jackhammer, now almost exclusively used in South African mines, is the product of much research and bears little resemblance to the original cumbersome machine of 50 years ago. When there is sufficient height, jackhammers are often operated on airlegs, or they are mounted on special carriages in tunnelling operations where several machines are employed together, thus relieving the operator of the strain imposed by the hand-held machine.

With the advent of the jackhammer, drill-heating furnaces and drill-sharpening machines were introduced, and many modifications were made to the size of the drill bit. However, the gold-bearing strata of the Witwatersrand are particularly hard and abrasive, and the general use of drill steel with a forged head presented a major problem in the daily transport of such steel to and from the surface for sharpening purposes. A forged detachable bit head was then produced to fit the tapered stem of the drill rod, which resulted in a considerable saving, for only these bits had to be transported for sharpening. The detachable bit was changed when its cutting edge became blunted after a few feet of drilling, but the stem itself remained in use for several shifts, being sent to the surface only for periodical checking of the taper or when it was worn out.

The detachable bit, however, did not improve the drilling speed, and consideration was given to the use of an abrasion-resistant material for the cutting edge of the drilling bit. Research along these lines was carried out in the 'thirties in other parts of the world, particularly in Germany. Many materials were tried, but the most promising proved to be tungsten carbide, a product of powder metallurgy. Eventually a tungsten carbide tipped drill stem was produced which has more than doubled drilling speeds and which can drill many times the footgage of the forged steel bit before requiring re-sharpening. The use of tungsten carbide inserts as the cutting medium has become practically universal and is one of the greatest advances in mining tools in recent years. An average of 40 holes per jackhammer-shift is common today, compared with six or seven holes from the comparatively few machines in use 50 years ago.

STOPING AND DEVELOPMENT With the need for concentration in mining operations, the removal of the broken ore in mines with a shallow dip became a serious problem, and the amount of ore which could be broken was limited by the cleaning facilities available. For many years the only method was hand-loading with shovels into trucks, and to keep production as high as possible, stope faces had to be long with numerous loading points. In the early 'thirties a device known as a scraper winch was introduced on the East Rand and was an immediate success. The machine consists essentially of a double drum winch, the ropes from which operate a hoe-type scraper which is dragged up and down the working face to pull the broken ore to a truck. Experiments were carried out to fix the optimum length of face which could be cleared without impeding a consistent advance of the face, and this information, together with great improvements in the machine itself, has resulted in the universal use of the scraper winch in all stoping operations where the broken ore does not run by gravity.

New stoping methods were devised so that enough rock could be broken in a small area to make the maximum use of the scraper. Scatter piles and subsequently barricades were built down the face to confine the blast to the scraper path. In the late 'twenties it was realized that the fines left behind on the footwall, after the coarse ore had been removed, contained considerable quantities of gold, and sweeping the footwall after normal cleaning became general practice. Scatter piles and barricades allowed sweeping to be carried out to within a short distance of the actual working face concurrently with the removal of the coarse ore by scraping.

A shovel loader clearing broken rock in a development end at the Western Deep Levels mine

The quality of the explosives used has been improved over the years, and the introduction of igniter cord and electric detonators to fire the charges, together with the extended use of ammonium nitrate and fuel oil as an explosive medium, has greatly reduced the hazard of blasting operations.

To gain access to the ore and transport it to the hoisting shafts, many miles of tunnels of varying dimensions have to be driven, which in 1917 was a laborious and time-consuming task with the cumbersome machines then in use. An average advance of 100 feet a month was considered reasonable, and this could be exceeded only if more than one blast in 24 hours could be obtained.

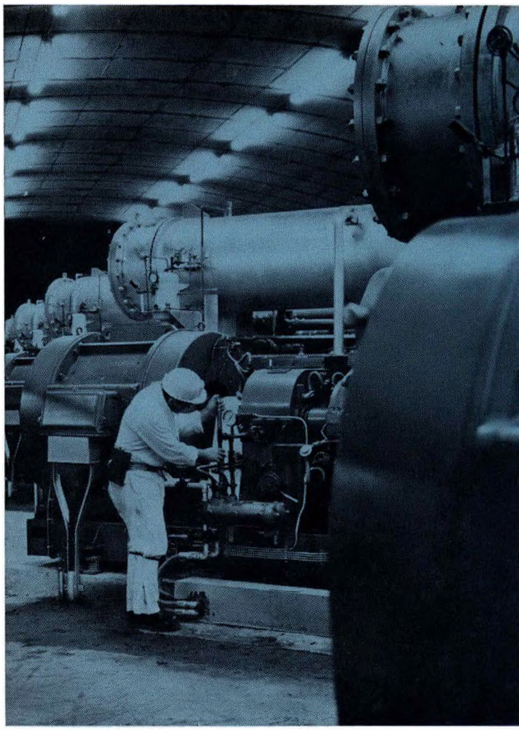
With the improvement in drilling machines and the introduction of a modified type of scraper winch for removing the broken rock, the average face advance improved to 200 feet a month, and in the middle 'thirties certain main headings developed on double or treble shifts recorded advances of 400 and 500 feet a month. In 1946, pneumatically driven shovel loaders were introduced and their success led to their universal adoption for cleaning out tunnels that were flat or of low inclination. Owing to the regulations for the control of dust and fumes from explosives, it was possible to blast only once each shift or a maximum of three blasts in 24 hours, which seriously reduced the potential speed of driving tunnels with modern equipment. Attention was therefore directed to the provision of better ventilation (described in more detail below) which would quickly remove the fumes and dust from the faces of the tunnels and allow work to be resumed. These efforts were so successful that blasting became possible many times in 24 hours. As only short breaks in tunnelling operations are needed to allow the fumes to clear after blasting, advances of more than 2,000 feet a month are now obtained in a single heading; and the time taken from starting development to build up a sufficient ore reserve on which to begin stoping and milling operations has been more than halved during the past 50 years. This has also enabled mines to begin milling operations with a much smaller ore reserve than previously, secure in the knowledge that ore reserves can be built up quickly by rapid development. Thus a mine earns profits much sooner, a matter of considerable importance in view of the large capital outlay now required to bring a mine to production.

VENTILATION As mines became deeper in the 'twenties, adequate ventilation became a problem. Bratticing of shafts, separating compartments into upcast and downcast sections, was tried with varying success, but some mines still relied on natural ventilation. It was then realized that mechanical means of forcing air to circulate through the workings were necessary, particularly on the deeper mines of the Far East Rand where the reef did not outcrop to the surface. The rise in the temperature of the rock as mines became deeper also called for adequate ventilation for cooling. Shafts purely for ventilation purposes were sunk and equipped with fans to exhaust the vitiated hot air from the mine, thus drawing fresh cool air down the operating shafts. In the early installations these fans were mostly of the large diameter, slow revolving, paddle type, but they gave way over the years to the modern efficient high-speed turbine type, some exhausting more than 1,000,000 cubic feet of air a minute. Attention was also directed to the efficient use of ventilation underground, and galvanized iron tubing, with small electric fans to force fresh air into, or to exhaust foul air from the face of, development headings, began to take the place of the earlier attempts to ventilate with brattice walls of brick or other material. It was necessary to direct air on to the working faces of stopes, and strike walls to course the air where it was required and the sealing off of worked-out areas to prevent leakage became standard practice.

In spite of these measures it was difficult to provide reasonably cool conditions at the working faces as mines became deeper still and rock temperatures rose above 100°F. There was an economic limit to the amount of air that could be circulated to reduce heat, and mining engineers began to consider artificial means of cooling. Initially blocks of ice were sent into the mine, but this was soon discarded as it was expensive and gave little benefit. Then refrigerating plants to cool the ventilating air were installed on the surface; large quantities of air, of the order of 400,000 cubic feet a minute, and cooled to a wet bulb temperature of less than 40°F., were delivered to the shaft and sent underground. This method had some success, but owing to the distance the air had to travel before reaching the working places much of the cooling effect was lost by heat absorption from the rock surfaces of the shafts and main airways.

To reduce the loss the plants were installed underground, but the choice of sites was limited because the plant had to be adjacent to a return airway leading to the upcast shaft into which the extracted heat could be directly dissipated without interfering with the general mine ventilation. In the early 'forties one of the mines in the Klerksdorp area adopted a method of using twin main headings, a practice common in coal mining. It comprised two narrow parallel headings driven some 50 feet apart in place of one wide heading. The headings were connected every 500 feet, one being used as an intake airway connected to the downcast shaft and the other as a return airway connected to the upcast shaft. This was highly successful: large quantities of air could be circulated; the face of each heading was never more than 600 feet from the last through connection; the hanging wall was under better control; and when the reef horizon was reached, development and subsequent stoping operations could be undertaken immediately as both an intake and return airway were available. This system, known as twin haulage development, has been largely adopted by all mines in the past 20 years.

The twin haulage system was ideally suited for operation with modern refrigeration units, because plants could be sited as close as desirable to the working places, and the extracted heat dissipated into the companion return airway. Immense benefits flowed from this arrangement, and the modern trend is to place the refrigeration plant as close as is practicable to the working places and to chill large quantities of water which are then pumped in insulated pipes to the air intake of the working place. There the chilled water is fed through a finned grille similar to a large motor car radiator and, by means of fans, the ventilating current is drawn through the grille and thereby cooled. The warm water is led back to the refrigerating plant, where it is again cooled and re-used. In this way a refrigeration plant of 300 ice-tons capacity can cool 60,000 cubic feet of air a minute through about 12° to 15°F. wet bulb and serve four or five working places. The trend is towards larger plants catering for a greater number of working places and,



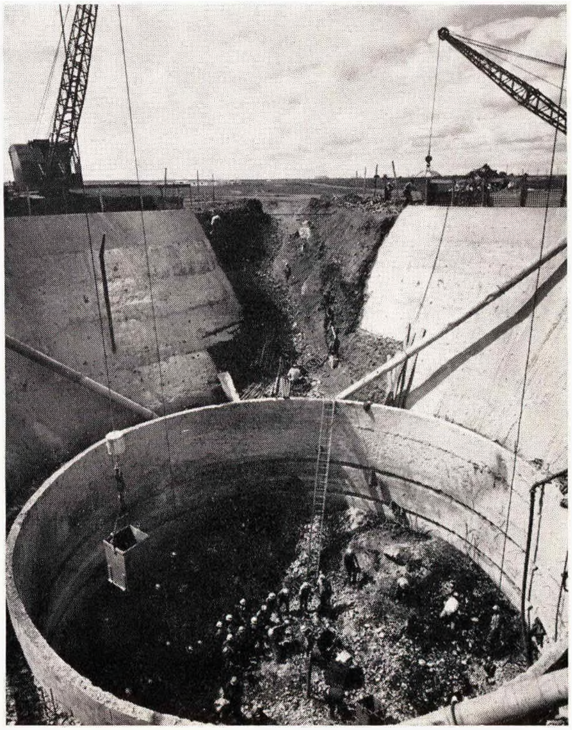
Underground refrigeration plant
at the President Brand mine

where this is possible, the cost of refrigeration is correspondingly reduced.

If development headings are far ahead of current workings it may not be economic to pipe chilled water, and to meet such cases small portable refrigeration units have been designed, which fit into the ventilating system of the tunnels. When the tunnel is being driven as a single end, the refrigeration unit cannot be sited beyond the nearest return airway; and, as the tunnel advances, the fixed unit becomes progressively less effective. But when twin headings are driven, the unit can be sited in an interconnection between the twin ends, the heat being dissipated into the return airway, thus allowing the unit to be kept close to the working face. A typical unit has a capacity of 30 ice-tons of refrigeration, cooling 6,000 cubic feet of air a minute through 15°F. wet bulb.

SHAFT SINKING One of the most spectacular advances in mining technique in the past 50 years has occurred in shaft sinking practice. In the early 'twenties an advance of 200 feet a month was considered highly satisfactory, but the average sinking rate was nearer 150 feet a month. During the next two decades there was little improvement until, in 1940, a shaft was sunk 450 feet in a calendar month, with an average monthly

A portable refrigeration unit, used for cooling underground workings at Western Deep Levels



The beginning of a circular shaft for the new gold mine, Vaal Reefs South

sinking rate of just under 400 feet to a depth of 5,200 feet. For many years this was considered to be the best that could be expected in shaft sinking. But the opening up of the Orange Free State and Far West Rand goldfields in the early 'fifties focused attention on shaft sinking, and remarkable progress has been made in the past 15 years, culminating in a record footage of 1,251 feet sunk in one month in 1962; average rates of more than 700 feet a month are commonly attained.

Fifty years ago in the South African gold mines the type of shaft sunk was generally rectangular, timber-lined and having from five to seven compartments. It was not difficult to sink these shafts and, as they were timbered and equipped simultaneously with sinking, they were ready for use soon after sinking had been completed. Stations were easily cut from this type of shaft and the timbering readily lent itself, when required, to bratticing certain of the compartments from the remainder of the shaft, thus providing a separate upcast and downcast ventilation system—a distinct advantage in the initial development from the shaft. A few circular shafts were sunk during this period but that type was not generally favoured, because sinking had to be stopped while the shaft wall was lined, and the overall speed of sinking was therefore low.

The increase in the price of gold following the devaluation of the South African pound in 1932 led to a vast expansion in mining activity on the eastern and western extremities of the Witwatersrand, and an extensive programme of shaft sinking in these new areas was undertaken. All the new shafts were rectangular and, on the eastern extension of the Witwatersrand, were completed expeditiously and without incident. On the Far West Rand, however, where shafts were sunk in heavily-watered and decomposed dolomites, the inherent disadvantage of the rectangular timbered shaft in that type of ground were soon revealed, and some companies reverted to sinking circular shafts in spite of the unsolved problem of lining them without interrupting sinking operations.

During this period steel shuttering for placing monolithic concrete lining was introduced but, except for minor improvements to equipment, there was no change in the basic technique. The distance advanced before it became necessary to suspend sinking depended on the strength of the surrounding country rock and the ability of the shaft wall to remain unsupported; at times it was limited to a few feet. The concrete lining had to set for some hours before the shuttering could be removed and sinking operations resumed, as the lining was immediately adjacent to the shaft bottom and was subject to the full force of the next few blasts. These delays, together with the time taken to transport the shuttering in small sections through the shaft, militated against rapid sinking. In addition, it took several months to equip the shaft after sinking operations had been completed.

South African mining engineers had for long recognized the merits of circular shafts, particularly in terms of ventilation, strength, suitability for sinking through water-bearing strata and weak ground and absence of fire hazard, but the slow speed of sinking for the reasons outlined had, in general, outweighed the advantages. This position remained unaltered until 1951 when a new method was evolved at a circular shaft being sunk in the Orange Free State: the concrete lining was placed concurrently with sinking by leaving the shuttering suspended in the shaft after a lift of lining had been completed. Sinking followed the conventional pattern of advancing as far as the unsupported shaft wall would allow. The broken rock from the last blast was then levelled off, and the complete curb ring with a section of shuttering was freed from the bottom of the previous lift of concrete lining and was lowered to the shaft bottom by hand winches on the sinking stage. It was levelled and centred on the broken rock, and concrete with a quick-setting additive was poured behind the shuttering. The removal of the broken rock below the ring then continued. The ring was left in position during the next blast to protect the concrete and, while the cleaning of this blast took place and during subsequent cycles of cleaning and blasting, further sections of shuttering were loosened from the lining above and lowered into position, concrete being poured during the drilling shift. The sinking hoists were used to convey the concrete from the surface.

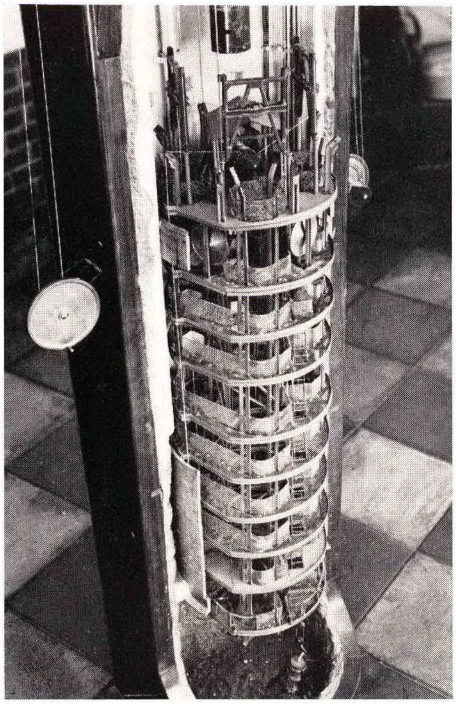
The process was repeated until the full lift of concrete was completed, the shuttering being left in position until the shaft had advanced sufficiently to require the next lift of lining. In this way only an hour or two was lost during the levelling-off of the broken ground and the preparation and pouring of the bottom curb ring.

This was a great advance on previous methods, but there were still certain disadvantages: sinking was still interrupted, although for only a short period; and the shuttering rings close to the shaft bottom were liable to be badly damaged by the blast.

The next improvement took place in another circular shaft in the Orange Free State by suspending the curb ring some 30 feet above the shaft bottom, scribing from the bottom of this ring to the side wall and pouring the concrete while normal sinking operations continued. This method removed the disadvantages of the previous system, and a rapid evolution of lining technique has followed; sinking rates increased and concrete lining has now become a subsidiary, instead of a complementary, function of circular shaft sinking.

MECHANICAL CLEANING Up to this time the broken rock had been removed by pick and shovel, and attention turned to the possibility of mechanical cleaning. In 1946 a mechanical grab had been used experimentally in a shaft on the East Rand, but it was not successful. The experiment did prove, however, that efficient mechanical cleaning of a shaft was possible provided that the equipment was designed for the conditions in which it had to operate. In 1949 a successful method was designed for mechanical cleaning in a rectangular shaft being sunk in the Orange Free State: it consisted of a pneumatically-operated clamshell-type of grab traversed on a carriage running on a frame suspended below the bottom set. This pioneering work led to the design of the now well-known pneumatically-operated cactus-type grab used in circular shaft sinking, which is traversed radially and circumferentially below the bottom deck of the sinking stage, and which was used initially in the sinking of a circular shaft on the East Rand in 1952.

During the past 10 years the use of the cactus-type grab has tended to give way to the pneumatically operated mechanical loader similar to that used in tunnel clearing. It is doubtful whether the speed of loading with this unit equals that of the grab, but the advantages of taking weight off the sinking stage and the increased mobility probably outweigh the disadvantage of a lower loading rate.



A model of the multi-deck sinking stage, used for various shaft-sinking purposes, including the lining of circular shafts with concrete. Sections of shuttering are lowered by a winch on the top deck of the stage

CEMENTATION As most shafts passed through water-bearing strata it had been normal practice to sink with full cementation cover. This is usually done by drilling percussion holes to a definite pattern and to a depth of 100 to 175 feet ahead of sinking. Cement grout is then injected under pressure until all water fissures intersected are sealed off. In 1955 at a new shaft in the Orange Free State a diamond drill hole was sunk adjacent

A pneumatically operated cactus-type grab drops broken rock into a kibble for hoisting to the surface during shaft sinking and station cutting at the Western Holdings mine

to the shaft site and injected with pressure cementation wherever fissure water was encountered. As the experiment reduced the expected volume of water and saved the time normally taken to provide full cementation cover from the shaft bottom during sinking, this method is generally used when considerable amounts of water are expected. Two or more boreholes are sunk around the perimeter of the shaft before sinking begins; and the part played by each borehole in sealing off fissures and cracks is found by introducing different coloured dyes in the grout used in the boreholes. This practice has speeded up shaft sinking and has helped to create better and safer conditions for the sinking crews.

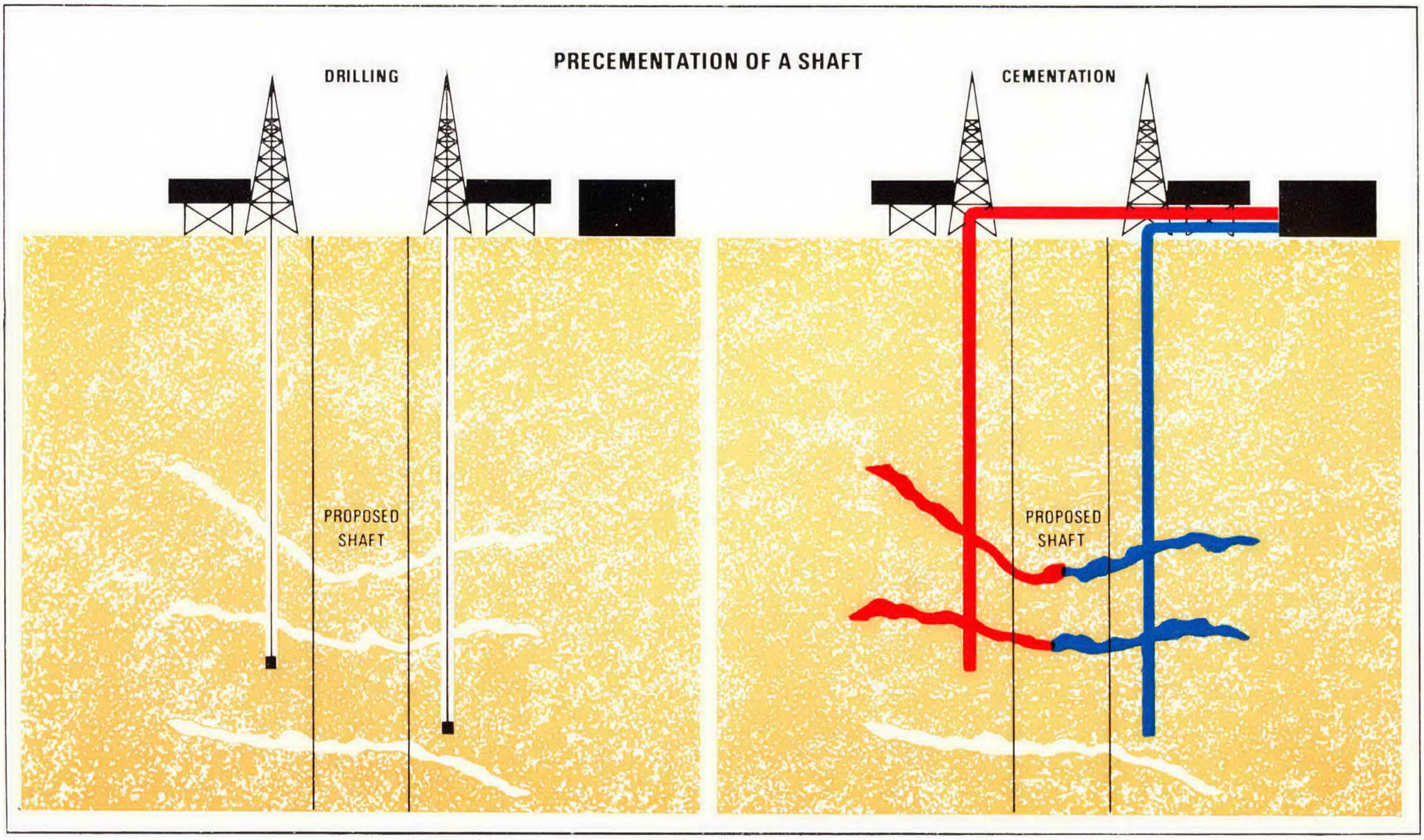
It is now generally accepted that the concrete-lined circular shaft is best suited for the South African gold mining industry. Most of the shafts recently sunk and those in process of sinking are circular. The advantage of the brattice wall in a rectangular shaft in providing separate upcast and downcast compartments for ventilation during the initial development phase has to some extent been retained by providing a brattice wall in certain circular shafts, but recent practice has been to sink twin circular shafts about 250 feet apart, one being used for downcast fresh air and for hoisting and the other solely for upcast air. This has been extremely useful in opening up a new mine or a new area in an existing mine, where return airways cannot conveniently be connected with the surface or to a remote upcast shaft. It has been of paramount importance in the Orange Free State mines, not only in the initial development of a badly faulted area but particularly in conjunction with twin haulages on the various working levels.

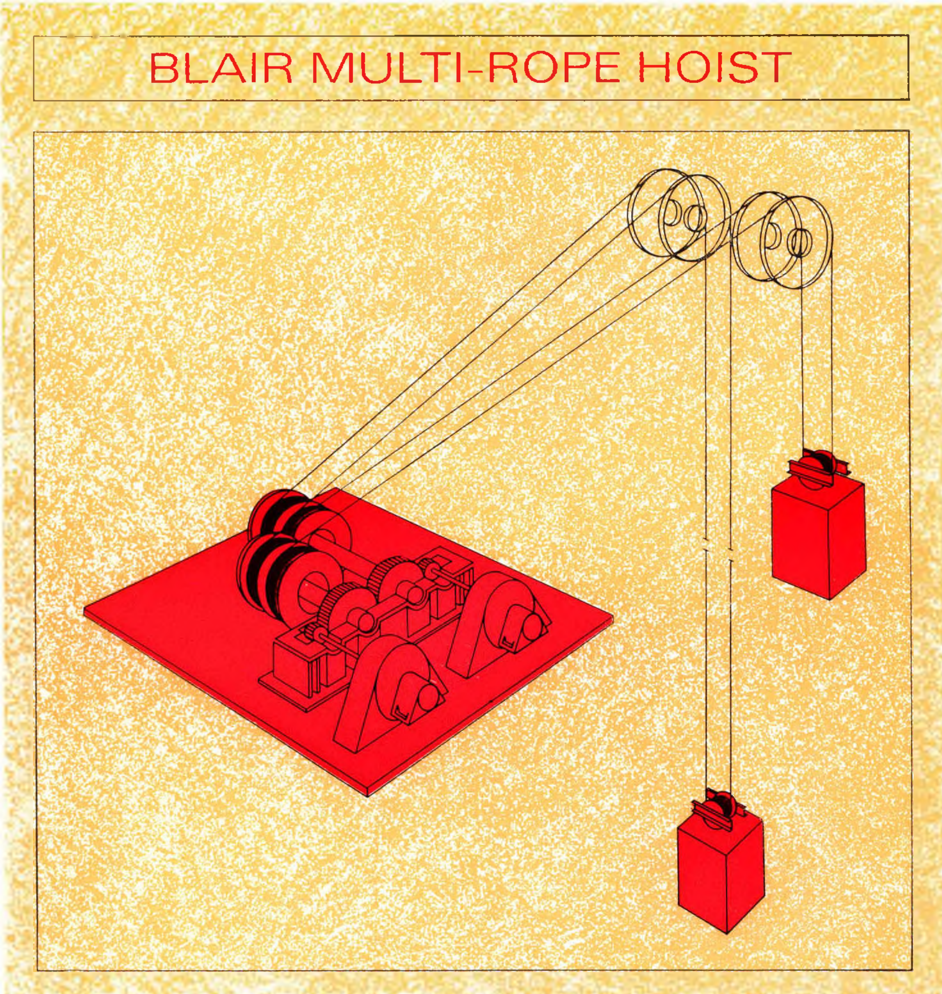
EQUIPMENT As in industry generally, there have been vast improvements in the mechanical and electrical equipment used by the mines. Fifty years ago motive power was supplied mainly by steam for heavy plant, such as winding engines, air compressors and ventilation fans. The use of electric power was then confined to small units, and to a certain extent it was replacing compressed air in the limited amount of underground mechanical equipment. Today the position is completely reversed, and steam power is now used only in the older mines whose limited lives would make it uneconomic to instal expensive new electrical equipment.

As shafts became deeper, the design of hoisting equipment grew more complex, and a limit was being reached in the depth of wind possible with an economic load. This was because, with the increasing size of the winding ropes required, the weight of the rope itself would ultimately be greater than the maximum permitted breaking load. Consideration was therefore given to a system of winding in two stages through a vertical and sub-vertical shaft system where depths of much more than 5,000 feet were contemplated.

Such a method is costly, and in the search for a more economical solution "Koepe" multi-rope winders have been introduced. As the name implies, the load is attached to a number of ropes of small diameter and the

Deep holes are drilled adjacent to the site of a new shaft and cement is pumped into the holes at high pressure to seal any water-bearing fissures before the shaft excavations reach them. Different coloured cement is sometimes used in each borehole so that it can be identified when the sealed fissures are later intersected by the shaft





The Blair multi-rope double-drum hoist winds two ropes for each conveyance, equal tension being maintained by the compensating wheel on top of the conveyance

weight is evenly taken up by a compensating device, which allows a much greater depth and heavier load to be attained than with a single rope. These hoists have been in use in other countries for some time, but they have certain disadvantages, being much less flexible than the conventional double-drum winder.

Recently, however, a new winding plant has been designed in South Africa incorporating all the advantages of the "Koepe" multi-rope hoist and eliminating most of its disadvantages, including that of being unsuitable for multi-level winding and for shaft-sinking operations. This new plant is a multi-rope, multi-layer, double drum winder of conventional design. The drums, however, are divided into two equal divisions, each division accommodating its own rope. The ropes are led from each drum over two separate sheaves in the headgear down to a compensating wheel on top of the conveyance. This compensating wheel guarantees equal tension in the two ropes at all times and is so designed that even if a rope should break the end load is transferred with a minimum of shock to the sound rope. The hoist is so successful that most deep shafts sunk in the past seven years have been equipped with units of this type.

Electrical equipment has increased greatly in size, and motors of more than 3,000 horsepower are commonly used in winding and other plant. Electric locomotives, both trolley and battery types, have been used for underground traction in the gold mines for several decades, and their performance has improved in keeping with modern engineering practice. In 1939 the first diesel locomotives were introduced in two East Rand mines. This innovation aroused considerable interest, and there would have been more extensive use of diesel locomotives had not the outbreak of war made importation difficult. However, a few locomotives were manufactured locally, and by the end of the war sufficient knowledge had been gained about the maintenance and operation of the diesel locomotive to make it a serious competitor of the electric locomotive, particularly as a collector to feed the main transport system. Since then the use of diesel locomotives has rapidly increased, and they now form a considerable part of the underground transport system. They have many advantages, being much cheaper in initial cost and being extremely mobile. They do not require the installation of expensive electrical equipment, and with proper maintenance are comparatively trouble-free. At first there was some objection to the exhaust fumes underground, but this has largely been overcome by the use of exhaust scrubber units, which remove the harmful gases, and provided attention is paid to the fuel atomizers, the noxious element is kept to a minimum.

METALLURGY Developments and improvements in gold metallurgy have kept pace with other aspects of mining. Perhaps the outstanding contribution was the introduction of the "all-sliming" process for the milling and cyanidation of gold-bearing ores. This was initiated in 1921 as an experiment and the results were so encouraging that when two new gold mines came into production two years later both plants were designed for all-sliming.

The all-sliming process using tube mills improved the percentage extraction and reduced both capital and operating costs, as stamp batteries and sand treatment plants were eliminated. The process was accepted for all new gold reduction plants in South Africa from then onwards, and it is in use on all but one of the 52 currently operating mines.

Ball milling, which is extensively practised in modern reduction plants, was pioneered in 1933 at an East Rand mine, and it was highly satisfactory, especially where narrow or friable reefs were encountered. At that time the all-sliming process had been improved by the introduction of stage grinding, which increased the milling capacity of existing installations by the separate functioning of coarse and fine mills. Most modern gold milling plants operate on this principle today, in many cases the primary grinding circuit comprising ball mills and the secondary or regrinding circuit consisting of tube or pebble mills.

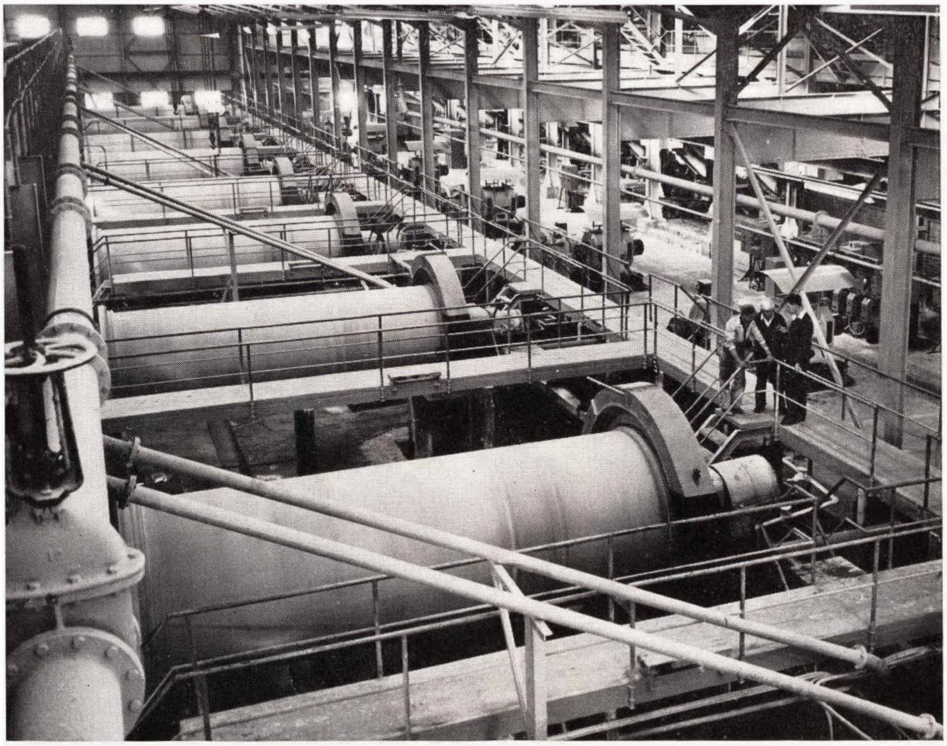
The first rake and bowl classifiers to segregate the fine and coarse product from milling operations were introduced in the mid-twenties and were thereafter in popular use on most South African gold mines until the introduction of hydro-cyclones in 1953. Since then many mines have changed to the use of this unit, which is extremely efficient and which occupies a fraction of the space required for the older type of classifier. The first milling plant to operate completely with hydro-cyclone classification began operation in 1956 and all plants erected since then have incorporated this system.

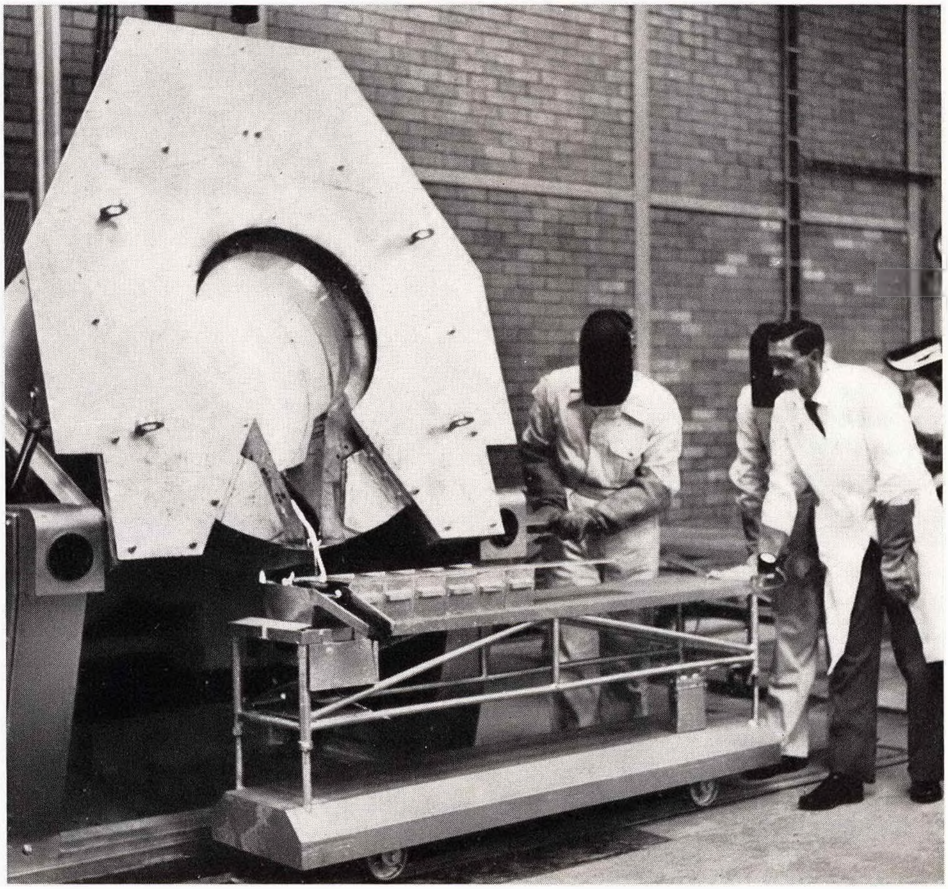
Another progressive step made in the early 'twenties was the introduction of zinc dust in place of zinc shavings for precipitating gold from cyanide solutions. The use of zinc dust combined with de-oxidation of the cyanide solution, known as the Crowe Merrill process, increased efficiency in extraction and reduced the operating cost, and this system is now generally adopted.

The elimination of amalgam plates in the milling circuit was also initiated in the early 'twenties, and, as a result, the handling of mercury in gold recovery has been greatly reduced, with consequent diminished risk of mercury poisoning.

The introduction of electric furnaces after the second world war was impeded by a shortage of power, but when new generating stations were erected the electrification of amalgam retorts, assay furnaces, calcining furnaces and smelting furnaces was rapidly carried out on many mines. The full benefit of these improvements is exemplified in the smelt houses and assay offices of the newer gold mines of the Orange Free State and Far West Rand. Submerged arc electric furnaces, which were specially developed for gold bullion smelting, have been of particular advantage to the bigger gold producers where the large number of bars to be melted each month would present difficulties if conventional reverberatory furnaces had to be used.

The metallurgical departments of the mining groups were closely associated in the development of the extraction of uranium oxide from gold ore residues. In the initial stages in 1950 two pilot plants were established to determine the suitability of various proposed extraction processes and, as a result of this research, the first commercial application of the ion exchange process was tested

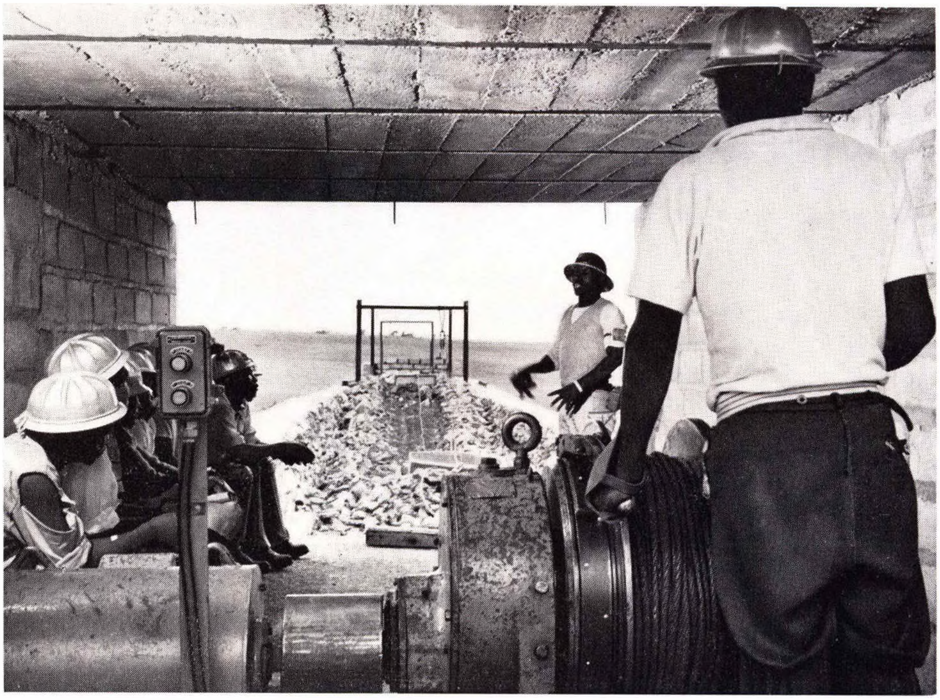




Above tube mills at the Western Reefs mine, used in the all-sliming process for the milling and cyanidation of gold-bearing ores

Below pouring gold from an electric arc furnace at Western Deep Levels and proved. Subsequently, pyrite flotation and sulphuric acid plants were erected on certain mines and large uranium oxide extraction plants were established on those mines which had uranium oxide in economic quantities. Since then extensive investigations have been carried out to improve the extraction process, and South African gold mines are in a sound position to take advantage of the expected increase in the demand for uranium.

The history of the metallurgical section of the gold mining industry over the past 50 years is thus one of steady advance in the efficiency of extracting the valuable mineral content of the ores mined, either by improving current practices or, wherever possible, by introducing new processes.



New African mineworkers being taught to operate a scraper winch at the Western Deep Levels training centre

TRAINING When considering the advances and improvements in gold mining during the last half-century, one automatically thinks about mechanization; but probably one of the major improvements has been the better and more efficient use of the available labour, especially African workers, who form nearly 90 per cent of the production strength.

Most of the Africans employed in the gold mining industry are recruited from the African territories outside the Republic and have had little or no experience with machinery—or even organized work of any kind. These Africans generally contract for periods of work varying from six to 18 months and, at the end of their contracts, they usually return to their homes for many months, during which time they quickly forget the skills acquired during their working period on the mines. To minimize the effects of the high labour turnover of African workers, and of the periodical shortages of this class of labour, the mining industry found it necessary to train Africans to be efficient, productive employees in as short a period as possible.

Many years ago, when labour was readily obtainable, such training as took place was usually of a desultory nature, and was done by placing the new recruit alongside an experienced African and allowing him to assimilate the required skill in this haphazard way. Under modern conditions and with ever-increasing costs this could no longer be the accepted practice and, during the last 20 years, short and rapid training methods have been devised. To group the Africans into the work categories for which they are best suited, aptitude testing has been adopted. A series of job analyses on the mines has revealed that although as many as 60 different jobs are performed, the duties in many of them are so similar that it is possible to combine them into six major categories, and for aptitude testing new African recruits are grouped into one or other of these categories. The tests have all been standardized and have proved to be very reliable, but, of course, they give only an indication of an African's suitability for a particular type of work.

To be fully effective, aptitude testing must be followed by appropriate training, and a correct combination of both measures can reduce the time required to convert a raw recruit into a satisfactory worker. Training schools have been established on most mines, and recruits, after being aptitude-tested, start their training with lectures and demonstrations on the surface, followed by a practical application in a non-productive or partly productive area underground. The type of training depends on the job and the test rating of the recruit, but even the elementary skill of handling a shovel has to be learned, as this tool is not generally used in African tribal life. A great deal depends on the instructor, and it is not always easy to find a European who has both the knowledge of the various jobs and the ability to teach, particularly as many different tribes, speaking different languages, are involved. However, progress has been made by using trained Africans to instruct in the appropriate African language, supervised by a competent European. As much as possible of the training is done by practical demonstration, supplemented by projectors showing coloured pictures of the jobs being demonstrated. Africans who have demonstrated in the aptitude test centre that they have the necessary skill, coupled with the quality of leadership, are given specialized training as supervisors.

In most mines European miners, on engagement, spend one shift or more in the training school in order to appreciate the methods and standards being taught. This is an important aspect of training as the relationship between the European miner, African supervisor and African workers has a vital bearing on the efficiency of production.

This then is an account, necessarily brief, of the developments and achievements in the gold mining industry of South Africa over the past 50 years. It is a story of increasing efficiency and the attainment of higher and higher standards in spite of growing difficulties, many of which would have been considered insurmountable 50 years ago. It is also a tribute to the engineers who, over the years, solved these problems and set a standard which has gained world-wide recognition.

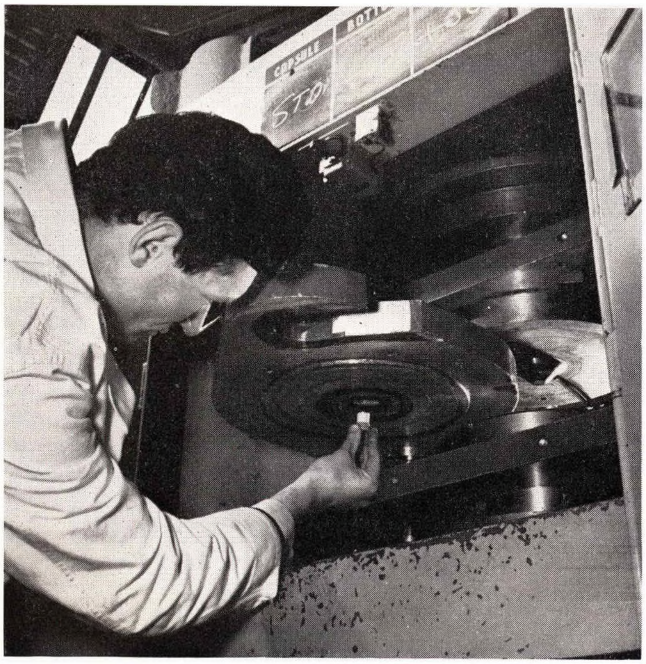
GROWTH AND DEVELOPMENT

Previous page Surveying on the slope of the iron ore deposit in Baffinland. Through Anglo American Corporation of Canada, the Group is participating in the development of Canada's natural resources

Below, left The development of a process for making synthetic diamonds led to the establishment of the Ultra High Pressure Units plants at Springs, in South Africa, and at Shannon, Eire. An operator inserts a capsule of graphite and metal into a high-temperature press before diamond synthesis

Below, right Pouring molten metal by night casts a glow over the heavy bay of Scaw Metals' steel foundry. Major extensions to the foundry were completed last year

Bottom South Africa's largest bridge is being built across the Orange River near Bethulie, Orange Free State. It will be 3,800 feet long and will carry road and rail traffic 180 feet above the river bed

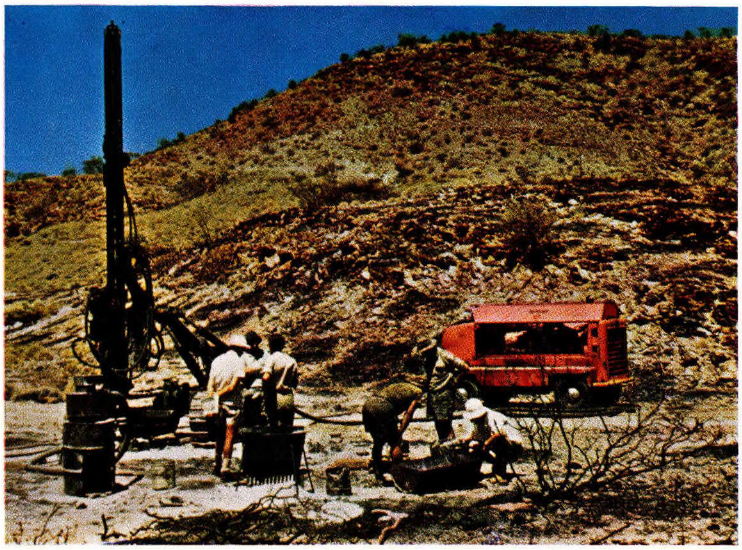


The shaft site of the new gold mine, Vaal Reefs South, which is expected to start production early in 1973. The planned milling rate is 150,000 tons of ore a month

Below Panning for tin in Malaysia. Charter Consolidated has a substantial interest through Tronoh Mines and other companies in Malaysian tin mining and in prospecting for new deposits

Bottom, left Mining interests range as far as, Australia, where Charter Consolidated is participating with other major mining groups in prospecting for gold and base metals in Western Australia and Victoria

Bottom, right Mining the "hill of iron" in Swaziland. In 1966 Swaziland Iron Ore Development Company delivered 1.5 million tons of iron ore from Bomvu Ridge under its 10-year contract to supply 14.5 million tons of ore to Japanese steel mills



Part of the Highveld Steel and Vanadium Corporation's R117 million complex at Witbank, Transvaal, at the construction stage reached in mid-1967. The plant, which is expected to start initial production next year, will have a capacity of 480,000 tons of pig iron, equivalent to 415,000 tons of steel products, and 23 million pounds of vanadium pentoxide contained in slag