

The opening of new mines and the expansion of existing ones in response to the large increase in export demand has led to the recent development of the involvement of the large oil companies in the coal mining industry in South Africa. This has been prompted by the desire of such companies to diversify their interests into other energy sources. In so doing they have supplemented the risk capital of the finance corporations which has facilitated the necessary expansion plans. The oil companies (BP, Total and Shell) act in partnership with the finance corporations, but according to dichotomised functions. The mining houses remain responsible for the actual mining operations, whilst the oil companies handle transport and marketing as well as having prospecting rights of their own. As a result, additional capital can be raised and utilised, whilst each organisation specialises in that activity which it is best suited and equipped to perform.

(b) Marketing of Coal:

The accumulated expertise of the oil companies is particularly valuable in the marketing of export coal. This stems from the administration, contacts, communications, and infrastructure which they have built up in overseas industrialised countries. (The export quotas of the different organisations involved in the coal mining industry have already been presented in chapter 2).

Domestically, there are large tonnages of coal which are not marketed openly. SASOL I, II, and III at Sasolburg and Secunda receive their total tonnages direct from "captive" collieries at Sigma and Bosjesspruit respectively. Likewise, ISCOR receives the total tonnage from Durban Navigation colliery and will receive the bulk of the output from Grooteegeluk colliery although some steam coal from this colliery will be marketed elsewhere. ESCOM also operates a large number of power stations from "captive" collieries. In addition, ESCOM and ISCOR (together with the South African Railways) directly negotiate their other purchases with the coal producers under long-term contracts.

The remainder of South Africa's coal is marketed on a co-ordinated basis on both the domestic and export markets by four producers' associations:

Transvaal Coal Owners' Association (TCOA),
Natal Associated Collieries (NAC),
Anthracite Producers' Association (APA),
Coke Producers' Ltd.

The TCOA markets and distributes coal from its member collieries in the Transvaal and OFS; the NAC handles the bituminous coal produced by its Natal members; the APA distributes almost all the anthracite mined in the Republic (which is almost exclusively in Natal); and the Coke Producers handles the sales of all coke except that produced for their own needs by concerns such as ISCOR.

All the associations are co-operative, non-profit-making organisations whose function is purely marketing. Thus they attempt to ensure the efficient supply of coal to both the export and domestic markets by matching the production of their members to consumer demands and rationalising distribution. They promote the sale of coal, coke, and anthracite throughout South Africa, adjoining territories and other parts of the world, and also provide technical advisory services to consumers in the proper and efficient use of solid fuels. The TCOA maintains advanced technical laboratories in Johannesburg and Witbank where research and coal analyses are carried out and works in close co-operation with organisations such as the Fuel Research Institute in research programmes. These associations are generally regarded as having contributed materially to the stability of the industry (12) but they have often been the subject of criticism (especially the TCOA) that they are exercising a monopoly (13). This is defended in that the trade network necessary to distribute coal efficiently is outside the usual pattern for commodities and requires special knowledge of the industry. Whatever the reason, the selling organisations are a tightly-knit group. Fowler believes that it was imperative for the industry that it had an association such as the TCOA (14). "The benefits are wide. Our range of coal types and qualities varies substantially and so do the markets and coal uses. The TCOA has played a vital role in finding the best markets for each coal type, in helping generate demand and ensuring that the best use is made of coal, and in helping maintain quality control". However, whilst "inside" industry men and analysts have traditionally lauded the co-operative system of coal marketing, "outside" economists have stressed the dangers of monopoly and lack of competitive marketing.

The TCOA was first formed in 1907 and has functioned continuously as a co-operative marketing agency ever since. The primary objects which the colliery companies envisaged when forming the Association were:

- to reduce the extreme competition for the country's limited trade which had adversely affected the collieries' financial positions,
- to develop the industry by establishing an export and bunkering trade through Lourenco Marques and having a large tonnage of uniformly high-grade coal at the immediate disposal of the Association,
- to reduce the cost to the individual collieries of marketing the coal produced by them.

Writing in 1931, Graham was of the opinion that whereas the first two objects had achieved only partial and varying success, there could be no doubt as to the success of the third object. "The cost of administration of the Association is below three farthings per ton of coal sold, and it is doubtful whether the sale of coal is effected anywhere else in the world at such a low figure. It is largely due to this economy in sales organisation that prices to consumers generally have not been increased" (15). The principal markets for the Associations' coal were the shipping companies, railways, mining industry, industry in general particularly engineering and manufacturing, the ESCOM-owned Witbank Generating Station, and municipal power stations.

Writing in 1948, Hall (16) revealed that the bulk of the requirements of the mines, electricity undertakings and larger industries were supplied by the Association on long-term contracts. The smaller markets were the only outlets open to competitors who were all small producers. At that date the Association handled over 70 per cent of the coal trade in the Transvaal. Hall explained that the Association acted purely as a selling organisation, controlling neither the mining nor the preparation of the coal for market. Coal was purchased at an agreed price at the pit's mouth by the Association which then supplied its customers from the nearest suitable supplier. All sales were pooled and any surplus or deficit between the sales value and the cost to the Association credited or debited pro rata to the individual members.

Lategan explained in 1961 that although the Association did not directly control mining operations, it did control production to the extent of providing and allocating orders for the various classes of coal produced by each of its members on allotment basis in the total trade of the Association (17). In collaboration with the collieries, the TCOA attempted to balance production of the various grades and sizes of coal in relation to the needs of the market. Its major function, however, remained to efficiently market those various classes of coal.

A further benefit to the collieries of co-operative selling derived from output stabilisation enabling them to regulate labour to maximum advantage. More-permanent employment with uniform wages was ensured "allowing the married man to settle down and educate his family free from the constant dread of having to move elsewhere to obtain work" (18). Output stabilisation also enabled more-efficient regulation of mining operations generally whilst guaranteeing the consumer security and regularity of supply. Lategan revealed that, in this manner, distribution costs had been reduced to the remarkably low figure of less than one penny per ton on coal sold, thus reiterating the point made by Graham thirty years previously.

Co-operative marketing of coal started much later in Natal although the same basic principles apply. The NAC was formed in 1930 in pursuance of an agreement entered into between the collieries to regulate and control the output and sale of coal for local consumption and allocating this trade among the parties to that agreement. However, there are much larger varieties in technical characteristics between the various Natal coals so that supply from a common producers' "pool" is more complicated and less satisfactory than where all the coal has the same characteristics.

hall was adamant of the advantages of co-operative marketing. Such a system could only be justified if producers benefited and consumers were not harmfully affected. His reply was immediate "that co-operative marketing has benefited the producers can hardly be gainsaid and the present low price of coal at the pit's mouth indicates that consumers are not being overcharged" (19).

In the domestic market the TCOA has suffered a gradual decline in sales tonnage marketed due to the decision by the Railways to switch over to electricity for traction and the phasing out of the national

grid of old power stations using TCOA and NAC coal in favour of new large stations fed from captive collieries. In peak years prior to 1975 total TCOA and NAC domestic sales stood at 25 million tonnes per annum, but then fell to a low point of 20 million tonnes per annum in 1979. However, over this same period the export market has acted as the saving grace with exports rising from one million tonnes to 13 million tonnes per annum. In 1980 total TCOA and NAC sales stood at 36 million tonnes (or approximately one-third of the Republic's total sales tonnage) comprising 21 million tonnes for the local market and 15 million tonnes for export. Certain individual members of the TCOA hold export permits in their own right as well as exporting through the TCOA.

The TCOA played a leading role in setting up the Richards Bay coal-export drive and establishing the Richards Bay Coal Terminal Company. The undertaking became a reality when the TCOA signed a large contract with Japanese steel mills in the early 1970's for a specially-prepared low-ash coal. Although the TCOA and NAC have traditionally been separate bodies they were rationalised following the signing of this contract, so that they use the same staff. Thus the managing director, for example, or the general manager exports, serve both associations which are run from the same Johannesburg offices.

In recent years the ranks of the co-operative marketing associations are reported to have lost and gained one member. In 1980, small independent coal producers who were not party to the decision to establish the Richards Bay Coal Terminal Company have grouped themselves into a body called the Independent Coal Producers' Association (ICPA) with the intention of gaining access to increased exports. The RBCT is at full capacity and because it has been financed by its members there is no possibility of allowing outsiders to use it. Correspondingly the ICPA members are forced to export through Durban. It is reported that "little love is lost between the two organisations, the TCOA generally regarding the ICPA as opportunists and the latter the TCOA, NAC, and APA as monopolists" (20). However, in April 1982 it was strongly rumoured that the APA had broken up as a result of disagreements between the members on market and export shares (21).

The TCOA has continually refuted the monopoly allegations, stressing that it is only one operator in a competitive market. "Coal placed in the inland market is sold either directly to large consumers or to merchants who undertake local distribution. Although offering

coal from a total of 24 collieries, and a far-larger organisation than any other body concerned with the marketing of coal, the TCOA fulfils the same function" (22). It is denied that the TCOA is a closed shop because new members can be admitted at the discretion of the Board. However, this virtually excludes small independent producers since "members are expected to have substantial coal reserves and to be companies of some substance" (23).

TCOA membership is dominated by Anglo American, General Mining and Rand Mines who cumulatively account for over 70 per cent of TCOA allocations, or respectively, 25,117, 21,496, and 23,784. Other large members are Tavistock, JCI (13,368) and Lonrho (8,668). Profits accrue to each member on the basis of its percentage stake in TCOA. On the export market, each member's profit accrues individually and on the internal market if members do not wish to participate in particular transactions, whatever profit or loss accrues is only for consenting members' accounts. The TCOA employs four wholesale agents who sell a substantial share of its trade in South Africa and neighbouring territories. Notably, the Price Controller not only sets pithead-coal prices, but also determines the wholesale agents' commission and ultimately the price at which coal may be sold by the merchant is also fixed.

(c) Chamber of Mines:

The group system is complemented by the Chamber of Mines in that the financial corporations and individual mining companies administered by them work closely together through the Chamber to further their common interests. The Chamber was formed in 1887 "to collect, arrange and from time to time publish information connected with the mining industries of the Transvaal and particularly of the Witwatersrand Gold Fields, and to watch over and promote those industries generally" (24). Essentially the Chamber's objectives were to provide a means whereby mining companies could act in concert on matters of general importance to the industry. The end result was a sort of loose federation of companies facilitating close co-operation and consultation between them.

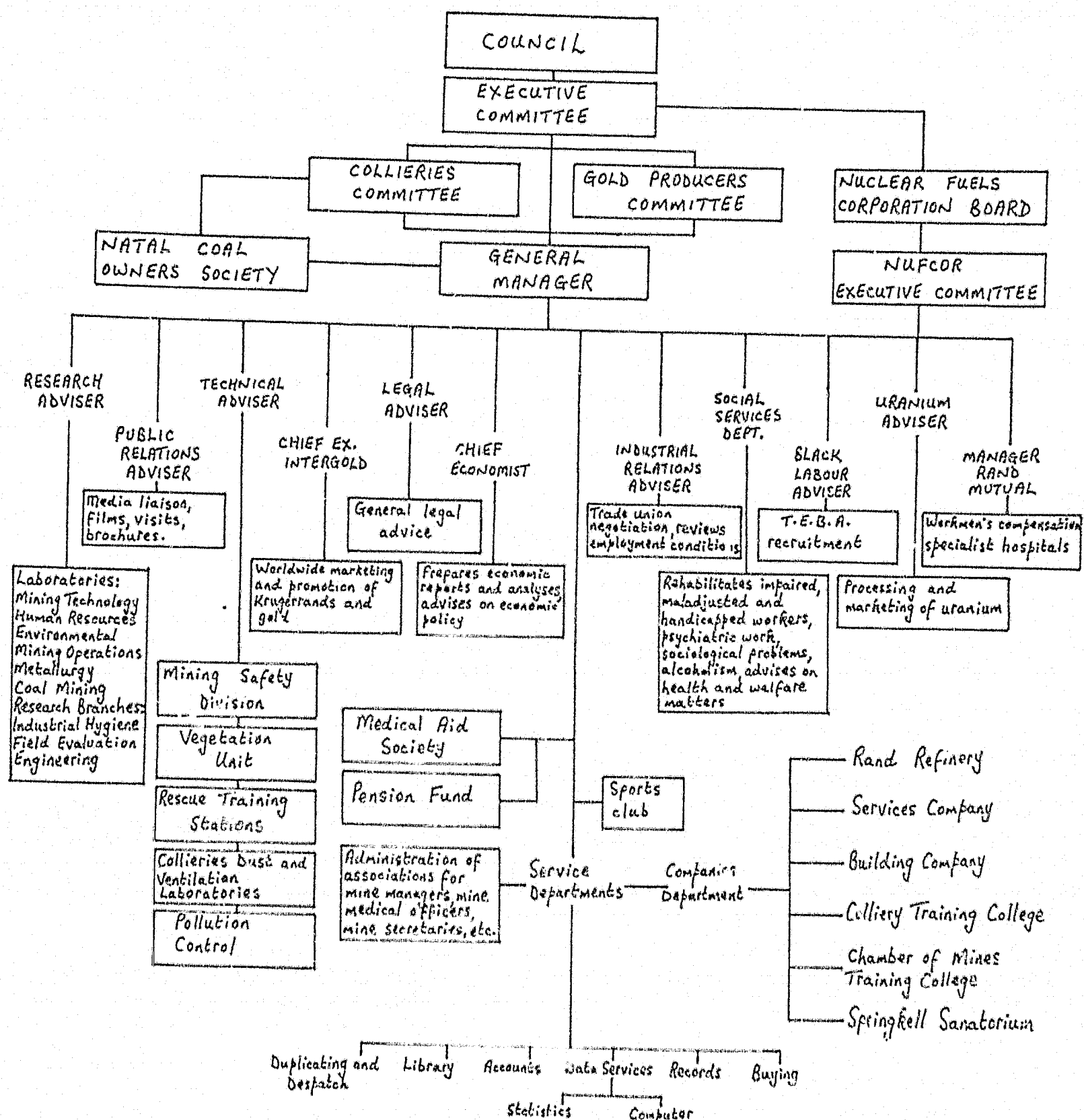
Its members finance the Chamber and also control it through an annually-elected Council. Decisions are made in the Chamber by committees consisting of seven people, one from each of the Groups.

There is a large number of such committees. The senior committee which makes industry policy decisions is the Executive Committee, complemented by two principal committees - Gold Producers and Collieries - which respectively consider matters concerned with gold and coal mines. The structure of the Chamber and its major functions are shown in figure 3.1.

Although the Groups work closely through the Chamber it does not in any way control or administer individual mines. Rather it could best be described as a central co-operative organisation charged with the function of looking after those mining interests of its members which are most efficiently handled on a co-operative basis. It is the accepted spokesman of the mining industry, speaking for the industry on all common matters of its members. It gives expression to the spirit of co-operation that characterises the industry and provides a forum for mining companies to discuss and formulate common policy and for recommendation or report on matters pertaining to the industry as a whole. The Chamber is also registered as an employers' organisation and, as such, it handles negotiations on all labour matters with its employees through their registered trade unions and officials' associations. It also acts as the spokesman of the employers in making representations to the Government.

Since the Chamber looks after the interests of its members on a co-operative basis, who, in turn, finance its operation, this enables them to pool resources and skills and provide a wide variety of services. It is, therefore, equipped financially, administratively and technically to serve the general interests of its members. As far as coal interests are concerned the Chamber has, since July 1975, incorporated the Natal Coal Owners' Society which has resulted in considerable advantages for coal-mining members from rationalisation of services and closer association. The full range of services provided by the Chamber to its members is shown in figure 3.1, and needs little further elaboration at this stage. More discussion of some of the services is undertaken in chapters 4 and 5. At this juncture it can be emphasized that there is a general belief that through the medium of the Chamber, with its expression of voluntary co-operation and accumulated experience in an atmosphere of free enterprise, there has been a significant contribution to efficiency and the expansion of the mining industry as a whole in

FIGURE 3.1 STRUCTURE AND FUNCTIONS OF THE CHAMBER OF MINES



Source: Chamber of Mines, Year-End Review, 1978

South Africa (25). It is claimed that, so far as is known, there is no other private-enterprise organisation anywhere in the world which compares with the Chamber of Mines of South Africa. "It is an employer organisation on a unique scale" (26).

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CHAPTER FOUR TECHNICAL FACTORS

Technical considerations are a strong causal factor in productivity growth in any industry, and coal mining is no exception. Such factors can be examined under two headings: (i) the mining method employed, and (ii) the rate of innovation of mechanical and technical advances into mining practice.

(i) Mining methods

The choice between available mining methods depends upon a combination of various factors:

- (a) Geological conditions. Important factors are the depth, thickness, dip, and relative proximity of the coal seams. These are compounded by the presence of faults, dykes, sills, dirt bands in the coal, the physical nature of the coal-bearing strata, the occurrence of underground water and inflammable gases, and the liability of the coal to spontaneous heating. All these factors must be borne in mind when deciding upon a particular extraction method to be employed in the interests of both safety and economics.
- (b) The "disagreeableness" of labour. In situations where labour is cheap, docile, and plentiful, labour-intensive methods will tend to be favoured.
- (c) The cost of mechanisation. Important considerations here are not only the purchase price of the capital equipment but the cost of borrowing and the nature of the tax structure.
- (d) The availability of funds. Since capital-intensive extraction methods require large initial financial outlays their introduction depends upon the profitability of the industry. This, in turn, is related to the selling price of coal.

- (e) The state of final demand. Capital-intensive extraction methods give rise to a larger level of output and hence require a buoyant and expanding state of final demand.
- (f) The extent of reserves. In a situation where reserves are generally regarded to be "unlimited", more-wasteful extraction methods can be employed.

Three methods of mining coal in the Republic have, and are, being employed with the magnitude of their utilisation depending upon the interaction of the six factors identified above. These are bord and pillar, longwall, and open-cast. Each of these will be discussed in turn.

Bord and Pillar

This method of mining originated in Britain and Europe, although it has been extensively amended and modernised over the decades. "Bord" is an old English word meaning "house". The miner used to excavate a bord in a coal seam using a pick axe, gradually hollowing out a "house" complete with roof, floor, and walls. Once the excavated cell reached the required size the miner abandoned it and commenced to hollow out another bord along the coal seam leaving an intervening pillar between the bords in order to support the roof (1). This concept has remained substantially unchanged over the years although the modern variant is to extract the coal by driving a chequer work of roads into the seam leaving pillars of coal between each road in order to support the roof. In driving this series of roads the miner's pick has been replaced by any of three methods (2):

- (i) Hand-got (labour intensive) where the coal is dislodged by pick or blasting and manually loaded by shovel into a tub mounted on rails which is run right into the area that is being mined. This is then pushed physically ("trammed") to a local station underground where it is attached to an endless-rope system for carriage to the surface.

- (ii) Conventional mechanisation, where the coal is dislodged by blasting after a chain cutter has cut a slot into the seam. An automatic loader gathers the fallen coal and transfers it to a shuttle car which carries the coal to a conveyor belt for transfer to the surface.
- (iii) Continuous miners (capital intensive) where a single machine cuts the coal from the face by means of a cutter on which is mounted a number of picks. The coal falls onto a gathering-arm loader which conveys it backwards and into a shuttle car which transfers the coal to a conveyor belt.

Thus, this method of mining may be undertaken with equipment ranging from the simple to the highly sophisticated. Whichever technique is chosen, bord and pillar tends to be a particularly wasteful method of extraction. A generally poor degree of recovery is necessitated through the requirement of leaving a high proportion of the coal behind in the form of pillars. The size of the pillars increases as the seams get deeper and thicker and at depths below approximately 160 metres the pillar size has to be increased to an excessive amount to meet safety standards (3). Pillar size also depends upon the strength of the coal. The initial degree of recovery also depends upon the height and width of the bords (roads) which are influenced by both economic and safety considerations. These include the nature of the roof, the type and size of mining equipment which has to pass along them, the extent to which the mining of other seams particularly overlying ones would be adversely affected and whether or not secondary extraction is likely to take place. Secondary extraction is particularly important. Coal can sometimes be recovered subsequently through the extraction of the pillars (stooping) allowing the roof to collapse in a controlled operation creating an abandoned collapsed area known as a "goaf" (4). However, this is not often possible in thick, shallow seams due to the danger of surface subsidence, and secondary coal-recovery operations may be confined to mining some or all of the coal left in the roof and/or floor, and/or "robbing" the pillars of only some of their coal.

Generally speaking, therefore, the deeper the seam the lower the initial degree of recovery due to the necessity of leaving large supporting pillars, but a high degree of final recovery can be achieved

through pillar extraction without the danger of surface subsidence. However, the shallower the seam the higher the initial degree of recovery because there is no necessity to leave large supporting pillars but subsequent extraction of these pillars may be impossible due to the danger of surface subsidence. Theoretically, therefore, bord and pillar mining is extremely adaptable in that it may be carried out over a wide range of working heights and seam depths. Maximum recovery is possible at deeper levels but this is outweighed by the greater mining complications and higher costs involved. Depending upon the economic and geological circumstances, and whether or not pillars are subsequently extracted, the degree of recovery may be between 30 and 80 per cent of the coal in an individual seam, and between 10 and 50 per cent of the coal in a mine with multiple seams (5).

In South Africa the traditional lack of concern regarding the depletion of her "inexhaustible" reserves, combined with the necessity to minimize mining costs, has led to the selective mining of only "easy" and shallow coal seams by wasteful methods. In the Transvaal and Orange Free State the shallow and thick nature of the seams has generally excluded pillar extraction. In addition, these pillars have tended to be large in order to support the roof indefinitely and thus avoid the expense of acquiring the surface rights and the need to compensate the surface owner for subsidence damage. Again this was necessitated by the need to minimize costs in the face of a low coal price and low profitability. (The recent developments of a higher coal price and bur,ant demand have led to plans to recover these pillars by open-cast mining). In Natal, however, where seams are generally thinner and of high quality it has been possible to practice pillar extraction and hence achieve a higher final degree of recovery.

Since the Coalbrook disaster in 1960 (when great loss of life was caused through a roof collapse stemming from pillars of inadequate strength) much research has been conducted on the optimum size of supporting pillars.

Longwall

Longwalling developed in Britain at the beginning of the nineteenth century, as a modification of bord and pillar mining. It involved the building of a track running alongside the coal face. The coal was picked or blasted from the face and loaded by hand into the rail-mounted

tubs for transport out of the mine. As the face advanced the worked-out area was propped with packs and the space between the packs was allowed to cave. The track was continually moved forward in line with the face and support at the face was provided by wooden and later steel props. Eventually these were superseded by hydraulic and friction props.

The modern variant of longwalling is to utilise a single machine which, in a series of to-and-fro traverses along the length of the face, strips the coal directly onto a conveyor-belt system for transport out of the mine. The roof is completely under-pinned for the full length of the face by a system of hydraulically-operated props which, as the face moves forward, are advanced in step. Occasionally the worked-out area is filled with waste material to hold up the roof, but more often "goafing" is practiced. This is the controlled process by which the roof over the worked-out area is allowed to fall in behind. The process is a gradual one, rather than a sudden collapse, with the subsidence continuing all the way to the surface. Depending upon the depth of the workings the whole process may take several months. The surface effect is often barely noticeable.

Longwalling is suited to deep or dipping coal seams where the use of bord and pillar mining would be impractical. It can be performed on the advance or on the retreat. In the advancing system the coal is extracted from the colliery shaft to the boundary edge, whilst in the retreating system the direction of recovery is the opposite. In longwall-advancing the coal is extracted in panels by advancing the face on a broad front into the unworked coal, steadily proceeding away from the main haulage roads to a boundary. This entails that the access, haulage, and ventilation roadways have to be kept open in the worked-out area by providing packing and other support in the form of packs of stone, timber props (originally) or hydraulic props (modern variant). This is not necessary in the case of longwall-retreating which, in effect, is a combination of longwall-advancing and bord and pillar extraction. Roads or headings are driven into the solid coal as far as a boundary marker, but at much wider intervals than in bord and pillar, leaving larger pillars. The pillars are then extracted on a broad front retreating from the boundary in the opposite direction from that in which the headings were driven.

Longwalling does possess several disadvantages. The equipment involved is specialised and expensive, and, therefore, capital

expenditure tends to be higher than in bord and pillar. Depending on the length of the face the capital cost of the machinery can exceed several million rand. In addition, because of the nature of the mining operation, involving the controlled collapse of the roof and the supporting of access roadways, more attention has to be paid to safety matters and accident prevention and more-elaborate precautions must be taken than in bord and pillar. In other words a more - disciplined mining technique is required involving a better-trained and more - sophisticated (and hence more-expensive) labour force. However, the additional costs associated with longwall mining can be outweighed by its greater efficiency. Extraction rates of up to 90 per cent are possible if the right combination of conditions is prevalent, so that little of the coal is wasted. In addition, the speed at which the coal is extracted per working shift is far higher than in bord and pillar.

Before longwalling can be practiced certain conditions pertaining to roof strata, depth below surface, and thickness of seam must be met. The roof strata must be sufficiently strong to eliminate the risk of premature roof collapse, particularly along the region of the coal face as this would damage and/or imprison the longwall machine and delay further mining operations. Because of the expensive nature of the machinery it is necessary to obtain maximum usage and longwalling would become an uneconomic proposition if frequent roof movements prevented uninterrupted production. Recovery and repair of the equipment, and the restoration of the working face subsequent to such events are not only dangerous and onerous tasks but may take days or weeks to accomplish, involving serious coal losses and idle machines and manpower. The minimum depth of longwalling is generally regarded as 160 metres. At shallower depths than this the practice of "goafing" results in serious surface subsidence necessitating the additional expense of the purchase of surface rights or the payment of compensation to surface owners. The alternative to "goafing", namely packing the worked-out area with waste material to prevent roof collapse, is, however, also an unduly expensive operation. Lastly, longwalling is not suited to a mining height of much more than 3 metres because in excess of that height safe support at the face becomes either too expensive or impracticable.

Even if the above conditions are met, high extraction rates and rapid coal recovery still depend crucially upon other factors. In comparison with bord and pillar, longwall is an inflexible system

because of the high degree of interdependence of personnel performance, geological conditions, and equipment capability. In mechanised bord and pillar, short-term failure or less than adequate performance of labour or machinery, or relatively adverse geological conditions, will not necessarily bring production to a standstill, as is often the case in longwalling. In conventional mining the replacement of equipment or the augmentation of labour can help to maintain production levels in adverse conditions which is not the case in longwalling. Other problems are related to the flow of water into the workings (which can hamper operations), the presence of dirt bands in the coal seam (which makes cutting difficult), and the presence of dolerite dykes (which complicates the longwall-panel layouts). Such dykes are located by means of long horizontal holes drilled into the coal face often up to two kilometres in length. What longwalling boils down to is an extremely efficient method given perfect conditions.

Shortwalling is a variation of longwalling with mechanised supports. Under this method a continuous miner works in front of the supports which have to be massive and need very long cantilevers over the miner. Because shortwall development is awkward it has not proved very successful and is infrequently used.

A method of extraction which can be described as a mixture between longwalling and bord and pillar with pillar extraction has recently been successfully introduced at Sigma colliery. It is called rib-pillar extraction although it is named the "wongawilli" in Australia where it was originally pioneered (6). Unlike conventional pillar extraction, which formed square pillars on the advance and were then extracted on the retreat, the wongawilli method advances with a few roadways to the end of a panel which is to be mined. Turning at right angles the coal is mined to the end of the panel width, creating long rib-pillars which are immediately extracted on the retreat. With this method, therefore, extraction takes place in a solid block of coal. It is specially designed for the continuous miner in the stooping process and not merely an after-thought of how to remove already-created pillars. Its two main advantages are a high-percentage extraction (in excess of 95 per cent) with low capital and working costs. It is a concentrated mining technique creating only a single working place to supervise, and since less intersections are involved than conventional pillar extraction, rockfalls are reduced (7).

Open-Cast

Historically this method of mining is the oldest, using simple tools to remove coal from surface outcroppings. It is also known as open-pit or strip mining and is closely related to quarrying. It involves a trenching operation from the surface down through the overlying rock and soil to expose the coal. This is then mined concurrently with the further clearance of overburden but as a separate operation. A series of deeper seams can be uncovered and mined in succession by progressively deepening the trench in a series of steps. The overburden which is removed is dumped back into a contiguous parallel part of the excavation from which the coal has already been mined.

Whether or not open-cast mining is an economic proposition depends upon the cost of removing the overburden in relation to the value of the seam mined. The higher the ratio of overburden depth to seam thickness the less viable the method becomes.

The major disadvantages of this method of mining concern the high capital expenditure incurred and the despoilation of the land surface (8). The stripping of overburden necessitates the employment of "walking dragline scrapers", together with equipment to win and remove the exposed coal, which may amount to capital expenditures in excess of R20 million. In putting this considerable capital outlay to most advantageous use, overburden-stripping operations are normally pursued 20 hours per day for seven days per week, and the coaling equipment used for two shifts per day, six days per week. The expensive nature of most walking draglines means that provision can seldom be made for a standby machine to take over in the case of a breakdown. Usually the entire operation relies on the uninterrupted functioning of a single machine, which necessitates that they must be of a particularly sound and robust construction. In addition, the delay between placing an order and receiving a new machine often runs into several years.

Unfortunately, this method of mining causes excessive despoilation of the land surface and many countries have found it necessary to legislate provisions to compel the mine owner to restore the surface to acceptable standards. This also is an expensive undertaking. It entails regrading the top of the spoil pile and returning the top soil to prepare the ground for suitable vegetation.

This expensive nature of open-cast mining means that extensive preparatory studies have to be undertaken to determine the feasibility of the operation. The ratio of overburden depth to seam thickness is not the only factor to be considered. The nature of the overburden can either be soft and easily removed (as in parts of Europe) or of a more difficult nature necessitating fracturing by explosives before it can be removed (as in South Africa). In addition, if poor-quality seams form part of the series mined, a ready-made market must be close at hand to utilise the inferior coal or else it will be dumped with the overburden. However, this has not been a problem in South Africa with several open-cast operations being "tied" to ESCOM power stations and this captive arrangement is ideal for poor-quality coal utilisation. Related to this is the depth of good-quality seams in relation to poor-quality seams. There is limited opportunity for economic success if poor seams have to be negotiated before reaching higher-quality seams. A sufficient quantity of coal must be produced and sold at a high-enough price for capital expenditure to be recouped within a reasonable time and well before equipment is worn out. However, the "captive" arrangement with ESCOM power stations has again by-passed this problem.

Set against the drawbacks of open-cast mining are the advantages of a high degree of recovery (often in excess of 90 per cent), with a small labour force, a greater degree of safety than can be attained by underground methods, and lower operating (as opposed to capital) costs.

(ii) The Rate of Mechanisation

The mining and preparation of coal involves four distinct operations:

- (a) the breaking of the coal (encompassing cutting, drilling, and blasting),
- (b) the loading of the broken coal into suitable containers prior to transporting,
- (c) the transporting of the coal (encompassing two stages, namely, hauling the coal from the face to the shaft bottom, and hoisting the coal from the shaft bottom to the surface),
- (d) the preparation of the coal for marketing (washing).

It will be convenient to examine the rate of mechanisation of these four operations under three separate historical periods. However, it is worth remembering that technological change has not been confined solely to the breaking, loading, transportation, and preparation of the coal. Advances are continually registered also in methods of mine drainage, ventilation, lighting, support, and other so-called auxiliary functions. Such improvements render possible the working of seams which formerly could not have been exploited. They must also affect productivity levels but mainly in ways which are indirect and difficult to evaluate (9).

Progress until the early 1930's

Coal output in 1933 was approximately the same as in 1920, the industry having just experienced a sharp recession. It was, however, poised for rapid expansion and hence the period of the early 1930's acts as a convenient watershed date.

The cutting of coal in the early collieries was performed by hand by black labourers using pick axes. In one shift (or longer, depending on the hardness of the coal) a labourer would undercut one "square", 6 metres wide and 75 centimetres deep. This was an extremely tiring task. Around the turn of the century some of the larger collieries began to experiment with various types of compressed air (pneumatic) machines for undercutting coal. Natal led the way with Natal Navigation introducing Jeffrey machines and St. George's colliery introducing Sullivan punchers both in 1904. The Transvaal lagged slightly behind Natal, but the Witbank colliery introduced Sullivan punchers in 1906 and other collieries introduced the improved Hardy and Siskol percussive cutters shortly afterwards. By 1908, a total of 66 compressed-air machines were in use. In retrospect these machines received a mixed reception. Some collieries considered them to be a great success whilst others described them as clumsy and cumbersome with disappointing performances (10).

Paradoxically the use of electric coal cutters preceded compressed-air machines. The first recorded use in Natal was in 1899 when a test machine was installed in an electrified colliery whilst the Transvaal introduced a test machine in 1902. The results of these initial tests proved successful and electric machines began to be permanently installed in Natal collieries from 1901 and in the Cape from 1911. The

Transvaal collieries had to wait until 1915 for the first permanently-installed machine, presumably due to problems in fiery mines. All machines were rail mounted and were either of British or American construction. The earliest machines were shortwall cutters manufactured either in America by Sullivan, Jeffrey, or Goodman, or in Britain by Mavor and Coulson. They were of the chain type and mounted on self-propelling trolleys to enable them to travel from face to face. Once in the desired position they were unloaded by means of their own power. They were "sumpted in" to a depth of approximately 2 metres and cut across a face 6 metres wide. In addition to cutting on the floor they could also operate from benches up to one metre high. Their weight was between 3 and 4 metric tonnes (11).

These machines reigned supreme for many years until they gradually began being replaced by arcwall machines in the late 1920's. The early arcwall machines suffered from their excessive weight of between 8 and 10 metric tonnes but when more-compact models were introduced about 1928 increasing numbers of them came into use. Arcwall machines were of various types either with a cutting jib permanently mounted at a fixed height or with a variable jib capable of cutting at various heights, and equipped with rotating performances between 270° and 360° . The machines were permanently mounted on self-propelling trolleys and had the advantage that they could be operated directly from the track. No time was wasted in loading or unloading the machines (12). Cutters manufactured by Mavor and Coulson (Britain) and Jeffrey and Goodman (America) were the most popular makes.

The early 1930's was, therefore, a remarkable period in that coal was cut by three different methods simultaneously - hand, air machines, and electric cutters (shortwall or arcwall) although the first two were being superseded by the latter. This is illustrated in the following table.

TABLE 4.1 COAL CUTTING IN THE WITBANK DISTRICT

YEAR	Number of Air Machines	Number of Electric Cutters	TONS BROKEN (in millions of short tons)		
			BY HAND	BY MACHINE	TOTAL MINED
1920	208	10	1,2	4,4	5,6
1925	241	14	0,6	5,1	5,7
1930	94	66	0,3	5,6	5,9

Source: A.C. Graham, The Coals of the Witbank District, Transvaal Chamber of Mines, Collieries Committee, 1931, page 35.

An associated activity of coal cutting is that of drilling which became necessary for the drilling of shot holes once the early collieries began to utilise gunpowder. The first and simplest innovation was that of the hand-operated auger, a metre-long round iron with a twist of steel welded on one end and an eye, for the insertion of a wooden handle, at the other. This proved to be satisfactory in soft coal but not in harder coal banded with shale where a hand-operated ratchet drill was utilised. These drills were stand-mounted and hence steadier than the augers but because they were utilised in harder coal they tended to have the same footage capacity as the augers.

Efforts to improve on hand drilling naturally centred around the use of compressed-air drills and electric drills. Paradoxically, as in the case of coal cutting, it was electricity which preceded the use of compressed air. A Jeffrey electric coal drill was used on test as early as 1899 at the Lewis and Mark's collieries at Vereeniging. However, permanent installation did not come about due to a combination of reasons: excessive weight, low horse power, inability to penetrate pyritic bands, and time taken to erect the drill on its stand. Instead compressed-air jackhammer drills were introduced and were fairly widely employed on collieries until the early 1930's. The weight of such a drill was approximately 20 kilograms and required two black labourers to operate it. It was only from late 1931 onwards, after successful experiments had been performed with more-efficient, lighter, and easily-transportable electric drills, that these jackhammers began to be ousted as the main form of coal drilling.

Again, therefore, as in the case of coal cutting, the early 1930's was a remarkable period in that coal was drilled by three different methods simultaneously - hand-operated auger and ratchet drills, compressed-air jackhammers, and electric drills, although the latter was poised to assume the ascendancy (13).

The last activity associated with breaking the coal is that of blasting. Although early coal production in the Cape did not utilise explosives at all, gunpowder was probably introduced fairly soon. The emphasis was on the production of a high percentage of large coal and this was effectively achieved by means of black powder in pellet form. The early Transvaal collieries towards the end of the century tended to use 30 per cent dynamite (i.e. 30 per cent nitroglycerine in composition) with the charges being blasted by the use of a fuse ignited by a naked light. The serious implications this had for safety led to experiments utilising hot irons to ignite the fuse as well as electric blasting. However, electric blasting suffered from the disadvantages of misfiring as well as difficulty in keeping check on the number of shots that had taken effect. As a result it was never really considered seriously, and the use of fuses for blasting predominated during the first three decades of the century. By the early 1930's the emphasis was still on the production of large coal and modifications in blasting practices were always made with this objective in mind. Limited experiments were carried out using liquid oxygen, but the prevalent method was to use dynamite varying in strength from 10 to 20 per cent to blast the coal and gelignite for use in stone work, such as taking up rolls in the floor, these being fired either by fuse or electric detonators.

The next activity after breaking the coal is loading the fallen coal into containers suitable for transporting out of the mine. By the early 1930's no progress had been made in mechanising this operation, it being carried out exclusively by hand labour using shovels. Mechanical loaders had been innovated into American collieries several years before, but South African mine management preferred to persevere with black hand loading. However, efforts were directed towards the means and methods of hand shovelling. Among other things, shovels were re-designed, lower tubs were constructed, miners were instructed in proper techniques of shovelling, and incentive wage schemes and bonuses were introduced. Even these small changes made for sizeable increases in labour efficiency.

In the early mines coal was undoubtedly loaded directly into baskets on the backs of mules for haulage from the face. Wooden tubs mounted on wooden skids were also probably employed, initially being hand trammed but later pulled by mules as the face advanced. These were later replaced by steel tubs running on steel rails, again either hand trammed or pulled by mules. The application of power to underground haulage occurred well before the end of the century. Gradually mules began to be replaced by single-drum winches of up to 15 horse power, or occasionally, gravity-operated jigs. Electric locomotives were even employed as early as 1903 at Elandslaagte and at Dundee but were soon phased out due to their expensive maintenance and the dangers associated with overhead conductors (14). Instead endless-rope haulage became the universally-accepted haulage method on South African collieries. Steam-haulage engines were soon replaced by electric engines and this remained the procedure for many decades.

Endless-rope haulage was particularly suited to South African colliery conditions for several reasons (15). The seams were generally flat thus eliminating steep gradients underground except for minor undulations. Roof conditions were good requiring no timbering, and haulage roads were wide - in excess of 6 metres. It was also a simple and reliable method which could be quickly understood by unsophisticated and untrained migrant black workers. Although the system remained unchanged, minor improvements and adaptations were continually made. By the early 1930's tubs were generally constructed of steel plate erected in sections, with the attachment for the hooks ("jockeys") either on the tub or on a bridle in the centre. The capacity of individual tubs varied between 600 kilograms and one metric tonne, the choice depending upon the colliery management. Ropes were usually plough steel approximately two centimetres in diameter. Each black loader was allotted a fixed number of tubs to fill during a typical 8½ hour shift. Depending upon the size of the tub and the undulations on the floor, either one or two loaders operated per tub. The loader obtained his tub at the nearest haulage rope, trammed it to the face, loaded it with coal, and trammed it back to the haulage. A crucial factor in tonnage loaded per man was, therefore, the distance involved in tramping and it was imperative that the haulage was as near to the working face as possible.

Once the full tubs had been hauled to the shaft bottom the next problem involved hoisting them to the surface. The first shafts in the early collieries were vertical following the usual practice in Britain and introduced into South Africa by British coal miners. The full coal tubs were hoisted to the surface by means of a steam-operated cage. The first incline shaft for hoisting was constructed at the Cassel colliery in the Transvaal in 1896. The early inclined shafts were fairly steep and made endless-rope haulage a hazardous task in view of the tension generated. However, with the gradual reduction in hauling gradients, improvements in the grading of the tracks at the surface and shaft bottom, and increased use of improved jockeys, endless-rope haulage through inclined shafts became the accepted system of hoisting coal tubs from relatively shallow depths. An alternative method of hoisting coal through inclined shafts was by means of a conveyor belt, first introduced in 1904 at the Transvaal and Delagoa Bay No. 2 colliery. Despite proving successful it was not until 1928 that other collieries followed suit in installing conveyor belts for hoisting. The full coal tubs were hauled into a rotary tippler at the shaft bottom which tipped the tubs and delivered the coal into a receiving hopper. The coal was then fed on to the shaft belt by means of jiggling feeders. Depending upon the depth and tension it was often necessary to handle the coal in two stages by installing two conveyor belts working in tandem. Halfway down the shaft would be a transfer station where the lower belt discharged on to the upper belt. By the early 1930's all three methods of hoisting just described were in operation at different collieries. Of the fourteen collieries operating in the Witbank district, two were using vertical shafts, four were using conveyor belts through incline shafts, and the remaining eight endless-rope hoisting through incline shafts.

The screening and washing of coal is the final activity prior to its marketing. The first efforts were extremely primitive. They were confined solely to screening out the small coal for which there was no demand. The full tubs were tipped onto an inclined fixed-bar screen, the large coal being trapped on the bars and slipping down on to a wooden chute for bagging. This method was extremely slow and became inefficient as colliery outputs rose rapidly during the 1890's. Brakpan colliery was the first to introduce a mechanical screen in 1892 and more-advanced screening plants were later introduced in Natal in 1898 at

Natal Navigation and St. George's collieries. These consisted of jigging screens and picking tables. Although these plants could adequately deal with large coal, it was difficult to pick clean the small coal produced from the thin Natal seams, and it became obvious that it was necessary to clean the smaller coal. 1904 saw the first washing plant introduced in Natal and by 1909 ten Natal collieries had installed washing plants (16). The object of cleaning coal is twofold. Firstly, clean coal burns better and requires a smaller boiler installation. Secondly, railway-haulage charges have been, and are, heavy, and it is uneconomical to pay railage on non-combustible impurities (17). The situation in the Transvaal was unlike Natal in that thicker seams were being worked and the coal roof did not contaminate the coal to the same extent as in the thinner Natal seams. Consequently no washing plants were installed in the Transvaal until as late as 1932 and collieries managed with only screening and hand picking. By use of either rotary screens or double-acting perforated-plate jiggers all coal in excess of 4 centimetres (classified as round coal, export coal, or cobbles) was localised and picked clean of stone, shale, and other foreign matter on the picking tables. Coal under 4 centimetres fell through the holes in the jigger to be subjected to a secondary screening process using a wire-mesh revolving screen to separate out nuts, peas, and duff coal.

Further Progress until the early 1960's

From 1932 to 1962 coal sales production increased more than fourfold from 9,7 to 41,0 million metric tonnes. Despite this expansion the vast majority of coal was still obtained in the early 1960's by the tried-and-tested method of hand loading, hand tramping, and endless-rope haulage. As late as 1960 two hand-got collieries were still persisting with mule haulage underground, whilst another two operated short endless-rope section haulages delivering to section tipplers feeding to a belt-conveyor system, and another colliery had section tipplers delivering to locomotive-hauled drop-bottom cars. The rest of the hand-got collieries used endless-rope haulage from the face to the shaft bottom (18). Hoisting on the hand-got collieries was mainly by endless rope through inclined shafts and with surface tipplers, but several operated conveyor belts through inclined shafts with underground tipplers, and one persisted with vertical hoisting with surface tipplers.

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The main feature of this period, however, was the innovation of power loading into South African collieries and the "trackless revolution" which this ushered in (19). The first mechanical loader was acquired by Klipfontein colliery in November 1947. The unit operated with eccentric arms and gathering flights and was caterpillar mounted thus making it independent of rail tracks and giving it greater mobility. The loader was initially used to fill tubs which were then hand trammed to the endless-rope haulage, but this process was slow and intermittent and could not compete with hand loading. Consequently the use of the shuttle car was decided upon. These arrived in December 1948, after the mine had closed down, but were transferred to the new Klippoortje colliery which was in the process of being established. Simultaneously, two other new collieries, New Clydesdale and Raleigh, and the already-established Albion colliery, were also commissioning mechanical loaders and shuttle cars. In fiery mines, battery-operated cars had to be used, whilst cable reels could be employed on non-fiery mines.

These "trackless" developments paved the way for the freeing of the arcwall coal cutters from rail mounting. Accordingly caterpillar mounted and rubber-tyre-wheeled coal cutters made their appearance underground.

The sequence of operations involved in this trackless mechanised mining encompassed the power loading of the fallen coal into a shuttle car which trammed the coal to the shaft bottom where the car deposited the coal into a receiving hopper which, by means of a feeder, regulated the flow of coal onto a conveyor belt for hoisting to the surface through an inclined shaft (20). As the face advanced away from the shaft bottom, however, the tramping distance of the shuttle cars increased to such an extent that the loader was under-utilised. Consequently the conveyor belt had to be extended periodically to reduce the shuttle-car tramping distance.

The above sequence was almost universal on the mechanised collieries, but with isolated exceptions. On two collieries the section conveyor belts delivered into mine tubs hauled by endless ropes, and one colliery employed eight-tonne drop-bottom rail cars filled by a rail-mounted loader and hauled by electric trolley-wire locomotives to a shaft-bottom bin discharging to a shaft conveyor belt (21).

By the early 1960's several significant developments had been made in blasting. The most generally-used explosive on hand-got collieries was Monobel No. 1. Since this was water sensitive, Ajax was used in wet holes either as a primer only or for the whole charge. The majority of such collieries used instantaneous electric detonators, but two non-fiery mines used safety fuse either wholly or partially. On mechanised collieries Monobel No. 1, Ajax, or Saxonite explosives were employed, only the former being water sensitive. Detonation was invariably by electric detonators predominantly of the instantaneous type. However, two collieries were using milli-second delay and one non-fiery colliery was using one-second delay (22). Delay firing causes more-effective fragmentation than simultaneous firing, but there is a problem that an early shot may release fire-damp which can be ignited by a later shot. This was particularly prevalent in the one-second delay but with the milli-second delay sufficient time is not allowed to elapse so that explosive gas can be liberated by one shot and ignited by another. Koornfontein colliery was the first fiery mine to employ milli-second-delay blasting in 1956. The advantages claimed for short-delay firing (more effective breaking, less explosives used, and less fumes and dust) were also claimed for another significant blasting development under trial in the late 1950's - the combination of blasting with water infusion (23). Water was infused through the shot hole into the surrounding coal and a charge was fired. Thus whereas conventional blasting operated by shockwaves, causing cracking, and gas pressure, resulting in bursting through the cracks, water-infusion blasting operated by high-pressure impulses in water.

A final significant development during this period was the employment in 1958 at Coalbrook North colliery of a machine which not only eliminated the need for blasting, but combined the cutting - drilling - blasting - loading sequence into a continuous operation. (24). This was achieved through the use of a borer-type of continuous miner manufactured by Goodman which produced the coal by means of a boring operation. The fallen coal was gathered onto a chain conveyor and loaded directly into shuttle cars.

By the early 1960's, therefore, coal mining in South Africa represented a combination of methods across the full range of sophistication - hand-got, mechanised, and continuous miner, although the former was destined to keep the ascendancy for several years to come. The table below shows the number of collieries operating different methods in 1961.

TABLE 4.2 MINING METHODS EMPLOYED IN SOUTH AFRICAN COLLIERIES: 1961

<u>AREA</u>	<u>NUMBER OF COLLIERIES</u>		
	<u>HAND-LOADING</u>	<u>MECHANISED</u>	<u>COMBINED</u>
Witbank-Middelburg-Breyton	19	6	5
Vaal Basin	3	1	2
Natal	19	-	1

Source: A.E. Fraser, "Coal Mining in South Africa", Transactions of the seventh Commonwealth Mining and Metallurgical Congress, 1961, page 901.

Finally, developments in coal washing can be mentioned. By 1932 no washing plants had been installed in the Transvaal, these being witnessed only in Natal. The early washers had employed the concept of inducing stratification of the closely-sized raw-coal feed in a suitable wash box according to the specific gravity of the individual particles, by means of a jiggling action or by means of air pulsations - the Baum washer being a popular version of the latter (25). Between 1932 and 1940 a "washer revolution" took place in the Transvaal with eleven plants being installed, in the main taking advantage of a new concept developed earlier in the United States of America. The principle employed an artificially-maintained high-specific-gravity bath in which inferior coal and shale sinks whilst clean coal floats (26). The bath maintained a constant high specific gravity by agitating a mixture of water and some suitable heavy medium in very fine granular form. A mixture of sand and water comprising the "Chance" process was the first successful process, followed by other heavy-medium washers using magnetite as the medium (27). By 1957 a total of 18 large-capacity washing plants were in operation in the Transvaal and the Orange Free

State accounting for 9 million metric tonnes per annum. Before the incorporation of heavy-medium washing, developments and improvements in jig plants had given coal producers many types of jig processes to choose from. They had reached the stage of being able to handle coal from 15 centimetres down and some jigs had even developed to the stage of incorporating a kind of double-stage separation. The competition from heavy-medium washing in the 1930's induced further modifications and refinements from jig manufacturers designed to improve washing performance and to increase the size range of coal handled, with the result that by the end of the 1950's coal producers had a washing choice between jigs, modified jigs, semi-heavy-medium jigs, sand flotation, and the heavy-medium processes (28).

Progress Since the Early 1960's

This has been a period of rapid expansion of the coal mining industry and has been characterised by three major developments, namely,

- increasing mechanisation of bord and pillar mining,
- the introduction of longwall mining,
- the rapid expansion of open-cast mining.

Developments in bord and pillar mechanisation can be examined under the usual headings of cut, drill, blast, load, haul, and hoist. Although caterpillar-mounted coal cutters continued to be utilised, rubber-tyre-wheeled cutters assumed popularity, the Joy 10RU and 15RU being favourite models, with hydraulic disc brakes and steering, and double front driving wheels. Caterpillar-mounted face drills also made their appearance underground, and more recently a popular innovation has been the crawler-mounted hydraulic rotary-drill rig which is one-man driven and uses a rotary-thrust boring action (29). A one-man-operated rubber-tyre-wheeled electro-hydraulic drilling machine has been another recent development. In the field of blasting, a system of breaking coal by means of highly-compressed air instead of explosives, the Armstrong Airbreaker, was innovated in 1962 at Natal Ammonium colliery (30). The unit consisted of a compressor which delivered high-pressure air to the various working areas through a steel-pipeline network. A steel shell placed in a drill hole was charged with high-pressure air through a special shooting valve which discharged at a pre-determined pressure causing the coal to break out. Other Airbreakers were quickly innovated at Northfield, Natal Anthracite, and Ballengeich (31).

A problem sometimes encountered in bord and pillar mining are lines of weakness in the roof which can develop into roof falls. Timbering is usually successful in dealing with these types of problems. However, in mechanised mining where bulky equipment, such as shuttle cars, is employed for tramming, there is the danger of dislodging such timber and hence, roof bolting becomes the only alternative. Roof bolting cannot deal with severe ground movements but can eliminate the smaller type of dangerous ground movement and falls, especially around the perimeter of advanced working areas. By reinforcing the immediate beds around excavations the forces acting around new openings may be controlled to some extent. At first bolt holes were drilled by means of rotary electric drills and bolts were fastened by hand, but a roof-bolting machine (Joy RBD-11) was installed in 1958 at Sigma (32). After this date roof bolting by machine became an accepted principle and several models were popularised (33).

The LHD system ("load-haul-dump", encompassing power loading of the broken coal into a shuttle car or other suitable conveyance for tramming from the coal face and dumping into a receiving hopper for feeding onto a continually-extendable conveyor-belt system) remained unchanged in concept, although improvements and adaptations to individual pieces of equipment have frequently been made. Shuttle cars in particular have been subjected to many modifications. The first diesel-driven shuttle car was installed at Blinkpan in 1962 (the Torcar being a popular model) (34). Of the battery-driven shuttle cars, the Jeffrey Ramcar was an interesting model and was first employed in 1967. It was basically a tractor-trailor arrangement pivoted in the centre. Loading from a gathering-arm loader was facilitated by an hydraulically-operated telescopic hopper and unloading by means of an hydraulically-operated ram (35). Witbank Consolidated Coal Mines provided an interesting substitute to shuttle-car tramming in the form of diesel-driven dump trucks. These were installed in 1960 (36). They received the coal from a gathering-arm loader and trammed it to a scraper-chain conveyor where it was dumped and elevated into eight-tonne main-haulage bottom-dump hopper cars. These were hauled to the shaft-bottom hoisting conveyor belt by an electric locomotive with overhead trolley wires. In 1962 these diesel dumpers were supplemented by two other six-tonne-capacity diesel dumpers, known as Ferret swivel coal cars, and powered by industrial-type tractors (37). The dumper bin was hydraulically tipped.

A recent development designed to eliminate the traditional loader and shuttle-car combination is the Dowson and Dobson Supa Scoop (38). The unit is battery operated and a low-profile machine designed to operate in low coal seams. Tight turning circles are achieved using an articulated chassis, and the carrying bucket handles a four-tonne payload with a pusher plate for discharging the coal. The Ingersoll-Rand S and S battery tractor is a competing unit also designed to carry out heavy scoop-tram-and-discharge work between the face and the conveyor-belt system (39). Smaller battery-operated scoops are also used for clean-up work behind continuous miners and for cleaning up spillage from shuttle cars.

The "continuous-miner revolution" combining the cutting-drilling-blasting-loading operations into a simultaneous activity had commenced in 1958 with the installation of a Goodman borer-type machine at Coalbrook North colliery but the first conventional-type continuous miners were not installed until 1960, at Sigma colliery (40). This can be described as basically a track-driven machine with a hydraulically-operated boom at the front on which is mounted a cylindrical cutting drum with tungsten-carbide-tipped picks arranged in a helical configuration. Cutting is effected by means of a sump-shear operation in which the revolving drum is advanced into the coal face and raised or lowered to shear away the coal in the cut. The fallen coal is removed via a gathering head and chain conveyor and loaded into a shuttle car at the rear of the miner for tramping to the conveyor-belt system. (A description of the operating characteristics of a Lee Norse continuous miner as introduced at the Sigma colliery in 1966 is undertaken by Coal, Gold and Base Minerals of Southern Africa in reference (41); whilst the introduction, technical characteristics, difficulties and modifications experienced with an unnamed rotary-drum miner at Coalbrook in 1970 are analysed by Burnton and Ferguson (42)). Although the operating concept of all continuous miners is universal, differences do exist in details between different models and manufacturers. Thus the Fairchild Wilcox 21, innovated into South Africa at Kempslust colliery in 1980 utilised dual forward-pointing augers rather than the more-usual lateral cutter drum. The machine has no crawler tracks and manoeuvres and advances by means of wire-rope winches and anchor jacks, and instead of cutting straight ahead, as most other miners do, it fans back and forth in windscreen-wiper fashion (43).

The operation of a shuttle car for tramping between the miner and conveyor-belt system still involves, however, the presence of a cyclical mining operation since the miner has to wait for the return of the car and, hence, production is of a stop-start nature and geared to the operating capabilities of the shuttle cars. A truly continuous operation is only achieved once the car has been eliminated and this can be achieved by employing a "bridge" at the rear of the miner over which the coal passes onto a continually-extendable conveyor belt which keeps pace with the miner's advance (44). By the end of 1979 over forty continuous-mining units were in operation on twelve different collieries. Five major suppliers were involved - Joy, Dowson and Dobson (Marietta), Jeffrey, Ingersoll Rand (Lee Norse) and Bateman (Fairchild Wilcox 21).

A significant piece of equipment in the "haul" stage is the continuous "feeder-breaker" situated at the front of the conveyor belt and designed to receive the coal dumped by the conveyance machine. The coal is then broken before being fed onto the conveyor-belt system thus preventing the belt from being pitted by large pieces of coal, hence extending its operating life. Klippoortje was the first colliery in 1963 to install such a feeder-breaker, namely, the Beine, designed and built in West Germany (45).

Longwall mining in South Africa has been attempted since 1920 in the thinner, deeper, and more-variable coal seams on Natal collieries but because of technical and economic difficulties this mining method was only seriously employed from 1963. In that year Enyati colliery employed hydraulic support props in conjunction with an AB Anderson-Boyes longwall coal cutter (46). Conventional explosives were used and the broken coal loaded into scraper boxes in preference to a loading belt. A similar method was later employed at Hlobane colliery except that coal was hand loaded directly onto a conveyor-belt system and this was followed in 1965 by another longwall face at Hlobane, this time semi-mechanised (47). The face was equipped with an Anderton shearer-loader behind which a plough operated to load the coal onto a face conveyor for transfer to a receiving bin. From here the coal was taken to the surface by endless-rope haulage. Further advances were made in 1965 when Durban Navigation colliery employed hydraulic self-advancing chocks for the first time in longwall mining in South Africa for the control and support of the roof at the face (48). Sigma colliery

operated a longwall face between 1966 and 1969 whereafter it was discontinued until 1974 using more-advanced equipment (49). This comprised self-advancing roof supports, armoured face conveyor, stage loader, and single-prop supports. The shearer was an Anderson-Mayor double-ranging shearer. By 1979 seven collieries were either already operating, or about to commission, longwall units, these being Sigma, Bosjesspruit, Durban Navigation, Vryheid Coronation, Matla, Coalbrook, and New Denmark. Major suppliers are Joy and Coalequip. The most extensive use of longwall equipment is made by Bosjesspruit colliery which was operating four units on separate faces by late 1982, all supplied by Klöckner-Becorit-Coalequip. The fourth face was installed in 1982 at a cost of several million rand and encompassed 141 shield-type support units (each 1,5 metres wide, weighing 16 tonnes, and with a support resistance capacity of 81 tonnes per square metre), a power pack, hydraulic pipelines, and impact breakers (50).

The first attempt at open-cast mining of substantial amounts of coal was pioneered by Hloba colliery in Natal in 1964 (51). Tractor-scraper units were used to strip the overburden without blasting and expose the top of the coal seam. Bulldozers fitted with ripper attachments loosened the coal, whilst one traxcavator and one shovel loaded the coal into 10-tonne diesel trucks. However, it was not until 1971 that the first walking dragline was installed on a South African colliery - the United States of America manufactured Marion 8000 - at Optimum colliery (52). The machine cost R3 million, weighed 2600 tonnes, and possessed a 42-cubic-metre bucket on a 90-metre boom. The second major open-cast colliery behind Optimum was opened in 1975 at Arnot to supply the ESCOM Arnot power station. This was installed with the largest dragline unit in Africa at the time - the Bucyrus Erie 1570W model (53). This machine cost R5,5 million, weighed 3600 tonnes, and possessed a 61-cubic-metre bucket on a 81-metre boom. The same dragline was also installed at Kriel colliery in 1978 to supply the ESCOM Kriel power station, and later at Duvha, Rietspruit, and Kleinkopje. Recent installations have become even larger and more expensive. Thus in 1981 Optimum colliery commissioned a Marion 8200, to complement its ten-year-old Marion 8000, at a cost of R15 million, weighing 4950 tonnes, and possessing a 55-cubic-metre bucket on a 99-metre boom (54). The Minerals Bureau Directory of Coal Mines listed a total of 34 open-cast operations at the beginning of 1979. Most of these, however, were only

small operations often attached to collieries operating a bord and pillar system, but several (mentioned above) were planned to expand substantially.

It is interesting to note that the change in mining methods over the past two decades has been more revolutionary than at any other stage in the history of the coal mining industry. In the early 1960's approximately 90 per cent of coal production was still hand loaded. The rest was obtained from mechanised bord and pillar mining with a minute percentage being obtained from a few continuous miners. Longwall mining and open-cast were yet to be pioneered seriously. By 1978 the picture had changed dramatically as indicated in the table below.

TABLE 4.3 RESPECTIVE CONTRIBUTIONS FROM DIFFERENT MINING METHODS:

1978

1978 TOTAL SALES PRODUCTION: 85,7 million metric tonnes.

<u>MINING METHOD</u>	<u>TONNES</u>	<u>PERCENTAGE</u>
Hand loaded	13	15
Conventional Mechanised LHD	49	57
Continuous Miners	6	7
Total: Bord and Pillar	68	79
Longwall	2	2
Open-cast	16	19

Source: King, P., derived from "Long-Term Trends in South African Coal Mining", Coal, Gold, and Base Minerals, March 1979, page 45.

Production from continuous miners, longwalling, and open-cast is expected to increase rapidly during the 1980's. Discussion of this aspect is, however, reserved for the following section.

Finally, although discussion has tended to concentrate on changes in extraction methods it would not be complete without, at least, mentioning improvements in the main ancillary activities in coal mining which affect productivity. These include improvements in power and lighting (55), drainage, ventilation (56), the introduction of stone-dusting machines (57), underground transportation of mining personnel (58), advances in heavy-medium washing techniques (particularly the cyclone washer) (59), and so on. Such advances have undoubtedly affected productivity levels but mainly in ways which are indirect and

more difficult to evaluate than changes in the primary functions of breaking, loading, and transportation.

Factors Determining Choice of Mining Method and Rate of Mechanisation

Reviewing, in retrospect, the development of the coal mining industry, six major events are prominent. These are, firstly, the initial dominance of labour-intensive bord and pillar extraction, followed by the introduction of: the coal cutter; the power loader and the trackless LHD revolution; the continuous miner; longwalling; and open-cast mining. Such developments can always be ascribed to geological, economic, or technological considerations. Several points have already been discussed earlier in this chapter, but additional arguments can be presented at this stage.

Bord and pillar mining has been practiced from the earliest coal-mining days in South Africa and has predominated ever since. A combination of several reasons explains this. The seams worked in the Transvaal and the Orange Free State were too shallow and thick for longwall mining to be practiced and their horizontal nature was ideal for haulage by endless rope. In the Witbank coalfield the high-quality coal in the lower portion of the No. 2 seam was worked first. If longwalling had been applied it would have resulted in irretrievable loss of the upper seams and the danger of underground fire through spontaneous combustion caused through caving (60). In Natal many seams are criss-crossed by dykes and sills which has made a flexible mining method imperative, hence the choice of bord and pillar. Besides favourable geological conditions other reasons can be mentioned:

- The existence of a cheap, plentiful, and docile black labour force. Since they were technically unsophisticated they were not suited to operating capital-intensive methods, but, nevertheless, were easily trained in the simple techniques of bord and pillar. There was also the danger of desertion of the labour force through fear when longwall caving was employed (61).
- The market for coal was small and variable, not suited to the high production rates of capital-intensive extraction.

- Coal reserves were generally regarded as "unlimited" hence there was little incentive to introduce high-extraction-ratio methods. Wasteful bord and pillar was quite acceptable.
- Because of the small and variable market and the controlled selling price of coal the industry was characterised by low profitability. Hence it could not afford to introduce expensive capital-intensive methods or to purchase surface rights or compensate surface owners for subsidence. Thus bord and pillar mining, leaving large supporting pillars, was the only acceptable method.

The early attempts at mechanisation in the form of replacing hand drilling and cutting with mechanical appliances (and the subsequent improvements in these machines) were prompted by two factors - improvements in efficiency and a shortage of suitable black labour to perform these arduous tasks. Although cutting and drilling efficiency increased significantly and black-labour complements were cut, the effect on overall cost per tonne sold was negligible, due to the larger employment of expensive white fitters and electricians, the cost of the machinery itself, plus spares, repairs, and maintenance (62).

The introduction of the power loader and the trackless LHD revolution which this ushered in was precipitated by the severe shortage of black labour in the years following the Second World War. Manufacturing industry and the gold mining industry expanded rapidly, drawing labour away from the coal mines. The newly-created jobs were better remunerated and less arduous than jobs available in the coal mines. As a result collieries were forced to increase their wage levels in order to compete for labour, but, even so, hand loading and tramping remained unpopular jobs, in view of their arduous nature, and progressive declines were observed in the loading efficiency of those blacks still prepared to load. The realisation, therefore, that black labour in the future was likely to be neither as plentiful nor as cheap as hitherto encouraged colliery managers to introduce mechanical coal loading at the face and to employ mechanical means for its conveyance (63). But wages were not the only consideration. Food, medical and welfare services, housing, recruitment expenses, and so on, were all additional costs associated with the employment of black labour (64). However, mechanisation was also expensive entailing not only the

purchase of the equipment itself but greater expense on the surface in the shape of workshops, machine tools, replacements and spares, and a larger employment of artisan staff. There was no shortage of comparative-cost studies carried out in the late 1940's and 1950's comparing the economics of hand loading and mechanised mining (65). Generally these studies favoured mechanised mining as being the more economical and new collieries being opened up after the war favoured such methods. However, the older collieries which had already sunk capital into hand-loading methods tended to persist in their old ways.

Aside from the economic considerations other factors can be mentioned. Black labour tended to lose its extreme docility after the War. Aggressiveness was observed in labour relations and in attitudes towards management and white supervision. It was also manifest in hostel riots and tribal conflicts (66). Mechanisation was thus one solution towards remedying this problem. Secondly, seam conditions were ideal for mechanisation. The thick seams and wide bords suited the tramming of shuttle cars together with a stable roof and generally dry, level solid floors. Thirdly, the market for coal was expanding particularly from industry and for power-station use and hence a mining method was required which gave higher production rates. Fourthly, a mechanised mine was more flexible when faced with wide fluctuations in sales or in the availability of railway trucks in that the smaller labour strength enabled it to minimise losses incurred by stoppages or short time and also such periods could be utilised for machine maintenance. Coal could even be stockpiled on the floor near the loading point of the main haulage. On the other hand for at least a few consecutive shifts an output well above average could be achieved without undue fatigue (67). Finally, a mechanised mine was safer than a hand-got mine in that it eliminated the main cause of accidents - those associated with endless-haulage tubs.

With regard to the increasing adoption of continuous miners, longwalling, and open-cast mining during the 1970's, four major factors have facilitated this trend:

- The growing "disagreeableness" of labour encompassing high and rising wages and associated services, shortages of suitable labour, and their growing troublesomeness.

- The buoyant state of final demand for coal particularly from ESCOM, ISCOR, SASOL, and the export trade in the wake of the world oil crisis, which has necessitated adoption of high-production-rate mining methods.
- The increasing profitability of the industry resulting from high demand, increases in the controlled inland selling price, and even higher prices received for export coal, which has provided the industry with the necessary funds to finance expensive machinery.
- Increasing concern over the long-term adequacy of coal reserves with the consequent emphasis on high-extraction-ratio mining methods.

Continuous miners suffered a chequered introduction in that although some operators greatly favoured them, to others they were a case of the "curate's egg". The main problems experienced were associated with the robustness and cutting performance of the machines. They were built in America to suit that country's soft coal conditions and had difficulty in mining the much-harder and more-abrasive South African coal. Accordingly, downtime was excessive and production rates did not meet local expectations (68). Individual mines tended to make modifications to suit their particular situation, mainly in pick qualities, pick spacings, and drum speeds, but there was little uniformity and diverse results were obtained. In addition, different collieries tended to set different objectives and use varying criteria in measuring the performance of their machine and this made comparisons between collieries difficult as well as the task of finding an objective yardstick. The Chamber of Mines found two adjacent collieries mining the same seam under similar conditions achieved different results using the same type of miner. An important factor was obviously the human element in ensuring economical performance. The Chamber found that performance improved with time as management and personnel gained experience with the machine. The differences between the outputs of individual machines were extremely wide. Thus in 1979 South Witbank colliery set a new world record by producing 90 000 tonnes per month whilst some units on other mines achieved only 3 000 tonnes per month. Seam height is an important variable in determining output levels. Thus of the 26 units operating in 1978: 6 units working in seams of less than two metres averaged 7 300 tonnes per month, 17 units working in

seams from two to three metres averaged 22 500 tonnes per month, and 3 units working in seams over three metres averaged 38 100 tonnes per month (69). The average output of continuous miners in 1978 was 20 000 tonnes per month, increasing marginally to 21 000 tonnes in 1979. The wide variance in outputs is illustrated by the fact that in 1981 a unit at Matla achieved 110 000 tonnes per month (70).

Downtime tended to be excessive and the cost of maintenance and repair of the machines is obviously high. During 1978 working time of the machines was restricted to about 50 per cent of the shift because of breakdowns and difficulties in moving the coal from the miner into shuttle cars or conveyors. The greatest cause of breakdown in 1978 arose from the abrasiveness of the coal which caused an average of 40 hours per month of downtime or about 50 per cent of total breakdown time recorded. Other causes were interconnections, for example hoses, and electrical failures. The high opportunity costs of downtime combined with the costs of spares, repairs and maintenance (including employment of additional electricians and fitters), together with the capital cost of a continuous miner (approximately R400 000 in 1979), implied that this method of mining was particularly disappointing and expensive, until as late as 1979.

These problems appear to have been abating in recent years due to accumulated experience and local production. The Chamber of Mines has also acquired valuable data on production and breakdowns from an experimental model on field trials at Kriel colliery. An additional difficulty experienced with these units is that they generate excessive amounts of harmful dust, and this has been the subject of research in both South Africa and the United States.

On the positive side continuous miners have boosted productivity and safety because of the absence of explosives. They generate fewer hazards such as sidewall or roof fractures that may accompany blasting with high explosives and expose a smaller number of front-line workers to other safety hazards (71). Another benefit is that the machines produce a smoother and more-uniform roadway profile, with less barring-down of the hanging walls and sides than is required by conventional mining. These units are also extremely flexible for not only can they be used for simple bord and pillar work, but also for pillar extraction, rib-pillar extraction, and shortwalling. Finally, the reduction in labour complements is a major cost saving. The number of black

operators required is usually three times lower compared with conventional mining methods.

As heavier-duty miners become available and personnel experience continues, it is predicted that their number on South African collieries will expand to, at least, 120 by 1988 accounting for 20 per cent of total production.

In comparison with continuous miners, longwall equipment is extremely expensive. Bosjesspruit's 1982 unit cost R10 million. The advantages lie in the high production capacity and low labour complement. Thus each of Bosjesspruit's units averages 130 000 tonnes per month and only 18 to 20 men per shift are required to run the entire operation (72). However, as with continuous miners, longwall mining in South Africa also suffered from an initial unfamiliarity and a lack of longwall-mining experience on the part of mining personnel in that it was a completely new mining technique, unlike continuous miners which were merely an incorporation into the familiar bord and pillar technique. Time again, however, was the solution, and black miners now perform excellently on mechanised longwall faces. Other early problems were associated with breakdowns. The equipment was not specifically designed for mining conditions and combined with personnel unfamiliarity resulted in excessive breakdowns. Production would be completely halted during this time which was compounded if the longwall unit had to be extracted from the mine, taken to the surface for repair, and then reinstalled underground. The tight profit margins imposed by price control, therefore, made this technique uneconomic. However, more-suitable equipment installed from the mid-1970's onwards, especially at Sigma, tended to alleviate this problem. Sigma's decision was also affected by its strained labour resources, the need for a higher-extraction-ratio technique, and the need for higher production rates to meet the expanding SASOL requirements (73). A major reason why longwall mining has not proved particularly popular in South Africa is the problem of strata control as well as other geological factors (74). The presence of massive dolerite sills in the roof strata of many South African coal seams means that the hanging wall does not subside and meet the footwall behind the work face gradually, but tends to break approximately 100 metres behind the face resulting in a massive regional collapse. Sometimes the roof subsides only up to the dolerite sill where methane can collect in the resultant gap which can be forced

through into the working area at short notice when the sill collapses (75).

Despite its success at Sigma and several other collieries the advantages of longwalling as a production-intensive, concentrated, high-extraction method which in the long-term is more adaptable to the available reserves than any other method have been insufficient to offset its economic, geological, and technical disadvantages as well as its operating inflexibility. Short-term longwall expansion will, therefore, probably be slow, centring on the opening of new mines and growth in total coal demand (76). Local suppliers expect increases in installation approaching three units a year during the 1980's (77).

The cost of machinery associated with open-cast mining exceeds both that of continuous mining and longwalling. A modern dragline, depending on size, costs between R6 and R9 million, but the final bill is approximately R20 million after adding transportation and assembly costs. In addition, there is the cost of heavy rockdrills, shovel extractors, coal-haul trucks and/or conveyor belting to carry the mined coal to the preparation plant or stockpile. A percentage cost breakdown on capital account for a typical open-cast mine would be: 30 per cent for draglines and stripping equipment; 33 per cent for services and infrastructure; 17 per cent for preparation plant; and 20 per cent for other equipment (78). Although capital expenditure is high, the unit operating costs of open-cast mining tend to be lower than labour-intensive methods because of minimum labour utilisation, providing that the machines can work uninterrupted with a minimum of downtime.

The major advantage of open-cast mining is that it represents a quicker way than longwalling or continuous mining to meet the expanding demand for coal at highest productivity and extraction ratio, provided the correct geological conditions (shallow, thick seams) are present. The largest, modern draglines with 100-metre booms and 60-cubic-metre capacity buckets can work to a depth of 70 metres compared with 30 metres in the mid 1970's. In other words, the extraction capability of open-cast mining has doubled (79). Increased safety has also enhanced productivity. For these reasons open-cast mining will continue to expand throughout the 1980's and provided that final demand remains buoyant and coal prices (particularly for export) continue to rise, this mining method should account for at least 30 per cent of total production by 1990.

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CHAPTER FIVE

HUMAN FACTORS

The human factor is still the crucial aspect in the coal mining industry, despite increasing mechanisation. This important strategic asset, therefore, demands as much research as any other resource in the industry. The Human Resources' Laboratory of the Chamber of Mines' Research Organisation was established in 1974 for the purpose of conducting wide-ranging research into the utilisation of human resources in the mining industry (1). Although most of its work is concentrated in gold mining, many of its findings can be generalised to other minerals. The Laboratory's main objective is to provide decision-makers with factual information about the behaviour of employees in the light of rapid social, economic, and technological changes taking place in the mining industry.

This chapter is devoted to the manner in which the coal mining industry has attempted to effectively utilise its human resources in pursuit of maximum productivity. This objective can be examined under various headings below.

The Recruitment of Labour

Recruitment is the responsibility of individual collieries, co-ordinated by the mining group to which the mine belongs, under the umbrella of the Chamber of Mines. White workers are recruited either by the colliery itself (as in the case of more-manual jobs such as miners, fitters, or electricians) or through the company head office (as in the case of more-senior or technical personnel such as accountants, engineers, or surveyors). White staff are housed with their families either permanently on the mine in subsidised accommodation, or in a convenient local town (such as Witbank) depending upon the distance of the mine from local centres.

The recruitment of black workers is more complicated. South African urban blacks have traditionally not been attracted to coal mining in large numbers in view of the relatively-low wages, the dirty and arduous nature of the work, the low status of the job, and the isolation of most collieries from urban townships. This has meant that the industry has had to rely in large measure on the availability of

migrant blacks. This has particularly been the case with Transvaal and Orange Free State collieries. In Natal, however, labour has generally been closer at hand from urban townships and rural Kwazulu sources. Several Natal mines also employed for many years men living with their families in nearby squatter villages. As a result Natal collieries have traditionally been less dependent on migrant blacks.

The recruitment of migrant labour is governed in terms of the Black Labour Act of 1964 and the Black Labour Regulations of 1965. The 1964 Act repealed and replaced the Native Labour Regulations Act of 1911. In addition the Republic has also negotiated separate agreements with independent foreign black states (such as Mozambique, Malawi, Lesotho, Swaziland, Botswana and Zimbabwe) regarding the recruitment and employment of its citizens in South Africa. It also negotiates separate agreements with ex-Homeland territories on their aspiring to independent states (Transkei, Bophuthatswana, Venda, and Ciskei). Blacks recruited from self-governing territories within the Republic of South Africa (e.g. KwaZulu, Lebowa, Gazankulu) are subject to a maximum one-year contract, whilst those recruited from independent ex-Homelands are subject to a maximum three-year contract. In the case of foreign states the length of the contract is subject to negotiation but this is usually (for instance in the case of Mozambique) a one-year contract which can be extended to 18 months by mutual agreement (2).

Chapter V of the promulgated regulations makes provision for recruitment on a group basis by groups of employers comprising ten or more employers in agriculture or mining who recruit labour and make it available to their members. Blacks recruited and allocated to a particular employer and particular premises cannot be employed by a different employer or on different premises. Two groups traditionally recruited, transported and repatriated labour for the mining industry in the Transvaal and Orange Free State, including coal mining, namely the Witwatersrand Native Labour Association (WENELA, which recruited outside South Africa) and the Native Recruiting Corporation (NRC, which recruited within South Africa). A recruiting association was also established for the Natal Coal Owners' Society which recruited mainly in Umtata. In 1966 the names of WENELA and the NRC were changed to the Mine Labour Organisations, and they subsequently amalgamated in 1976 to form the Employment Bureau of Africa (TEBA). Unlike other industries, requisition orders do not have to be obtained from the local labour

bureau for permission to import black workers, nor do the recruited workers have to report to the bureau for registration on their arrival. Collieries which require labour merely send a requisition to the recruiting organisation which supplies the workers within a few weeks, and which, in effect, acts as the labour bureau in the sense that it performs its own registrations and keeps complete statistics and labour records. In recent years the significance of TEBA in recruiting labour for the coal mining industry has declined, individual companies (such as Amcoal) preferring instead to operate their own recruiting organisation.

Popular recruiting areas have traditionally been Mozambique, Transkei and Lesotho, and because of the unpopularity of the job a high proportion of black workers have been novices. This was compounded by the fact that a returning worker would not necessarily work on the same mine or in the same class of work. As a result the labour force tended to be unstable and of a low level of skill, but this was not particularly a problem due to the simple tasks involved in hand-got mining. However, as mechanisation has advanced and individual companies have assumed more responsibility for their own recruiting, there has been increased emphasis on cultivating a more-stable work force, especially amongst blacks with some skills training. Mines have become loath to lose these workers. Accordingly, some companies have introduced a "re-engagement certificate" guaranteeing certain categories of blacks re-employment at their old job and/or pay level provided they returned to the mine within a set period of time. This has acted to stabilise the workforce to some extent and reduce the proportion of novices. The increased wages, mechanisation, and changing image of coal mining have also attracted larger numbers of South African blacks to the industry thus reducing the dependence on foreign (especially Mozambique) workers. Stabilisation has also been hampered by the lack of married accommodation for blacks on the mines, traditionally fixed at 3 per cent by Government regulation, in an effort to ensure that blacks retain their roots away from the white areas. However, several mines, particularly Rietspruit, have recently made efforts to permanently house their more-trained married blacks on the mine.

TABLE 5.1 TOTAL EMPLOYMENT IN COAL MINING (in thousands)

YEAR	WHITES	NON-WHITES	TOTAL	YEAR	WHITES	NON-WHITES	TOTAL
1920	1,8	32,7	34,5	1950	3,3	51,5	54,8
1921	2,1	37,8	39,9	1951	3,3	51,5	54,8
1922	1,6	33,7	35,3	1952	3,4	53,4	56,9
1923	1,7	33,1	34,8	1953	3,4	52,6	56,0
1924	1,7	35,1	36,8	1954	4,0	52,5	56,5
1925	1,7	34,9	36,7	1955	5,3	54,1	59,4
1926	1,7	36,6	38,3	1956	5,5	54,2	59,7
1927	1,7	35,5	37,2	1957	5,8	56,5	62,4
1928	1,7	34,8	36,5	1958	5,9	59,7	65,8
1929	1,6	33,5	35,1	1959	6,0	61,0	67,0
1930	1,6	31,0	32,6	1960	6,0	60,3	66,3
1931	1,5	26,1	27,6	1961	6,4	63,9	70,3
1932	1,4	22,2	23,6	1962	6,7	65,4	72,1
1933	1,4	22,5	23,9	1963	7,0	65,8	72,8
1934	1,4	23,9	25,3	1964	7,9	68,5	76,4
1935	1,6	27,3	28,9	1965	8,6	72,3	80,9
1936	1,8	29,1	30,9	1966	8,6	73,7	82,2
1937	1,9	29,9	31,8	1967	7,8	70,6	78,4
1938	1,9	31,7	33,7	1968	8,0	71,0	79,1
1939	2,0	32,7	34,7	1969	7,6	68,5	76,1
1940	2,1	35,2	37,3	1970	7,3	67,4	74,7
1941	2,2	36,8	39,0	1971	7,4	69,2	76,6
1942	2,4	39,3	41,7	1972	7,5	68,1	75,7
1943	2,5	40,8	43,3	1973	7,3	66,0	73,3
1944	2,7	46,4	49,1	1974	7,5	66,5	74,0
1945	2,9	48,7	51,6	1975	8,1	68,7	76,8
1946	3,0	48,6	51,6	1976	9,2	74,7	83,9
1947	3,2	48,0	51,2	1977	10,9	81,1	92,0
1948	3,1	46,8	49,9	1978	12,5	81,8	94,3
1949	3,2	49,3	52,5	1979	12,8	81,2	94,0
				1980	12,7	81,2	93,9

Source: Department of Statistics, Union Statistics for 50 years 1910-1960, Government Printer, Pretoria; and Quarterly Bulletins.

Employment in Coal Mining

Total employment of whites and non-whites in the coal mining industry for the years 1920-1980 is presented in table 5.1. Due to reasons already stated (low wages, arduous work, unglamorous image, and competition from manufacturing and gold mining), the industry has suffered periodic shortages of labour, especially in times of expanding demand. However, as mechanisation has proceeded, and wages have been increased and stabilisation programmes implemented, these shortages have tended to disappear until in recent years the availability of black labour has exceeded the number of jobs available, and recruiting organisations have been able to be more selective in their choice of workers.

Changes in total employment have closely mirrored changes in production and demand, but changes in the ratio of white to non-white workers have been more dependent on the rate of mechanisation. As mechanisation has proceeded the demand for technical skills has increased accordingly so that skilled white surface workers (e.g. fitters and electricians) have tended to replace unskilled black underground workers (e.g. loaders and track layers). Since the early 1920's the employment of whites has increased by a factor of approximately 7,5 whilst the employment of blacks has increased by a factor of 2,4. Correspondingly, the ratio of whites to non-whites has changed from 1:19 to 1:6,5. Whereas white workers comprised only 5 per cent of the total labour force in the early 1920's, this had increased to 13,5 per cent in 1980. Although mechanisation has destroyed the number of jobs available on individual mines it has not decreased the total strength of the labour force in the industry due to the opening of several new mines especially since 1974.

TABLE 5.2 LABOUR AT WORK

Transvaal and Orange Free State collieries, Members of the Chamber of Mines

<u>YEAR</u>	<u>Percentage of Total</u>		<u>All Races: Surface</u>
	<u>Whites: Surface</u>	<u>Non-Whites: Underground</u>	
1953	4,1	63,9	33,8
1978	5,7	56,6	38,4

Source: derived from Chamber of Mines, Annual Reports, 1953 (page 112) and 1978 (page 79).

The figures in table 5.2 above illustrate clearly that the trend over the 25-year period 1953-1978 has been towards an increasing percentage of surface workers particularly at the expense of underground blacks. Although there is now no general shortage of black labour the effects of mechanisation and the increased demand for coal have resulted in a severe shortage of mining engineers and qualified artisans.

The Racial Hierarchy of Employment

Occupational discrimination on the grounds of race has been entrenched in the mining industry since the earliest days in terms of both precedent and statutory legislation. The natural cultural differences between the skilled and unskilled elements in the labour force enabled a rigid division to be established on racial grounds. Jones and Griffiths write,

"the skilled workers were mainly of overseas origin, English-speaking, articulate, literate, and relatively socially sophisticated. The unskilled workers, however, comprised local black labour, unsophisticated and tribal in their habits, naturally superstitious, inarticulate, and mainly illiterate. As a result skilled workers were able to isolate their ranks with relative ease" (3).

This differentiation of workers enabled skilled labour to enjoy a privileged position, free from local competition, and it was not long before this informal situation was formalised in the guise of statutory legislation. The Mines and Works Act, No. 12 of 1911, (repealed and replaced by No. 27 of 1956) restricted all the top management and technical positions (for instance, mine manager, overseer, electrical and mechanical engineers, surveyors, gangers and miners) to holders of recognised certificates of competency, but denied the possession of such certificates to black workers. In addition, Determination No. 27 of Section 77 of the 1956 Industrial Conciliation Act reserved certain sampling, surveying and ventilation duties for whites only. Finally, conservative white trade unions, closed-shop agreements, and traditional bars on black artisans have played major roles in demarcating the job hierarchy on racial grounds.

Underground, the heavy manual work has been performed by black workers with the white miner acting in a supervisory capacity. A hand-got colliery was divided into sections, each section being the responsibility of one miner supervising the work of between 30 and 55 blacks. (depending on local conditions and output levels) performing the tasks of loading and tramping, cutting, drilling, timbering, roof bolting, track laying, winch drivers, and section bossboy. The miner was (and is) generally responsible for the safety of the black workers under his control and the enforcement of mining regulations. Specific tasks would include; marking the face for cutting and drilling, the preparation and charging of explosives, testing for gas, supervising track laying, maintaining discipline, and performing a small variety of clerical tasks. The same principle is followed with mechanised coal getting, the coal cutter, drillers, loading machines and shuttle cars being operated by blacks under the supervision of the section miner, although the number of blacks under his direct control is less than half of hand-got mining. In both cases the resulting efficiency of the whole operation depends largely on the organisation, discipline, and motivational ability of the section miners and their bossboys.

In the case of longwall sections and with continuous miners, the blasting operation is dispensed with and hence the need for a certificated miner for this purpose disappears. The minimal number of blacks associated with such processes also dispenses with the need for close supervision and discipline. Nevertheless, in practice, a white miner is invariably retained for supervisory purposes. In the case of continuous-miner operations one white miner would supervise either one or two machines, each machine being manned by a black "gang" of between 8-12 workers, for instance, one team leader, two continuous-miner operators, three roofbolters and ventilation workers, three shuttle-car drivers, one scoop driver, and two belt attendants. With the increasing volume and complexity of machinery operated underground it has become customary to establish an underground workshop for simple repairs and maintenance, manned (depending upon the amount of machinery) by one or more fitters, one or more electricians, their respective black assistants, and perhaps a foreman.

Surface workers on collieries have also tended to operate according to a racial hierarchy, established both by precedent and legislation. Thus jobs involving supervisory and/or technical skills have tended to

be dominated by whites. These include mine manager, mine overseer, mine secretary, accountant, surveyors, mechanical and electrical engineers, secretarial and clerical staff, hospital superintendent, compound manager, timekeeper, storekeeper, weighbridge operator, artisans, apprentices, and so on. More-progressive mines have also tended to employ such white personnel as work-study officers, labour-administration officers, training officers, planning officers and computer staff. The whole of an open-cast operation involves, of course, surface work, and since most of these enterprises have been established in the latter part of the 1970's in an increasing atmosphere of more-liberal labour relations they tend to be less dominated by rigid racial hierarchies. Thus, all jobs at Rietspruit, for example, have been classified into grades and are open to all employees, black and white, with the necessary qualifications and skills. Blacks are responsible for operating and driving even the most-expensive and complicated machinery, from the electric face shovels or front-end loaders, to 136-tonne coal haulers, and even the Bucyrus-Erie walking draglines.

The abolition of job reservation in concept, the granting of trade-union rights to blacks and the abolition of the closed shop should eventually result in the gradual disappearance of the racial job hierarchy in the coal mining industry. This depends, of course, on the speed with which blacks acquire the necessary skills and education and the breaking down of traditional discrimination amongst white attitudes. In the meantime the barriers implied in the Mines and Works Act and the Industrial Conciliation Act, Section 77, still remain.

Labour at Work

It will be recognised that the magnitude of labour in employment (on the books) is not the crucial variable in determining production and productivity levels. Rather emphasis should be laid on the magnitude of labour at work. Two factors are important in this discussion - the level of absenteeism and the number of shifts (or man hours) spent on the job.

(a) Absenteeism: This measures the difference between labour in employment and labour at work. Traditionally absenteeism has not been so severe in the mining industry as in other industrial sectors due to

the fact that the majority of both black and white labour is housed on the mine property and hence greater control can be exercised over the difference between genuine and contrived absentee excuses. A priori, it would be expected that absenteeism has become less of a problem in more recent times as hand-got methods have been replaced by more-mechanised methods, for two reasons. Firstly, the work is safer and less physically tedious resulting in less accidents and sickness, and secondly, the quality and skill of the men retained by individual mines is of a higher standard, resulting in more motivation. This is, indeed, found to be the case by perusal of Department of Mines' statistics relating to labour in service and at work (4). Over the period 1950-65, average annual white absenteeism was 7-8 per cent and black absenteeism approximately 4 per cent. However, over the period 1974-80 these figures fell to 6,5 and 3 per cent respectively.

Reasons for the white absentee rate are invariably categorised by most collieries as, simply, leave and sickness. More control, however, is usually exercised over the black absentee rate with typical reasons being categorised as sickness (divided into illness, mine accidents, accidents other than mine, and assaults), on leave, awaiting allotment, loafing, or in jail.

(b) Number of shifts and man hours: One can go beyond the concept of the average number of man units at work per time period by recognising that levels of production depend more on the total number of hours or shifts worked by those man units per time period. It has been customary for the mining industry to demand more input from each man unit, in comparison with manufacturing or commerce, in terms of more working days per week and longer working hours per shift.

Modern coal mining has traditionally been a six-day-working-week industry, Monday to Saturday. In the early 1930's, Graham (5) reported that a miner on a Witbank colliery would work 8½ hours per day and receive guaranteed payment of 48 hours per week whether the mine worked or not. In terms of section 12 (1) (s) of the 1956 Mines and Works Act the State President may make regulations as to

"the number of hours and the number of shifts during any specified period which employees may work ... and the travelling time from the shafthead to their working places and back again".

Consequently, Regulation No. 344 of 1962 stipulated that no person could work underground in a coal mine for longer than 8 hours during any consecutive period of 24 hours, or 48 hours during any consecutive seven days, exclusive of the time occupied in travelling to and from the working place, which could not exceed one hour for any one shift (except by written exemption of the Inspector of Mines). However, these maximum hours of work did not apply to work necessitated by an accident or other emergency or to any employee exempted by the Inspector of Mines performing work related to securing safety or transporting employees to and from their working places underground.

Many collieries adopted the convention of not exceeding the limit of 48 hours in any 7 consecutive days by employing two shifts per day, Monday to Saturday - the day shift working 8½ hours Monday to Friday and 5½ hours on Saturday (48 hours), and the afternoon working 9½ hours Monday to Friday, with Saturday off (47½ hours). Travelling time of one hour per shift, not part of working time, was paid at overtime rates. A number of collieries also arranged it so that underground employees could work a system of a maximum of 96 hours per fortnight on the basis of one Saturday on and one Saturday off, i.e. an eleven-shift fortnight per worker, working day shift one week and afternoon shift the next. At the end of 1976, a total of 20 out of 49 collieries were operating this system. Other collieries, however, operated a six-shift-per-week (every week) system, Monday to Saturday, for each underground worker, of 54 hours bank to bank (48 hours working and one hour per shift travelling). With both the eleven-and twelve-shift-fortnight systems the colliery itself operated every Saturday, the difference being that with the latter system every employee worked every Saturday, but with the former every employee worked each alternate Saturday. However, there were exceptions to both these systems. Some categories of employees were regarded as 6-day workers even under an 11-shift fortnight in view of their key nature. In addition, the increasing adoption of capital-intensive longwall, open-cast, and continuous-miner systems had led the affected collieries to adopt 7-day working on a 3-shift-per-day system to obtain maximum utilisation of expensive machinery.

This was the situation which prevailed at the time of a protracted dispute (1975-6) between the Chamber of Mines and the Mine Workers' Union which demanded the immediate introduction of a 5-day, Monday to Friday, working week of 46 hours per week comprising 5 shifts of 9 hours 12 minutes each plus an extra one hour per shift travelling time. This, in effect, would have closed down each colliery for two days every week. The Chamber was prepared to concede a 5-day man week but not on a Monday to Friday basis. Rather it was prepared to negotiate a rostered 5-day man week within the context of a 6-or 7-day mine week thus avoiding the loss of production over the weekend. The Chamber and the Union could not agree on these terms and instead compromised on an 11-shift fortnight for members of that Union from April 1977 of 92 hours, with the proviso that 96 hours would continue to be worked, but with overtime payment for four. However, an employee could volunteer to work his alternate Saturday off on an overtime basis. For many collieries this agreement signalled little or no change, but others were forced to adapt their system. However, the agreement was subject to certain conditions, namely,

- union workers in some occupations would have to continue on a 6-or even 7-day-week basis,
- highly capital-intensive operations such as open-cast, longwall, and continuous miners would have to continue on a 6-or 7-day-week basis, operating as much as three shifts per day,
- some collieries would not be able to maintain production on an 11-shift-fortnight basis and would have to be the subject of special arrangements,
- colliery management would retain the right to arrange shifts to suit the requirements of their collieries.

To facilitate these changes the Mines and Works Regulations were changed in 1976 so that the restriction curtailing work underground to 48 hours in any 7 consecutive days be waived and the limit set at 96 hours in any 14 consecutive days. Officials, other than those involved in the working of a cycle or rotation of shifts, also switched to an 11-shift fortnight but members of unions other than the Mine Workers' Union

(e.g. artisans) continued to work a 6-day week by choice of their unions. However, artisans changed to an 11-shift fortnight in 1981. Black workers, depending on their job, worked either a 6-day week or an 11-shift fortnight.

The whole agreement was regarded as an interim measure in the sense that the two parties would await the conclusions and recommendations of a Commission of Inquiry (the Franzsen Commission) on the possibility of a 5-day working week in the mining industry. The Commission reported in April 1977 and rejected the idea of a Monday to Friday 5-day working week of 46 hours (6). However, it did support the idea of a 5-day rostered working week for each employee in a 7-day mine week to avoid the loss of production and other problems associated with closing each mine for 2 days every week, and recommended that the two parties work towards this objective. In the meantime the 11-shift fortnight, initially conceived as an interim measure, should continue in operation until management and labour reached a negotiated breakthrough on the 5-day-week system. This breakthrough has not yet been achieved and the 11-shift fortnight continues, amid complaints from the Chamber that it has adversely affected productivity and working costs aggravated by the Mine Workers' Union's interference, contrary to the agreement, with members wishing to volunteer to work on their Saturdays off and wishing to work overtime.

The Effort of Labour

It will also be recognised that rates of production and productivity depend not only on the physical number of man hours or man shifts worked, but on the effort supplied by labour during those working hours and shifts. Effort can be regarded as being functionally related to two broad variables which, in themselves, may be interdependent - the ability and quality of the workers (related to health, education and training) and the motivation of the workers (related to his job satisfaction, will to work, and so on).

The Quality of Labour

The general states of health and education of a labour force help to determine its capacity to acquire and apply skills (7). Both public and private expenditure on health and education will produce a labour force of a given quality depending upon the size and type of these

investments. These expenditures are regarded as investments by economists as they are designed to enhance the levels of human capital in the labour force in that they increase the levels of skills and capabilities of workers.

Health in Coal Mining

In common with other sectors of the economy, mining has no direct control over the general health of prospective employees offering themselves for employment. General health is a function of the diligence of the public authorities. A worker's health can be impaired by two causes - disease and inadequate nutrition, which make themselves felt in three directions, namely, debility (impaired productivity), morbidity (higher absenteeism), and mortality (higher incidence of death). Many diseases are endemic to South Africa and its surrounding countries from which the mining industry draws its migrant labour. These include malaria, cholera, typhoid, smallpox, poliomyelitis, bilharzia, worm infestation, leprosy, and tuberculosis. The list of diseases and the numbers of people affected by them are almost endless and although preventative - and curative - medicine advances have made inroads into the incidence of diseases in Southern Africa their adverse affect on the quality of the labour force cannot be underestimated. Nutrition refers to a person's intake of calories, minerals, vitamins, fats, and proteins (the opposite being malnutrition). Malnutrition in later life causes debility and a lowered resistance to disease but has no lasting effect on mental or physical capabilities. In infants, however, (especially during the first year of life) it produces significant losses in physical ability and intelligence. This, in turn, means longer training periods in later life and probably poorer jobs and lower wages. The lack of vitamins A,B,C, and D produce, respectively, poor eyesight, fatigue and stress, scurvy, and soft bones. Insufficient protein results in fatigue, poor digestion and waste elimination, a low resistance to disease, and slow construction of muscle tissue. The main causes of malnutrition are ignorance, tribal customs, overpopulation, inefficient farming techniques, and poverty.

Before he commences his employment each black worker is thoroughly medically examined, usually twice, once at the source of recruitment and secondly on arrival at the recruiting depot or colliery in South Africa. Those found (or believed) to be under 18, or medically unfit,

are rejected. However, in practice, a completely effective screening process is not possible due to the large numbers of workers involved and their constant oscillations. In addition, a large number of these migrant workers have probably experienced a debilitating disease or inadequate nutrition of some magnitude at some stage in their life, resulting in an unquantifiable impact on their working ability.

In the case of prospective white employees disease and malnutrition are of minor consequence with the possible exception of heart disease which has been found to be more endemic in whites than rural blacks. Hall suggested in 1948 (8) that a fair proportion of white underground staff had "migrated" from gold mines because they found the heavy conditions to be too strenuous for their health, thus casting some aspersions on their general physical capabilities. However, this point should not be stressed. All white workers employed on "risk work", as defined under the Occupational Diseases in Mines and Works Act of 1973, must be in possession of a certificate of fitness (Red Ticket) issued after an examination by the Medical Bureau for Occupational Diseases. This certificate is renewable at specified intervals after further medical examinations and in certain circumstances certificates are issued restricting the holder to certain duties.

Food and Accommodation

Once in the employ of the colliery a worker's health can be more directly controlled, more so than is the case with other economic sectors. This is because the vast majority of colliery workers are housed, fed, and cared for on the mine premises. Whereas, for example, in manufacturing or commerce, an individual employer has no control over how his workers allocate their income to decent accommodation, adequate nutrition, and proper medical care, these factors are directly controlled in the mining industry. In the case of black workers very comprehensive regulations, framed initially under the 1911 Native Labour Act and currently under the 1965 Black Labour Regulations, make provision for their housing, feeding, hospitalization and general care. All these benefits are, and always have been, provided free of charge, although until recently it is arguable that the services have been of a very low standard. Many writers have addressed themselves, often in an emotional manner, to the poor conditions and harsh treatment suffered by black mineworkers, as well as a condemnation of the whole

migrant-labour system. In particular, two books by Wilson (9) have attracted international attention, and a recent study by Lipton (10) has stirred controversy. Graham (11) in the early 1930's reported that blacks were housed "in the compound in rooms of the barrack type". This involved large numbers of men, deprived of their families, crowded into single rooms and sharing communal washing and toilet facilities. Privacy was non-existent, and individual possessions amounted to a bed (often bunks), blankets, and a locker. Food was served in the adjacent compound kitchen and carried by the workers back to the compound for eating. The food ration was Government controlled and consisted of the following:

<u>FOOD</u>	<u>MINIMUM ALLOWANCE</u>
MAIZE MEAL (both for eating and brewing)	24 ozs per day
BREAD	6 ozs per day
BEANS and PEAS	3 ozs per day
MEAT (not more than 25 per cent bone)	3 lbs per week
SOUP MEAT	3/4 lbs per week
PEANUTS	2 ozs per day
COFFEE or COCOA (plus sugar)	1/6 oz per ration
VEGETABLES	5 ozs per day
SALT	

Graham claimed these facilities to be "unique" and that they were "appreciated" by the black workers (12). Some 18 years later in 1948 Hall was able to claim that owing to the competition which existed for black labour and to humanitarian considerations the housing amenities provided were "on a much more generous scale than of old". Comparing the compound conditions on a new mine such as the Douglas colliery with those on older mines there were striking changes in "bodily comforts, food, bathing" and other facilities (13). These changes, however, could only have been relative, and food and accommodation would still have appeared rather austere and spartan to a modern observer.

Even today this concept of communal compound living and eating has not been abandoned on a large number of collieries. However, several of the newer progressive mines (particularly open-cast) have made significant changes, and the Chamber of Mines has been quick to

publicize the large amounts of money spent recently on modernising and upgrading the standard of accommodation and general living conditions of its black workforce (14). Mechanisation has laid greater emphasis on a smaller, more-skilful, and more-stable black-workforce which has implied the employment of local urban South Africans and/or married men rather than migrant single rural workers. The coal mining industry has received recent co-operation from the Government regarding the traditional 3 per cent married accommodation on collieries and it is their target to be able to house, over a period of time, most married blacks in semi-skilled or supervisory jobs. This, however, is expensive as the collieries only have finite lives. In addition, many blacks do not want to bring their families to the mines because that would interfere with their traditional way of life. The number of blacks residing in urban townships with section 10 rights is increasing and such blacks receive a "living-out" allowance from the colliery. The recent concession regarding nationwide mobility for section 10 blacks subject to a job and accommodation being available should increase this supply of workers to the collieries as there is now no question of losing section 10 rights in one urban area.

Rietspruit is an example of one of these "new-generation" collieries (15). 75 per cent of the 750 black workers are married men residing with their families in three-bedroomed semi-detached Sardinian-style houses with separate toilet and bathroom and interleading lounge and dining room. These are provided rent free as are basic food rations for each family. More-senior married black employees receive four-bedroomed detached houses with a garage for a nominal rent. Single men reside not in hostels or compounds but in 8-roomed bungalows with private bedrooms for each employee with separate toilet and bathroom and a television lounge (16). These also are rent free. Married men eat at home but single men eat in a separate modern canteen and for most food items there is no ration.

White married men in coal mining have traditionally been accommodated with their families in 3-or 4-bedroomed detached houses on the colliery with free water and electricity. For this they have paid a nominal rent (between R10 and R20 a month in 1980 depending on the colliery) and this includes even the mine manager who would be occupying a house worth between R15 000 - R40 000 on the open market. A colliery close to an urban area would allow personnel to live out for which they would receive an allowance. The men, of course, take their meals at

home but are given no food allowance nor free rations. Single white men would either live out, or else reside on the property in a hostel which, in effect, resembles a boarding-house. Each single men's hostel is run by a "landlady" and the men live either one or two to a room (depending on the pressure of accommodation) and eat in a small communal dining-room. Depending on the colliery, hostel food and accommodation is either provided free of charge or at heavily-subsidised rates.

Accidents and Disease

Coal mining is a dangerous occupation and a worker's health can be impaired by both accidents and disease. Very comprehensive regulations framed under the 1956 Mines and Works Act make provision for safety enforcement and the creation of conditions which would minimise disease.

Safety regulations in relation to natural and geological elements have already been examined in chapter I, but more wide-ranging safety aspects will be discussed here. In table 5.3 below, statistics are presented showing the magnitude of accidents in coal mining at 5-yearly intervals since 1925. Although statistics relating to numbers of accidents and total killed and injured are interesting, of more significance are those concerning death and accident rates per 1000 employed per annum. Death rates (with the exception of the Coalbrook disaster in 1960) have shown a steady downward trend since the peak of the 1920's and 1930's. Accident rates have shown the same trend since the peak of the 1940's and 1950's. By far the majority of accidents have been caused by "trucks and tramways" followed by "falls of ground". These two factors combined have usually accounted for 75-90 per cent of all accidents, with most of the remainder being due to: falls of material - below surface, machinery, and falling and slipping.

TABLE 5.3 ACCIDENT RATES IN COAL MINING

YEAR	NUMBER OF SEPARATE ACCIDENTS	NUMBER KILLED	NUMBER INJURED	ACCIDENT RATE PER 1000 PER YEAR	DEATH RATE PER 1000 PER YEAR
1925	482	86	419	13,1	2,34
1930	681	118	637	20,9	3,62
1935	1070	141	1024	37,0	4,88
1940	1055	65	1006	28,3	1,74
1945	3146	116	3113	61,0	2,25
1950	2891	91	2837	52,8	1,66
1955	3598	88	3564	60,6	1,48
1960	2800	496	2773	42,2	7,48
1965	2672	84	2622	33,0	1,04
1970	1788	79	1757	23,9	1,06
1975	1651	100	1608	21,1	1,28
1980	1272	104	1200	13,5	1,11

Source: Department of Mines, Annual Reports and Mining Statistics, published annually, Government Printer, Pretoria.

A reading of the literature on mine safety particularly before 1968 reveals either a certain flippancy or else a defeatist attitude. Both Graham (17) and Fraser (18) writing in 1931 and 1961 respectively stressed that safety education was difficult in view of the "very low mentality" and "completely illiterate" nature of migrant workers. Consequently notices and warnings in writing for the prevention of accidents were "of little use". Fraser recounted that new recruits were given a talk by an official warning them of the more-serious dangers they faced, and sometimes, after an accident, they were given a short talk over the public-address systems in the compound. His dissatisfaction at these methods appeared clear. Graham criticised new regulations regarding safety on the grounds that they increased costs of production and "one fails, at times, to see the necessity for them". He placed most responsibility on the colliery staff and white miners to exercise special supervision for the safety of blacks underground. Even as late as 1968 the Financial Mail was deriding the ability of black first aiders - "did the first-aid badge with its big red cross pinned to his boiler suit ... mean he was a qualified first-aider? Well, no - it was just a pretty badge someone had given him" (19).

These accounts may appear to suggest that the coal industry has paid only lip service to safety aspects in view of the poor quality of the manpower it was compelled to utilise, but this would probably be unfair. Safety involves two elements, preventative and curative, and the involvement of the industry in each of these two can now be examined. The contribution of the State to safety prevention is afforded through the Mines and Works Act and its Regulations. The Act itself creates the post of the Government Mining Engineer, various Inspectors, and the Mine Safety Committee, already discussed in chapter 3. In addition it promotes safety through:

- the power of inspectors to try certain offences, impose fines, inquire into accidents, and summon witnesses to appear at trials and inquiries,
- the restriction on juveniles and females working underground,
- giving power to mine managers to make special rules for accident prevention,
- making a criminal offence of any act or omission which endangers safety or causes serious bodily injury.

The Regulations to the Act dealing with safety in regard to natural and geological factors have already been dealt with in chapter 1. Safety in other regards is well covered in the Regulations, for example, in connection with explosives, winding, elevators, traction, machinery, electricity, boilers, pressure vessels, compressors, outlets, ladderways, travelling ways, protection and responsibility in workings and on the surface, and so on. These Regulations are far too extensive to be examined. However, of particular interest is chapter 24 of the Regulations concerning first-aid and rescue brigades. Adequate first-aid equipment and a first-aid room must be maintained at every colliery. Every white colliery worker, underground and surface, must receive training and possess a certificate in first-aid and the mining companies also encourage as many of their black workers as possible to undertake first-aid training. Many lives have been saved by prompt action at the scene of an accident, and without doubt a miner feels safer when he knows that there are people around him who have the

training to assist him in an emergency. Rescue brigades must also be formed in accordance with the Regulations and the men comprising them must be chosen, trained and utilise equipment and apparatus as stipulated. All brigadesmen are volunteers who primarily work as mine officials and carry out rescue work as a special duty as and when required (20). A recent development has been the creation of black task forces, led by two whites, to assist brigadesmen in rescue and fire-fighting operations.

The industry itself has been active in the field of safety primarily through the Prevention of Accidents Committee of the Chamber of Mines, first formed in 1913, and now called the Mine Safety Division. The Division operates according to a clearly defined set of objectives and functions in the areas of accident prevention and loss control (21) but, basically, it is active in spreading first-aid knowledge and in instilling safety awareness throughout the industry in a variety of ways. It uses films, posters, and lectures to promote safety consciousness by motivating mineworkers towards an awareness of the hazards and dangers found in underground work as well as a knowledge of corrective measures needed to avoid accidents. In the early years attention was mainly given to personal injury, but since the late 1960's more stress has been placed on the motivational and educational aspects.

The Division has continuously promoted safety and first-aid competitions and objectives between collieries. Two of the most popular have been the Millionaires Competition and the International Mine Safety Rating (IMSR) system. The former was introduced in 1953 with the objective of encouraging mines to achieve one million consecutive fatality-free shifts. In 1982 a special competition between collieries, attracting a Millionaires Shield, was commenced. The IMSR system was started in 1978 as part of the Chamber of Mines' loss-control programme, whereby mines are graded according to a star-rating system (up to five stars). To obtain maximum rating a mine has to score more than 90 per cent in each of 22 separate elements of a safety and loss-control audit and also show a frequency rate for fatalities and reportable injuries of 25 per cent below the average for its class of mine. By 1982, two collieries - Greenside and Kilbarchan - had achieved five-star status.

The Chamber of Mines also took an interest in safety through the Collieries Research Laboratory formed in the wake of the Coalbrook

disaster in 1960 to study the stability of bord and pillar workings at collieries. Subsequently this subject became more the prerogative of quasi-academic research (particularly by Dr. Salamon, as evidenced by a series of articles in the Journal of the South African Institute of Mining and Metallurgy), and the laboratory was disbanded. However, in 1977 the Chamber established the Coal Mining Laboratory. Its work is not directly involved with safety, but aspects of its work will undoubtedly impinge on such matters.

The curative side of the safety aspect is provided in the form of medical services and compensation. All black employees who fall sick or are injured at work receive medical services (medicine, doctor's fees, hospitalisation, etc.) free of charge. White employees do not receive this free service and must make monthly contributions to a mines' benefit society which then assists them to meet the costs of medical, dental, and prescription fees.

Medical services for blacks are available on three levels: mine, regional, and central (22). Each colliery employs a mine medical officer who is responsible for the supervision of the day-to-day health and medical needs of every mine employee. He holds daily clinics for minor complaints at the "dressing station" attached to each mine hostel. Most large collieries have their own hospital with doctors, nursing and administrative staff. Others in close proximity to one another make use of a regional hospital for the common needs of several collieries, i.e. the S.A. Coal Estates' Hospital, Witbank, the Delmas Collieries' Hospital at Delmas, and the Kilbarchan Collieries' Mine Hospital at Newcastle. In 1982, Rand Mines announced the commissioning of a group hospital at Douglas Colliery, Wolvekrans, near Witbank, to serve its Eastern Transvaal collieries. Mine and regional hospitals often do not have sophisticated medical expertise or equipment to treat complicated cases and these are referred to the central Rand Mutual Hospital in Booyens, Johannesburg, which has 500 beds and a full-time staff of specialist consultants. It is operated by the Rand Mutual through the Chamber of Mines.

As far as white employees are concerned, medical services are usually provided by the family doctor and hospital of their choice. However, in the case of more-serious, work-related injuries, they are invariably hospitalised at the Chamber of Mines' Hospital at Cottesloe, Johannesburg, again operated by the Rand Mutual. This is a 100-bed

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hospital staffed by full-time personnel and offering sophisticated treatment. Whites can also be referred to the Chamber's Social Services' Department for various reasons related to mental ill-health, personal problems and alcoholism. The Department utilises one ward of the Springkell Sanatorium where specialised psychiatric treatment is available. In 1978 the Department extended its services to non-whites.

Workmen (or their dependents) injured (or killed) in the course of their employment are entitled to receive compensation in terms of the Workmens' Compensation Act of 1941. The Rand Mutual assumes the responsibility of providing the stipulated benefits to the mining industry. It can be seen, therefore, that the role of the Rand Mutual is a comprehensive one covering accident prevention, provision of medical care, rehabilitation services, and monetary compensation (23). It not only provides the compulsory statutory benefits laid down by the 1941 Act but goes further by providing various extra-statutory benefits. For instance, while the Act applies only to employees earning less than the statutory ceiling, the Rand Mutual also compensates employees on an earnings-related basis whose earnings are above the ceiling. It also supplements the statutory benefits in certain earnings bands. The 1941 Act was amended in 1977 to provide for equal treatment for different racial groups in the structure of compensation benefits.

In the case of industrial diseases contracted through coal mining by far the most serious is pneumoconiosis (historically called phthisis or silicosis) which may or may not be accompanied by tuberculosis. The same routine of prevention and cure is relevant here as with safety aspects. The disease is caused through the continued inhalation of dust over a prolonged period of time, and hence, efforts to prevent the disease have centred around controlling the production and inhalation of dust. Comprehensive regulations with this objective in mind are contained in chapter 10 of the Mines and Works Regulations (already examined in chapter 1 of this thesis) and centre on adequate ventilation, dust determination and measurement, and dust suppression during drilling, cutting, loading, and transport of the coal.

The State and the Chamber of Mines have long co-operated on pneumoconiosis matters, starting soon after the formation of the Union with the establishment of the South African Institute for Medical Research. In 1916 the Miners' Phthisis Medical Bureau was established to examine workers for phthisis before employment and at regular periods

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thereafter and to publish statistics on the incidence of the disease. The Miners' Phthisis Act of 1925 created the Miners' Phthisis Prevention Committee to conduct investigations devoted to problems connected with temperature and humidity of mine air. The same period also saw the establishment of the Committee on Dust Prevention and Ventilation in Mine Development. In 1935 the Silicosis Research Advisory Committee was formed as well as the Dust Sampling Committees of the Chamber of Mines and the Department of Mines. In 1952 the Institute for Medical Research in conjunction with the Medical Bureau established a Pneumoconiosis Research Unit to carry out basic research work into the development and prevention of silicosis. This unit gradually expanded its scope beyond silicosis and in 1971 became the National Research Institute for Occupational Diseases. Finally, the Collieries' Dust and Ventilation Laboratories have already been described in chapter 1.

Succeeding Acts of Parliament (namely Silicosis Act 1946, Pneumoconiosis Act 1956, Pneumoconiosis Compensation Act 1962, and the Occupational Diseases in Mines and Works Act 1973) have accepted the principle of compensation for affected miners. The Medical Bureau for Occupational Diseases not only carries out pre-employment examination of white mining recruits, and periodic examination thereafter, but also performs examinations arising out of claims for compensation. It can request that patients be investigated at the Springkell Sanatorium. The Bureau also carries out research into pneumoconiosis and tuberculosis. Those miners who are in receipt of compensation (including ex-miners) can obtain treatment from the Springkell Sanatorium where approximately 140 beds are available. There is also operated in conjunction with the Sanatorium a state-financed Miners' Chest Clinic which provides free diagnostic and therapeutic services for white miners and ex-miners suffering from respiratory disorders, particularly pneumoconiosis.

Training in Coal Mining

As in other sectors of the economy, in-service training in coal mining has traditionally been along racial lines. It will, therefore, be convenient to initially examine black-and white-worker training separately for the pre-Wiehahn period followed by a concluding section on recent developments made possible in the post-1979 era.

Traditionally there has been little emphasis on training black workers above the level of rudimentary skills. The reason for this has

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Traditionally there has been little emphasis on training black workers above the level of rudimentary skills. The reason for this has

lay in the existence of the racial job hierarchy described earlier whereby all managerial, skilled manual, administrative, technical, and supervisory jobs have been held by whites, and all lower (mainly manual labouring) jobs have been held by blacks. The existence of this hierarchy is explained by several causes. Statutory job reservation (in the form of the 1956 Mines and Works Act and Determination No. 27 of Section 77 of the 1956 Industrial Conciliation Act) is the major explanation, re-inforced by the denial of trade-union rights to blacks and the operation of the "closed shop". It was, therefore, pointless to formulate extensive training programmes for blacks if they could not be advanced into higher job categories. The conservative nature of white trade unions (especially the Mine Workers' Union) has also played a part. It is the policy of that union "to resist any attempts at integration with blacks on any level in the mining industry. Blacks only to be employed as labourers" (24). The repeal of section 77 of the Industrial Conciliation Act in 1979 prompted the General Secretary of the MWU, Mr. P.J. Paulus, to accuse the Minister of Labour of "treason against the white worker", and condemned the move as "the greatest act of treachery against the white man in South Africa yet perpetrated by the Government" (25). Other white unions in the industry, such as those representing artisans and surface officials, tend also to be cautious, but are not as conservative as the MWU.

The official policy of the Government, rooted in separate development, and outlined in the 1971 White Paper on the Decentralisation of Industries (26) has also discouraged the system of blacks acquiring and practicing skills within white South Africa, even though the Apprenticeship Act has always been "colour-blind". A full explanation of the reasons why blacks have been denied entry into apprenticeships and the role of the Apprenticeship Committees is provided in Jones and Griffiths (27). Furthermore, the "cinderella" status of coal mining has also contributed to a lack of black advancement. Because of its traditional depressed status it has never experienced a general shortage of white workers (other than in artisan categories) and there was, therefore, no economic reason for training and promoting blacks into higher job categories.

Other reasons revolve around the nature of the black worker himself, as postulated by Griffiths and Jones (28):

- his lack of formal education, many of them being completely illiterate or possessing only one or two years of formal schooling,
- his non-technological background due to life in a rural environment,
- his inability to adapt to an industrial environment,
- his lack of motivation, drive, and ambition, unwillingness or inability to assume responsibility, give orders, or accept promotion,
- his laziness, superstition, and tribal affiliations,
- his tendency to run away or not return from leave which meant that money spent on his training was wasted.

Whilst it may be true that many of these attributes are inherent to the black worker they are undoubtedly compounded by decades of cultural conditioning and deprivation inherent in separate development, racial discrimination, and the migrant-labour system.

The combination of the above reasons resulted in a situation where black workers were restricted to manual unskilled tasks. Accordingly, the primary screening device was the physical fitness of the labourer which mainly determined the ardour of the job he would be allotted to. Time was spent on teaching him the common language of the mining industry - Fanakalo - to facilitate communication between white supervisors and the different ethnic workers under their control. What training there was concentrated on issues of general induction, safety and acclimatisation followed by the teaching of specific activities such as drilling, cutting, loading, etc. This was of the informal type, namely, "watch me" and "now you try". Workers with leadership qualities were groomed to be boss boys (team leaders) to act as the "go-between" between the miner and his workers. Such training was always conducted on a mine-to-mine basis and hence the need for centralised training centres has been traditionally avoided. Mine-to-mine training is a far-superior method when only acclimatisation and simple duties are being taught, but this is beginning to change as black training becomes more sophisticated.

The recent growth of the coal mining industry and its trend towards mechanisation has exacerbated the need for skilled workers and led individual collieries in the direction of a smaller black workforce, but more skilful, stable, and highly paid. This has been achieved through the payment of increased wages, better living and working conditions, the provision of married and urban local township accommodation, the granting of re-engagement certificates, greater emphasis on local recruiting, and more-generous leave provisions, all of which have led to more stability and security in the industry, to such an extent that Rand Mines was able to claim in 1982 that "all employees are now effectively on permanent employment contracts with annual paid leave" (29).

Accordingly, the emphasis in training has changed from physical fitness and acclimatisation to "machine-orientation". Training is still mainly conducted on a mine-to-mine basis, with the accent on "smooth man-machine interaction" (30) and the imparting of multiple machine-handling skills. With manual labouring tasks reduced to a minimum, the black coal miner is now largely a machine monitor or driver. Accordingly, physical skills have given way to conceptual skills in a constant search for signs of machine departure from desired conditions, detectable through noise, smell, vibration, sight, or other senses. This has created a demand for a different calibre of black worker and collieries now look for characteristics such as the speed of reaction, two-hand co-ordination, correct timing, mental concentration and mental awareness. Colliery induction tests are framed with this in mind. Spandau claims that machine-training programmes are now as rigorous as a "military drill" (31).

This new personnel and training approach towards mechanised coal mining at colliery level is well illustrated by Thompson and Henderson (32) in their 1975 study of Usutu colliery in Transvaal. Black training within the mining department is the direct responsibility of the Training Officer (Mining Labour) who is accountable to the Administration Officer (Labour). The department of the latter carries out recruitment, selection, and placing of black labour for the mine. All new black workers receive instruction in Fanakalo, discipline, safety, and working standards. All men between the ages of 24 and 45 years undergo a mechanical-aptitude test for the purpose of selecting potential mobile-machine operators. Those successful are allotted to underground production sections for training which begins with simple

tasks such as cable handling and switchgear operation and progresses to machine inspection and operation. After one week he can control the machine under supervision and after one month is usually issued with a licence permitting him to drive on his own. Those not successful in the aptitude test are placed according to their potential and individual wishes. Usutu made use of the Classification Test Battery devised by the Chamber of Mines' Human Resources' Laboratory to meet the need for the rapid selection, placement in jobs, and job training of novice mineworkers, whereby sound psychological principles were applied in the selection and placement of labour largely characterised by illiteracy and without a common language. However, as a result of the increasing levels of education and sophistication of novice mineworkers it is considered likely that the Classification Test Battery will outgrow its usefulness in the near future. Present research is, therefore, aimed at modifying the CTB as well as developing tests for placing migrants in more-skilled jobs such as artisan aide, team leader, and operator of mechanical equipment.

A recent development in the mining industry resulting from increased mechanisation and the consequent growth in demand for fitters, electricians, and boilermakers, has been that of black artisan aides (similar to a trademan's mate overseas) who perform some of the more tedious and repetitious tasks normally performed by the artisan thus allowing him to concentrate on more-skilful and demanding tasks. Such aides at Usutu are chosen by aptitude tests, preference being given to South African blacks. Newly-selected aides work as artisan helpers for two months and then spend two weeks in the surface training school learning how to inspect and lubricate machines, change wheels, replace defective hydraulic hoses, mend broken flight chains, and so on. White artisans are fully involved in the training of aides and assist as examiners.

Despite these changes Spandau still contended in 1979 that they in no way threatened the traditional racial job structure in the industry (33). Black operators were not allowed access to maintenance and repair functions. They were neither trained nor authorised to undertake for themselves, or co-operate in, the repair of machine breakdowns. Training manuals stipulated a rigid sequence for the reporting of machine failure, namely, the operator must inform the team leader (boss boy) who reported to the white miner who would then call in an artisan

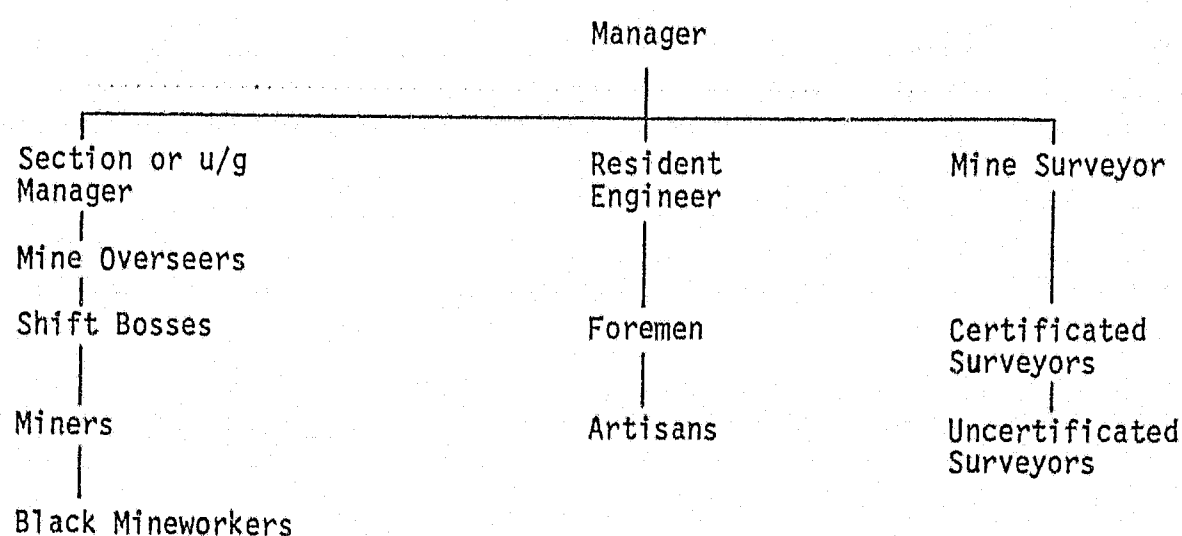
fitter or electrician. The functional task-related (i.e. racial) hierarchy was, therefore, clearly defined. Colliery manuals abounded with regulations designed to re-inforce the superiority of the white supervisor over his black workers. For instance, black team leaders were instructed: "You are a good listener. You carry out your work as you are instructed to do by the miner" (34).

Within the white section of the racial job hierarchy, career and promotion prospects are extremely high for personnel with the correct education, motivation, and training. The range of jobs available to whites has expanded with increased mechanisation. Non-mining jobs on the surface have expanded in range and magnitude over recent years as collieries have become larger and more complex. Openings are available for people with skills ranging from simple clerical aptitudes to those with qualifications in accounting, business management, statistics, economics, psychology, social sciences, computers, and so on. Departments tend to be small and specialised, but basically these administrative/clerical/professional-type positions on the surface are no different in concept to those which may be found in any other industrial sector, and promotion and career prospects are determined in the same manner.

Underground, the labour-force hierarchy of a typical colliery is shown in figure 5.1 below, and discussion will concentrate on this hierarchy.

The mine manager carries final responsibility for all surface and underground operations, but direct responsibility for mining the coal and transporting it to the surface is delegated to the section or underground manager. The underground labour force is split into sections each headed by a mine overseer. Each overseer exercises control over two or three shift bosses and each shift boss in turn supervises the work of two or three miners and their black workers. These production men are assisted by the various technical or service departments such as engineering, surveying, and sampling.

FIGURE 5.1 WHITE UNDERGROUND JOB HIERARCHY OF A TYPICAL COLLIERY



Source: A Career in Coal Mining, publication of the Anglo-American Corporation and General Mining, Penrose Press, no date, page 3.

The miner is the lowest white worker in the hierarchy, and the least educated. The job is suited to early school-leavers who have small academic potential but a flair for organising and leading men (especially blacks). They are accepted with a Standard-VI education into the Colliery Training College at Witbank. The objective is to acquire the Government Certificate of Competency in Blasting ("blasting ticket") which is obtained by satisfying a Board of Examiners that they have an adequate theoretical and practical knowledge of blasting operations, mine gases, the duties of a gang supervisor as set out in the Mines and Works Regulations, a knowledge of safety and first-aid, Fanakalo, the ability to lead and discipline black workers, and familiarisation with mining machinery. Most learner coal miners acquire a provisional blasting certificate after passing a gas test at the termination of an 18-week basic-training period at the College and at New Clydesdale colliery in a specially-adapted training section. The trainee then commences work at a colliery under the supervision of a qualified miner, and receives his permanent blasting certificate after completing 312 shifts, after which he is placed by the College in employment (35). The College commenced training in 1962 and by 1978 a total of 1503 trainees had successfully completed the course. During 1978, 320 learner coal miners were in training. The Natal Coal Owners'

Society runs a similar Colliery Training Centre to meet the needs of Natal collieries. A high wastage rate has generally been observed in this type of training as recruits drift off to other jobs without completing their training. Enterprising miners can rise to the position of shift boss and with further study, to obtain the relevant certificates of competency, they can become mine overseers and even mine manager. Many of the larger collieries now train their own miners. For instance, at Bosjesspruit colliery, candidates over the age of 20 and with at least a Standard-VIII certificate are given theoretical and in-service training at their own training centre. After completing 154 shifts and passing their gas-test examination the miner is qualified to assume responsibility.

Alternatively, entrance into the industry can be via the colliery student officials' scheme for young men more-academically inclined (36). The Colliery Officials' Training Centre at Blinkpan colliery is run jointly by Anglo American and General Mining to train mine officials to meet the needs of their collieries. It was opened in 1966. All entrants are matriculants between the ages of 18-23, invariably single, as only single accommodation is available, with passes in mathematics and physical science or another appropriate subject and with leadership potential. Before being accepted they must write an aptitude test and obtain the certificate of fitness from the Medical Bureau for Occupational Diseases. After engagement students undergo a six-month period of induction and basic training comprising Fanakalo and basic mining procedures both in the classroom and underground. At this stage gifted students may be awarded a bursary to attend University to study for a BSc degree in mining engineering. The rest, however, complete their first-year training with a sandwich course at the Blinkpan Centre after which they write national examinations. The second, third and fourth years of training are spent at a colliery, alternatively on practical training and attending full-time sandwich courses at the Witwatersrand Technikon. Students progressively obtain a temporary blasting certificate, gain experience in running an underground section, and undergo training in the survey, engineering, and other service departments such as the time office, stores, coal-preparation plant, and black hostel. The sandwich courses give the student background knowledge in mathematics, mining, geology, surveying, mine engineering, coal preparation, mineral analysis, and mine management. On successful

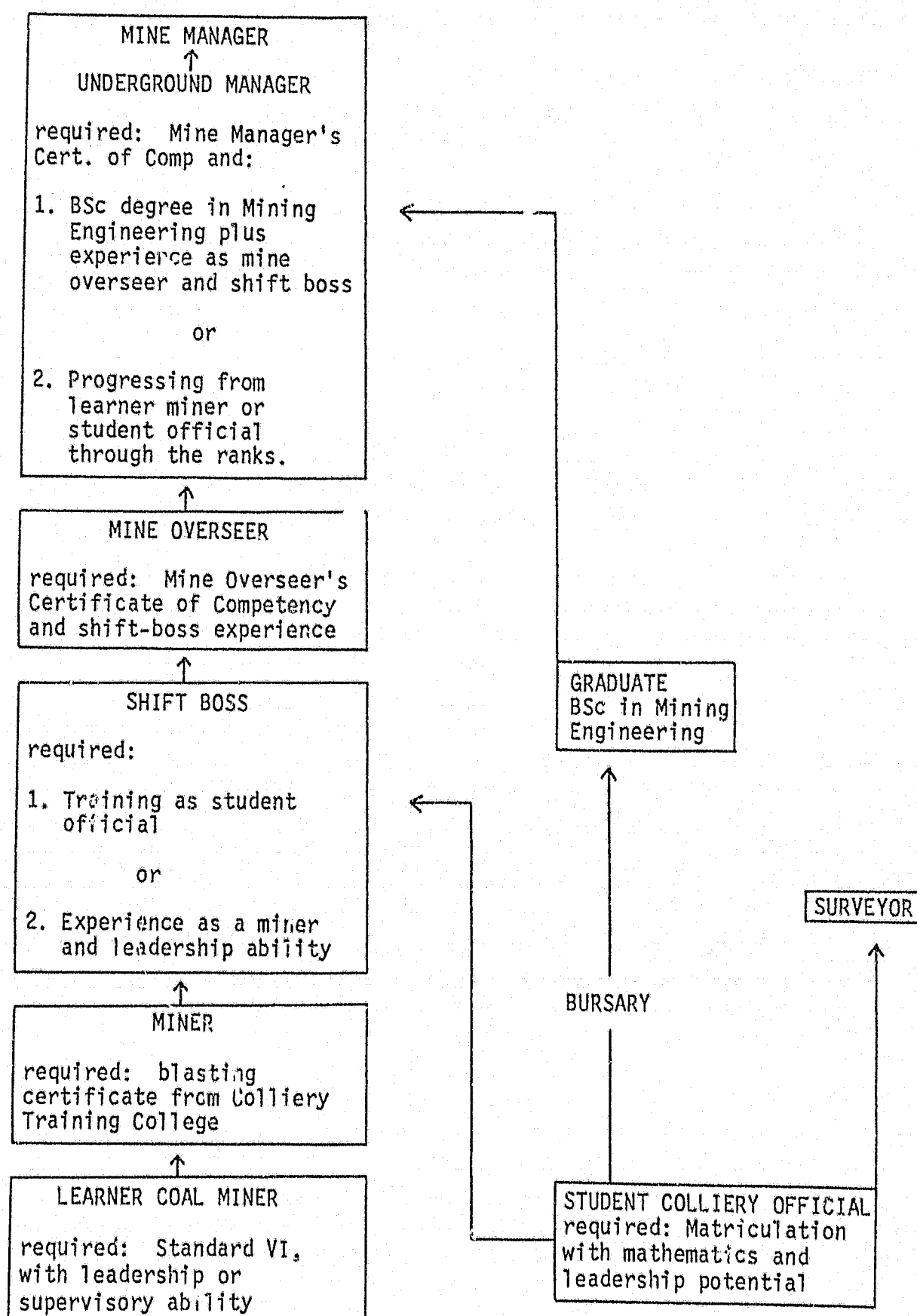
completion of the four-year course he obtains the National Diploma for Technicians (Coal Mining). He is then absorbed into employment by a colliery where he receives further experience and "on-the-job" training where he can attend management and training courses at the group's training centre. Certificates of competency for Mine Overseer, Mine Manager, and Mine Surveyor are now open to him, guaranteeing his movement up the promotional ladder.

The mining-engineering graduate is usually posted to a mine to learn the practical side of mining, taking over the duties of a miner and performing stints as shift boss, overseer, and in service departments. After two years he is eligible to write the Mine Manager's Certificate of Competence. Within five years of graduating an able graduate should be holding the post of underground manager.

A synopsis of these various promotional routes in coal mining is presented below in figure 5.2.

On the engineering side of coal mining a different occupational hierarchy is observed (37). The lowest position is that of an artisan. The industry indentures its own apprentices at the Colliery Training College in the trades of fitter and turner, electrician, and plater. They receive theoretical training at the College and practical training on the mines in terms of the regulations of the Apprenticeship Act. The Natal Coal Owners' Society provides a similar College for Natal collieries. In the past most artisans qualified after four years by effluxion of time, but today, by obtaining higher academic qualifications and writing trade tests, the average candidate can qualify in under three years. In the early 1970's an average colliery employed roughly equal numbers of artisans and miners but by 1980, due to mechanisation, there were almost twice as many artisans as miners on coal mines. To meet these requirements the College has stepped-up its intake of apprentices and in 1981 qualified about 200 artisans. The industry also employs journeymen who have been trained or acquired experience in other industrial sectors. These artisans undergo full acclimatisation in the needs of the coal industry. For instance, at Usutu colliery newly-acquired artisans undergo one-week's full-time training in the surface training centre. The artisans are mainly

FIGURE 5.2 PROMOTIONAL ROUTES IN UNDERGROUND COAL MINING



Source: Careers in Mining, Chamber of Mines' Publication, P.R.D. Series No. 231, 1979, derived from page 7.

fitters and electricians and training is devoted to the maintenance of underground equipment. In the case of fitters the special emphasis is on hydraulic systems and in the case of electricians on fault-tracing. Enterprising artisans can qualify as junior engineers (electrical or mechanical) as indicated in figure 5.3. The same applies to student mine officials who pass an engineering diploma. Graduates with BSc degrees in electrical or mechanical engineering are appointed immediately as junior engineers. In all these cases the acquiring of an Engineer's Certificate of Competency opens the way to promotion to the posts of section engineer and resident engineer.

A synopsis of the above discussion is presented below in figure 5.3.

It must be admitted, however, that the objective of the industry and Government is to move away from this racial hierarchy towards a multi-racial skilled workforce. This is certainly in the industry's interests in view of recent growth and the chronic shortage of skilled manpower. Likewise the Government has moved away from the concept of job reservation by repealing section 77 of the Industrial Conciliation Act, allowing the indenturing of black apprentices in white areas, and admitting blacks into the registered trade-union movement. This has been prompted by a combination of economic, social, and political motives, as detailed in the Report of the Wiehahn Commission. At the time of writing, however, such changes had hardly affected the mining industry. The discrimination inherent in the Mines and Works Act had not been repealed. By denying black the possibility of training for a blasting certificate they are effectively kept in sub-miner work categories and all promotional routes in underground coal mining as depicted in figure 5.2 are blocked. The Mineworkers' Union continues to deny any community of interests with black workers seeing them as a source of employer cheap labour and, hence, a threat to their standard of living and ultimately their jobs. It staged a brief and largely unsuccessful strike in 1979 over the question of the Wiehahn Commission proposals. The Chamber of Mines contends that the white man's future is secure in the industry because the demand for skilled labour will always outweigh the supply: it is not their intention to replace them with cheap black labour.

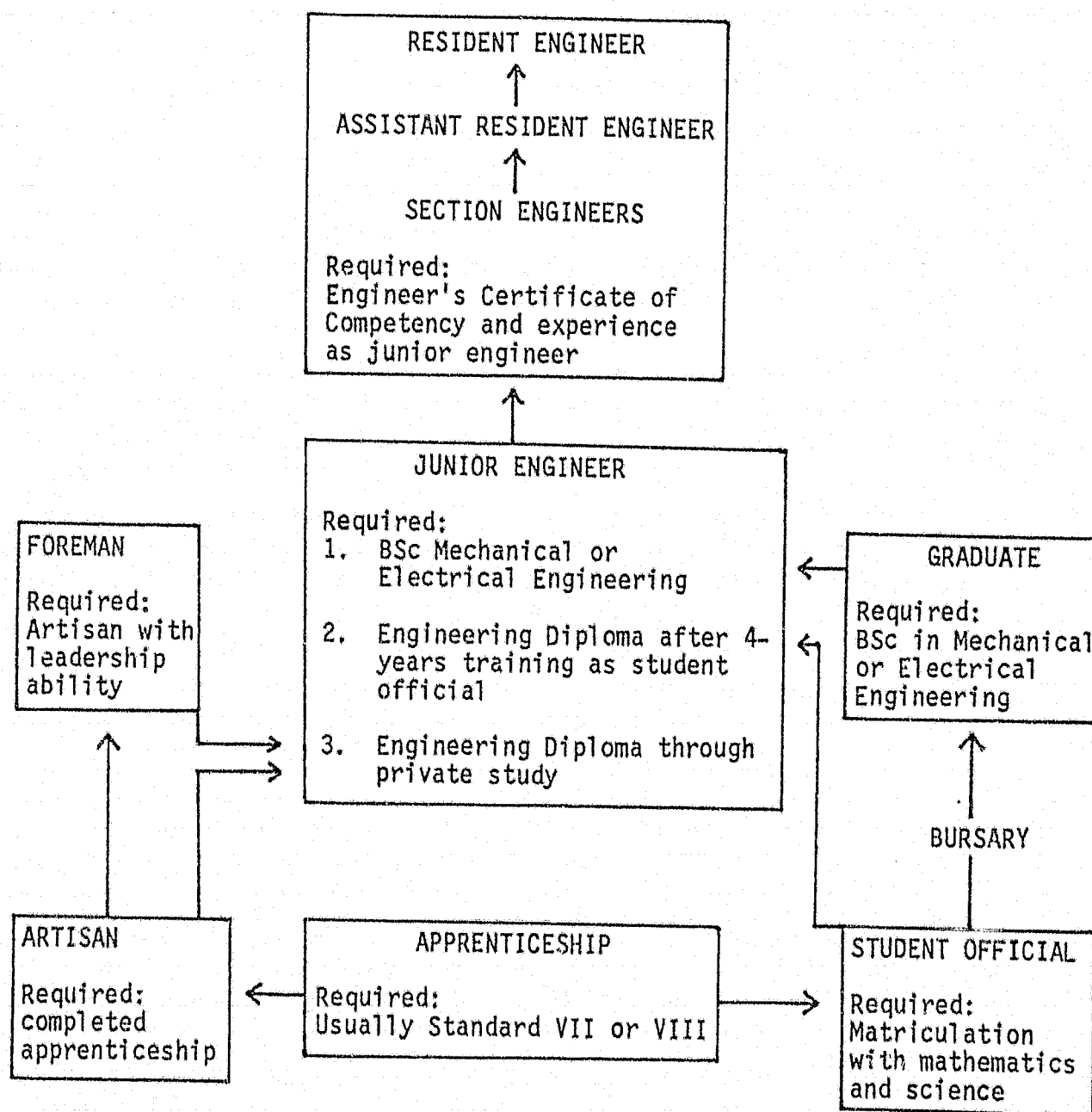
The Union is particularly conservative because its members are the least skilled in the industry and would be the first to be replaced by general black advancement. On the other hand, unions representing

artisans and surface officials realise that because their members are more skilled and less vulnerable, no danger to their job security is presented. They are, therefore, prepared to allow orderly black advancement and (with the exception of the Amalgamated Engineering Union) seek to incorporate eligible blacks into their membership. With the change in Government policy, and the absence of any statutory barriers, the industry has made cautious strides in advancing blacks along the engineering promotional ladder depicted in figure 5.3.

The major success has been the indenturing of blacks as apprentices, and this has been facilitated by the recent development of group training centres. Amcoal has established such a centre at Schoongezicht colliery near Witbank. It was built in January 1974 using black artisan aides (bricklayers, electricians and fitters mainly) to gain experience. In 1977 this centre took over from the Colliery Training College the responsibility of training Amcoal's apprentices as fitters and electricians. Practical training is received in the workshops of the group's individual collieries (38). Rand Mines was the first group to indenture black apprentices. An artisan-training centre to serve the needs of the group's collieries has been in operation since the beginning of 1981 and is situated at Duvha colliery. The Criterion Reference Instruction (CRI) method has been adopted in the training programme because it allows each apprentice to progress at his own pace instead of at the group's pace. The centre is multi-racial, but whilst white apprentices attend technical college in Witbank, the blacks have to go to Pietersburg because such colleges are not integrated (39).

Centralised group training centres do not only meet the needs of apprentice training. For example, the Amcoal centre at Schoongezicht also contains a unit devoted to black-worker training. Typical courses are held in machine familiarisation, general team leader, and artisan aides. Courses last from one to six weeks and students are selected by colliery management. Learner control programmes in all aspects of mechanised mining have been devised by the centre for use on the collieries supported by one-week courses at the centre. Other "on-the-job" training facilities are available at Schoongezicht to provide the established worker with further opportunities to develop his potential and gain added experience and qualifications. For instance, one unit is concerned with graduate-and professional-development programmes. These schemes train individuals who are sent to a specific mine for the

FIGURE 5.3 PROMOTIONAL ROUTES IN MECHANICAL/ELECTRICAL
ENGINEERING IN COAL MINING



Source: Careers in Mining, Chamber of Mines' Publication, op cit., derived from page 10.

duration of the course. Development is monitored by the centre. The duration of the programmes varies - two years in the case of engineering, mining, and personnel trainees, while those following a metallurgical programme spend 18 months on it. A new course for administrators was started in 1980. The programmes are designed to give the trainee both a general and specific knowledge of the industry and his role in it, whilst at the same time allowing him to develop within his discipline. The centre works in close co-operation with training centres established on individual mines. The latter are expanding rapidly, for instance, Kriel colliery is in the process of developing a major training division on its premises.

Rand Mines has decided to locate their non-apprentice training facilities away from the school at Duvha and separate premises have been constructed at Douglas colliery. These incorporate an artisan-aide training centre in the three major trades of fitting, electricians, and plating. Training of operators is also carried out. Employees are given basic training and issued with certificates of competency as operators of various types of equipment and machinery. In addition, Criterion Reference Instruction courses have been developed for all miners, team leaders, artisans, shift bosses, foremen, and mine overseers (40). Management training has traditionally been carried out by Rand Mines at the White Lodge Centre, Crown Mines; whilst the Rand Mines' Training Centre established in 1953 in Maraisburg has concentrated on learner officials, supervisory and specialist ad hoc courses and job training. This arrangement is scheduled to be changed in 1982 when the new Rand Mines' Training Centre is opened at Ormonde, Crown Mines. The new college will take over all the training responsibilities of the present centre and the middle-management courses provided at White Lodge, which will then be used exclusively for senior-management seminars (41).

The coal division of General Mining also takes a keen interest in management training and development. The philosophy of "decentralised management" is practised with seminars being held at the group training centre at Stilfontein and backed up by lectures and discussions on individual mines. Group discussion and problem-solving exercises are stressed.

The first training centre in South Africa to cater specifically for open-cast colliery workers was commissioned in 1981 at Kilbarchan colliery to serve the needs of employees of the McAlpine group (42). However, other mining groups appear not to see the need for this development, and teach both underground and surface skills in the same training centre.

Despite these recent attempts to train, localise, and stabilise the black workforce, the industry will continue to rely on rural migrants for many years to come. Hence, the lack of formal education and a non-technical background will continue to hamper the advancement of black workers. According to Mr. H. Oppenheimer, Chairman of the Anglo-American Corporation, black advancement to senior positions has been disappointing in the industry. He contended that blacks would only be able to compete with whites in senior positions when their upbringing, experience, and training was in a mainly white environment - a development still a long way away (43). For these reasons alone black advancement can only be circumspect regardless of the policies of the Government and the industry, or the attitudes of trade unions and the state of statutory provisions. Individual promotion opportunities are good "up to a certain level, admittedly no further" (44).

The Motivation of Labour

No matter how healthy or educated a labour force may be, if it is poorly motivated in the work environment this will have a negative effect on productivity. The major writers in the field of motivational theory (Taylor, Mayo, Maslow, McGregor, Herzberg, and so on) are well known and have been extensively studied. There now appears to be wide consensus that motivation is based upon needs and that these needs are arranged in a hierarchical configuration. A need, once attained, fails to continue to motivate, and the individual moves on to attempt to attain the next-highest need in the hierarchy. Disagreement amongst writers occurs in the classification of needs, but this amounts to differences in detail and not concept.

The "lower" needs are based upon the basic requirements for food, clothing, shelter, minimal education, and safety. Translated into the work environment this implies the need for decent wages and working conditions, fringe benefits, and job security. This lower section of Maslow's hierarchy is what Herzberg would call "hygiene" factors, that is, they lead a worker to feel not dissatisfied with his situation (a negative reaction) but they do not in isolation instil a definite feeling of satisfaction (a positive reaction). This latter position is only achieved through genuine "motivators" which are inherent to the nature of the job itself and not peripheral to it. Translated back to Maslow's hierarchy this would involve the "higher" needs based on belonging, recognition, prestige, status, esteem, and finally, self-actualisation.

With very few exceptions blacks have traditionally not regarded their jobs in the mining industry as careers (although this has slowly been changing in recent years with the advent of mechanisation and the increased emphasis on a more-stable and skilful black workforce). This has been due to the existence of the racial job hierarchy which has relegated them to the lower job categories and also to the nature of the migrant-labour system. Migrants are believed to have been motivated solely by a "target income", i.e. a set amount of money which would be sufficient to meet their requirements and those of their families for the next season. Once this target has been achieved they are content to return home and only seek renewed employment once further income is required. For these reasons the real "motivators", such as recognition and prestige, have been absent from the black-worker's environment and emphasis has concentrated more on "hygiene" factors. In contrast, white workers have not been restricted to this lower portion of the hierarchy. It would, therefore, not be inaccurate in concentrating a discussion of motivation on the provision of facilities by the coal mining industry which lie in the lower portion of Maslow's hierarchy, i.e. wages, working conditions, fringe benefits, and job security.

In many respects the range and magnitude of these factors depends upon the system of labour relations, that is, the relationship which exists between management and workers, and particularly upon the negotiation power of organised labour. A discussion of labour relations as it has existed in the coal mining industry is therefore called for.

Labour Relations in the Coal Mining Industry

Workers have traditionally been racially divided both by statute and convention in their negotiations with management. Government has always been suspicious of black trade unions, regarding them as "slumbering giants" capable of eventually forcing social and political changes. For this reason, and others (45), blacks have been statutorily banned from membership of registered trade unions in terms of the Industrial Conciliation Act (renamed the Labour Relations Act in 1981), the first Bill being enacted in 1924. It is only since 1979 (stemming from the recommendations of the Wiehahn Commission) that blacks have been allowed membership of registered trade unions. Initially only "urban blacks" were permitted into the movement as members of racially-separate unions (or multi-racial unions with the special authorisation of the Minister of Manpower Utilisation). However, by 1981, and via a series of separate steps (described by Jones (46)), the position had been achieved whereby all blacks were eligible for membership of registered trade unions, and such unions were allowed complete autonomy as regards their racial membership composition.

However, there has never existed any explicit statutory ban on the formation of unregistered black unions, but such unions have experienced difficulties in practice. They have often fallen foul of security legislation; their leaders have been inexperienced and lacked organisational ability; employers have refused to recognise them; and black workers have not joined them in substantial numbers because they lacked power. Because of these factors they have been characterised by instability. The African Mine Workers' Union has typified these developments and, in addition, it has suffered from an impermanence of personnel and leaders caused through the migrant-labour system. As a result it has never been a force in the industry, and has been all but ignored by the Chamber of Mines.

In the absence of an organised and legally-recognised black trade-union movement an alternative system of works and liaison committees at the factory (or firm) level was devised for blacks by the first Nationalist Government under Dr. D.F. Malan in terms of the Black Labour (Settlements of Disputes) Act of 1953 (renamed the Black Labour Relations Regulation Act in 1977 and finally repealed in 1981). However, the gold and coal mining industries were specifically excluded from the provisions of the Act (except that by proclamation the

provisions of the Act could have been applied to these industries in any area, but such a proclamation was never enacted).

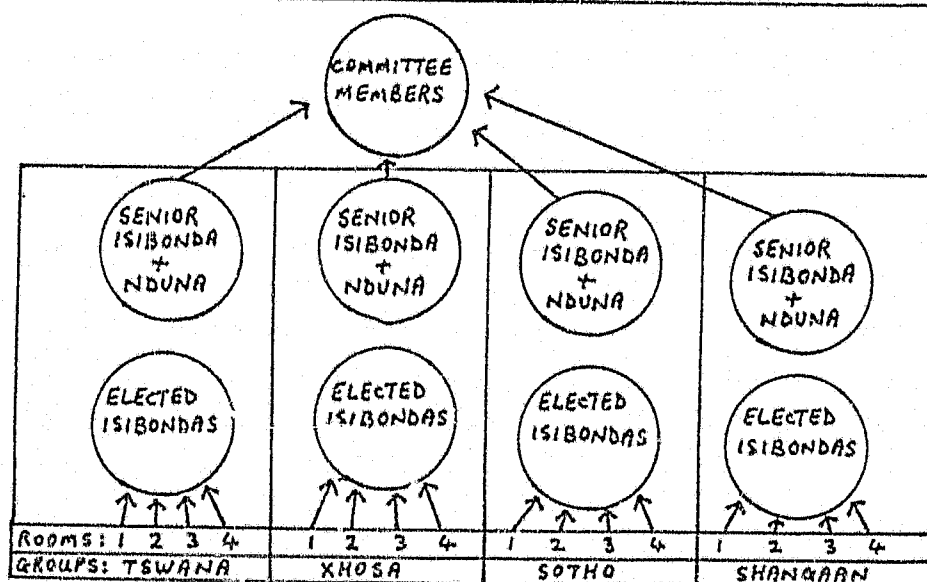
Consequently blacks in the coal mining industry have traditionally been statutorily denied both registered trade-union representation at industry level and committee representation at company or mine level. This has implied that negotiation with management on matters of common interest has been absent. Wages and other conditions of employment have been fixed centrally and unilaterally by the employers and handed down to black workers in an atmosphere of paternalism. In other words, the approach has been to do things "for" the black worker and not "with" him on the pretext that management knows better than the black worker what is best for him. In the absence of negotiation, labour relations has, therefore, been mainly concerned with grievance channels and disciplinary procedures.

In terms of the Native Labour Regulations Act of 1911 (repealed and replaced by the Black Labour Act 1964 and the Black Labour Regulations 1965) no provisions were made for black labourers to organise themselves for the purpose of negotiating with management or redressing grievances. Instead grievances had to be addressed to Inspectors of black labourers who were appointed by the Governor-General to watch the interests of black workers and make representations on their behalf by enquiring into and redressing, if necessary, any complaints from them. Inspectors were also empowered to arrest any blacks suspected of contravening any regulations, and could also enquire into, and determine, several categories of breaches of discipline on the part of blacks. These included such misdemeanours as: neglecting to perform any work which it was his duty to perform; being unfit to properly perform his work through intoxication; refusing to obey any lawful command of his employer or any person in authority; and committing a breach of any rules prescribed for good order, discipline, or health. Any black found guilty by an Inspector of such an offence, or of a contravention of any regulation, could be fined, and the amount was deducted by the employer from the black's wages.

Administration, discipline, grievance, and communication channels between labour and management in compounds and hostels on individual mines have traditionally been provided through the Isibonda system, based on compound-room elections and not related to work groups. Room-mates usually of a particular ethnic group, although this is not always

necessarily the case, elect Isibonda (local headmen) and that particular group, in turn, elects senior Isibonda who then become Committee members. In addition, management appoints Indunas (chief counsellors) who elect one of their numbers for each ethnic group to act as a representative on the Committee. It must be stressed that many sources regard Indunas as "management men" and not worker representatives. The concept can be shown structurally as in figure 5.4 below.

FIGURE 5.4 THE ISIBONDA SYSTEM OF BLACK REPRESENTATION



Source: Tlhopane, S.E.N., "Training for Communication: an Important Facet", Coal, Gold and Base Minerals, August 1980, page 125.

Together with tribal representatives for each tribe (often referred to as "police boys" and appointed by the Indunas), the Isibonda system is under the control of a licenced white compound manager or black-personnel manager. In addition, the larger mining groups employ group black-labour advisors responsible for overall supervision and guidance to the compound managers under their control. The Indunas and Senior Isibonda act as extensions of management in the compound situation and have to administer discipline and also act as a grievance outlet, representing the workers in the compound in their capacity as committee members. This has often brought about an element of "role conflict" in that they are expected to discipline the men and at the same time expect the workers to approach them with problems and grievances. However, such role conflict is basically an Induna problem, since Isibondas have a minimal disciplinary function.

Increasingly, throughout the 1970's, the Chamber of Mines has foreseen the possibility of a change in the law to legalise black trade unions and that this would eventually make redundant the 1953 Black Labour Relations Regulation Act. They also anticipated the eventual amalgamation of the two Acts (a Wiehahn Commission recommendation) on a non-racial basis, creating provisions for a two-tier system consisting of national and/or regional trade unions, and works councils or committees at factory level (also a Wiehahn Commission recommendation). These developments became a reality in the form of the 1981 Labour Relations Act. Accordingly, the Chamber voluntarily instituted a system of liaison-type committees outside the context of the 1953 Act to be established on every mine consisting of management and worker representation to be responsible for the negotiation and settlement of parochial issues as they affect each mine. These committees have gradually been established since 1976 and are giving black workers valuable experience in the negotiation of local issues as they affect their own personal situation. They have also facilitated the creation of additional career opportunities for labour-relations officers who are generally responsible for maintaining good relations between workers and management and being involved in the liaison-committee negotiations. These posts are invariably created within the personnel department and exist on most of the large, progressive collieries. When, and if, a thriving black trade union is established in the mining industry these local committees will provide an important component of the negotiations hierarchy.

By the end of 1982 four new unions were recruiting black workers in the industry: the Federated Mining, Explosives and Chemical Employees' Union; the Black Mineworkers' Union; the Black Allied Workers' Union; and the National Union of Mineworkers (47). These were in addition to several established unions in the industry which had extended their scope to include black members. The most successful new union has been the National Union of Mineworkers which in December 1982 claimed a membership of 10 000 despite problems over recognition criteria with the Chamber of Mines, access to individual mines, and the attitudes of various mine managements and white workers and their unions (48).

The situation as regards white workers is totally different. Since the first Industrial Conciliation Act of 1924 they have been defined as "employees" and hence have been entitled to form and join registered

trade unions and take part in the provisions of the Act. The Act was originally passed following the experience of the 1922 Rand Rebellion which highlighted the lack of organised negotiation machinery. It makes provision for the registration of trade unions and employers' organisations. The Chamber of Mines is the registered employers' organisation for the mining industry, whilst mining workers are represented by several trade unions, discussed below. The Act makes provision for both parties to voluntarily form an Industrial Council (which must also be registered) to act as the forum for negotiating conditions of employment and settling disputes. Any agreement of an Industrial Council is legally binding for the duration of the agreement. However, the mining industry has not chosen to establish an Industrial Council, opting instead to regulate its labour relations through an "open-door" policy of collective bargaining at the various management levels. Only in the event of a deadlock is the appointment of a conciliation board, in terms of the Act, resorted to in settling the dispute. Such conciliation boards have been formed on many occasions in the past. A detailed report on labour relations in the mining industry has been prepared by the Wiehahn Commission (49) in which it recommended that both parties give serious consideration to the establishment of an Industrial Council for the mining industry.

In 1937 a "closed-shop" agreement was negotiated with the Chamber of Mines in terms of which only the following eight trade unions would be recognised in the mining industry,

- Mine Workers' Union,
- Amalgamated Engineering Union of South Africa,
- Amalgamated Society of Woodworkers of South Africa,
- Ironmoulders' Society of South Africa,
- South African Boilermakers', Iron and Steel Workers', Shipbuilders' and Welders' Society,
- South African Electrical Workers' Association,
- South African Engine Drivers', Firemen and Operators' Association,
- Amalgamated Union of Building Trade Workers of South Africa.

The basis of the closed-shop agreement is that every non-black employed in certain specified job categories is required to be, or

become, a member of one of the recognised trade unions which embraces his type of work. All eight trade unions are aligned in two federations: the Federation of Mine Production Workers (Mine Workers' Union and the South African Engine Drivers', Firemen, and Operators' Association) and the Federation of Mining Unions (the remaining six mechanics or craft unions). The former comprises workers with generally a low level of formal education and easily-acquired industrial skills who are not job mobile outside the mining industry, whilst the latter comprises workers who are generally skilled artisans, having served a recognised apprenticeship, and who are mobile both industrially and geographically. The two federations together constitute the Council of Mining Unions, which is itself a registered trade union and acts as a single collective-bargaining entity when negotiating with the Chamber of Mines.

There are three recognised officials' associations, namely:

- Mine Surface Officials' Association of South Africa,
- Underground Officials' Association of South Africa,
- South African Technical Officials' Association.

These associations are registered trade unions, but are not signatories to the closed-shop agreement. However, by unofficial agreement with the Chamber, officials are required to be, or become, a member of the relevant association.

A potential change in direction was indicated in November 1982 when the Council of Mining Unions together with two of the three officials' associations (the Underground Officials' Association being the exception) formed the Confederation of Associations and Mining Unions, which is open to all registered unions in the industry. Its constitution allows for integrated membership, implying that for the first time the official worker body which negotiates with the Chamber of Mines is theoretically open to all races. However, an application to join the Confederation by the Federated Mining, Chemical and Explosives Employees' Union was turned down in November 1982 when it failed to achieve the necessary two-thirds vote.

In the international context white trade unions in South Africa have constituted a paradox in refusing to entertain any community of interests with black workers. Internationally, trade unions have viewed any attempts at racialism in the workplace by the State and employers as attempts to "divide and rule" the organised labour movement, and hence diffuse its power. But white trade unions in South Africa have viewed any attempts to dismantle racialism in the work place as an attack on the living standards of white workers and an attempt to undermine their job security through the introduction of cheap labour. The Mine Workers' Union has probably been the most conservative white union in the country, mainly because its members possess low formal academic qualifications and easily-acquired industrial skills, making them extremely vulnerable to black advancement. This century is peppered with examples of industrial action taken by white mining workers in response to attempts by the Chamber of Mines to foster black advancement - the most serious being the 1922 Rand Rebellion and the most recent being the abortive 1979 strike in response to the (anticipated) Wiehahn recommendations. The Mine Workers' Union remains a member of the South African Confederation of Labour - an all-white body determined to resist black advancement. The General Secretary of the Mine Workers' Union, Mr. Arrie Paulus commented,

"the Minister has betrayed us. There are far more black miners compared to white and they will just overwhelm us. I am a member of the white ethnic group and it is their interests I will try my best to protect" (50),

when trade-union rights were extended to black workers in 1979. However, not all of the other trade unions and officials' associations in the mining industry are as conservative as the Mine Workers' Union. Although the Amalgamated Engineering Union is staunchly committed to remain white the other artisan unions and officials' associations are generally in favour of orderly black advancement and multi-racial unions provided that standards are maintained - their jobs are more secure in view of their high skills. Accordingly, they have either already acquired multi-racial status, or have expressed a desire to move in that direction.

As far as the Government is concerned it has given notice of its intention to eradicate job reservation in the interests of optimum manpower utilisation. Although "the writing is on the wall" it would appear that it wants the present situation to be dismantled by negotiation and for a new formula to be found to safeguard white-worker interests (51). However, Mr. Paulus has stated that "his union was not prepared to negotiate with anyone for the removal of job reservation" (52).

The position of the employers can be summarised as follows:

- The field of industrial relations presents the biggest challenge in the near future.
- The dismantling of discrimination in the workplace is a necessity mainly for economic reasons, but for social and political ones as well.
- It is not the intention to replace white workers with cheap labour. They will always have a place in the industry because the demand for skilled labour will always exceed the supply. However, there is a credibility gap between the Chamber and white workers. The latter are suspicious of the employers and an atmosphere of trust must be engendered.
- Any future industrial-relations negotiation structure must be tailored to meet the peculiar needs of the mining industry. The industry is different from others in numerous ways - for instance the large proportion of foreign migratory workers.
- Industrial relations is a matter for management and workers only - Government should stay out (53).

Wages and Wage Policy in Coal Mining

There are several reasons why it is believed that relatively high and rising wage levels in a firm or industry give rise to greater productivity.

- (i) There is no shortage of studies to show that workers (especially in the lower echelons of the job hierarchy) are attracted into jobs and activities with the highest monetary remuneration. This is often in preference to jobs which may be more-mentally stimulating but lower paid. Brits and Reese quote a study undertaken at the Vauxhall works at Luton in England where workers voluntarily and eagerly sought boring but highly-paid jobs on the assembly line in preference to more-satisfying jobs elsewhere in the factory (54). The same tendency is observed amongst black migrant workers in South Africa who voluntarily leave their rural home and family to undertake more-highly-paid work in the urban areas than can be obtained in the Homelands. The moral for an individual firm or industry is, therefore, quite clear that no matter how intrinsically satisfying or mentally rewarding the work may be, it will suffer high labour turnover and be unable to attract the right calibre of staff if it remunerates its workers below the average level prevailing elsewhere. High wages are necessary to retain and attract good calibre and experienced staff.
- (ii) Higher wages paid to an individual worker imply an increased ability to buy more and better nutritious food, clothing, housing, health care, and education. As a result he becomes stronger and fitter; morbidity and debility fall. He becomes a more-productive worker.
- (iii) Low wages imply that management can afford to be slack and inefficient in their operation of the organisation without running the risk of liquidation. This is known as "management slack". However, high and rising wages force management to be efficient in the search for all-round economic operation of the organisation. The taking-up of management slack is, therefore, a crucial element in productivity improvement.
- (iv) Higher wages prompt workers to feel more sympathy and affiliation with the firm. They come to associate with the organisation. The attitude of "us" and "them" begins to fall away. This leads to greater motivation and job satisfaction.

- Labour unrest declines, strikes become infrequent. This type of atmosphere induces maximum productivity.
- (v) Higher wages lead management to substitute capital equipment and machinery for labour. This alone induces greater productivity and although many workers are made redundant those who remain are skilled and highly paid. Spread throughout the economy, an era of self-sustaining, capital-based, economic growth begins, so that those workers initially unemployed by automation are drawn back into employment by the consequent multiplier effects.
 - (vi) Higher wages will prompt migrant blacks to abandon their oscillatory urban-rural movements voluntarily. They will feel an affiliation for the urban area and be able to afford to bring their families into the cities and purchase permanent accommodation. Thus they become a stabilised unit in the urban area. Training is, therefore, facilitated bringing further wage rises and higher productivity.

The arguments quoted above have been persuasive in convincing many newly-independent African Governments to legislate a system of high minimum-wage levels in the quest for maximum productivity and economic development. (However, political considerations have also been dominant). But the system of high wage minima has not been without its opponents and these criticisms may well explain why the policy has generally failed in African states (55). There is no guarantee that higher wages will be necessarily spent on more nutritious food - they could be spent on cigarettes, liquor, gambling or otherwise squandered away, and the extended-family system inherent amongst African peoples means that distant relatives can always appear demanding a share of the higher wealth. Poor nutrition is not necessarily caused by low wages and poverty - it is exacerbated by ignorance, large families, tribal customs, and inefficient farming methods. There is also no a priori reason why a well-nourished individual should feel more disposed to work harder than an under-nourished individual. What is important is an inherent "work ethic", and this is independent of the state of nourishment. Also important are extraneous factors such as high taxation and socialism which can destroy personal initiative, and hence productivity, regardless of nutrition. The notion that high wages can

also take up managerial slack and induce capital-based growth has also been challenged in the African context. Management can merely pass on higher costs to the consumer, or they can choose to go out of business. These are obvious courses of action to take when management does not possess the ability to take up slack. In addition, the second phase of capital-inspired growth has never taken off in the African context because of the lack of skilled labour and technological initiative. The unemployment of the first phase has persisted and worsened into the secondary stages which were meant to be dominated by expansion and employment creation. Nor do higher wages necessarily imply a greater affiliation for the firm and less labour agitation. They could result in an unrealistic heightening of expectations leading organised labour to ask for more and not less. In like manner the notion of a skilled, highly-paid and stable urban work force has not materialised. Since the second phase has never materialised the result has been an unskilled, unemployed or lowly-paid, unstable urban work force living in shanty towns surrounding the major urban areas. Accordingly, it cannot be said that high minimum-wage policies have had the desired effect in black Africa.

The Chamber of Mines of South Africa has traditionally followed a low-wage policy in comparison with wages being offered in the manufacturing and commercial sectors. The mining industry has also been characterised by a large racial wage gap in comparison with other sectors. Several factors explain this:

- whereas the white wage structure has been negotiated with aggressive trade unions and/or dictated by periodic shortages of skilled labour, black wages have been unilaterally determined by the Chamber of Mines on the basis of what the industry could afford, and handed down to blacks in an atmosphere of paternalism,
- migrant workers are generally more docile than urban blacks and have acquiesced far more readily to low wages and poor working conditions,
- the existence of job reservation and conservative white trade unions,

- the marginal profitability of the coal mining industry,
- the belief by the Chamber of Mines in the "target-income" hypothesis and the existence of a backward-bending supply curve of migrant labour.

Graham (56) reports that in the early 1930's a white miner on a Witbank colliery would receive R13,20 for a guaranteed 48-hour week. Artisans received the same pay. The rates of pay for black workers depended upon the task performed, some examples being: loaders 20-30 cents per day; drillers 18-23 cents per day; coal cutters 20-30 cents per day; others 16-23 cents per day; and surface workers 16-25 cents per day. The average daily rate of pay per black worker underground and on the surface could not be less than 20 cents and 18 cents respectively. Furthermore he was guaranteed payment for 22 shifts per month, work or no work, bringing the average rate of pay to 30 cents per day.

In 1946, Hall (57) reports that the average earnings per white worker were R1068 per annum, about 6 per cent below the comparable figure for gold mining. Typical white salaries and wages were as follows: mine manager R240 per month; chief mechanical engineer R140 per month; chief surveyor R120 per month; compound manager R100 per month. Miners could expect approximately R2,28 per shift, and artisans between R2,20 and R2,30 per shift. The average earnings per black worker were R80 per annum, about 9 per cent below the comparable figure for gold mining. The white/black racial wage gap was, therefore, 13,5:1 in coal mining in 1946.

By 1967 the average earnings per white worker had risen to R3636 per annum (58). Typical starting salaries were: assistant sampler R123 per month; handyman R160 per month; first-year surface apprentice R53 per month; and a male matriculated clerical assistant R114 per month. Underground black workers were paid an average of R15,47 per month, with starting rates varying from R8,84 to R9,62 a month. Surface black workers were paid an average of R13,50 per month, with the starting rate being R7,02 a month. The highest-paid tasks involved underground operations requiring skill or heavy manual work. Bonus and piecework payments could be earned, but there was little scope for overtime. Hand

loaders were paid an average of R17,80 a month (ranging from the minimum starting rates up to R36 in individual cases). Other examples were: drillers R21,70 (ranging up to R35); drivers of mechanical equipment R22,80 (ranging up to R49); underground boss boys R26,33 (ranging up to R60); surface boss boys R15,18; indunas, clerks, orderlies, etc, R29,25 (ranging up to R55). The white/black racial wage gap had risen by 1967 to 20:1.

The wage structure during the 1970's is reflected in table 5.4 below.

TABLE 5.4 BLACK AND WHITE WAGES IN COAL MINING AND

MANUFACTURING: 1970 - 1980

COAL MINING

AVERAGE ANNUAL PAY RATE (RANDS)

<u>YEAR</u>	<u>CPI</u>	<u>WHITES</u>		<u>NON-WHITES</u>		<u>RACIAL WAGE GAP</u>
		<u>NOMINAL</u>	<u>REAL</u>	<u>NOMINAL</u>	<u>REAL</u>	
1970	100,0	4701	4701	214	214	22,0
1974	138,5	7146	5160	524	378	13,6
1975	157,2	8473	5390	904	575	9,4
1976	174,7	9276	5310	1073	614	8,6
1977	194,4	9535	4905	1271	654	7,5
1978	215,6	10079	4675	1521	705	6,6
1979	244,0	10942	4484	1776	728	6,2
1980	277,6	13111	4723	2204	794	5,9

MANUFACTURING

AVERAGE ANNUAL PAY RATE (RANDS)

<u>YEAR</u>	<u>CPI</u>	<u>WHITES</u>		<u>BLACKS*</u>		<u>RACIAL WAGE GAP</u>
		<u>NOMINAL</u>	<u>REAL</u>	<u>NOMINAL</u>	<u>REAL</u>	
1970	100	3817	3817	660	660	5,8
1980	277,6	11468	4131	2688	968	4,3

*Coloureds and Asians excluded.

Source: derived from Dept. of Statistics: Quarterly Bulletins.

It can be seen that by 1970 the white/black wage gap had widened further to 22:1. Since then, however, it has declined rapidly, and by 1980 had fallen to 5,9:1. During the same period the manufacturing wage gap also fell from 5,8:1 to 4,3:1. Black workers, on average, are better remunerated in manufacturing than in coal mining by approximately R470 per annum, roughly the same absolute difference as in 1970. Although the percentage rate of increase is far higher in coal mining this is misleading in view of the lower 1970 base figure.

Two views are prevalent concerning the size of the racial wage gap. The "liberal" argument holds that it is an indication of the magnitude of racial discrimination in the industry (in a perfect non-racial situation the ratio would be 1:1). The "conservative" argument holds that it is an indication of the magnitude of the skill difference between white and black workers (workers being paid according to their marginal productivity). In reality, elements of both are undoubtedly at work.

Several factors can account for the rapid closure of the racial wage gap during the 1970's:

- the publication in the early 1970's of Francis Wilson's two books on the gold mining industry and the migrant-labour system. The damning indictment of these books politically embarrassed both the industry and the Government,
- the increasing profitability of the coal mining industry,
- the increasing aggressiveness of black workers and their heightened expectations,
- the changing image of coal mining which is now attracting more local urban South African blacks and married men as well, in preference to foreign, single, rural blacks. These men are more stable and are now regarding coal mining as a career,
- the increasing mechanisation of coal mining which is giving rise to better-trained and more-skilful black workers,

- the increasing social conscience of the mining groups, particularly Anglo American, Rand Mines, and the oil companies,
- the Government's declared policy of the training and material advancement of black workers generally and the payment of equal wages for equal work,
- a reduction in the wages-skills gap, that is, reducing the traditional differential between the wages commanded by skilled and unskilled labour,
- the need to be more competitive, from the point of view of attracting and retaining suitable labour, with other sectors of the economy.

It is readily admitted that increases during the 1970's have not been related to productivity,

"this has been the result of a deliberate policy of allowing white wages to follow their normal upward course, determined largely by economic forces, while increasing the much lower unskilled black wages at a higher rate" (59).

The reasons for this have already been stated. However, many sources find it difficult to justify large black wage increases unrelated to productivity, arguing that high wages cause mechanisation in the industry and inflation in the economy. The objective should be to create the maximum number of jobs, not to maximise the wages of those workers who survive in employment (60). So-called "progressive" organisations such as Anglo American and Rand Mines, with a declared social conscience, disagree. They adopt the argument presented earlier that one must take the long view on productivity, namely, increases in black wages and a narrowing of the racial wage gap will eventually lead to greater productivity through a more-stable black work force, acquiring higher skills, and feeling a greater affinity for the industry (61). In other words, higher wages can cause greater motivation and productivity and should not merely reflect actual increases in productivity. It is also implied that prior to the 1970's black wages were kept artificially low through an unrealistic fixed gold price.

Accordingly, an unacceptably low-wage structure was forced on the industry which fell well behind manufacturing wages. The developments of the 1970's, therefore, merely reflect an attempt to catch up and to progress towards a more-equitable wage structure, economically, politically, and morally (62). Anglo American has recently adopted the policy that increased black wages are necessary "in the interests of justice and racial peace" (63). In view of their social objectives they reject the policy of allowing the market to determine equilibrium wages. This would be "gravely unjust and dangerous" in the present South African conditions "for what it would involve is not a low-wage structure for all workers but a policy of maintaining high wages for whites and low wages for blacks. We surely cannot afford to tackle the problem of inflation along these lines" (64).

An element of realism, however, is evident from other quarters, in that it is realised that future increases will inevitably have to reflect productivity improvements. Considerations other than economic cannot continue into the long run if escalating costs must be checked,

"the scope for further improvement in wages must inevitably depend on the economics of the industry, especially the ability to contain costs through greater productivity; on the removal of statutory-imposed race discrimination in the workplace; and on the willingness of white workers to accommodate the progress of black workers into more-skilled and productive work while fully acknowledging, out of human considerations, the need to continue maintaining acceptable minimum wages, the escalating costs equation has critical implications for both wage and employment levels" (65).

Although black wages may still appear low in Western, industrialised terms, they are not low in third-world terms, or in regard to regional economics. The non-monetary benefits are estimated at between R50-R60 a month per black mineworker by the Chamber of Mines, so that in terms of the total wage "package" black coal-mining wages now exceed those in manufacturing. TEBA operates a savings scheme for black mineworkers and savings averaging over R100 per month per worker are now not uncommon. TEBA also provides a free service whereby miners can voluntarily elect to have a proportion of their wages remitted monthly

to their families. Some governments (e.g. Lesotho, Mozambique and Malawi) insist that 60 per cent of the wages earned by their nationals on the mines be paid out in their home country.

Spandau describes the developments of the 1970's as an "unprecedented improvement" constituting a "new deal" for black mineworkers (66). Not only has there been an impressive and sustained transition in regard to the magnitude of black wages, but the incentive nature of wage payments has changed. In earlier years the bulk of the black labour force on collieries was paid approximately the same basic pay for unskilled work. On top of basic pay, incentive and bonus schemes were operated for certain tasks (e.g. drillers and loaders) and this was facilitated by the fact that in hand-got mining black workers could work individually, or with one or two colleagues to perform their particular task. However, individual incentive schemes could not be applied to all tasks, and there was also a problem related to jealousies, tribal pride, customs, and so on. For instance, trouble could be imminent if a Tswana received more than a Zulu, or a young man more than an older man. In modern mechanised coal getting two changes have been observed in the nature of wage payments. Firstly, the black basic-pay distribution has become more unequal due to some measure of skills training and occupational advance. Secondly, mechanical mining depends for its success on the efficiency of large groups of men, and accordingly group incentives are now favoured over individual incentives. Spandau reports that on the coal mines of the General Mining group, group bonuses were set at 133 per cent of basic pay in mid-1979 (67). Several difficulties are inherent, however,

- group bonuses are difficult to evaluate in that exogenous factors such as seam height, stone intrusion, and the conditions of the roof and floor must be taken into account,
- there is a lack of skilled work-study officers making introduction slow and administration difficult,
- black workers have displayed an inability to fully comprehend a sophisticated incentive-pay system.

Finally, mention can be made of an exceptionally important motivational aspect related not only to equitable wage payment, but also to training and advancement. This is the concept of job evaluation. Late in 1978 the Chamber of Mines commenced on the task of evaluating all white jobs on the mines with the objective of producing a comprehensive white job-grading catalogue containing the job-evaluated gradings of all white positions up to and including mine-overseer level. A similar exercise for non-white jobs has also been planned. The Chamber has used the Paterson plan, a technique created by T.T. Paterson of the University of Strathclyde, Glasgow. It takes as its starting point the hypothesis that decision-making is common to all jobs and that all jobs, therefore, should be differentiated according to the various kinds of decisions. Basically there are six kinds of decisions that define the whole range of jobs within an organisation - policy making, programming decisions, interpretative decisions, routine decisions, automatic decisions, and defined decisions.

Working Conditions, Fringe Benefits, and Job Security

These factors complete the lower section of Maslow's hierarchy, and also Herzberg's "hygiene" elements. It is generally accepted that the quantity and quality of these benefits provided by the mining industry is in excess of those provided by other economic sectors. The benefits are provided on a racial basis. Black workers generally enjoy free food, accommodation, medical services and workmens' compensation, protective clothing, transport expenses, and social, recreational, and sporting facilities. Primary-school facilities are provided at some mines for the children of married workers. For instance, a R220 000 school was opened in 1980 at Rietspruit, ultimately to accommodate 1500 black pupils. (The school actually forms part of a R20 million programme to provide housing, recreational, educational, medical, and other community facilities for black workers at Rietspruit). Section 10 urban blacks who actually reside in a nearby township and not on a colliery's premises receive a "living-out" allowance to supplement their wages by way of compensation for missing several of the benefits provided to other black workers. Details of the improvements in black working conditions and fringe benefits are regularly provided in Chamber of Mines' publications (68).

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Name of thesis Productivity growth in the South African Coal Mining industry 1950 - 1980 1983

PUBLISHER:

University of the Witwatersrand, Johannesburg

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