Pillar extraction with conventional Trackless Mechanised Units

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SYNOPSIS

A description is given of the extraction of pillars in a seam of coal which normally varies in thickness from 10 feet to 14 feet using conventional trackless mechanised units.

By using the pocket and fender method of pillar extraction, the high capital cost of hydraulic supports is eliminated, and a volumetric extraction of 85% to 90% of the seam of coal is possible.

This method of mining opens up the possibility of extracting vast tonnages of coal which hitherto would have been left in situ as pillars.

The major benefits likely to accrue from this technique are seen as follows:

1. Greater volumetric extraction of the seam;
2. Longer panel life with less frequent transferring of sections;
3. Preservation of our natural resources.

The authors deal with the history of this development at Springfield Colliery, discuss the present results and outline the future trends in the light of current experience.

INTRODUCTION

Springfield Colliery is situated on the eastern edge of the South Rand coalfields, 14 miles south of Balfour North and 4 miles East of the Heidelberg-Villiers national road.

The mine was started in 1948 to supply the requirements of Escom's Klip Power Station, at the rate of 200 000 tons per month. In order to meet the additional requirements of Escom's new 1 200 megawatt Grootvlei Power Station, currently being built 3 miles from the existing colliery, a new shaft system was sunk, two miles South of the two vertical hoisting shafts.

This area, known as Vlei Shaft, was equipped with conventional trackless mechanised units loading onto conveyor belts, in contrast to the hand loading methods still being practised in the original mine. Both areas operate on a double shift basis.

The seam of coal varies in thickness from 6 ft. to 50 ft. of which, on average, only 16 ft. is saleable coal.

In the area currently being mined, the seam is split into three distinct bands by virtue of sandstone intrusions in the form of sills. These bands are referred to locally as the top, middle and bottom seams.

The top seam, being only 3 ft. thick, is not worked and mining is being done in the middle and bottom seams, which are approximately 10 ft. and 16 ft. thick respectively.

The seams lie at a depth of 600 ft. and a typical borehole section and detailed section through the seams are depicted in Figures 1 and 2.

Underground layout

The panel system of mining is practised. A standard panel consists of 7 headings, 16 ft. wide driven at 100 ft. centres, for a length of 2 500 ft. from the main development roadways. Main development sections also consist of 7 headings at 100 ft. centres. After initial experimentation, the deployment of machinery in a section is as follows:-

1 × 14 BU 10 gathering arm loader
2 × 10 SC 9 ton shuttle cars
1 × 10 RU coal cutter
1 × Beien breaker
4 × C.P. drilling machines
3 × fans.

Volumetric extraction

Normal mining height in the panels is 10 ft. on primary development, giving a factor of safety of 2,2 and a volumetric extraction of 32,8%. In order to improve on this percentage of volumetric extraction, thought was given to top coaling. Although the average thickness of the bottom seam has been quoted as 16′, there are areas

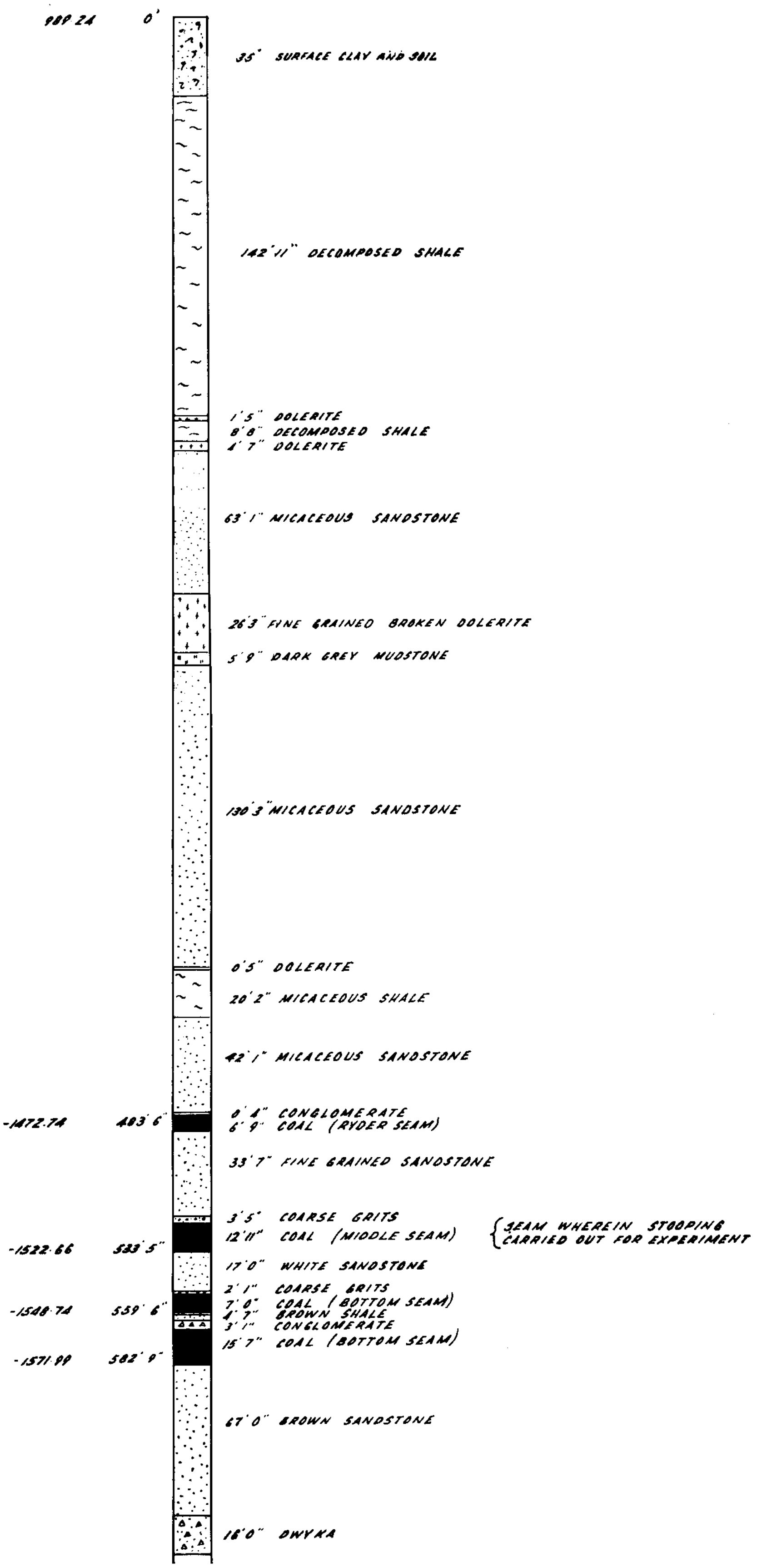

Fig 1—Borehole in close proximity to stooping section.
B.H. 116.

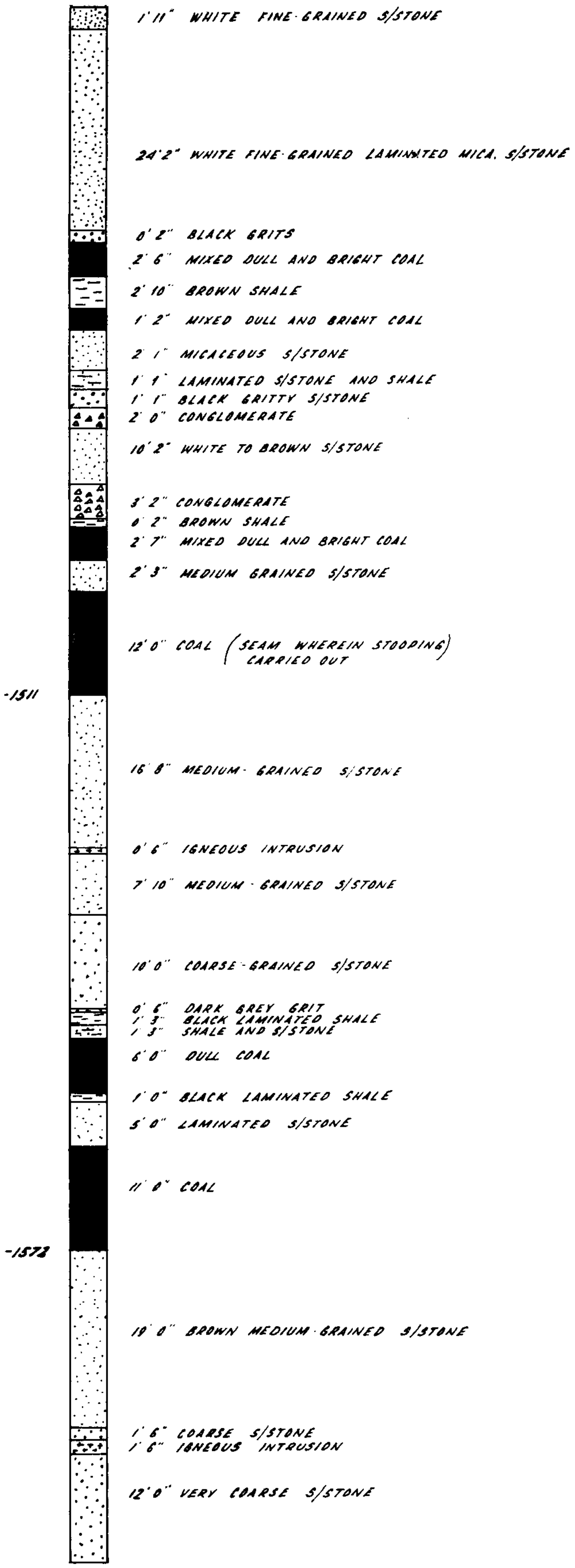

Fig 2—Underground B.H. 31.
SCALE 1 200

which are locally up to 20 ft. thick and more. A panel known as Section 6 was developing in one of these thicker areas of the seam and was selected as an area for top coaling on a trial basis. The experiment was carried out over a period of 21 days with top coaling being done on the advance. Lifts of 6′ to 8′ were blasted down and subsequently loaded out. The initial roof bolting was destroyed by the blast and the new roof was roof bolted to ensure safety of operations. The final factor of safety was 1,3, a figure which is consistent with the requirements of the Inspector of Mines in the area. This resulted in a volumetric extraction of 52,4%. This was, of course, a move in the right direction since it resulted in a 60,0% improvement in volumetric extraction over the primary development.

However, the following problems were foreseen in the widespread application of this technique:-

1. It would only be possible in the thicker areas of the bottom seam.
2. The middle seam being only, on average, 10 ft. thick, would not lend itself at all to this method.
3. In order to comply with a final panel safety factor of 1,3 large pillar centres are necessary thus inhibiting high productivity in initial development.
4. In the thicker areas of the bottom seam, the B.T.U. values are not always consistent, and there are large areas where only 10 ft. of the seam contains saleable coal—the balance of the seam height contains coal of a calorific value which is unacceptable to Escom. Even attempting to blend this with coal from other sections, the value of the total output sold would be below Escom's minimum requirements.

Consideration was given therefore to longwalling and pillar extraction using existing equipment.

After exhaustive enquiries and investigation, longwalling was discarded because of the high capital outlay and the anticipated difficulties, using powered supports, in longwalling a 10′-12′ seam of coal. Sufficient mechanised equipment to meet the current sales demand was already available and the further purchase of expensive longwalling equipment would have meant that equipment would be available for outputs far in excess of the requirements.

At this stage, section 20 in the middle seam, was nearing the sub-outcrop. The decision was taken to commence pillar extraction in this section when it reached its geological boundary.

Consideration of the various methods of pillar extraction

In this seam thickness there are two methods which present possibilities for stooping.

(a) *The open end lift method.* Fig 3 refers.

It can be seen from Fig. 3 that the 'open end' of the lift must be supported adequately in order to induce the roof to shear along this line. This can be done by either wooden or steel supports. Without using excessive labour, the only method is quick setting

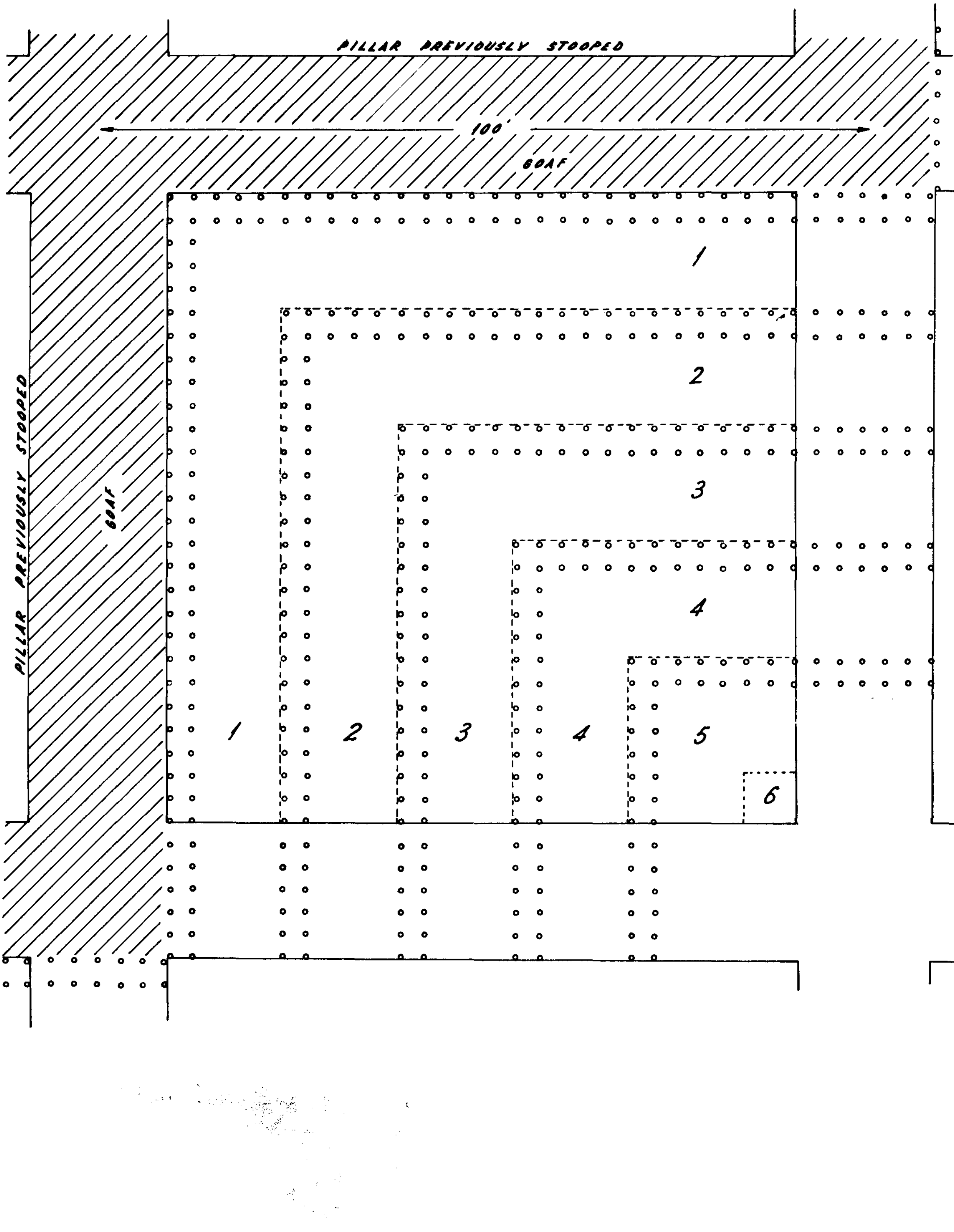

Fig 3—Open-end method of stooping.
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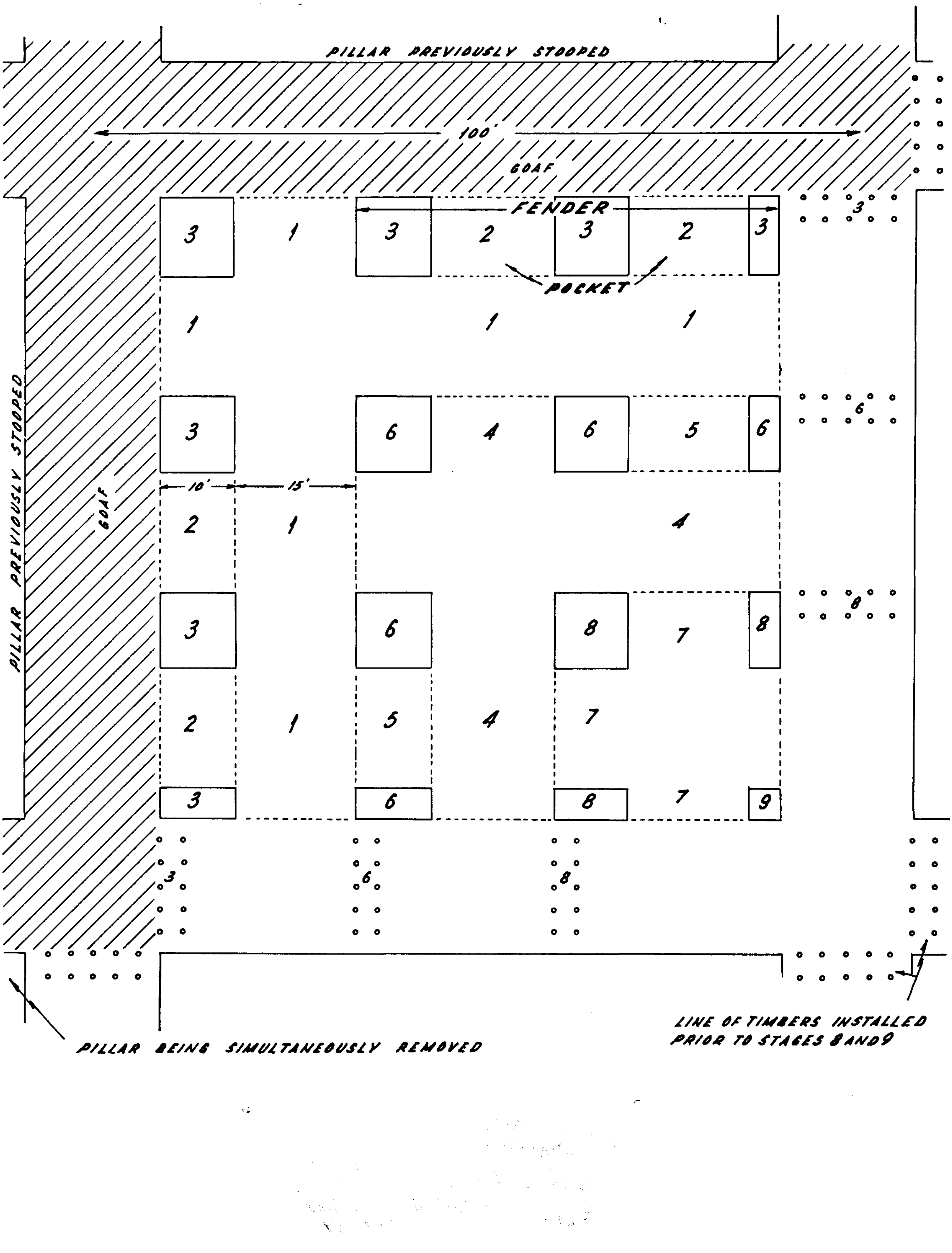

Fig 4—Pocket and fender method of stooping.

hydraulic supports. On the double lift per pillar method at 100′ centres, in this height, approximately R80 000's worth of hydraulic supports per section would be required. Also, at this height it was felt that these supports would be subject to excessive damage as caving occurred. For these reasons this method was rejected.

(b) *The closed lift or pocket and fender method* Fig. 4 refers.

In this method of extraction the goaf edge support consists of a thin pillar of coal equal in width to the height of the workings. This is referred to as the fender.

As each lift holes, the fender is then cut through in appropriate places into the goaf; these holings are referred to as pockets. The small pillars left in the the fender are known as snooks.

Following discussions with the area Inspector of Mines, this method was decided upon as being the most practical.

OPERATIONAL PROCEDURE AND RESULTS

Training, instruction and supervision

Approximately one month prior to development work being completed, the following action was taken:-

1. A large scale plan of the sequence and method of stooping was drawn up by the survey department.
2. Copies of this plan were given to the mine overseer, shift bosses and miners, who were instructed in the procedures to be adopted. The Bantu Training Superintendent carried out similar instructional procedures with the teams of bantu in the section.

The main items attended to in these discussions were:-

(a) Correct sequence of lifts;

(b) Pillars being removed in their proper sequence;

(c) Need to drive splits at the correct width and on line;

(d) Drilling of pilot holes into the fenders at right angles to ensure that fenders would be the correct width;

(e) Necessity for the fenders to be completely blasted down when all pockets had holed into the goaf;

(f) Installation and removal of roadway end supports;

(g) Ventilation requirements.

The ventilation officer was instructed to carry out, on a weekly basis, tests to check for spontaneous combustion and excessive emissions of methane.

On the 6th October 1969, the first 4 lifts were taken marked (1), (1) on the plan in Fig. 5.

Fig. 4 depicts the order in which lifts and pockets are taken in a pillar. Reference to Fig. 5 will show the sequence in which pillars are removed. (*Note*—in order to obtain the correct sequence and yet maintain production, the pillar, numbered 1, was only split and quartered. This was done in conjunction with developing "dummy" ends as shown on the plan).

The work proceeded according to plan with both Europeans and Bantu adapting themselves readily to this new method.

By the time pillars numbered 2 had been extracted, minor falls of the roof (2 ft. thick) in the goaf, were taking place. This was 21 days after stooping had commenced.

During the operation of taking out No. 2 lift of No. 3 pillar, the left hand side of the section goafed to a height of approximately 28 feet, while the right hand side still, as yet, showed no signs of goafing.

The distance of unsupported roof at this stage was approximately 160 feet from the solid coal. Five days after the minor break took place the major break occurred throughout the section. This, perhaps fortunately, occurred at the weekend when no one was underground.

Prior to the major break occurring, there were signs of weight on the pillar sides near the goaf line, and the fenders were scaling. After the major break it generally took 12 hours for the roof to goaf after each successive fender had been blasted out. An indication that the imminent collapse of the roof was about to take place was given when water started coming out of the roof bolt holes in the unsupported roof area.

Subsequent caving followed a fairly set pattern, in that, as can be seen from the plan Fig. 4 there is 25′ of roof exposed when the fenders are blasted, and this roof goafs ½-5 hours after snooks have been blasted out.

With the exception of the back-to-back splits in the Main, where scaling of pillar sides and roof weighting occurred, very little weight was experienced.

Machinery problems

Making a comparison between normal primary development and pillar extraction, no problems were experienced with the operation of the mechanised equipment.

Prop setting and withdrawal

The installation and withdrawal of wooden props and head boards at roadway ends was carried out by two spans of timber boys—each span consisting of six bantu.

When the new breaker line was installed and the holes in the snooks had been charged up, the old breaker line was withdrawn by encircling it, with a steel wire rope sling 7/8″ in diameter, 60 ft. long, and with eyes 16 inches long, spliced at either end. The rope encircled the props near the roof and was held with wire tied to the props. One eye was threaded through the other eye and was then attached to the bumper of a full shuttle car.

Usually, no more than two or three timbers were lost each time goaf edge supports were withdrawn at the end of each roadway.

Initially this operation was somewhat lengthy and resulted in loss of output. However with experience the time taken was reduced considerably.

A graph of the output Fig. 6 shows this improvement.

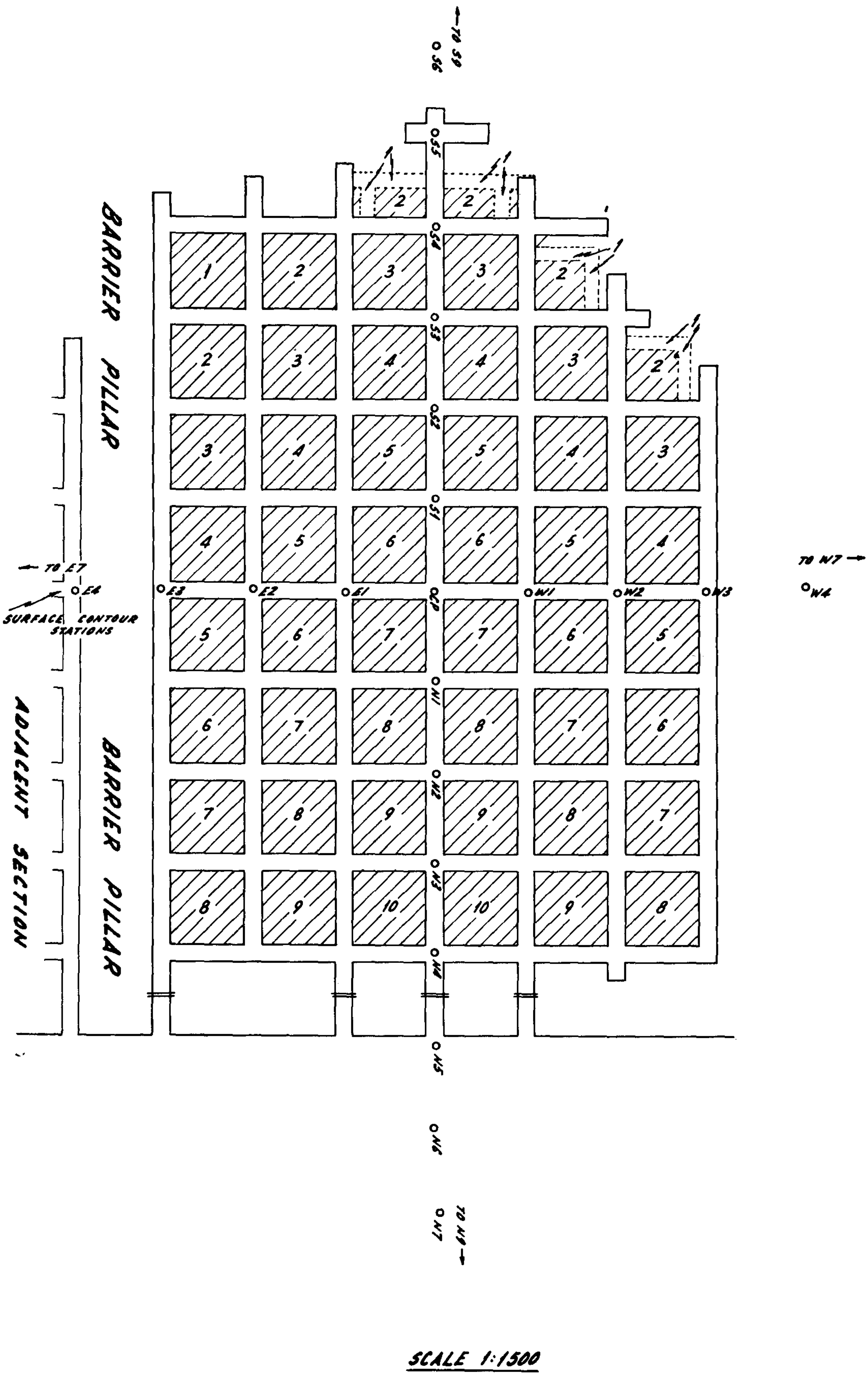

Fig 5—Plan showing stooping section 20.

Sealing off the panel

The operation proceeded as planned and on the 9th January 1970 the panel had been completely stooped. Material for stoppings had been made available prior to this date, and the area was sealed off by the 12th January 1970 with 4×9″ stoppings as will be seen on the plan Fig. 5. A 2″ valve was placed in the stopping across the main road and air samples were taken at regular intervals to determine the CO/O_2 deficiency ratio in the sealed area. No unfavourable conditions have so far been detected.

Life and tonnages

As previously recorded, the life of the panel on pillar extraction was 82 days (including maintenance days) and during this period 111 500 tons were mined. Thus the planned objectives were achieved successfully. The following information gives some indication of this.

1. Even assuming that the panel had been designed for primary extraction only (i.e. at a 1,3 safety factor and with 70 ft. pillar centres) the expected extraction would not have exceeded 99 800 tons at a volumetric extraction of 40,3% (including 10% loss on dykes, barriers etc.). In fact a total extraction (primary and secondary) of 191 100 tons resulted in a volumetric extraction of 83,2%. The percentage improvement in volumetric extraction was thus 42,8%.
2. Using the same data as stated in item 1 above, the planned life of the panel on primary development only would have been 76 days. Pillar extraction increased this to 158 days—an improvement of 108%.
3. Following on items 1 & 2 above, and subsequent stooping in other panels since this experiment, significant changes in forward planning have been possible, e.g. one area, previously calculated to have 10 years of life, has now been calculated to have 18 years life.

The section was double shifted and a comparison of the primary and secondary mining results are set out hereunder:-

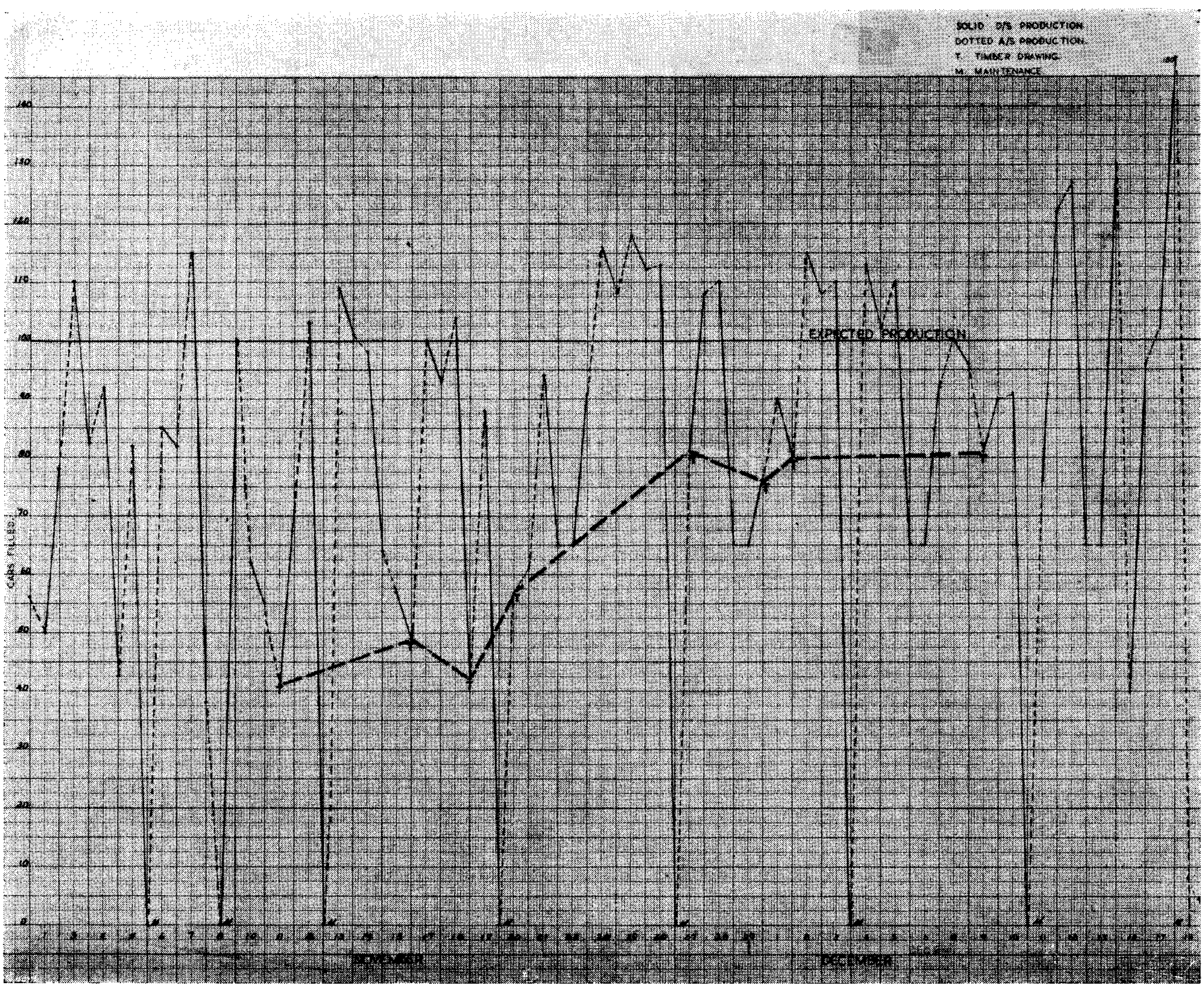

Fig 6—Production in shuttle cars from stooping section.

	Primary Development	Pillar Extraction
Life	56 working days	82 working days
Average daily tonnage R.O.M.	1 544	1 486
Tons/Section Bantu/Shift	22,7	20,1
Section costs per ton	34,5c	36,0c
Total accidents	One	Four
No. of incidents in which CH_4 was reported	Nil	Nil

Observed effects of the surrounding strata

In the nine months that have elapsed since pillar extraction ceased in this panel a similar panel has been developed parallel to section 20. This panel worked to the same geological boundary, leaving an 84′ barrier pillar between it and section 20. Frequent observations in this panel have not revealed any visible deterioration in roof and pillar conditions, or excessive weight on the barrier pillar, that could be attributed to the large goafed area immediately adjacent to this panel.

Fig. 7 depicts the surface contours over section 20. These two graphs should be read in conjunction with Fig. 5. Graph 'A' shows the transverse contour line running North-South over the centre of section 20. Graph 'B' is a similar line, running in an East-West direction.

The contouring done on the 12th September 1970, almost 8 months after stooping ceased, shows that the central portion over the section, marked C.P. has subsided 2 feet. The initial subsidence of 1′10″ took place within the first 2½ months of the closure of the section, and has subsequently only subsided a further 2″ since the 14th March, 1970.

It will be observed that between points S_2 and S_7 and N_5 and N_7, the ground has risen by approximately 18″ and 4″ respectively.

The authors are of the opinion, that due to the limited area stooped, the main break has not yet reached surface. The overlying strata being more elastic, has bent in the form of a trough or basin, the fulcrum points being the edges of the stooping section. Consequently as in the case of a beam resting on two fulcrum points, due to the sag in the middle, the overlying extremities beyond the fulcrums have risen.

At this stage, between N_4 and N_5, there has been no sag or rise recorded on surface.

These points are shown in Fig. 7 as "static points" X & Y. The positive angle of draw between the "static point Y" on surface and N_4 underground is thus 9°. We believe that when the adjacent panel parallel to section 20, together with the barrier pillar has been stooped the subsidence on surface will be considerably greater than 2 feet.

Subsequent developments and future trends

Since January 1970, when this panel was completed we have had three further opportunities to undertake pillar extraction. Two of the panels currently being stooped are situated in the middle seam and are operating in conditions similar to section 20.

One of these panels, section 22, is the panel that was developed alongside section 20. During the course of

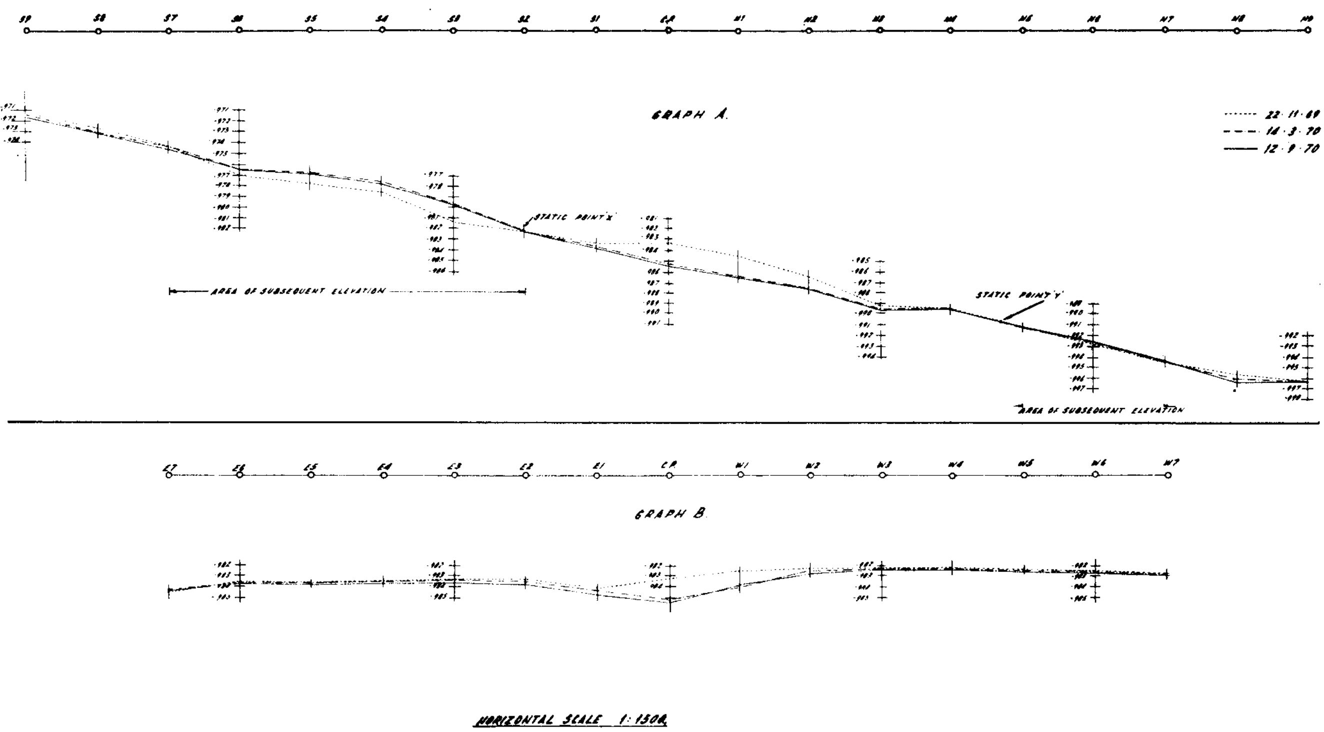

Fig 7—Surface contours over stooping area.

stooping this panel, the barrier between it and section 20 has so far been extracted successfully.

The third area currently being stooped is located in the bottom seam. Different conditions exist in this section which are as follows:-

1. The lower 10 ft. of the seam (18 ft. thick in this area) was initially worked.
2. Due to variations in calorific values in the seam the mining horizon was altered and the section was developed up into the top 10 ft. of the seam. This gave better B.T.U. values.
3. This action resulted in the roof of the workings being a massive sandstone.
4. For this reason roof bolting was no longer necessary and was discontinued.
5. During the course of developing up into the top portion of the seam, the roof coal was deliberately taken down as it became thinner. The result of this was that for about 200′ of advance, workings were a maximum of 14 ft. high.

Stooping in this section has so far been successfully accomplished and the stooping line is presently passing through the 14 ft. high workings.

Investigations have been done into the pillar sizes and a section, currently being developed at 75′ centres, will be stooped upon reaching its boundary.

One of the difficulties so far experienced when stooping a standard size panel, is the excessive pressure encountered in the main, on what is commonly referred to as the "back to back" pillars. (The V-shaped stooping line is necessary to eliminate excessive tramming distances in panels which are 700 ft. wide).

In order to eliminate this difficulty a five heading panel is being planned. The 4 pillars will be stooped back on a 45° straight line. The narrower panel will reduce tramming distances and no loss in either primary or secondary rate of extraction is expected.

While the boundary pillar has so far been extracted successfully by conventional means, a shortwall experiment to extract the barrier pillar is being prepared.

If this technique is successful, it is intended to extend this method to stooping lines of pillars in a panel.

Reference was made previously to the northern portion of the mine where coal is won by ordinary handgot methods. The thickness of the seam in this area varies from 40′—70′.

A panel has been developed on 80′ centres on a horizon 10 ft. below the roof of the seam, and pillar extraction has commenced. At this date the first line of pillars have been extracted by hand loading into tubs. The unsupported roof has goafed to a height of 18 feet. Pillar extraction here is very much in its infancy and little can be recorded of this method at this stage. The pocket and fender system is also being used.

Conclusions

A greater volumetric extraction is possible in a safe manner by mechanised pillar extraction.

While all the techniques possible have not been explored, it holds promise for perhaps more widespread application by other mining engineers.

If the experiences related in this paper enable this technique to be adopted at other mines it will have helped in some small way to exploit our natural resources more fully.

Acknowledgements

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