

# Problems encountered in the operation of a new colliery

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## SYNOPSIS

This paper describes some aspects of the planning of a new colliery which commenced production in the Middleburg district in 1966. An account is given of some of the problems encountered in the early years of operation and of what was done to solve them. The conclusion is reached that design of plant and machinery should be flexible to permit multiplication of units.

## INTRODUCTION

Bank Colliery was designed to replace Kromdraai Colliery, one of the oldest in the Witbank district. The original Coronation Colliery produced coal on the farm Blesboklaagte to the west of Witbank and in the 21 years of its existence, between 1903 and 1923, 4½ million tons of coal were sold.

Between 1923, when the Colliery closed, and 1926, small tonnages were mined from the Arnot and Tavistock Collieries, which were under the control of the original company.

In 1926 production commenced at Kromdraai and between that date and closure in 1966, over 43 million tonnes of high grade coal were sold.

Bank Colliery is a member of the Transvaal Coal Owners' Association and a producer of steam coals for the inland and export markets. In 1966, the Company's declared capacity within the Association amounted to approximately 105 000 t per month and the colliery was designed to produce 122 000 t which was considered to be a reasonable excess in capacity over sales, which at the time were of the order of 100 000 t per month.

This paper describes some aspects of the planning of the Colliery and the problems encountered in the early days of operation. Initially these problems were related to difficulties in attaining the planned production of 122 000 t per month and in later years were aggravated by demands in excess of this figure.

The most serious difficulties occurred with conveyor belt capacities, from underground sections through to the plant, and with the removal of duff prior to washing. The former was solved by the construction of a 180 t surge bin at the shaft bottom and by increasing the speed of belts, whilst the original screen was replaced twice before successful screening was obtained.

*Note:* Metric figures have been used throughout this paper but in areas where they will, as yet, have little significance, the equivalent imperial measures are shown.

## LOCALITY, PROPERTY AND COMMUNICATIONS

The Colliery is situated approximately 29 km south of Middelburg and leases mineral and surface rights from associated companies on the farms Blesbokvlakte, Wolvenfontein and Bankfontein from which it derives its name.

Mineral rights in respect of all seams other than the No. 5 seam are held over an area of 4 230 ha, whilst the extent of the surface rights is approximately 480 ha.

The Colliery is well served by provincial roads and a private branch railway, common to Blesbok, Schoon-gezicht (which has now closed) and Bank Collieries, terminating at the South African Railways junction at Brooksnysersplaas, a distance of some 11 km from Bank.

## GEOLOGY AND RESERVES

The area is underlain by the usual succession of seams in the Witbank district, viz. Nos. 5, Upper 4a, 4a, 4, 3, 2 and 1. The No. 5 Seam which is present on the south-east portion of the lease area is mined by Blesbok Colliery as a blend coking coal. The Upper 4a, 4a and 4 Seams are irregularly deposited, whilst Nos. 2 and 1 are present over most of the area with the exception of No. 5 seam. The seam of economic importance at present is No. 2, as No 1 is generally of poor and variable quality except in one area of the property.

The workable limits of No. 2 Seam are generally defined by quality and yield, except on the eastern side of the mine where the seam is missing due to pre-Karoo topography. A typical borehole section is shown in Figure 1.

Stratigraphy in the immediate neighbourhood of No. 2 Seam consists of between 6 and 10 m of carbonaceous shales in the roof and between 1 and 3 m of shales and grits separating the seam from No. 1 Seam. Unless affected by disturbances, the roof is generally good and requires a minimum of support.

The depth below surface of No. 2 Seam varies from 110 m to 12 m with an average of 52 m, whilst the variation in elevation above sea level of the seam floor is approximately 61 m. It was expected that the dip would generally be from north-east to south-west and of the order of between 1 in 30 and 1 in 60, but experience at Schoongezicht Colliery, which adjoins Bank, indicated that steep local dips would be encountered.

## RESERVES

During the exploration of the lease area, approximately 100 boreholes were drilled, the frequency as an average over the whole area thus amounting to approximately 40 ha per hole. Samples taken from cores were subjected to float and sink tests and proximate analyses carried out on the various fractions.

BOREHOLE SECTION					SECTION OF COAL SEAM				%		
ELEV.	DEPTH	SECTION	WIDTH	RECORD OF STRATA	ELEV.	DEPTH	SECTION	DESCRIPTION	CORE RECOV	SAMP WIDTH	SAMP N°
+5211-32	0'-0"										
	23'-0"		23'-0"	SOIL & CLAY	+5155-32	56'-0"		SANDSTONE	7'-6"		
	32'-0"		5'-0"	SANDSTONE DECOMPOSED		5		COAL BRIGHT	70	4'-6"	426-5-I
	48'-6"		16'-6"	DO. DECOMPOSED SHALEY	+5150-82	60'-6"		SHALE CARBONACEOUS	1'-9"		
+5155-32	56'-0"		7'-6"	DO.	+5078-49	132'-10"		SHALE MICACEOUS	5'-0"		
+5150-82	60'-6"		4'-6"	COAL N° 5 SEAM		44U		COAL BRIGHT	100	3'-6"	426-4-B
			1'-9"	SHALE CARBONACEOUS	+5074-99	136'-4"		FLOATS 77-0% SINKS 23-0% SANDSTONE	NOT ANALYSED		
			55'-0"	SANDSTONE LAMINATED MICACEOUS	+5088-07	143'-3"		SHALE CARBONACEOUS	2'-2"		
	117'-3"		10'-7"	DO COARSE		4A		COAL DULL WITH 1/2" STONE BAND AT 147'-6"	100	5'-0"	426-4-C
+5078-49	127'-10"		5'-0"	SHALE MICACEOUS	+5063-07	148'-3"		SHALE & GRIT	2'-8"		
+5074-99	128'-4"		3'-6"	COAL N° 4A UPPER				SHALE CARBONACEOUS	8'-10"		
+5068-07	143'-3"		4'-9"	SANDSTONE CARBONACEOUS	+5051-57	159'-9"		COAL BRIGHT	100	1'-6"	426-4-D
+5063-07	148'-3"		3'-2"	SHALE N° 4A SEAM		4		SHALE CARB. EXCL.	1'-0"		
			2'-8"	SHALE & GRITS				COAL BRIGHT	100	3'-6"	426-4-E
+5081-57	159'-9"		8'-10"	SHALE CARBONACEOUS	+5045-57	165'-9"		SANDSTONE LAM. MIC.	7'-3"		
+5045-57	165'-9"		6'-0"	COAL N° 4 SEAM	+4967-32	244'-0"		SHALE CARBONACEOUS	32'-8"		
	172'-0"		7'-3"	SANDSTONE LAMINATED MICACEOUS				COAL DULL LUSTROUS	100	6'-0"	426-2-F
	179'-3"		1'-9"	COAL NOT SAMPLED				COAL DULL LUSTROUS	100	5'-0"	426-2-G
	178'-3"		4'-6"	SHALE CARBONACEOUS				SHALE EXCL.			
	182'-7"		9'-4"	COAL & SHALE NOT SAMPLED				COAL DULL LUSTROUS	100	6'-7"	426-2-H
			15'-0"	SANDSTONE LAMINATED MICACEOUS	+4947-32	264'-3"		GRITS	2'-4"		
	199'-4"		12'-0"	DO.	+4944-74	266'-7"		COAL DULL	100	6'-0"	426-1-I
	211'-4"		32'-8"	SHALE CARBONACEOUS				SHALE CARB. EXCL.	3'-2"		
+4887-32	244'-0"		20'-3"	COAL N° 2 SEAM	+4933-07	278'-3"		COAL DULL	100	2'-6"	426-1-J
			2'-4"	GRITS				SANDSTONE LAMINATED MICAC.	10'-0"		
+4947-32	264'-3"		6'-0"	COAL N° 1 SEAM							
+4944-74	266'-7"		1'-2"	SHALE CARBONACEOUS							
+4933-07	278'-3"		2'-6"	COAL N° 1 SEAM							
	288'-3"		10'-0"	SANDSTONE LAMINATED MICACEOUS							
			11'-9"	DWYKA SHALES & GRIT							
+4901-32	310'-0"										

IK. 38

Fig 1

The following criteria were used in the calculation of reserves:

- 1 The minimum calorific value to be of 28,88 MJ/kg (12,80 lb/lb) when washed at a specific gravity of 1,525.
- 2 If the workable seam height was in excess of 3,7 m, extraction would be in two operations, i.e. development at approximately 2,4 m and top coaling of the remainder. Below 3,7 m mining would be confined to one operation.

On this basis the reserves were estimated to be as follows:

<i>Reserves in Development</i>	38 million t
	29,42 MJ/kg
	19,1 per cent washery discard.
<i>Reserves in Top Coal</i>	11 million t
	29,31 MJ/kg
	17,5 per cent washery discard.

### SHAFTS AND SHAFT SITE

The proposed shaft system was a conventional arrangement of a downcast incline shaft which served for the hauling of coal and the transportation of men and materials, and a vertical upcast shaft. The site for the shafts and the general surface arrangements are shown on Figs. 2 and 3. Criteria used in the selection of shaft sites were as follows:

- 1 The site is situated on land held under freehold.
- 2 The No. 2 Seam is generally of below saleable quality in this area.

3 It is the most suitable site in respect of a branch railway and sidings.

4 The shaft could be located near the plant site, thus minimising the length of the overland belt.

5 The coal-bearing area in the vicinity of the shaft bottom is not restricted and adequate pitroom could be developed in a relatively short time.

6 Whilst not ideal in respect of exploitation of the reserves, from the point of view of distance and geographical centre, it was considered that the advantages enumerated justified the selection.

The area in the vicinity of the shaft had been well drilled and surveyed with a magnetometer. It was appreciated that the latter survey might, for various reasons, have been inconclusive, but as far as could be seen, the shafts were to be situated on the workable limits of No. 2 Seam and approximately over a sill of dolerite which pitches through the seam in this vicinity. The incline shaft would pass through the sill which was approximately 9 m thick, but it was not anticipated that the seam at the shaft bottom would be affected by the dolerite.

The depth to the floor of the seam at the shaft sites is 61 m and the incline was to be sunk at an inclination of 18 degrees. It was anticipated that in the vicinity of the dyke, bad ground would be encountered and in order to minimise the span which might have to be supported, it was decided that the greatest dimension should be vertical rather than horizontal. These considerations resulted in the unconventional two-tiered

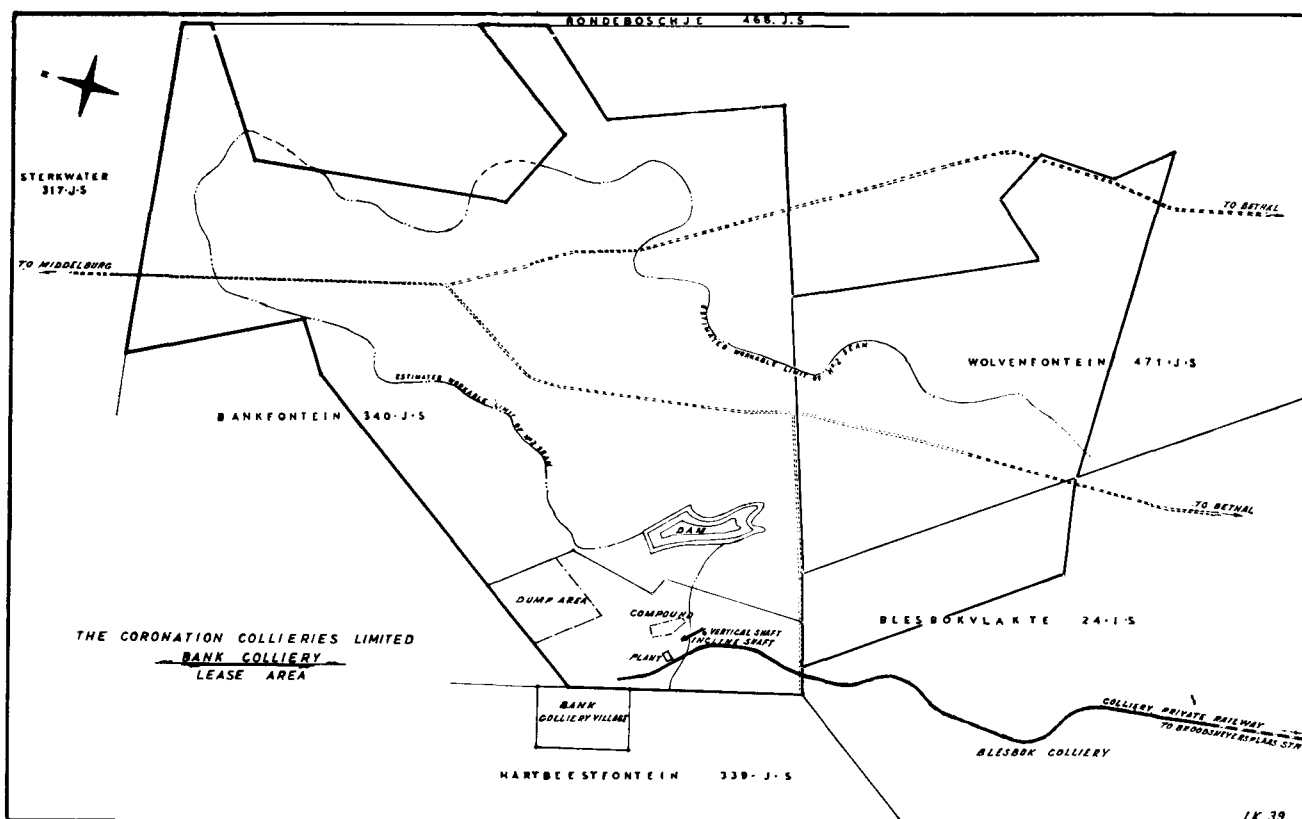


Fig 2

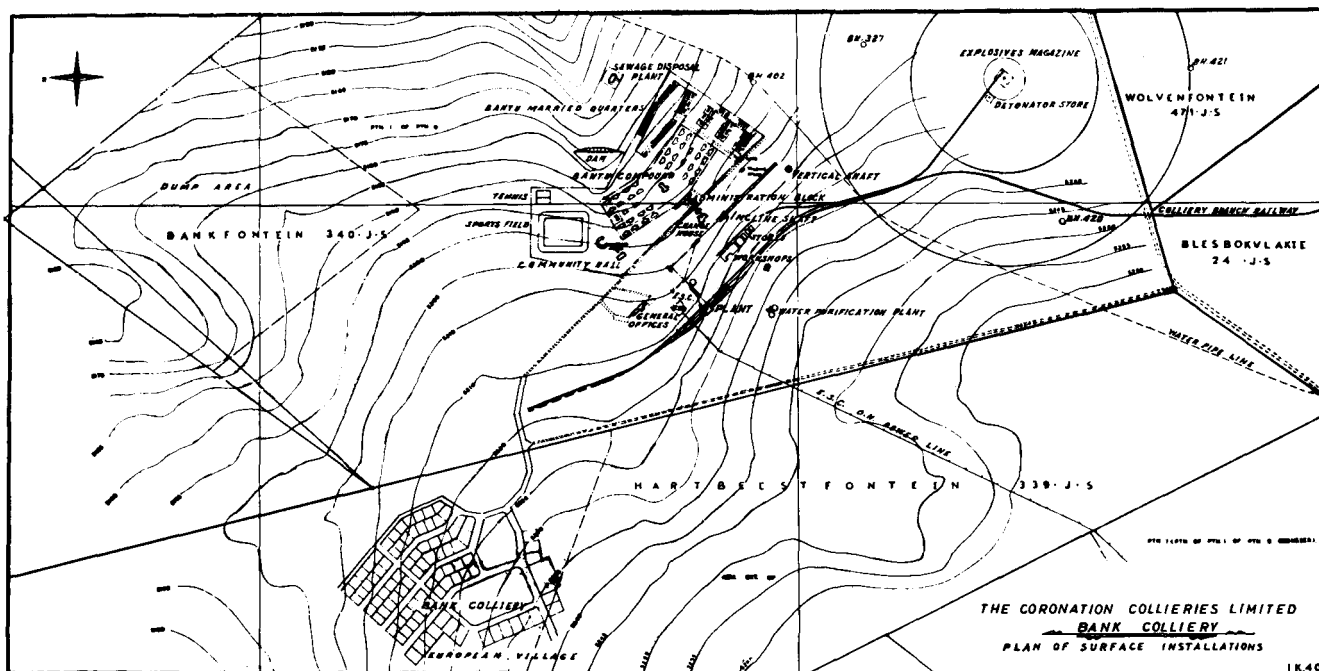


Fig 3

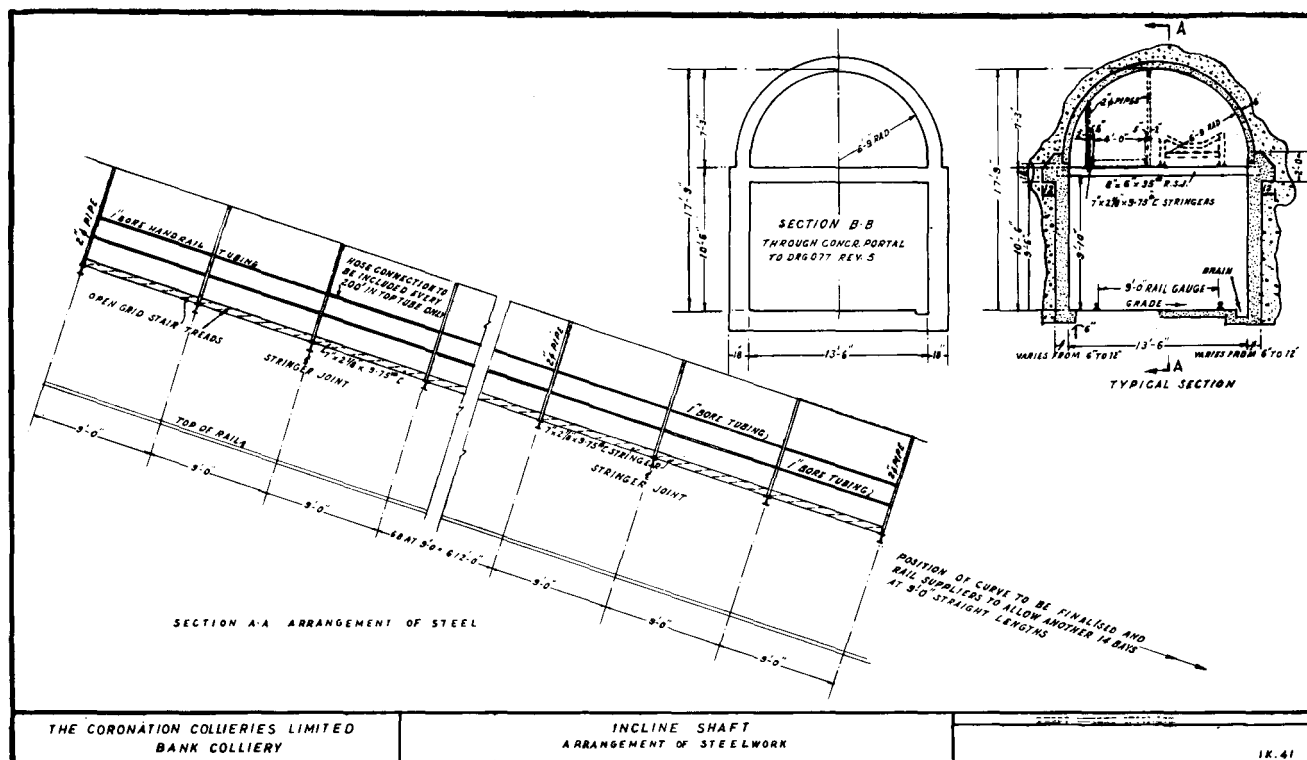


Fig 4

shaft, the general arrangement of which is shown in Fig. 4. The conveyor belt and travelling way are situated on the first floor as it were, whilst the skipway is situated on the ground floor allowing an unrestricted passage for heavy equipment and materials.

Trailers containing stores and mechanised equipment were to be loaded on a rail-mounted skip thus minimising materials handling. At this depth it was not considered necessary to install a lift for the raising and lowering of men and the stairway in the incline shaft was to be used for this purpose.

It was estimated that ultimately 188 cubic m per sec of ventilating air would be required and the 4,9 m diameter vertical shaft was equipped with a fan capable of passing this quantity at a pressure of 12,5 mbar.

The nominal area of the incline shaft was approximately 18,6 square metres and thus maximum velocity in the shaft would amount to approximately 10 m per sec. This was considered to be acceptable but any air in excess of this figure would have to be carried in additional shafts.

### MAIN ENTRIES

Boreholes had been drilled along the line of the main entry and no major disturbances were anticipated. It was proposed that the main entry should be a five road system developed at a height of 3 m on the seam horizon producing the highest grade of coal. During construction the problem was the usual one of providing the maximum amount of pitroom and at the same time restricting the production of development coal to a minimum. Approximately 300 m of entry were required to provide pitroom before the mine came into full production, as this length of development would permit the turning away of four sections from the main entry system. The preliminary estimate of advance tonnage was as follows:

Metres advance per month . . . . .	10
Run of mine tonnes produced per month . . . . .	12 000
Months of development required . . . . .	4
Run of mine tonnes produced . . . . .	48 000

It was proposed to stockpile development coal arising from the operation and recover it at a later date when the mine was in production.

### MINE LAYOUT AND PANEL SYSTEM

The colliery was designed before the advent of Dr. Salamon and his sophisticated approach to strata control on the South African mining scene. Nevertheless, the Coalbrook disaster was fresh in our memories and the value of a panel system to contain incidents such as subsidences, fires and floods was appreciated.

Pillar centres were calculated by a formula which had been in use by the Group for many years.

As will be seen from Fig. 5, the design called for panels of 610 x 530 m inside barriers, the exact dimensions depending on pillar centres. The width of the barrier pillar was to be twice the normal pillar width and pierced with as few entries as possible, generally not more than three.

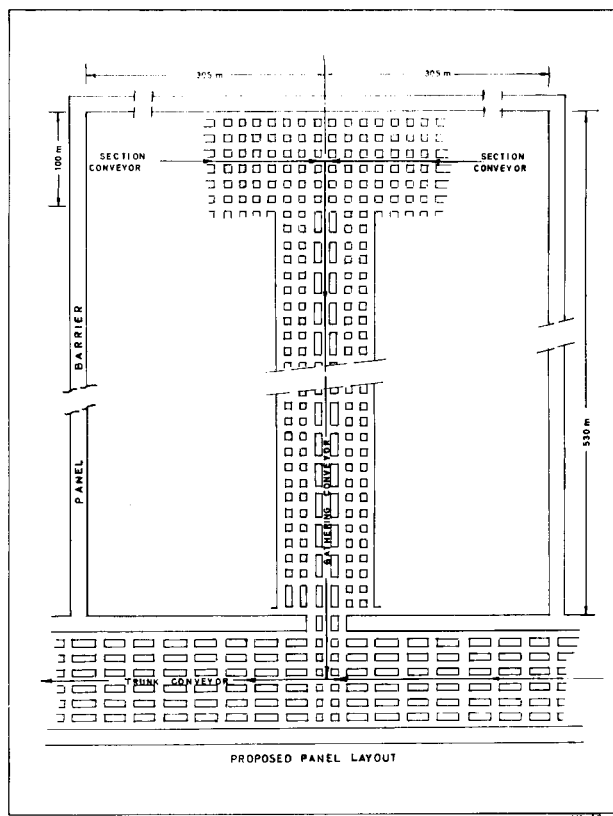


Fig 5

Panel entry was to be a seven road system up the centre of the panel and sections were to be turned off right and left of the panel entry, also on a seven road system. The length of each section was thus approximately 260 m and where possible, these were to be driven at development height and top coaled on retreat. The dimensions of panels were selected with the following desiderata:

- economical section belt lengths
- the number of faces required for maximum production per unit
- minimum tram distances
- minimum face advance to obviate frequent belt extensions

The proposals in respect of the height of workings have been mentioned earlier but are repeated here:

- for a workable seam height of less than 3,7 m, mining should be in one operation;
- for a workable seam height in excess of 3,7 m, mining should be in two operations, i.e. development at 2,4 m and top coaling the remainder on retreat. It was realised that due to variations in coal quality, selective mining in both horizontal and vertical senses would be necessary though at the time it was not clear how this could be planned in advance. However, it was apparent that extensive and routine face sampling and underground drilling in order to control grade was going to be an important feature of the operation.

## UNDERGROUND OPERATIONS AND MINING MACHINERY

The mine was one of the Group's earliest mechanised operations and the selection of underground machinery was largely based on what could be learnt from the experience of others, and it was interesting but a somewhat frustrating experience to discover such divergences of opinion on underground equipment.

In respect of main conveyors and the preparation plant, the mine was designed for a maximum output of 122 000 sales t per month, equivalent to 153 000 run of mine t with a washery discard of 20 per cent. However, it was not expected that sales would exceed 110 000 sales t per month for some time and underground equipment was ordered to match the equivalent of this tonnage in run of mine t, i.e. 136 000 t.

It was estimated that 750 t per shift could be expected from a conventional unit consisting of a cutter, loader and two shuttle cars. On a double shift basis, therefore, four such units would be required.

In making the selection of underground equipment, consideration was given to the following factors:

### Coal Cutters

It was anticipated that the mining floor would frequently be above the seam floor and thus in coal. Experiments at Schoongezicht had shown that in this area it was difficult to blast a smooth floor and it was decided, therefore, to cut on the floor to protect shuttle car tramways. Universal machines in the form of Joy 10 RU cutters were, therefore, selected in preference to standard arcwall machines.

### Loaders

Joy 14 BU loaders were selected.

### Shuttle Cars

At that time Ferret dumpers were becoming popular and serious consideration was given to these machines on the grounds of price and simplicity. However, diesel engines were not popular in the Group and there was some doubt as to their ability to operate on the steep dips which might be encountered. Consequently, conventional shuttle cars in the form of a Torkar 48-AC-48 were selected.

### Feeder Breakers

It was realised that large coal, particularly from top coaling sections, would be produced and the mechanical engineers were sensitive to the effect of large pieces of coal on conveyor belts. At the same time it was realised that a great deal of floating stone would be encountered and a very robust type of breaker would be essential. Consequently the Beien breaker type RF 500, which appeared at the time to be the most robust on the market, was selected.

## CONVEYOR BELTS

The mine was to be equipped with conveyor belts conforming to the following specifications:

### Section Belts

Duty required	181 t/h	200 tons/h
Width	91,4 cm	36 in
Speed	91,5 m/min	300 ft/min
Drive motor	Multiples of 22,35 kW	Multiples of 30 h.p.

### Panel Belts

Duty required	363 t/h	400 tons/h
Width	91,4 cm	36 in
Speed	106,8 m/min	350 ft/min
Drive motor	Multiples of 22,35 kW	Multiples of 30 h.p.

### Trunk Belts

Duty required	544 t/h	600 tons/h
Width	106,7 cm	42 in
Speed	106,8 m/min	350 ft/min
Drive motor	Multiples of 74,6 kW	Multiples of 100 h.p.

### Shaft Belts

Duty required	544 t/h	600 tons/h
Width	106,7 cm	42 in
Speed	106,8 m/min	350 ft/min
Drive motor	Multiples of 74,6 kW	Multiples of 100 h.p.

## TRANSPORT EQUIPMENT

Transport of material underground was to be by means of trailers drawn by Kersey battery tractors.

## COAL PREPARATION PLANT

The design capacity of the preparation plant was based on a saleable output of 122 000 t per month and obtained from 153 000 run of mine t and a washery discard of 20 per cent.

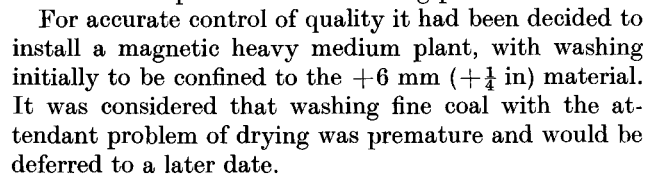
Thus, on the basis of a 2 × 8-h shifts per day, input to the plant would amount to 400 t per h.

Consultation with the T.C.O.A. indicated the following requirements in respect of products:

- 1 As a high grade mine a minimum calorific value of 27,07 MJ/kg (12,00 lb/lb) was required of all products. In addition, it was necessary to produce lumps of not less than 28,88 MJ/kg (12,80 lb/lb) in order to remain on the list of export collieries.
- 2 The colliery should be able to fill orders for export coal, the sizes of which at that time were 229 mm × 102 mm and 102 mm × 38 mm (9 in × 4 in and 4 in × 1½ in).
- 3 For the inland market, the following sizes were required:
 

(a) 152 mm × 102 mm	6 in × 4 in
(b) 102 mm × 64 mm	4 in × 2½ in
(c) 64 mm × 38 mm	2½ in × 1½ in
(d) 38 mm × 22 mm	1½ in × 7⁄8 in
(e) 22 mm × 6 mm	7⁄8 in × ¼ in
(f) — 6 mm	— ¼ in
- 4 It should be possible to crush the whole output to — 64 mm (— 2½ in).
- 5 It should be possible to mix (e) and (f), i.e. to produce mixed smalls.

- 9 Storage was required for products (d), (e) and (f). The T.C.O.A. recommended anti-degradation and anti-segregation storage bunkers. It was, however, considered that undersize in these products was primarily due to inadequate screening rather than storage and in the event, no such measures were taken.
- In order to assess the duties of the various elements of the plant, tests were carried out at Schoongezicht and the records of production over a long period studied.



The flow sheet which appeared to satisfy these requirements is shown in Fig. 6 and is that which accompanied the enquiry to contractors.

The contract was awarded to Fraser and Chalmers (S.A.) Limited and the flow sheet and general arrangement of the plant finally erected are shown in Figs. 7 and 8. The main elements of the plant were as follows:

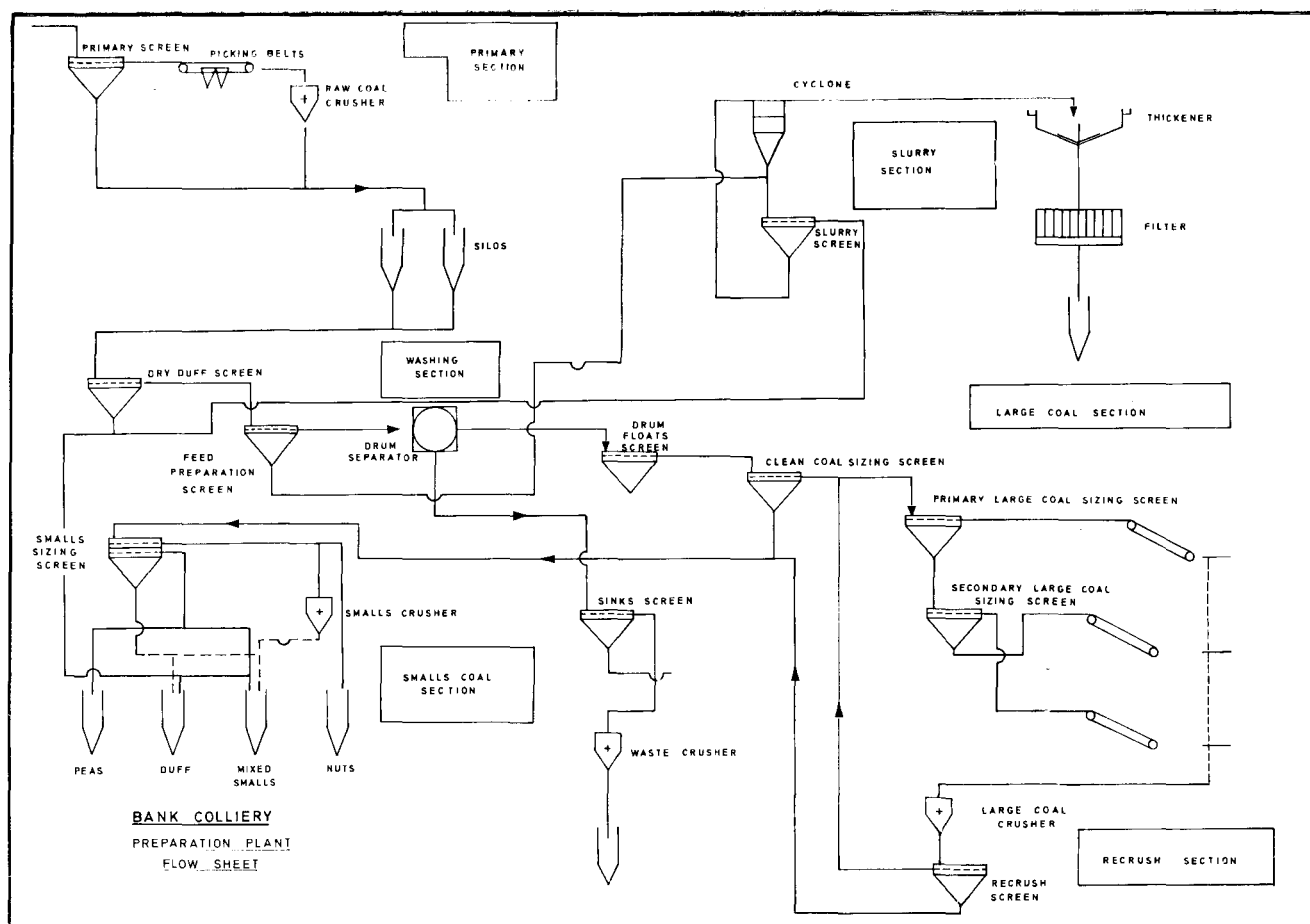
### Raw Coal Stockpile

To reduce degradation it had been decided to replace the conventional conical stockpile normally used in this Group with circular concrete silos of a nominal capacity of 900 tonnes each. These silos were to be equipped with Qualter Hall spiral chutes and trunking over the discharge chutes.

**Fig 6**



**Fig 7**



**Fig 8**

### Primary Screen

Flamrich single deck vibrator 3 000 mm × 1 400 mm  
with 100 mm (4 in) openings.

### Raw Coal Crusher

Jeffrey Galion 76 mm  $\times$  91 mm (30  $\times$  36 in) double roll crusher.

### Dry Duff Screen

Flamrich single deck resonance screen, 2 200 mm × 7 500 mm with 6 mm ( $\frac{1}{4}$  in) openings.

### Feed Preparation Screen

Flamrich single deck resonance screen, 1 800 m × 3 750 mm with 9 mm (3/16 in) openings.

### *Drum Separator*

Wemco 427 cm diameter  $\times$  366 cm long (14 ft  $\times$  12 ft) single compartment drum separator.

### *Drum Floats Screen*

Flamrich single deck resonance screen, 1 600 mm × 4 500 mm with 0,5 mm slot stainless steel wedgewire.

### Drum Sinks Screen

Flamrich single deck resonance screen, 1 400 mm × 4 500 mm with 0,5 mm slot stainless steel wedge wire.

### Slurry Screen

Flamrich single deck vibrator, 300 mm  $\times$  1 000 mm with 0,6  $\times$  4,5 mm slot woven wire.

### Thickener

12 m (40 ft) diameter  $\times$  3 m (10 ft) deep thickener.

*Filter*

122 cm (4 ft) diameter  $\times$  double disc Agidisc filter.

### Primary Large Coal Sizing Screen

Flamrich double deck vibrator, 1 800 mm × 5 000 mm with woven wire decks. Top deck with 64 mm (2½ in) openings and bottom deck with 38 mm (1½ in) openings.

### Secondary Large Coal Sizing Screen

Flamrich double deck vibrator, 1 800 mm × 3 500 mm decks with top deck of woven wire with 102 mm (4 in) openings and bottom deck blank.

### Smalls Sizing Screen

Flamrich double deck vibrator, 1 800 mm  $\times$  3 500 mm decks of woven wire with top deck 22 m ( $\frac{7}{8}$  in) openings and bottom deck 6 mm ( $\frac{1}{4}$  in) openings.

### Smalls Crusher

British Jeffrey-Diamond 91 cm  $\times$  122 cm (36 in  $\times$  48 in) flex tooth crusher.

### Large Coal Crusher

Jeffrey-Galion 76 cm  $\times$  152 cm (30 in  $\times$  60 in) double roll crusher.

## Recrush Smalls Sizing Screen

Flamrich type double deck vibrator 1 800 mm × 3 500 mm ( $\frac{7}{8}$  in) openings and bottom deck  $\frac{1}{4}$  in openings.

## Waste Crusher

British Jeffrey Diamond 91 cm × 122 cm (36 in × 48 in) slugger crusher.



This concludes the first section of the paper in which the planning of the colliery has been discussed. In the section which follows, some of the problems encountered and the steps taken to solve them are described.

PRODUCTION

In comparing operations with planning, the most striking departure from the latter has been in respect of the level of production. The following tabulation shows monthly sales in tonnes since production commenced and it will be seen that on many occasions tonnages well in excess of the planned 122 000 have been achieved:

MINING LAYOUT AND PANEL SYSTEM

The panel system and approximate panel dimensions have been retained as originally intended but the method of entry and working of the panel has been changed. In place of entry up the centre of the panel, development for this purpose now tends to be along the side of the panel and consequently the length of the section has been extended from  $\pm 229$  m to  $\pm 610$  m, the advantage lying in the fact that movement of section conveyors is less.

The inference to be drawn from this is that non-productive movement is important and should be avoided as far as possible as it results in much overtime or loss of production. There have been no major geological interferences, except stringers from the Oogies dyke in the area adjacent to the Schoongezicht Colliery workings.

The maximum length of a panel is determined by the belt capacity. Section conveyors are 91,4 cm wide and are powered by 1, 2 or  $3 \times 22$  kW or 30 kW motors, as required, depending upon length and grade.

The South-East Main, which is the main arterial way for the workings, is bounded by a safety pillar on either side, through which a limited number of entries are made to production panels. The safety pillar is normally 10  $\times$  maximum height of workings or approximately 55 m. Entries through the safety barrier on the South-East Main are permanently sealed off with 4,6 m wide barriers of sand and stone, when the production inbye is completed.

Fig. 9 shows the present extent of the workings and the panel system now being used.

UNDERGROUND CONDITIONS

The No. 2 Seam now being mined has been found to vary between 4,9 m and 7,0 m with an average of 5,5 m. It is separated by a parting of  $\pm 1,5$  m from the No. 1 Seam, which is often partly comprised of a torbanite shale. The No. 1 Seam varies from 1,55 m to 2,125 m and being generally inferior to the No. 2 Seam, is not worked at present.

The No. 4 Seam (often in 3 splits) which overlies, is present over much of the lease area and is a potential power station fuel. The underground workings are, therefore, designed with a minimum safety factor of 1,6 in order not to jeopardise future mining of the No. 4 Seam.

Depending on calorific values, it has proved possible to mine up to 5,5 m high on the southern side of the South-East Main. This is done by primary mining on the lower horizon (2,7 m to 3,1 m) and then top coaling or secondary extraction on the retreat.

To the north of the South East-Main, workable horizons gradually diminished to only 2,4 m due to inferior coal, heavily impregnated with pyrites. A full-time European sampler is employed, taking face samples, together with drill samples in the roof and floor. He is in daily liaison with the Mine Captain and is an essential part of the production team.

As mentioned earlier, the original thinking at Bank called for cutting on the floor, since it seemed to be the only way to maintain a smooth floor for shuttle car operation. This has proved to have been a wise decision and floor cutting is practised to this day.

The floating stone in the seam, whose presence was suspected at the outset, has proved to be more of a problem than was anticipated. There are normally two and sometimes three of these bands, varying from 15 cm to 60 cm at varying horizons, which cannot be drilled with an electric rotary drill. Jack hammers are far too slow and consequently the coal is over-blasted in an attempt to break the stone into a manageable size. Very large pieces can be discarded by the loader operator, but much stone is loaded into the Torkars, causing

	1966	1967	1968	1969	1970
January		87 322	108 868	116 091	116 298
February		73 491	102 642	112 219	95 131
March		102 579	116 406	121 333	129 658
April		102 520	115 902	132 770	129 964
May		102 640	131 136	137 087	101 308
June	30 519	97 459	118 320	118 509	109 656
July	53 366	101 619	114 387	132 582	128 973
August	70 992	102 731	114 827	125 802	135 752
September	85 162	84 364	128 783	128 430	115 583
October	81 013	99 022	123 128	119 133	137 384
November	82 827	95 434	124 786	133 353	119 656
December	90 824	106 726	123 991	128 479	148 100
Sales t for year	494 703	1 155 907	1 423 176	1 505 788	1 467 463
Gross t for year	586 861	1 252 779	1 626 471	1 724 390	1 643 331
Yield	84%	92%	88%	87%	89%

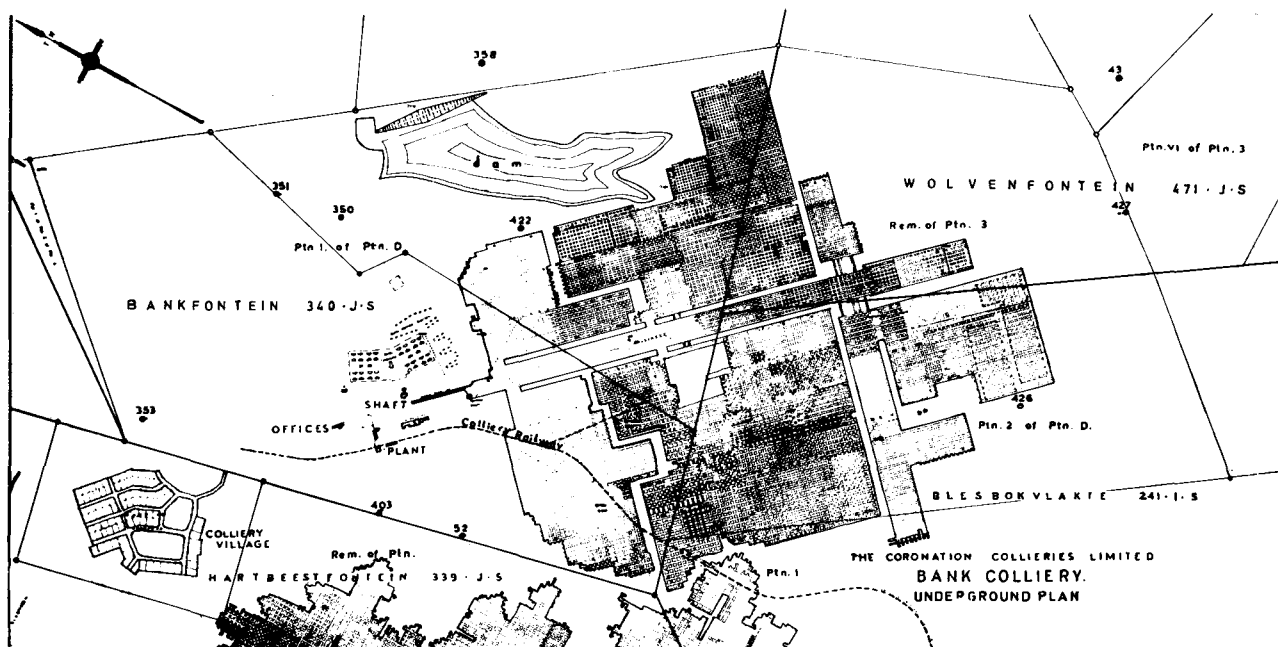


Fig 9

wear and tear on conveyors, transfer chutes and blockages in the surge bin. A picking belt on the surface, manned by six Bantu is essential at present to prevent stone entering the primary coal crusher.

The original Beien coal breakers have been abandoned as they could not break the stone and were continually being damaged and coal is, therefore, presently loaded directly by the Torkars on to the conveyor belts.

It has been established that a Beien impact breaker is capable of breaking the stone and one of these machines is presently being installed for trial. In the first instance the breaker will be installed in a section but it is probable that eventually one or more would be sited at the junction of gathering and trunk belts and that some sort of grizzly would remove the minus say 100 mm (4 in) material before the crusher. The main requirement is that stone will be broken small enough to pass through the primary roll crusher without affecting it or alternatively that stone, and coal, will be broken small enough to allow the primary crusher to be removed altogether. In both cases, the majority of stone would be removed in the washery though no doubt some picking would be practised.

### MINING MACHINERY

The following equipment is presently in use underground:

- 6 Joy 14 BU Loaders
- 6 Joy 10 RU Coal Cutters
- 10 Torkars
- 1 Joy 60 D Battery Shuttle Car

Production from mechanised units has exceeded that originally envisaged and in place of the four double shift units for which the Mine was planned, it has been possible to maintain production with three double shift units and one skeleton single shift unit which is

used for development through panel barriers and dykes.

Normally, units are equipped in a conventional fashion, i.e. 1 cutter, 1 loader and 2 shuttle cars and an average production of 150 cars or 1 000 t per shift can be expected. However, demand and truck supplies are to some extent unpredictable and to meet sudden increases spare machines are introduced into the sections converting them to 2 loader and 3 car sections, improving production to 200 cars and 1 400 t per shift. Output is thus increased by one third at the added expense in labour of 2 loader and 1 shuttle car operators and generally, an additional European miner.

This method of meeting the irregular demand is preferred to maintaining a fully manned and equipped fourth unit, which would frequently be idle.

### CONVEYOR BELTS

The original speed of the 107 cm (42 in) shaft conveyor was 106 m per min (350 ft per min) as was the first 107 cm (42 in) trunk conveyor, whilst that of the three section conveyors which initially loaded directly onto the trunk conveyor, was 92 metres per minute (300 ft per min).

To some extent the Beien breakers whose primary purpose had been to break coal to manageable sizes, acted as feeders and resisted overloading of the conveyors. They could not, however, prevent overloading of the shaft belt, which became more and more serious as the output rose, and in any event, they were continually out of action as the incidence of stone increased.

It was then decided to construct a 180 t surge bin 610 m from the shaft bottom which could control the feed onto the No. 1 trunk conveyor and thus onto the shaft conveyor. An overload trip triggered by the load current on the shaft belt stops the loading from the No. 1 trunk thus protecting the shaft belt. The surge bin has

successfully prevented overload of the shaft belt (there has not been a broken shaft belt since its inception). but does not, of course prevent surge loading and overloads of the conveyor system inbye.

The shaft conveyor, however, remained the principal bottleneck to maximum output, and during 1969 the speed was increased to 146 m per min (480 ft per min) and an additional 74,6 kW (100 h.p.) motor added to the drive, making a total of 224 kW (300 h.p.) driving power ( $3 \times 74,6$  kW units). The system of three driving units is considered a flexible arrangement in that if a breakdown of one motor occurs, a limited output can be obtained from the remaining two motors. 74,6 kW units are standard on the mine and are used in multiples of two or three for driving all the underground trunk conveyors. At present a programme of increasing all the conveyor belt speeds to 168 m per min (550 ft per min) is taking place.

## TRANSPORT OF MEN AND MATERIALS

Europeans and certain Bantu ride bicycles to their working places whilst the remainder walk. During 1971, however, distances to be traversed will reach 4 000 m and alternative means of transport will be essential. Consideration is being given to the issue of bicycles to all persons underground and to men riding cars drawn by battery or diesel tractors. Whilst the latter is favoured, the fundamental issue in respect of high speed transport is the construction and maintenance of roadways which has not been resolved satisfactorily.

Materials have so far been transported in trailers drawn by three Kersey battery cars, 2 Model 944D and 1 Model 1144E. There has been a considerable amount of mechanical trouble with these machines which seems to have been overcome and transport of material is not at present a problem. These tractors have also been used to haul mechanised equipment where necessary and also conveyor gear-heads. An electrician maintains the inbye battery charging station and repairs trailing cables.

## PRODUCTS

It will be seen from the tabulation shown above that yields of saleable coal from gross tonnes mined have been in excess of those originally envisaged. This is due to some extent to the fact that in the original calculations the fact that smalls would not be washed was ignored and yields were calculated on the basis of washing the whole coal. In addition, it has been possible to sell a slightly lower grade of coal in the smaller sizes than anticipated and it has seldom been necessary to drop the washing specific gravity below 1,65 compared with the planned 1,525. During 1970, the average calorific values of the various products sold were as follows:

Rounds and Cobbles	29,10 MJ/kg	12,90 lb/lb
Nuts	29,08	12,89
Peas	28,83	12,78
Smalls	28,47	12,62
Duff	28,18	12,49

The specific gravity of washing during this period was 1,68 and yield 89 per cent.

In practice it has been found that acceptable qualities and yields are obtained if the grade of raw coal is maintained by selective mining at 27,07 MJ/kg (12,00 lb/lb).

### Storage Silos

Although the designed capacity of each silo was 900 t, in practice this has been found to be only 680. Amongst other effects, this has been an important factor in plant maintenance in that it limits the time available for maintenance if done during production hours to three hours.

The silos had been equipped with spiral chutes and trunking over the discharge chutes to prevent breakage and segregation. The trunking was removed from one silo as it was thought to be affecting the capacity, and there was no visible difference in respect of segregation between the two silos. The importance of the lack of segregation, which seems to be a feature of discharge from silos, will be appreciated by those concerned with operation of washing plants.

## PRIMARY CRUSHER AND WASTE STONE DISPOSAL

This crusher has operated satisfactorily. However, it was not designed to break stone and, to protect it, the picking belt must be fully manned at all times. Originally it was planned that stone picked from the belt would be passed down chutes to a conveyor and, after joining the washery waste, through the waste crusher to the waste bin. This machine was to crush waste to  $-62$  mm to minimise dump firing. However, the amount and size of stone, much of it with dimensions up to 750 mm arriving from the picking belt was completely beyond the capacity of the crusher and the system was discarded. At present stone from the picking belts is discarded via chutes to a ground table outside the building and loaded by a front end loader into lorries for disposal on the dump.

## DRY DUFF SCREEN

Raw coal from the silos was originally screened on the Flamrich resonance screen to remove  $-6$  mm ( $-\frac{1}{4}$  in) material. Due to repeated fatigue fractures of the frame it was replaced by a Humbolt Screen, also a resonance screen, and at  $9,2$  m  $\times$   $2,4$  m ( $30$  ft  $\times$   $8$  ft) the largest single screen in South Africa. Similar mechanical troubles were soon experienced with this screen and massive reinforcement of the side plates was necessary to prevent disintegration. In addition to mechanical difficulties, both screens had been unable to remove more than 60 per cent of the duff in the run of mine coal. Consequently, excessive quantities of fines were passing to the feed preparation screen and thence into the slurry circuit or into the drum separator. Results of a test in 1969 revealed that the run of mine coal contained 27 per cent and the feed to the drum separator 8 per cent of  $-6$  mm ( $-\frac{1}{4}$  in) material.

In 1970, an extension was made to the plant and two 1,8 m x 4,9 m (6 ft x 16 ft) Bateman Inland rod deck screens with 8 mm (5/16 in) apertures were installed in the run of mine circuit, with provision for a third if necessary. Whilst the efficiency of these screens is no more than that of the Humboldt, viz. approximately 60 per cent, the combination has resulted in the almost complete elimination of duff from the wet circuit. Consequently, the load on the thickener and filter and the consumption of magnetite has been greatly reduced, the latter from a figure in excess of 0,3 kg/t to approximately 0,1 kg/t.

### SLURRY CIRCUIT

It was immediately evident that the Eimco vacuum filter was too small to remove the excessive amount of fines entering the wet system due to the inefficiency of the dry duff screen. As a result, slurry built up in the thickener tank, jamming the rakes and causing stoppages of up to 12 hours whilst the tank was cleaned out. This problem was overcome initially by pumping surplus slurry to a convenient natural pan but eventually a filter with four times the capacity of the original was installed. Although the washery normally now operates on a closed circuit in so far as water is concerned, it has

been found necessary to retain a small slurry pond for use in emergencies.

Another problem was encountered with the filter cake from the vacuum filter. Originally it was intended to dispose of this material with the washery refuse in the waste bin and thence to the dump. However, the cake was found to be so sticky that it virtually formed a cement with the refuse and it became impossible to withdraw either from the bin. Eventually a separate bin suited to this type of material was designed and built.

### LIFTING EQUIPMENT

One of the most serious omissions was the failure to provide means to lift heavy items of equipment and though provision of such equipment has been in progress for some time, it is not yet complete.

### LARGE COAL LOADING AND ROAD LOADING

The original concept of this section of the plant was that three products would be made and loaded by boom, i.e. +152 mm (+6 in), 152 mm x 64 mm (6 in x 2½ in) and 64 mm x 38 mm (2½ in x 1½ in). In fact, only

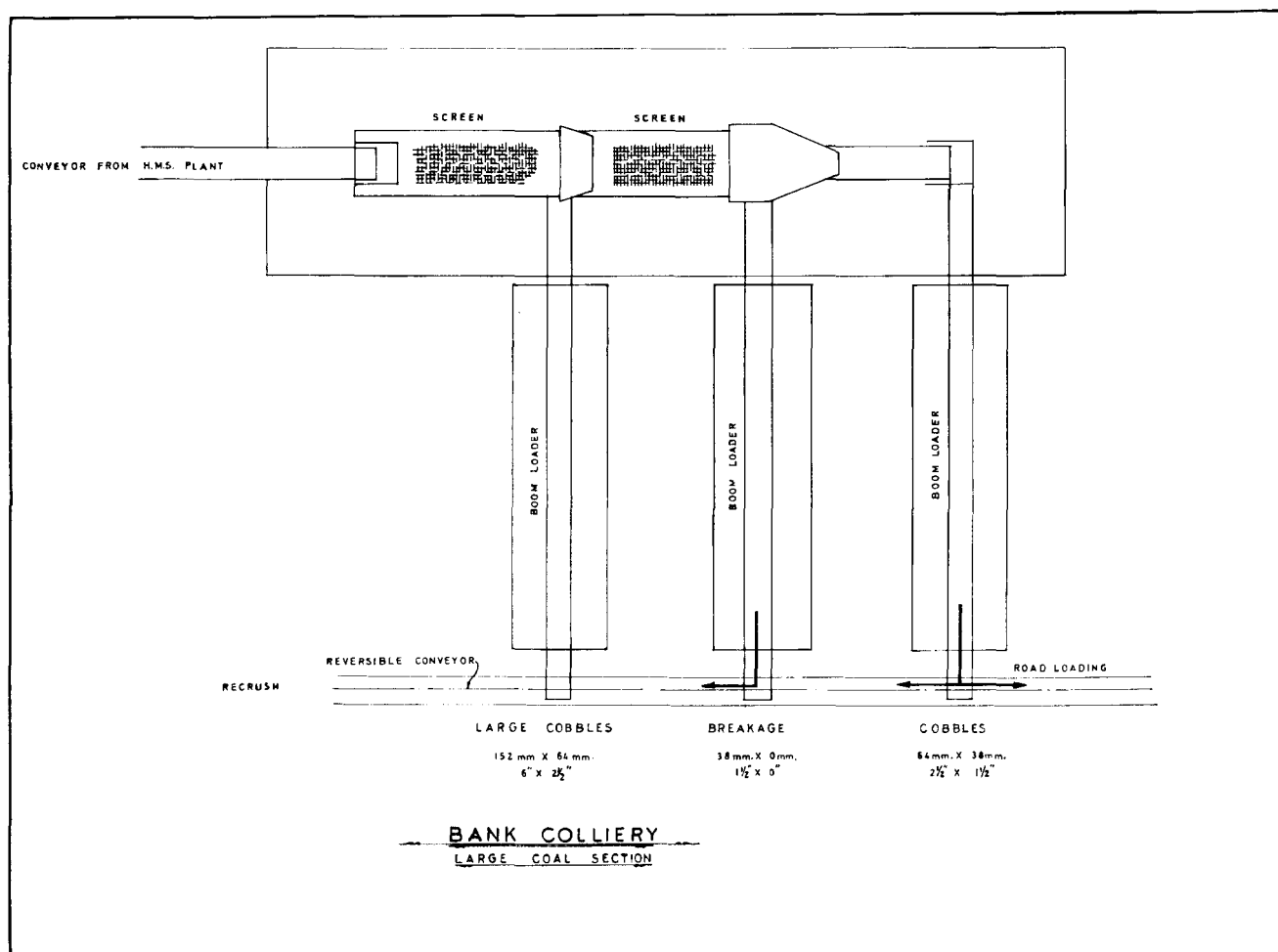


Fig 10

the latter two products have been sold and screening arrangements have been as shown in Fig. 10. The use of the third boom loader has been confined to returning - 38 mm material to the recrusher circuit.

Originally there were no road loading facilities provided but sales to local industries have increased and a 54 t bin was erected for the storage of large nuts, prior to loading into lorries. Although these sales have not been large, generally of the order of 8 000 to 9 000 t per month, the bin has been found to be too small. Consideration is also being given at present to the provision of facilities for road loading the smaller sizes.

### RECRUSH SYSTEM

The crusher in this system was designed to crush +102 mm material to -64 mm, and when performing this duty, has a capacity of 180 t per h. Existing markets, however, require smaller sizes and when set to crush to -38 mm, the capacity falls to approximately 80 t per h. This is inadequate when prolonged crushing is necessary and a slow build-up of +38 mm material in the circuit takes place. If any change in market conditions occurs, it will be necessary to install a larger crusher.

### DISPOSAL OF REFUSE

Originally it was planned to dispose of the washery waste from the waste bin by means of a diesel loco and side tip hoppers running on tracks to the dump. Lorries were, however, used in the early days of plant operation and have been completely satisfactory and their use will probably be retained.

Lorries (up to 3 per day for 12 hours handling 700 t per day) have a low capital cost ( $\pm$ R5 000) and an approximate life of three years. They are flexible in that they can tip refuse anywhere in an emergency such as a fire on the dump. The dump at Bank is on fire, but no problems are found normally in dumping directly over the side, provided that the overall height of the dump is not too great. Present height is  $\pm$ 15 m. If taken too high, land slides on the edges of the dump can make tipping directly dangerous. By limiting the height, the continuous transport of lorries over the surface of the dump assists in its consolidation. When the area of the dump is sufficiently large it is intended to increase its height by tipping to another bench height of say 5 m, or the most suitable height found by experience.

### RAILWAY SIDINGS AND TRUCK MARSHALLING

The truck marshalling arrangements for loading S.A.R. trucks have generally been successful though flood

lighting have been installed on the empty and full sidings to assist loading at night. Lack of this lighting was responsible for a fatal accident which occurred on the sidings when the cap lamp of a Bantu fell between the tracks.

### MAGAZINE CAPACITY

The magazine was originally designed for 600 cases of dynamite and 100 packets of detonators. Increased output above that originally planned and the incidence of hard floating stone bands, led to the necessity to build a further magazine to hold a further 200 cases. This has proved inadequate, however, and storage for a further 600 cases will be provided this year.

### COMMUNICATIONS

The mine has a P.A.B.X. 'Intercom' telephone system with 50 lines which is now working to capacity. Telephone communications through the G.P.O. are generally poor but it is said that they will improve when automatic dialling is installed. The installation of a telex system from the inception of the mine would have saved many man-hours and an application for the installation of such a system has now been made.

### CONCLUSION

The problem of under-design is a common one and is faced by all engineers when capital expenditure is restricted by the estimate of profitability of an enterprise. Our experiences at Bank have led us to the conclusion that the solution does not lie in using an excess capacity factor, or to put it another way, a safety factor, when choosing equipment. Preferable is a flexible design which permits multiplication of units of plant and equipment to achieve increases in production or meet weaknesses in capacity.

In the light of our present knowledge and experience, the conveyor belt speeds originally planned were too low but fortunately the design of drive heads was such that multiple motors could be used and the increased horsepowers required by higher speeds readily achieved.

More difficult was the solution to the screening problem as the design of the building and the flow sheet did not permit simple duplication of the dry duff screen. Had this been possible, it may well have been preferable to the provision of a complete new screening unit.