bulk solids handling Volume 3, Number 1, March 1983

Reclaiming Gold and Uranium in South Africa

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Summary

Bucket wheel excavators coupled with mobile conveyor systems are used almost exclusively in open-pit operations for removing overburden and mining minerals.

The purpose of this article is to describe the technically and economically successful application in a new field, viz. reclaiming slimes dams containing gold and uranium.

1. Background

Since gold was discovered in 1886 on the Witwatersrand which extends from Springs 50 km East of Johannesburg to the West as far as the Klerksdorp goldfields and the Orange Free State goldfields at Welkom, slimes dams were constructed.

They originate from underground gold mining and are the remainder of a gold containing pyritic conglomerate, found extensively in the Witwatersrand basin, which was crushed and pulped before extraction of the gold, and then dumped on the surface of the mining area.

Apart from gold "left-overs" significant quantities of uranium minerals are contained in this waste product. The dam construction consisted of an initial dike frame of compacted dry material. These were filled with slurry and were allowed to dry before the next layer of slime was deposited.

Incidentally, the slimes dams surrounding Johannesburg became a most striking landmark with their golden yellow colouring and their desert-like dust clouds over them on windy days, until grassing of the old mine dumps began some years ago.

A few decades back gold mining processing had not developed far enough to make close to 100 % yields economically possible. It was easier to mine the gold containing conglomerate in the traditional fashion with abundant available labour than to use a sophisticated chemical extraction method whose cost would have been prohibitive anyway regarding the relatively low gold price in those days.

Consequently the waste material was dumped with a considerable amount of gold remaining in it together with significant quantities of uranium, a mineral whose importance and values were not recognised.

Since gold mining rapidly became costlier over recent years, especially through payment of higher wages, and because the demand for uranium increased heavily on the world market, the viability of re-mining the previously uneconomic old mine dumps became an important issue in South Africa.

A case in point is the Stilfontein Gold Mine. It was established that the mine's slimes dams contain a certain amount of gold together with significant values of uranium representing considerable value in foreign exchange and strategical terms.

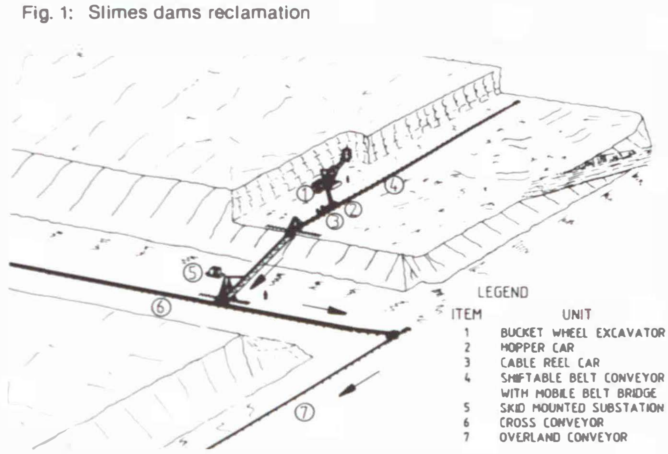
2. Reason for the Application of a Bucket Wheel Excavator Together with a Shiftable Conveyor Belt

In March 1978 Stilfontein Gold Mine's parent company "General Mining and Finance Corporation" (now Gencor) asked Weserhütte South Africa (now PHB Weserhütte S.A. or PWH S.A.) to develop an overall plan with detailed design for a continuous reclaiming system of the gold mine's slimes dams.

To transport the sand from the slimes dams to the extraction plant a conventional hydraulic pressure system is normally used which consists basically of a high pressure water jet generator (water cannon), pumps, repulpers and pipelines.

The Stilfontein Gold Mine decided against the application of this traditional equipment and a bucket wheel excavator coupled with a shiftable conveyor belt was selected instead (Fig. 1). The criteria finally deciding the method to be

Fig. 1: Slimes dams reclamation



employed were: water and energy consumption, wear and tear cost, flexibility of the equipment and the requirements of the material's subsequent metallurgical treatment.

The water used for the conventional hydraulic pressure system as transport medium can only partly be re-utilised which results in a significant waste of a commodity which is rather scarce in South Africa and the energy required to maintain adequate water pressure in the conveying pipes represents a substantial cost item in a mine's profit calculation.

Water is also not an ideal transport medium for sand because its density degree in relation to sand causes the latter to sink very quickly unless a strong impetus is prevalent to keep it flowing. Consequently, the water has to be agitated continually through turbulence in the pipes; or, alternatively, a flotation agent must be introduced into the water which then carries the sand along. Either way additional costs occur.

Pipes, repulpers and pumps are all subject to heavy wear and tear because there are many points of metal friction which cannot be eliminated. The extensive pipework needed for conveyance must be dismantled for shifting. For the subsequent extraction treatment, viz., leaching and filtering, one half of dry material reclaimed and transported by the bucket wheel and conveyor system and one half of diluted material were needed. The excessive water in the pulp would have presented a distinct disadvantage, because it would have had to be removed again. (In the case of Stilfontein Gold Mine the diluted material is supplied by a neighbouring mine).

3. Time Schedule and Production Program

The plan designed by PWH South Africa for reclaiming the slimes dams at Stilfontein Gold Mine provided for a "crawler mounted bucket wheel excavator" together with a "shiftable face conveyor coupled with a mobile belt bridge".

The contract, concluded in March 1978, specified delivery times too short for the construction of such a specialised plant but by sharing the work load with PWH's parent company in Germany completion was achieved in time. The design of the bucket wheel excavator was carried out in Germany. The shiftable conveyor belt with hopper and cable reel car as well as the conveyor bridge were designed in South Africa.

The time schedule adhered to was as follows:

Completion of all engineering work	end of May 1978
Delivery of the most important imported parts for the bucket wheel excavator	December 1978
Supply of the locally manufactured components	February 1979
Erection completed	June 1979
Commissioning period	end of July 1979

4. Geometric Requirements

The hourly processing requirements for this project were relatively small and called for a compact type of bucket wheel excavator. (For the first working period 250t/h based on a specified annual production of 1,800,000 t). A compact type of excavator is designed mainly for work where high-cuts are required because the short bucket wheel boom cannot make extensively deep cuts. Cutting can be done without difficulty up to 9 m digging height which allows for one block up to 10.5 m wide if the slope inclination is not below 45 degrees and provided the slope does not collapse (Fig. 2).

The geometric dimensions of the bucket wheel excavator were a result of the specified reclaiming capacity which determined a length of 8.8 m for the excavator boom and a length of 16 m for the discharge boom. With these dimensions a well balanced load combination of the slewable super structure and the load receiving undercarriage was achieved.

Reclaiming operations were started at slimes dam No. 3 and the downward operating conveyor bridge was designed especially for this type of dam operation.

The height of the dam varies and contains approximately $1475 \times 15 \times 325 = 7.2 \times 10^6$ m^3 mining material which equals approximately 10.0×10^6 t with a bulk density in situ of 1.4 t/m^3.

The effective excavator capacity (according to contractually laid down capacity increases at later stages) determined the volumetric dimensions of the plant as a whole and the static dimensions of the bucket wheel excavator and of the conveyor bridge were calculated in accordance with the European regulations for the construction of mobile open pit equipment (FEM).

5. System Description

PWH South Africa received the order from Stilfontein Gold Mine for a complete reclaimer plant consisting of:

- One crawler mounted bucket wheel excavator
- One rail mounted hopper car
- One rail mounted cable reel car
- One shiftable face conveyor coupled with a rail mounted mobile belt bridge
- One mobile substation on skids
- One bulldozer with side arm attachment and shifting head
- Electrical fittings and complete installation for the reclaiming plant (Figs. 3 and 4).

Detailed descriptions of the bucket wheel excavator, technical data and basic working method have been published and are available from the relevant literature.

Main data are contained in Table 1 providing general information. For the application of the excavator at the Stilfontein Gold Mine certain modifications had to be made and special features had to be incorporated in the various components. The special cutting conditions at this mine and the cutting

Table 1: Technical data of the bucket wheel excavator SR 250 (Fig. 5)

Theoretical digging capacity	750 m^3/h
Bucket content	250 liter
Number of discharges	50 per minute
Bucket wheel diameter	4.8 m
Belt width	1050 mm
Belt speed	2.62 m/s
Digging height	9.0 m
Bucket wheel boom length	8.8 m
Discharge boom length	16.0 m
Average ground pressure	65 kPa

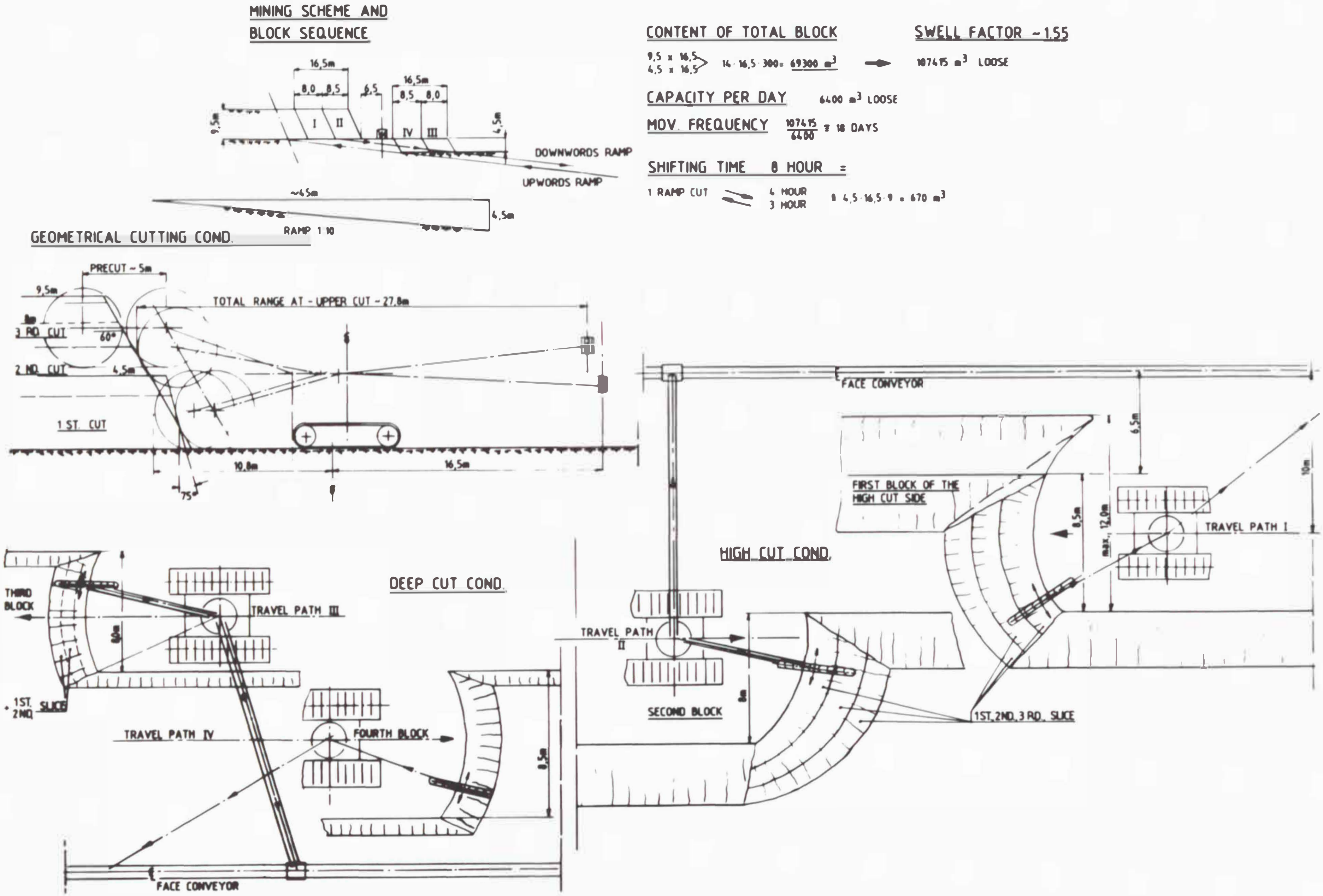


Fig. 2: Cutting configuration

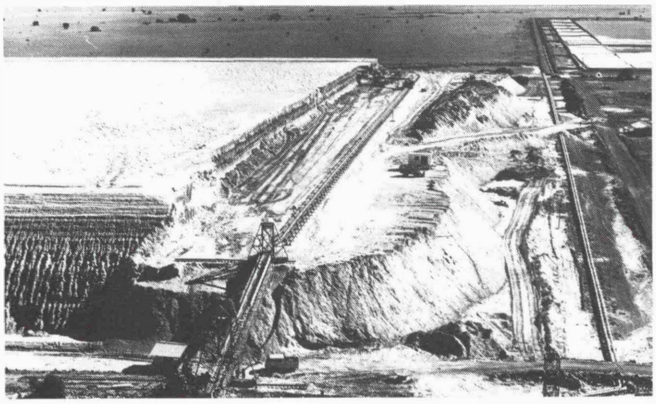


Fig. 3: Plain view after opening cut

Fig. 4: View of the plant at the second cut

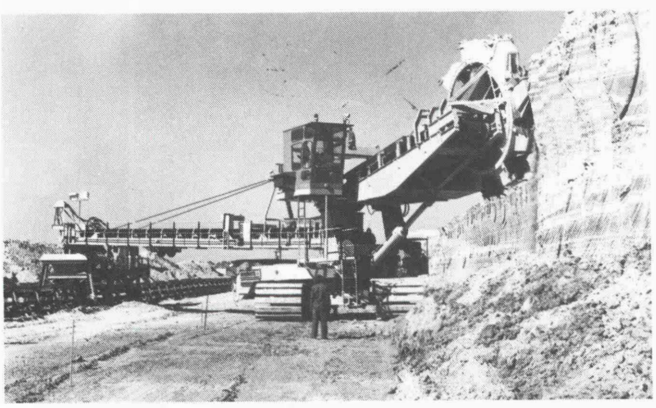


Fig. 5: Bucket wheel excavator while digging

method applied are demonstrated in Fig. 2. Buckets, ring body, ring and discharge chute had to be adapted to the wet and sticky properties of the conveyed material. All points coming into contact with the material were coated with HDPE (High Density Polyethylene). The internal gearing of the slewing device was made completely spillage-free and the foot-plates of the crawlers were broadened to compensate for the comparatively low bearing capacity of the ground which can contain up to 40 % water.

The foot-plates were also coated with an anti-caking layer for safety reasons. Friction moments between foot-plates and ground made it necessary to enlarge travel drives. The driver's cabin and the electrical room were insulated and pressurised.

The reclaiming method designed by PWH South Africa is shown in Fig. 6 and demonstrates the various working phases from formation of the travel ramp up to the block mining method at the slimes dam No. 3. A detailed description of the working stages would take up too much space in this article, but a short description outlining the major concepts of the design follows (Fig. 6).

The conveyor belt system was designed for a two-cut mining method because the total mining height ascended from 15 m to 20 m (slimes dam No. 3) and because of the order in which the belt was arranged. For the upper cut the shiftable conveyor belt is positioned on the cutting level of the bucket wheel excavator but later re-located to the natural surface level when making the lower cuts. The shiftable conveyor and the belt bridge are a coupled unit. The belt forming the link with the shiftable conveyor is designed to be established on any working level of an inclination between Nil and 13 m transporting the material downwards or horizontally between the excavator and the overland conveyor. The head pulley of the bridge drives the conveyor belt. The bridge is hinged on two supporting frames which are wheel mounted on rails and move independently of each other. Conveyor bridge and shiftable face conveyor move simultaneously to their new position.

A mobile hopper is installed between bridge and overland conveyor. Contrary to original apprehensions due to the convex guide line of the belt at the transfer points between the shiftable part and the wheel mounted bridge, the steel cord belt performs well and retains its troughing shape. To achieve this performance the belt is pretensioned to the limit of the transportable force able to be transmitted.

Table 2: Technical data of the shiftable face conveyor (Figs. 7 and 8)

Conveying capacity	750 m³/h (1,150 t/h)
Belt width	900 mm
Belt speed	2.62 m/s
Troughing angle	35°
Lift distance	from —13 m to + 4 m
Belt quality	ST 500 (5 + 5)
Length between the pulleys	350 m

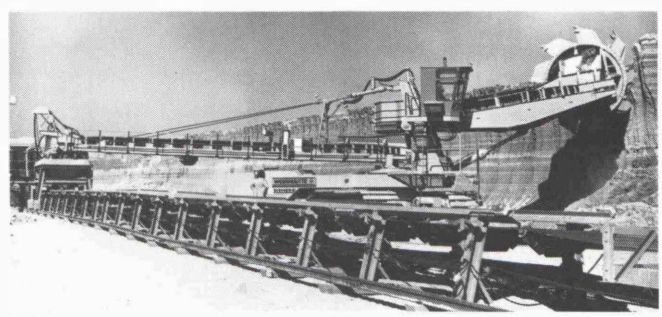


Fig. 7: Bucket wheel excavator in operation

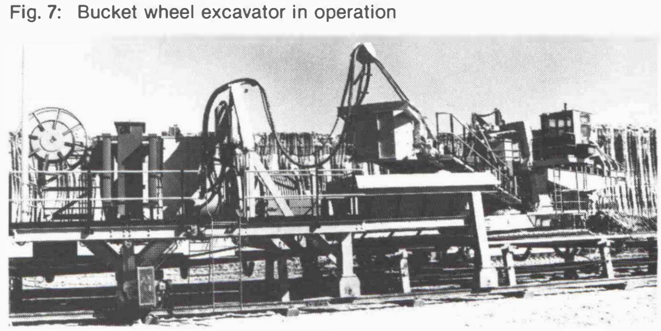


Fig. 8: View of the hopper and cable reel car

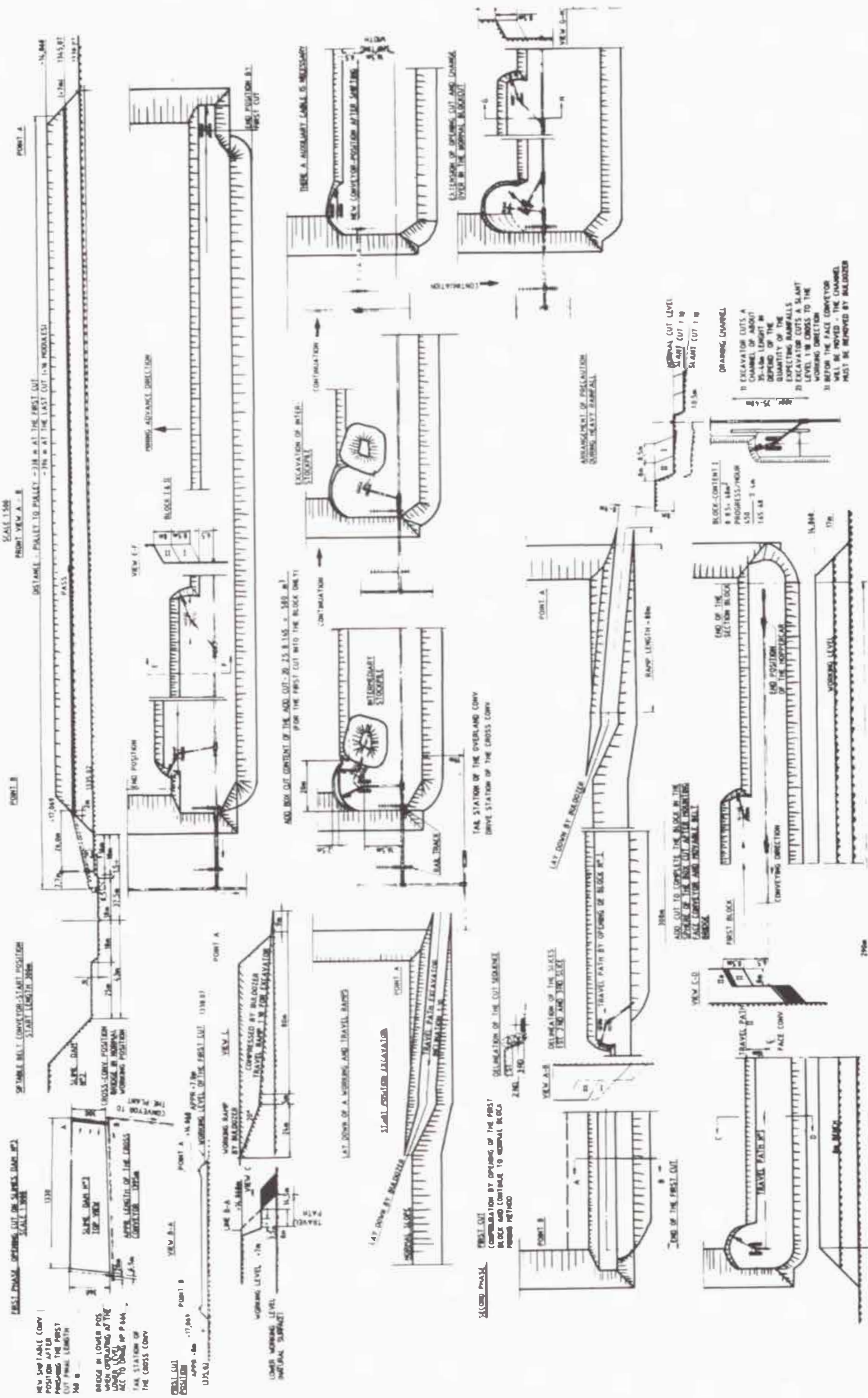


Fig. 6: Working plan

6. Operating Experience and Evaluation of the System

After a short time of operation and training of personnel the plant performed reliably according to the designed capacity. The results even exceeded expectations from the beginning. During the first months after commissioning, approximately 400 t/h on average were processed and these quantities were intermittently increased to 650 t/h, compared with 250 t/h budgeted and peak performances of 1,050 t/h were achieved from time to time.

The quantities above were, however, produced sporadically and were not within the scope of the average requirements of the plant.

During the initial years of operation at the lower reclaiming rate of 135,000 tons per month (approx. 4,500 t/day) the operating costs excluding depreciation and interest have been around 0.39 R/t. When the reclaiming rate has reached the 270,000 ton per month level planned for later years the operating cost will be around 0.20 R/t.

Loss of production time due to shifting the face conveyor equipment was recorded at 18 hours in the beginning and reduced to 16 hours during the later production periods reaching 8 hours under extremely favourable conditions after each 380 working hours, during which time approximately 107,000 m^3 bulk were mined.

The useful life of the hard metal faced welded bucket cutters and teeth was extended up to 9 months or approximately 3,500 working hours, respectively.

Wearing chute liners and plates made from HDPE lasted for approximately 12 to 14 months. The break-down time of all conveyor idlers, after a running-in period, was reduced to 4 % of the total numbers per year.

The efficiency of the bucket wheel excavator increased from approximately 65 % during the first year to approximately 80 %. During the following years a further improvement to approximately 86 % was achieved. The availability of the whole plant was increased from approximately 68 % to 74 %. The comparatively high capital outlay required for the plant had been justified by the high degree of utilisation as well as the low operating cost achieved.

Bucket wheel excavator coupled with conveyor belt equipment used in a continuous system of reclaiming the slimes dams has certainly distinct advantages over other transportation systems and the application at the Stilfontein Gold Mine has proved that the changeover to this new technology can be very successful.

Acknowledgement

The author wishes to thank the management and staff of General Mining Union Corporation Limited (Gencor) for their contribution towards this article and the management of PHB Weserhütte (S.A.) for permission to publish this paper.

Photographs and drawings:
PHB Weserhütte (S.A.) (Pty.) Ltd.