Discussion of the previous paper

by M. G. SPENGLER* and W. D. ORTLEPP†

Mr More O'Ferrall must be complimented on a paper that will be a useful reference for the re-working of previously abandoned workings. His paper so closely mirrors experiences at East Rand Proprietary Mines, Limited, that it could well have been based on occurrences in that mine.

The mining of an isolated pillar should not be examined only in the light of present knowledge and the results of computer simulations; the conditions experienced when the pillar was last mined should also be considered. Pillars were often left for very good reasons. The presence of discontinuities in isolated pillars must be thoroughly investigated prior to mining since rock bursts in faulted pillars have been known to occur at depths where damaging seismic events are almost unknown. Isolated small pillars can also be a hazard to off-reef development. Under no circumstances should any pillar be regarded as crushed without proper investigation. For example, in 1978 a footwall drive developed close to a very small pillar that had been formed in 1921 was badly damaged by a major rock burst.

The optimum sequence for the removal of pillars can be determined by digital or analogue simulations, but, in the re-opening of old workings, the sequence is sometimes determined by the time and cost of developing access to the pillars. Under these circumstances, the selective mining of pillars can be done provided it is recognized that certain pillars may become so highly stressed that they should never be mined.

The mining of a reef band above a horizon that has already been stoped out does not necessarily result in poor conditions, provided the first cut has been adequately supported to reduce bed separation to a minimum. Without adequate support in the first cut, hangingwall control can be very difficult as a result of bed separation and face-induced fractures from the lower stope. In such cases, hangingwall control can be ameliorated by the mining of short panels at right angles, or as close to right angles as possible, to the face-induced fractures.

The use of pillars in a high stoping-width second cut below a stoped-out area is a very sensible method. Stiff support of this generally fractured, flexible hangingwall is particularly beneficial. In a similar situation on E.R.P.M., a marked improvement in hangingwall conditions resulted when 219 mm-diameter pipe sticks were used instead of packs. The deterioration of the hangingwall that can occur with the removal of the original permanent support when re-mining stopes for footwall or hangingwall bands can be reduced by the use of hydraulic props on the 'face'. The benefit is not only safety, but also a reduction in the dilution of what is often a low-grade reef band.

The re-opening of old areas often requires the sliping or re-development of footwall drives. Where these excavations are close to stopes in which total convergence has occurred, overbreaking and failure of the tunnel are not uncommon. The combination of relatively high re-generated stress and fractured rock is not conducive to good conditions. Where such circumstances exist, it is necessary to re-develop as far from the stope as practicable.

The re-opening of shallow old workings has resulted in support problems as far as both surface protection and hangingwall control are concerned. An examination of surface subsidences and the use of pillars in the old areas showed no clear pattern. The design of pillars for surface protection was further complicated by a lack of the type of information that is available for the design of pillars in coal mines. The two pillar-support layouts, shown in Figs. 1 and 2, that were eventually adopted were arrived at by the use of a much reduced uniaxial compressive strength of the rock and a generous factor of safety. The major consideration was to ensure that no surface subsidence occurred.

With the upper workings of the mine being ventilated by return air, rapid timber decay is a constant problem. This is particularly serious in the support on the sides of reef drives. The support requirements in the shallow workings of a mine are different in that little convergence takes place, but massive falls of hangingwall can occur with inelastic closure. The support must thus have a minimum of organic material, and be stiff enough to prevent separation and still accommodate the convergence. Pipe sticks with the protruding timber coated with creosote are used extensively for internal support. Sandwich packs of gum planks and concrete bricks are the most common packs used, with a mortared-concrete brick pack being used on the very top levels. The inability of the mortared-brick pack to yield more than a few centimetres before failure is recognized, and an attempt

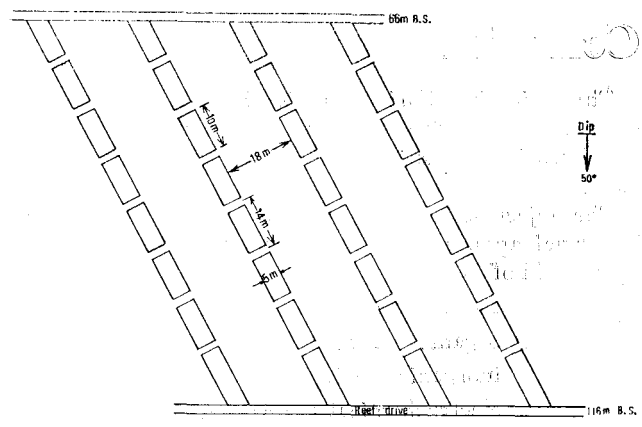

Fig. 1—One pillar-support layout adopted for old areas at E.R.P.M.

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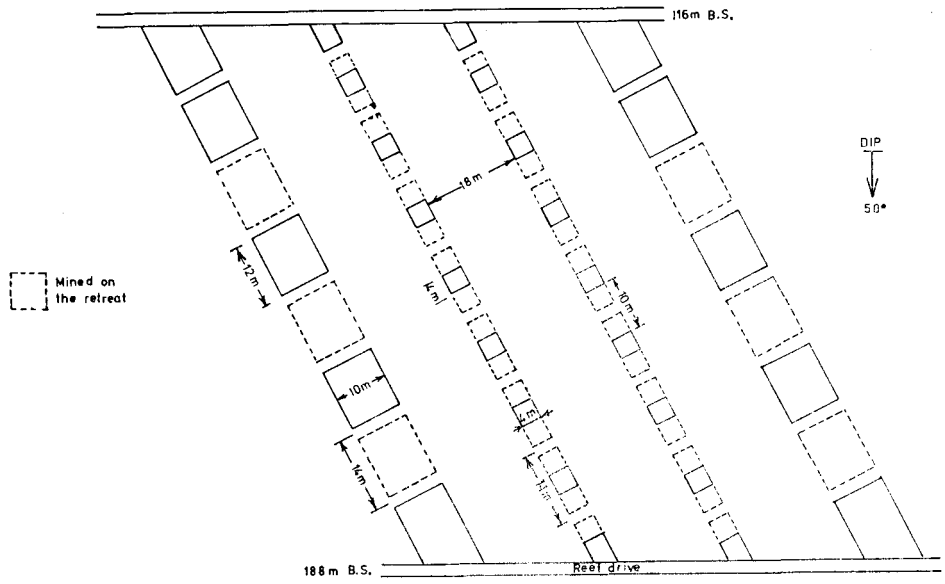

Fig. 2—Another pillar-support layout adopted for old areas at E.R.P.M.

has been made to improve its performance by alternating each layer of bricks with a layer of welded mesh.

Fig. 3 shows the results of compression tests on the packs discussed above. All the packs had a height-to-width ratio of approximately 2, and identical bricks were used in each pack. The weldmesh was 25 by 25 by 3,15 mm galvanized mesh, and the gum planks had a rise of 5 cm.

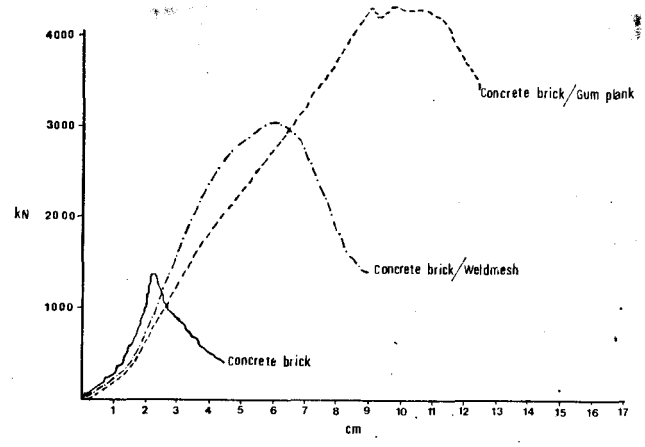

Fig. 3—The results of compression tests on three types of sandwich packs

Corrosion

The Scientific Society of Mechanical Engineers is organizing the 115th event of the European Federation for Corrosion in Budapest, from 18th to 22nd October 1982.

The object of EUROCORR '82 is to demonstrate the industrial application research-and-development results in the field of corrosion protection concerning

- metal coatings
- organic coatings
- inorganic coatings
- electrochemical protection.

One day will be devoted to each topic. There will be invited plenary papers, as well as survey and poster papers.

Working Groups of the European Federation for Corrosion will be holding symposia in parallel.

All inquiries should be directed to the Scientific Society of Mechanical Engineers, H-1372 Budapest, P.O. Box 451, Hungary. Telephone: 327767.

During this European Corrosion Week, the exhibition HUNGAROCORR '82 – Exhibition for Corrosion will take place in Budapest. Participants of EUROCORR will have free admission to the Exhibition. For furher details in connection with the Exibition contact HUNGEXPO, Hungarian Foreign Trade Company for Fairs and Publicity, H-1441 Budapest, P.O. Box 451.

The reclamation of gold from worked-out mines by the Boshoff method*

by G. J. KRIGE†

SYNOPSIS

An account is given of the Boshoff Group of Mines, which has been operating in South Africa for more than forty-five years. The Group works abandoned mines, and during the past ten years has reclaimed 65 million rands worth of fine gold (if the price is taken at $500 per ounce).

The Group's methods are very thorough, involving the examination and assaying of worked out mines; the putting down of winzes and the opening of old shafts and drives; the building of panels and stonewalls; the washing, breaking, and tramming of rocks (very little waste rock is taken to the surface); and the surface extraction of the gold from the ore. The equipment used by the workers is fashioned from discarded mining equipment, and nothing is wasted. Even the water tins used underground, the boots of the workers, and old mine timbers are treated for the gold they may contain.

SAMEVATTING

Daar word verslag gedoen oor die Boshoff-myngroep wat al meer as vyf en veertig jaar in Suid-Afrika bedrywig is. Die Groep ontgin verlate myne en het gedurende die afgelope tien jaar 65 miljoen rand se fyn goud herwin (as die prys as $500 per ons geneem word).

Die Groep se metodes is baie deegliks en behels die ondersoek en essaiëring van uitgewerkte myne; die grawe van daalgange en opening van ou skagte en strekgange; die bou van pilare en klipmure; die was, breek en tremming van rots (baie min afvalrots word na die oppervlak geneem); en die bogrondse ekstraksie van die goud uit die erts. Die toerusting wat die werkers gebruik, word van uitgediende myntoerusting gemaak en niks gaan verlore nie. Selfs die waterblikke wat ondergronds gebruik is, die stewels van die werkers en ou mynhout word behandel vir die goud wat dit mag bevat.

Introduction

For more than forty-five years, the Boshoff method of reclamation has been successfully practised on the gold mines. The late Mr W. P. Boshoff started 'mining' operations in 1934 at the Primrose Gold Mine. Since the Boshoff Group is solely dependent on 'left overs' from previous mining activities, a completely new approach was necessary to make Boshoff Mining an economic and viable proposition. The late Mr Boshoff found it an arduous task to convince and persuade people to put money into such a venture. Even the Government Mining Engineer thought that he was one of those entrepreneurs pouring his hard-earned money down the drain who would very soon be out of business. Although people were found to put a few pounds into this risky enterprise, they did it in a spirit of bidding farewell to their money. How wrong they have all proved to be: the little-known Boshoff Group is still, after more than forty-five years, producing gold and paying exceedingly high dividends to its shareholders. Why, then, is this Group successful in extracting gold for the benefit of the country – gold that would have been lost and left underground if there had been no Boshoff Group to extract it?

Examination and Assaying

Whenever there were surfaced outcrops on an abandoned mine and the records showed that fair gold values had existed, staff of the Boshoff Group utilized all possible entries and available openings to examine the conditions of the underground workings. This meant that they spent weeks in taking samples on all the reef horizons where access was possible. Broken rocks, fines on the footwall of stopes, and drives along tramming levels provided an indication of the values that could be obtained. Naturally, they found pillars as well as reef in the footwall and hangingwall. The deciding factor was whether there was enough tonnage available for a small-scale operation with enough gold content to warrant the re-opening of the mine. They carefully studied all the old records before they made their final assessment. Once they had purchased a mine, they set the wheels in motion without any further delay.

Winzes and Old Shafts

They put down winzes on either the Main Reef or the Main Reef Leader horizon, whichever would provide the quickest access to the first level. Any old shaft that could be re-opened was systematically tackled from surface. It must be borne in mind that, because the mines worked by the Group were generally outcrop propositions, the shafts were inclined, which gave quicker access to the reef horizons without the need for any further development work. It was also found that, except for the first 30 m, the hangingwall conditions on the whole were fairly stable and good. Production was therefore possible on a small scale practically from the beginning of the operation, but the main aim was to reach the first level so as to start the proper Boshoff method of reclamation. All the material used was acquired second-hand. For many years, and even till today, the Boshoff Group and its workmen did not know what the term *new material* meant or what new material looked like.

Old Drive Opening

O.D.O. is an abbreviation for the term *Old Drive*

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* Paper presented at the colloquium on 'The Influence of a Fluctuating Gold Price on the Potential Mining of Low-grade Areas', which was held by the South African Institute of Mining and Metallurgy in Randburg on 5th June, 1981.

† The Boshoff Group of Mines, P.O. Box 193, Germiston 1400, Transvaal.

Opening. Once the Boshoff operators reached the first level, they start the O.D.O. They sweep and clean the old drive of all fines, and use waste rock to lay the second-hand tracks. On the north side of the track, they build a stonewall of waste rock to a distance of 4 m above the drive. They do the same on the south side. They clean the areas adjacent to the drive thoroughly before they pack waste rock into the stonewalls. They keep the north siding about 4 m in advance of the south siding to prevent any fines from falling down and penetrating the stonewall on the south side. If required, they install timber setts. As the north-side stonewall progresses, they place a split lagging on the footwall to prevent any fines seeping or filtering into the stonewall, and they place another lagging where the workman is barring reef or cleaning out the accumulated fines to prevent contamination of the newly erected stonewalls. The stonewalls serve as support and also to get rid of the waste. They pack all the waste rock in the underground workings.

The O.D.O. is the Boshoff Group's 'development' of drives. The whole mine is re-developed by the O.D.O. process to the mine boundaries. Small or even substantial pillars are often found alongside an old drive, apparently left for support purposes. Any such find is a happy event. Very little blasting is done, except where the reef has lifted from the footwall or dropped from the hanging-wall and large rocks need to be broken so that they can be packed into the stonewalls. O.D.O. work, as well as mining progress in panels, is measured monthly so that management is kept informed of the progress of the 'development'.

Panels

At intervals of 40 to 60 m, depending on conditions, the workers start a panel from the lower level to the level above. This panel is considered to be the 'raise'. The panel is carried at least 4 m wide with a 2,5 to 3 m wide stonewall in the centre. The stonewall is solidly built, except where there is not sufficient waste, when breaks are left. Depending on the dip, two uprights with lagging are used to support the stonewall, and steps are taken to prevent fines from contaminating it. Should the dip be too steep, the panel is put in on a zig-zag pattern. Areas where the hanging has caved in are bypassed by use of a zig-zag panel. Once the panel that is producing fines and reef all the time has holed, the two reclamation faces are ready for cleaning operations.

Faces are worked outwards in an underhand attitude

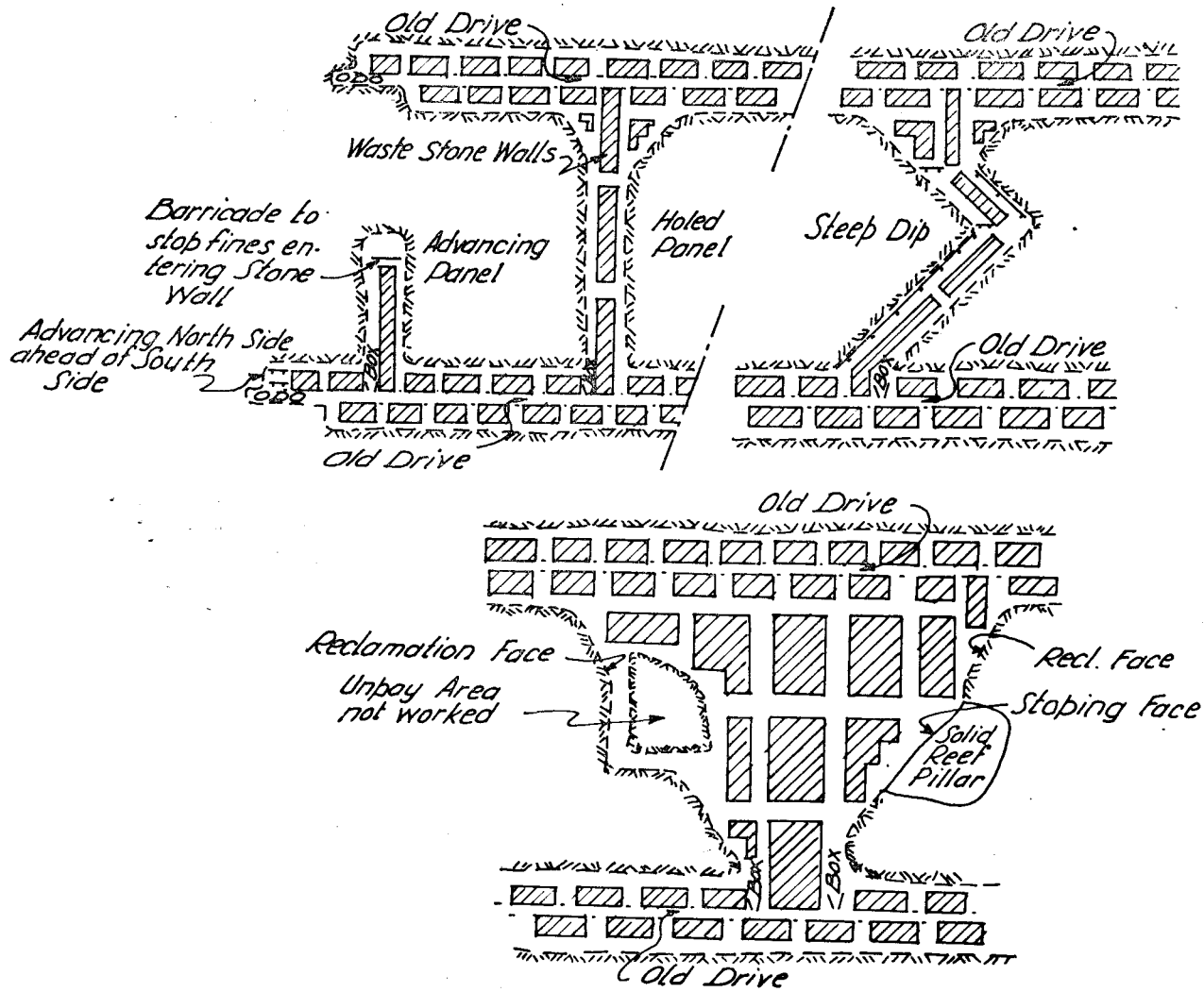

Fig. 1—Method of reworking an old mine

to prevent contamination, and three or four 'pick operators' are employed on each face to bar and sweep the reclamation face. Small timber boxes are installed immediately above the level to contain the ore, from which point it is trammed to the shaft. In this way, with the O.D.O. and panels being put up, the whole mine is reworked systematically (Fig. 1).

Areas where working conditions are dangerous or the values are too low are left 'intact'. A new underground plan is started, ignoring the old plans, which shows the advance in the worked-out areas. The advances are measured monthly. Only one such underground plan is used for each mine, the different reefs being depicted in different colours.

Working Method and Equipment

Each panel block, as well as the blocks worked in O.D.O., is issued with a pinch bar made from discarded jumpers; a scraper made from a discarded shovel and shaped to a point; a wire brush made of a piece of 20 mm-diameter pipe with wires from a piece of old winding rope, the pipe being flattened with a hammer to contain the wires at one end; a 4lb hammer; a water tin; and a shovel.

The pinch bar is used to loosen and dislodge crushed fines and reef, and the scraper to scrape the fines. The larger rocks are washed in the tin of water. If a worker recognizes a rock as waste, he immediately packs it into the stonewall. Any rock containing half reef and half waste, after it has been washed and the reef is clearly visible, he hammers to break off the waste portion. He then hand-shovels the reef to the box. He uses the wire brush to clean the footwall completely before the waste stonewall is extended. Water is used sparingly as watering down to allay the dust is hardly necessary. No watering of the footwall is allowed since this washes the gold into the crevices in the footwall. Each miner has a jackhammer to use should it be necessary to drill large rocks, reef pillars, or reef in the hangingwall or footwall.

It is surprising how much reef is found in the footwall. Of this reef, 60 per cent can usually be barred out with a pinch bar. The tonnage sent to the mill is small, but no waste ever reaches the surface. Thus, it can be seen that the support consists almost exclusively of waste-rock walls. It will be realized that the method of reclamation does not lend itself in any way whatsoever to mechnization for the removal of ore; the methods therefore rely very heavily on human efforts.

Control of Grade

The shift boss is held responsible for evaluating the ore in each panel and in O.D.O. work. The panel labourer brings up grab samples at regular intervals as instructed by his shift boss or mine overseer, and he then crushes the sample in a mortar made from a length of 100 mm-diameter pipe that has a solid bottom. He screens the sample through a sieve, fills a condensed-milk tin with the fines, and washes them in a sampler's or prospector's pan. The shift boss evaluates the 'tail' and enters the results in his notebook. At each panel and O.D.O., a plank is nailed onto a timber support showing the date, the value of the sample, and the name of the worker, who is informed of the value.

Whenever the mine overseer or mine manager visits the panel, the worker shows him all the 'grade equipment' that he uses and the purpose of each individual tool, and he proudly states that his ore is worth so many 'pennies' – this refers to the old measure of pennyweight per ton.

When no gold is visible in the pan, a sampler is sent down to take grab samples or pillar samples. The samples are assayed in the assay office and plotted on a sample sheet. However, this is seldom required. If there are grade difficulties, the sampler takes box-grab and car-grab samples, which are assayed so that the reasons for the low grade can be traced. Even the team leaders are taught how to pan a sample. Any action considered necessary is taken promptly, and the workmen are rearranged if required. O.D.O. work and panel-establishment work are kept well in advance of the working faces.

No Waste

The water tins used underground by the panel and O.D.O. workers are cleaned out at least once a week, and the washed fines are mixed with the ore. After completing a shift, the workmen wash their boots in a tin of water on the surface and this fine mud is fed straight to the mill. Old timber is brought to the surface and is used for the calcining of gold slimes. The ash is screened and washed, and the sediment is taken to the mill. These activities may seem trivial to the gold-mining industry at large, but for the Boshoff Group it is important to recover every gram of gold. After all, the Group believes itself to be the expert in reclaiming gold wherever it may be found. But perhaps more important is the fact that the worker is made aware that no 'pennies' must be lost anywhere along the line. The target is the recovery of gold, and the search is extended everywhere, however small the quantity.

Supervision

Naturally, close supervision, especially underground, plays a vital role in the achievement of maximum results and recovery. The main duty of the underground shift boss and mine overseer is to make sure that no gold-bearing ore is left underground during the reclamation operations. They must examine the footwall carefully for reef leftovers and the stonewalls for reef inclusions. If they have any doubts as to whether the footwall has been cleaned properly, the newly extended portion of the stonewall has to be broken down until they are satisfied that no fines have been left. The team leader has also to pay special attention to this aspect.

Experience through the years has shown that the special attention and time devoted to this subject have reaped benefits and dividends. More pressure is exerted on working 'clean' than pushing for tonnage. The Group works on a small scale, but efficiently. It is contended that anyone who works a mine after the Boshoff Group have finished with reclamation work will have an exceedingly lean time.

Extraction

Gold is extracted very much in the same way as on the older gold mines today. The ore is fed to a tubemill, and

then over corduroy tables. The corduroys are washed every 3 hours in a screened and locked tub, the concentrates being charged into an amalgam barrel. The amalgamation process receives 65 to 70 per cent of the gold.

After passing through the cones and cyclones, the sand and slimes are treated separately by the ordinary cyanidation method. The slimes are first treated in a Browns tank and then in slimes tanks. From here the pulp is transferred from one tank to the next until most of the gold has been extracted. Colour tests are taken after each transfer, and no tank is discharged to the slimes dam before the foreman has satisfied himself that the colour is clear. A sample of the residue is taken for assaying.

The gold-bearing solution is piped to a steady-head tank, and from there through boxes packed with zinc shavings. Once a month the black zinc shavings and sediments are burnt in an acid vat, put through a press, and calcined. On smelting day, the amalgram is retorted and both the sponge and the buttons obtained from the cyanide section are smelted and the bars poured.

Whenever a tubemill or a portion of a tubemill is relined, the liners are conveyed in a tray, and are washed and brushed very carefully. The concentrates behind the liners on the shell are removed in a container, and all the concentrates thus obtained are fed into an amalgam barrel. Extraction varies between 95 and 98 per cent in the reduction plant, with residues between 0,18 and 0,22 g/t.

Grass is planted on all the current slimes dams to prevent pollution by dust.

Personnel

Being part of a small organization, the workmen of the Boshoff Group form a very close-knit team. Experience in all the facets of the Group plays an important role in the success of the mining venture. There are a number of senior personnel with over forty years experience in their respective fields, and a hard core of well-trained men in the senior category form the nucleus of the organization. Most of these men have come through the school of hard practical experience, and can tackle any job with perseverance and success. The personnel are a bank of loyal and enthusiastic workmen – White and Black – whose combined efforts could be equalled only seldom anywhere in the mining industry.

Furthermore, the management is well aware of what is going on in all the different departments. The manager has acquainted himself with all the details of each department, and has a good working knowledge of the reduction works, the accommodation of Black workers, the stores, the assay office, the workshops, etc. Regular meetings are held with all heads of departments to discuss problems and future work layout. Without these men, there would have been no Boshoff Group of Mines. No wonder that Piet Meiring wrote a book to pay tribute to these pioneers and stalwarts on the occasion of the thirtieth birthday of the Group.

Conclusion

At one stage, the Boshoff Group had eleven operating mines. At present only three mines are still producing gold. Even the Boshoff Group works a mine to an end when it has to be closed down.

It can be pointed out as a matter of interest that the present three operating mines have, during the past ten years, produced 65 million rands worth of fine gold if the price is taken as $500 per ounce. The Boshoff Group feels proud that it could play its small part in obtaining foreign currency for the Republic, and that it has unearthed gold that would otherwise have been left buried underground. It is fortunate in not having to pump any water or to install fans for ventilation. Its underground conditions are cool and pleasant.

Formation of Chromium Centre

In October 1980, at the International Ferro-alloys Congress (INFACON 80), which was held in Lausanne, the President of the Council for Mineral Technology (Mintek), formerly the National Institute for Metallurgy, announced that Mintek was to establish a Chromium Centre. One of the main aims of the centre was to be the stimulation of research and development work on new uses for chromium in metallurgical and other fields. The centre would start on a modest scale by collecting, monitoring, and disseminating information on a worldwide basis on the production and uses of chromium in its various forms.

On 14th August, 1981, a meeting was held between representatives of Mintek and the South African chromium industry in order to discuss this proposal. The general idea was well received by the meeting, and the representatives present agreed unanimously to recommend to their companies that they actively support the Chromium Centre. It was decided to form a steering committee with members from Mintek and each participating company, which would hold its first meeting in the near future. A matter for early discussion by the steering committee would be the extension of membership of the centre to representatives of the chromium industry in other countries.

Enquiries will be welcomed, and should be addressed to The Chromium Centre, Council for Mineral Technology, Private Bag X3015, Randburg 2125, South Africa.