fig. 9 — Representation of differences in conveyor equipment at face-ends.

The ranging drum shearer facilitated horizon control, as cutting below the pan line could be done at will. Should full seam section cutting prove costly, the possibility of cutting the face in two passes could be experimented with. 200 h.p. was specified should hard cutting conditions be encountered.

PRINCIPLE APPLYING TO LOWER SEAM PANEL LAYOUT

In order to avoid abutment pressure at the edge of upper seam goafs, lower seam panel dimensions in relation to the overlying upper seam panel's were reduced by 19 m across the face axis and 20 m along the longer panel axis (see Fig. 10).

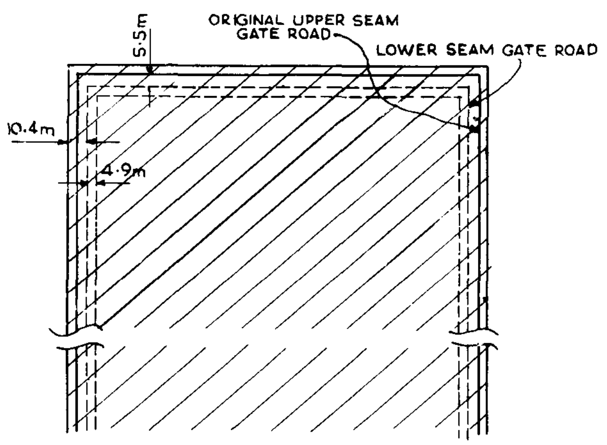

Fig. 10 — Typical lower seam panel layout. Lower seam gate roads well within periphery of top seam goaf.

This reduction in panel size was done purely arbitrarily based on local experience but proved to be adequate.

LOWER SEAM EXPLOITATION

Operation – First Lower Seam Panel (August, 1968, to January, 1969).

Lower seam equipment was acquired on a rental/ton basis with option to purchase should results prove economical. For this reason, to risk a smaller amount of capital, a short face, 125 m, was prepared for the initial trial panel.

With this relatively short face, the AFC was to be driven from the main gate side only using a free running return end. Equipment installation was completed by July, 1968, and as the top seam panel 5 became exhausted, face crews transferred to this face.

From the start, operations were plagued with teething troubles. Initially, the shearer, assembled on the pans, fouled the spill plate to such an extent that the boom cover plate had to be machined off (approximately 9 mm). This step was, however, insufficient for an operating clearance and a major alteration of machine mounting was then carried out. The shearer shoes were altered in the mine workshop to shift the machine body 25 mm over towards the face and thus ensure operating clearance. This affected the trapping arrangements and the trapping shoes also required modification.

By this time some production loss had been incurred and mine officials and consortium representatives were anxious to start up. The first full seam section cut, 1 219 mm, was attempted early in August, 1968, and failed dismally. Three complete sets of picks were worn out after one half web had been cut. Shearing was persevered with at an exorbitant pick cost and excessive machine vibration until it was realized that an alternative would have to be found.

The possibility of sacrificing the lower 250 mm of coal was suggested so that the floor of the face would lie above the No. 1 band (indicated in Fig. 11); but this idea was discarded as the parting between lower seam roof and top seam goaf would be dangerously thin under these circumstances. Finally, a suitable used shearer drum was cut down to 914 mm diameter in the workshops and 2-pass cutting was tried, virtually in desperation.

Fig. 11 — Lower seam stone band indicated, approximately 610 mm floor dinted for main gate.

It was soon evident that a 914 mm top cut, cutting from main to tail gate followed by a floor coal rip including the No. 1 band from tail to main would result in some coal production even though pick costs would be high.

Low output from the longwall face had by now severely affected total mine production and demands were made on the face crews to step up production. This was probably a contributing factor towards the then gloomy prognosis being altered and very soon good tonnages were being reported albeit with high pick costs and severe shearer vibration.

As time progressed, it became very evident that production volume was no problem and roof control presented few problems. The high pick cost aspect and shearer vibration were now major difficulties. Minor trouble was experienced with shearer drums and shearer shoes as these items were mine fabricated and required regular strengthening and replacement.

By November, 1968, the high pick cost aspect had received attention from South African manufacturers and the first drum fitted with local quick release pick holders and picks commenced operation (see Fig. 12). Results were sufficiently encouraging to initiate a switch over completely to these picks and the panel was completed using them.

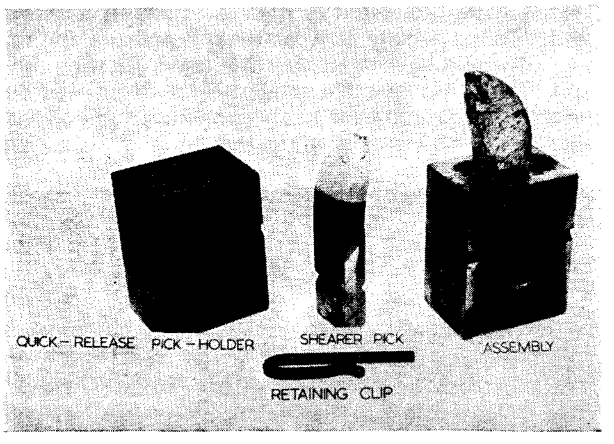

Fig. 12 — South African made quick-release pick-holder and accessories.

The shearer vibration problem culminated in seizing-up of the ranging head after 5 months operation. This was not surprising as the head had been subjected to severe stress when lifting coal on the tail-main cut especially when in contact with floor. It must also be mentioned that as the head had not been designed for this purpose, floor cutting could not really be prevented and the machine was required to run depressed onto the haulage chain on the tail-main run. This in turn resulted in severe wear on the ranging head, followed by a recurrent oil leak. A wearing pad was fitted to prevent further damage.

During this period, a more suitable head had been manufactured at Motherwell and arrived just prior to the original head seizing-up. The new head was then installed and operated very well for the last month in this panel.

Roof control had been excellent, but during December, 1968, heavy pressure near the tail-gate caused $\pm$ 20 chocks to yield suddenly with dramatic collapse of the immediate roof. The goaf material, however, did not run through, but a Bantu operator was seriously injured between articulated bar and spill plate as the chocks suddenly converged. The situation was rapidly restored to normal after the shearer had been carefully traversed back through this disturbed zone.

Lower seam panel 1 – face length 125 m
panel length 523 m
cutting height 1 219 mm (in two passes with 914 mm drum)
average monthly output 20 994 t
best monthly output 23 504 t

Operation – Second Lower Seam Panel (September, 1969, to March, 1970).

During the dormant period between first and second lower seam panel operation – another top seam panel being worked for this period – attention was given to the problems encountered in the first panel.

The modified head was far more suitable for the shearer and the pick point could now be lowered well below the tip of the ramp plate without the head fouling the haulage chain. Horizon control was therefore facilitated.

The shearer mounting, i.e. goaf side shoes, were completely redesigned and obtained ex factory. Mine fabricated drums were manufactured without haste, care being taken to lace the picks more precisely on a special jig.

The second panel face length was longer, viz. 194 m, and the panzer conveyor required to be driven from both ends. For this purpose a short driven return end was acquired which did, however, necessitate a larger stable hole.

During development for this panel, the parting between the seams in the main-gate fell through on two occasions. The roadway was, however, successfully recovered and the gap was cribbed with timber.

Exploitation was highly successful with few problems except at the final stage when the planned limit of the panel was over-mined on the tail-gate side. Bad falls occurred, the goaf running through onto the face and 20 chocks yielded. Fortunately, the conveyor was able to clear this material which eventually 'hung-up' making it possible for temporary supports to be erected. The equipment was successfully extracted in spite of these difficulties.

The best ever monthly production on either seam was attained on this face and pick costs dropped dramatically, coinciding with the softness of the coal which became evident as the dolerite sill gradually settled down onto the goaf below it (see below – rock mechanics' aspects).

Lower seam panel 2 – face length 194 m
panel length 440 m
cutting height 1 219 mm (in two passes with 914 mm drum)
average monthly output 24 265 t
best monthly output 33 040 t

A graphical representation showing monthly longwall output since 1965 on both top and bottom seams indicates a gradual improvement in productivity (see Fig. 13).

LOWER SEAM PANEL DEVELOPMENT

All longwall development is planned on the basis of permission to develop 305 m single entries. Before starting any below goaf development, a trial heading was developed below a top seam goaf for a distance of 9 m in the lower seam, then turned parallel to the long axis of the goaf and developed a further 18 m. Apart from some pressure at the solid edge, no adverse effects were observed in this trial roadway. Lower seam development for the first panel started simultaneously from several points on the periphery of the panel and was at first confined to seam height development only. Most of the work was done by conventional hand methods but light scraper chain conveyors were also used in an endeavour to improve the rate of development.

In the main gate, 0.6 m of dinting (floor ripping) was done after the initial roadway development. Very little roof trouble was experienced. Some heaving of floor, especially on the tail-gate side, occurred but this had no adverse effect on operations.

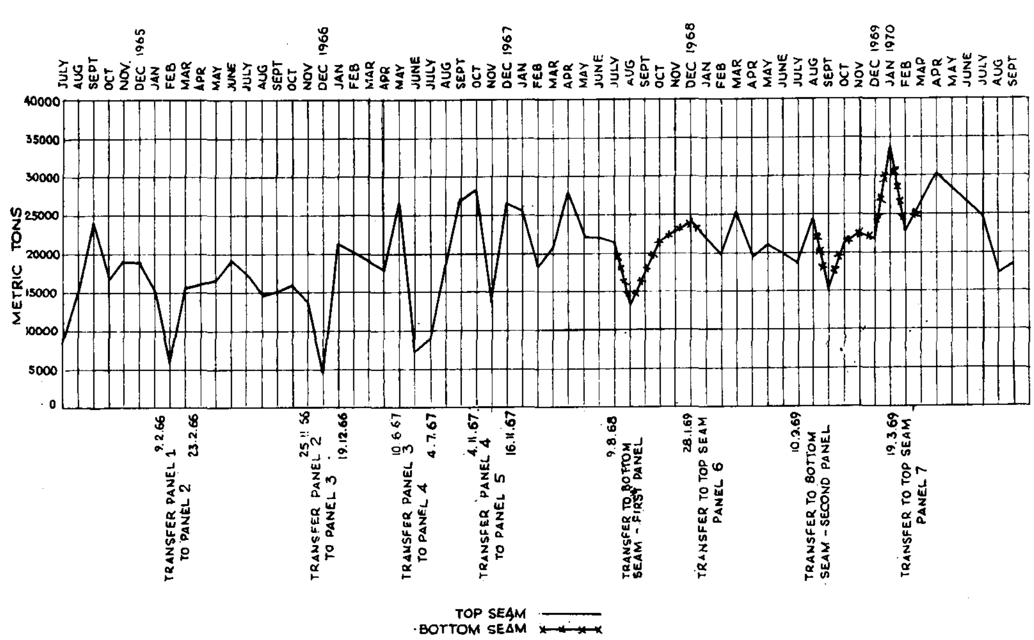

Fig. 13 — Longwall tonnages mined.

The scraper chain conveyors were not successful and unsophisticated methods have been reverted to. Development for the second panel was uneventful apart from the collapse of parting in two spots, both of which presented few problems in recovery.

For top seam panel development, layouts are facilitated by having a contractor on site for drilling prospect in-seam diamond drill holes up to 700 m in depth. Any likely longwall area is first probed with the diamond drill to prove it free of geological disturbance, e.g. dykes, before a layout is made.

MAINTENANCE

The equipment specified for the lower seam had been selected to reduce face maintenance to a minimum and proved so in operation.

The chocks performed extremely well and hose replacement was facilitated by using staple lock fittings. The use of a filter on each chock contributed largely to the good results obtained – deleterious particles in the soluble oil – water feed lines were prevented from entering the complex chock hydraulic circuits. Bent rams were experienced on occasions due to over pushing at high pressure but this was not embarrassing. The ramp plates did an excellent job of clearing spalled coal and spillage and the chocks generally operated on a clean floor.

The heavy duty conveyor required virtually no on-face maintenance but both the free-running return end on the first panel and the driven return end on the second panel required frequent attention.

The shearer, especially on the first panel, required constant attention resulting mainly from vibration. Holding down bolts worked loose continually, fabricated shoes frequently fell apart and the ranging head leaked oil.

On the second panel, the better designed shoes and drums worked far more reliably but vibration was still experienced which caused the underframe bolts to loosen. Ultimately the underframe itself failed on the weld and had to be repaired in the workshops.

Generally, the lower seam equipment requires far less attention from maintenance personnel than top seam equipment and has thus far proved more economic from the aspect of spares consumption.

COSTS

General

A comparison of the cost of spares consumed at the take-over stage of top seam equipment compared with that for the lower seam equipment at the same stage was:

Metric tonnage mined	Top Seam	Bottom Seam
	268 617	259 092
Shearer – cost/t (spares only)	0.4c	0.9c
AFC – cost/t (spares only)	6.1c	0.6c
Chocks – cost/t (spares only)	4.7c	2.4c
Signalling equipment – cost/t (spares only)	1.0c	0.1c
Total spares – cost/t	12.2c	4.0c

These costs indicate very definitely the superiority of the more robust lower seam equipment apart from the shearer which was exposed to far more arduous duty.

Operating and maintenance labour costs for both units are more or less identical but when a complete cost study is made, the capital requirements for the lower seam are $\pm$ 30 per cent higher. To reduce the depreciation factor, consideration is now being given to a 3-shift operation.

Shearer Picks

As was the case with the top seam, the high cost of this consumable item nearly led to the abandoning of the project in its very early stages. Attempts to cut the full seam section failed completely – even at the most exorbitant cost. Two-pass cutting with re-tipped bayonet type picks realised reasonable production but at high pick cost (see Fig. 14).

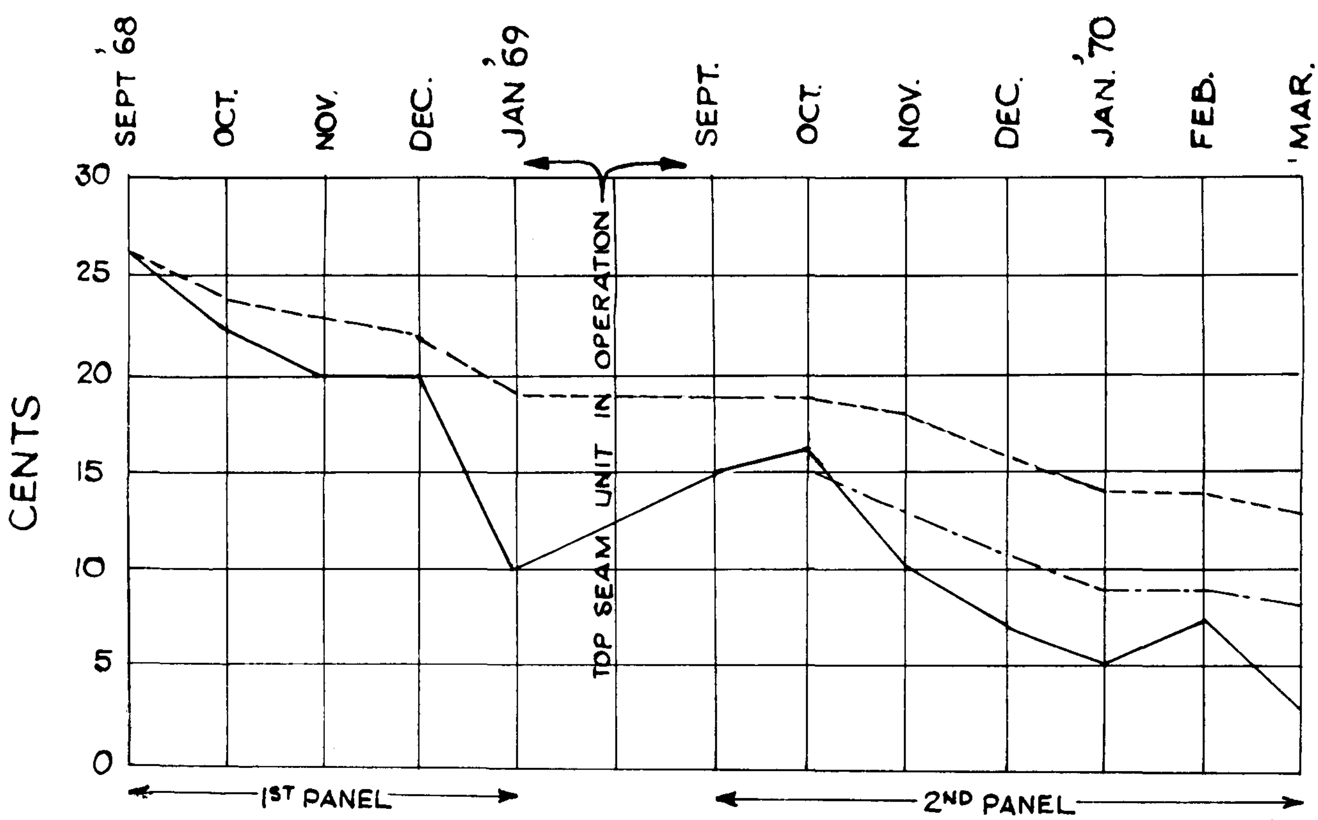

Fig. 14 — Shearer pick costs, longwall bottom seam.

Cost per ton, both panels ————————
Cumulative cost per ton, both panels ----------
Cumulative cost per ton, panel 2 only -.-.-.-.-.-.

Towards the end of the first panel, R.S.A.-designed quick-release picks (see Fig. 12) were experimented with on mine fabricated drums and proved worthwhile. The graphical representation shown (Fig. 14) indicates how results have improved on this item, especially when the coal became soft. This coincided with gradual dolerite subsidence.

The total cost forecast for the newer equipment is that the ultimate cost/ton delivered onto the section belt will be the lowest for all current D.N.C. methods.

THE ROCK MECHANICS INVESTIGATION

Resumé – February, 1967

At this stage, top seam longwall panels having a face length of 213 m resulted in goafing of strata to the base of the dolerite sill only and minimal surface subsidence.

In order to determine the mechanism of sill subsidence over hand-got stooping areas, another investigation was commenced over an isolated stooping area to determine if the longwall pattern would be repeated.

Stooping Results

The superincumbent strata overlying the stooping section, at first behaved similarly to those overlying longwall panels in the top seam but when the double seam stooping area dimensions were $\pm$ 1 097 m $\times$ 457 m the subsidence pattern accelerated from 88 mm to 384 mm in 4 months. From this it was deduced that the sill had settled and no adverse effects were noted underground.

This was extremely encouraging for the continuance of longwall experiments both at Durban Navigation Colliery and other collieries in South Africa.

To prove that the dolerite sill was in fact bridged over top seam longwall panels, a borehole was drilled into the gap and a photograph (Fig. 15) was taken by the C.S.I.R. sinkhole experts, showing clearly that a gap existed below the base of the sill.

Sill Behaviour during Lower Seam Extraction

FIRST PANEL

The subsidence pattern over the first lower seam panel prior to exploitation had been determined as follows:

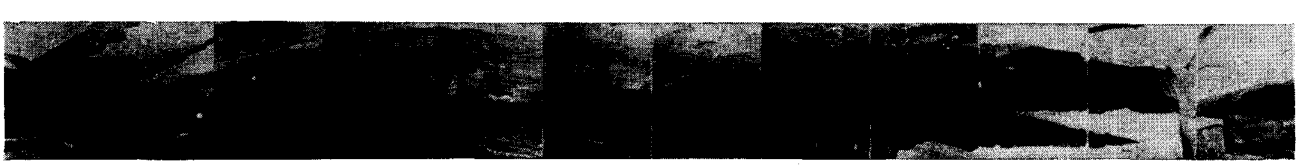

Fig. 15 — 360° photograph of gap below the dolerite after extraction of top seam only (Panel 3)

Surface levelling pegs at 30.5 m intervals were established along the short and long axes of the panel.

Regular traverses conducted along these pegs revealed an average subsidence of 3 cm with a maximum of 6.71 cm, being located at the geometric centre of the panel.

Following the completion of this upper seam exploitation, underground convergence stations were established in the intervening pillar between top seam panels 2 and 3 (see Fig. 1). Readings were recorded at these stations to establish exact roadway heights before lower seam extraction commenced.

Prior to the commencement of exploitation, a surface borehole was drilled on the geometric centre of the panel, to a total depth of 84 m. The bottom of this borehole was approximately 126 m above the upper coal seam horizon. Flameproof photographic equipment was lowered into the hole and photographs revealed a gap of 35.56 cm in the strata immediately below the dolerite. An extensometer anchor was established below this gap and a stainless steel wire led to a measuring station at the collar of the hole where readings of wire movement were observed regularly. Readings that were taken concurrently with exploitation indicated that the gap increased with extraction of the lower seam and was finally measured at 147.32 cm.

Continued surface levelling results revealed no change in the elevation of the pegs, the amount of subsidence being static at an average of 3 cm and a maximum of 6.71 cm.

Methane that escaped to the surface via the borehole was passed through a flame trap as a safety precaution.

An air velocity triggered safety device to cut off power should a sudden collapse of the dolerite sill occur, was installed prior to the start of face exploitation.

During November, 1968, some floor heave was evident in the central pillar haulage and companion roads but was of limited extent and some slabs of floor heaved as much as 10 cm. The convergence stations, i.e. rock bolts grouted into floor and roof, indicated a maximum convergence of 4.57 cm.

SECOND PANEL

During top seam exploitation, regular traverses were run on surface levelling pegs and a comparison of elevations prior to, during and after exploitation was thus determined.

The average subsidence amounted to 4.88 cm with a maximum of 11.58 cm being located on the geometirc centre of the block.

As the lower seam was being extracted on this longer face, the amount of surface subsidence accelerated at the stage when the lower seam face reached the approximate centre of the block. The total amount of subsidence recorded was 110.5 cm with a maximum weekly subsidence of 15.24 cm. It was deduced from these results that the dolerite sill had failed. No adverse effects were experienced on the face.

The general condition of the intervening pillar between the two panels was practically unchanged after the exploitation of both seams in each of the adjacent longwall blocks.

As in the case of block 3, a surface borehole was drilled on the geometric centre of this block. The prime reason for this hole was to allow accumulated methane to escape to the surface and bleed off through a water trap.

The air velocity triggered safety device, used in the first lower seam face, was again used but as there was no sudden collapse at any stage its future use has been dispensed with.

Rock Mechanics Commission

Arising from certain doubts pertaining to the exact behaviour of the dolerite sill under conditions of total extraction, a commission was appointed to hold a watching brief over the experimental project from the time it was evident that the 'normal' subsidence pattern for overseas longwall faces was not being repeated.

The members of the commission comprised senior Iscor management staff (mainly mining department), senior members of the G.M.E.'s staff, the Director of the Controlling Council for Coal Mining Research, the Chief Inspector of Mines (Natal), an outside consulting engineer and the mine management. Regular meetings at approximately 12-month intervals have been held since 1967 and progress has been carefully monitored by this commission.

THE FUTURE

Both seams have now been successfully extracted by mechanised longwall methods in geologically undisturbed areas at D.N.C. The dire predictions in respect of dolerite sill behaviour have been proved inaccurate.

It is felt that the method is now established and full attention can be paid to improving productivity. The original unit is obsolete and uneconomic as it is insufficiently robust for local conditions and will probably be replaced during the next 18 months.

The life of the mine will probably be extended by the adoption of longwall methods in areas free from geological disturbance. This is a very important factor when one considers the limited reserves of 'straight' coking coal in South Africa.

CONCLUSION

As is being experienced throughout the world where mechanised longwalling is being practised, more robust, virtually face-maintenance free, equipment must be acquired. The lower seam equipment was a step in this direction and all future equipment will be specified with this in mind.

In planning any new low seam (1.2 m or less) mine in this country, consideration should be given to the adoption of mechanised longwalling, provided geological disturbances in the form of dolerite dykes, faults, washes, etc. are not too severe.

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