The design and operation of a double-V compartment vertical-flow settler

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SYNOPSIS

This paper describes the development of a vertical-flow settler for underground pumping installations in the mines of Gold Fields of South Africa Ltd. The recommended settler employs the principle of 'dynamic filtration': the solids that are in suspension in mine water are filtered through a stable horizontal bed of flocculated particles, a technique that was established in about 1958.

SAMEVATTING

Hierdie referaat beskryf die ontwikkeling van 'n vertikaalvloeibesinker vir ondergrondse pompinstallasies in die myne van Goudvelde van Suid-Afrika Beperk. Die aanbevole besinker maak van die beginsel van 'dinamiese filtrasie' gebruik: die vasté stowwe wat in suspensie in die mynwater is, word deur 'n stabiele horisontale laag geflokkuleerde partikels gefiltreer, 'n tegniek wat in ongeveer 1958 ontwikkel is.

Introduction

The effective settling of the water encountered underground has long been a problem associated with mining, in that the water made or utilized underground is contaminated by the mining operations.

The design of settling arrangements underground has been the subject of many papers, and the systems employed have ranged from batch settling in stagnant sumps, through long, rectangular, shallow continuous settlers in which the unsettled influent is introduced at one end and the clear effluent is removed at the other end, to the vertical-flow conical or V-type of settler employed today.

Settlers on Gold Fields Mines

Initially, the type of settler employed by Gold Fields of South Africa varied from mine to mine, the design normally being based on past experience. In 1958, Gold Fields started work on underground settlers with the view to establishing a standard Gold Fields settler, and by 1963 the principles of operation of the vertical-flow double-V settler employing filtration through a 'floc' bed had been established. The results of investigations leading to the adoption of this principle were published by J. W. de Villiers[1].

During these investigations, the following points were established.

(1) The effluent must be introduced at an elevation below the zone of settling particles and must be distributed over the entire area of the settler.

(2) A settler working at its maximum flow rate produces effluent of maximum clarity.

(3) Particles in suspension are removed from the water during its upward passage through a bed of settling particles by virtue of the interference offered by the settling particles or flocculated particles.

(4) The effluent must be drawn off over the entire surface of the settler, thus inducing a uniform upward flow over the settler area.

(5) The filter bed or 'floc' bed should be kept at a constant depth below the surface by the provision of means to decant excess solids from the bed at the same rate as they are introduced in the influent.

It was also established that, for efficient filtration to occur, the concentration of solids in the 'floc' bed should be about 7 per cent and that, once this concentration is established, remixing with water should not occur without agitation

The following conclusions were also drawn.

(a) If a 'floc' bed having a 7 per cent concentration of solids can be established and maintained, efficient filtration of the suspended solids in the rising solution will occur.

(b) If the 'floc' bed is bled continuously, the 7 per cent concentration of solids can be maintained.

(c) The build up of the 'floc' bed can be maintained at this solids concentration by the bleeding of 'floc' from the top of the bed, and the storing and thickening of this draw-off in a quiescent portion of the settler.

(d) As the 'floc' bed has a higher specific gravity than that of the unsettled influent, it is inherently unstable and is maintained in position by the kinetic energy of the upward-flowing influent in a diverging compartment. Therefore, ideally, there should be a uniform distribution of the influent over the length of the settler, giving rise to a uniform upward velocity over the length of the settler so that no local areas have an upward velocity greater than the settling velocity of the particles in the water.

The general arrangement of a settler based on the above conclusions is shown in Fig. 1. Fig. 2 shows an alternative arrangement that is based on the same principles. This arrangement includes the following features and is the basis for the Gold Fields standard settler.

(i) Owing to the difference in specific gravity between the 'floc' bed and the influent, the influent is fed into the settler from a launder with sufficient head to support the relatively dense 'floc' bed.

*Gold Fields of South Africa Ltd, Johannesburg.

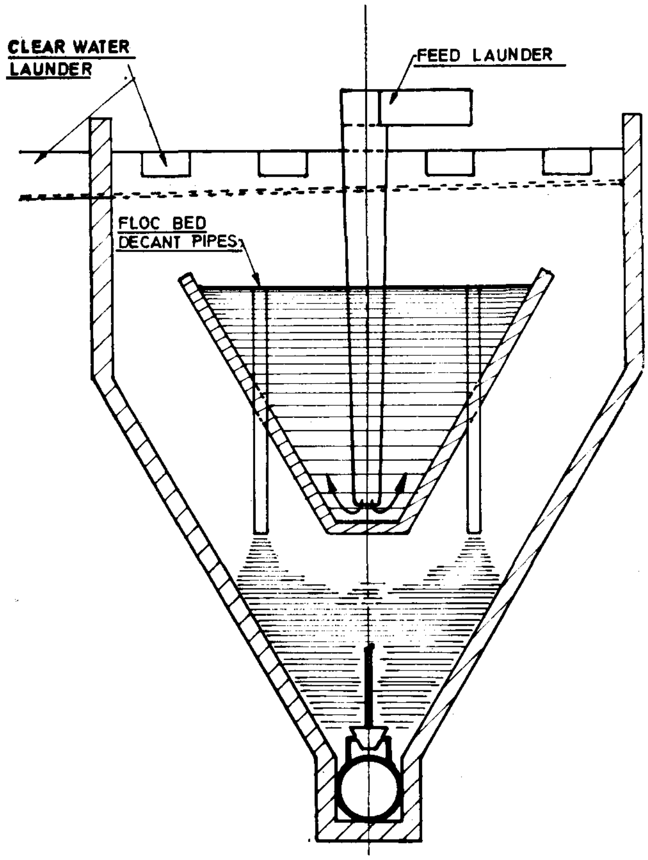

Fig. I—General arrangement of a settler based on the findings of the Gold Fields investigation[1]

(ii) As it is essential that no entrained air is introduced into the influent below the 'floc' bed, the influent is fed from the inlet launder into a manifold or belmouth of larger diameter than the down pipes. Entrained air bubbles are released at this point and not carried below the 'floc' bed.

(iii) The water above the 'floc' bed is clear, and a depth of 500 to 600 mm is maintained, the clear effluent being drawn off by lip launders.

(iv) The influent is delivered to the bottom of two divergent compartments, one on each side of the settler, the excess 'floc' bed being drawn off through apertures in the top of the divergent sections and delivered into the quiescent section between these divergent compartments, where the thickening of the excess 'floc' takes place. The thickened mud is drawn off from this quiescent section by means of a longitudinal draw-off pipe provided with simple bung-type valves.

(v) The divergent compartments are provided with manually operated flaps to allow for the discharge of the 'floc' bed when the settler is emptied. The dividing wall sections are designed to withstand the differential head of the 'floc' bed only when the settler is full.

Settlers based on these principles were designed and constructed at Free State Saaiplaas G.M. Co. Ltd, West Driefontein G.M. Co. Ltd, Doornfontein G.M. Co. Ltd, Libanon G.M. Co. Ltd, Venterspost G.M. Co. Ltd, and Kloof G.M. Co. Ltd. The construction and detailed

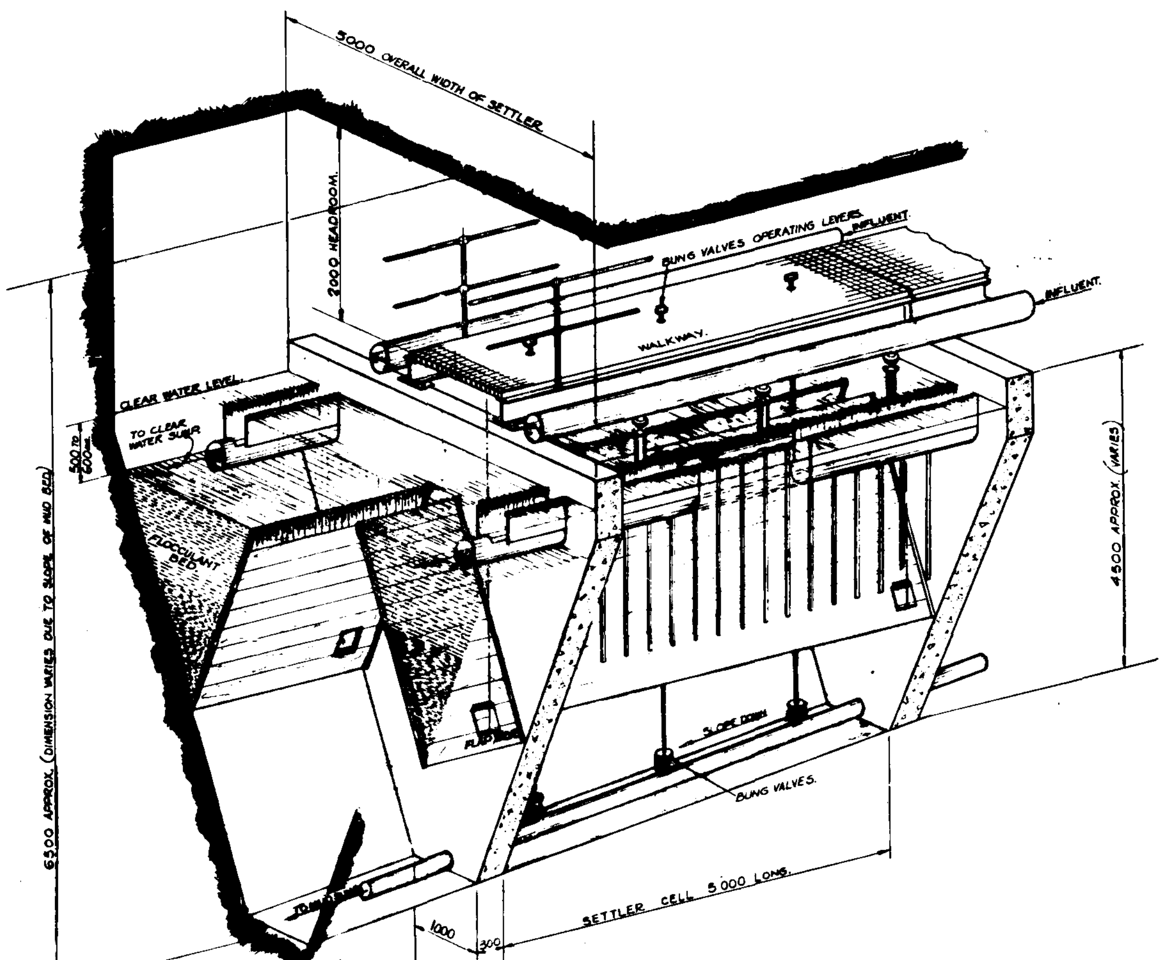

Fig. 2—Alternative arrangement to that shown in Fig. I; this formed the basis for the Gold Fields standard settler

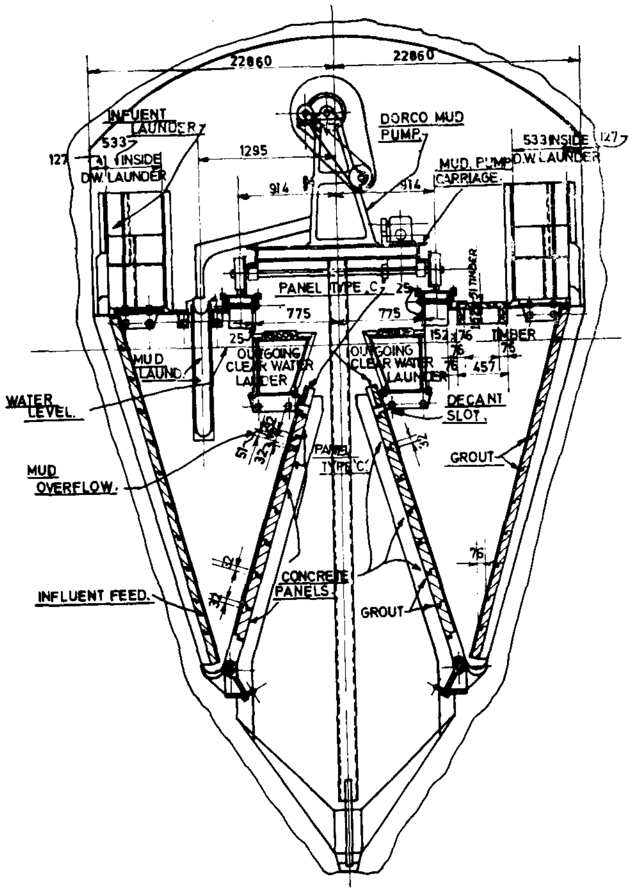

Fig. 3—Settler of No. 5A S. V. shaft, 23 level at West Driefontein

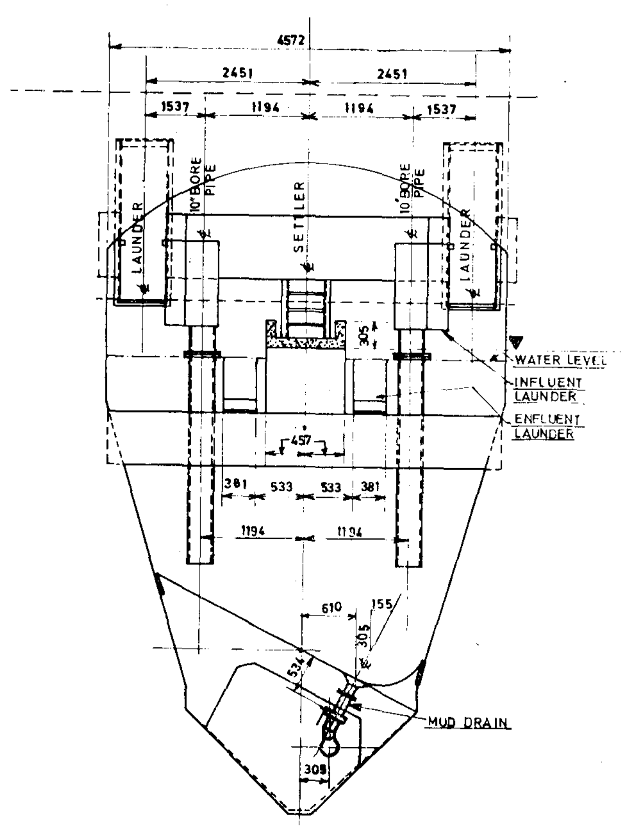

Fig. 4—Settler of Harvie Watt shaft, 25 minus 60 level at Libanon

design were often done by the company concerned, generally being affected by existing excavations and local conditions, and these settlers varied to some extent in feed arrangements, brattice walls, mud compartments, and the discharge arrangements for settled mud (Figs. 3 to 7).

After reports from Kloof G.M. Co. of difficulties encountered in stabilizing the 'floc' bed in the No. 2 Settler of the Main Shaft pumping system, it was agreed that an investigation would be carried out on all the existing settlers in the Group, with the aim of establishing the final design and operational parameters for a standard settler. After observations and performance tests were made on all the settlers in the mines of the Group, it was decided that the settler most suitable and available for modification and experimentation was the No. 2 Settler at Kloof G.M. Co. Ltd. Consequently, all the testwork was confined to one cell of this unit.

Requirements of a Settler

Before the experiments on the No. 2 Settler are described, it may well be advantageous to establish the characteristics and duty of a settler.

Clarity of Effluent

It has been the opinion of practical engineers in the mining industry that it is uneconomical and unpractical to attempt to achieve extreme clarity of effluent; they are quite satisfied with a 'cloudy' effluent from the settler, feeling that this does not greatly affect the operational life of high-lift water pumps in mines. However, it has been shown that, apart from solids settling out in the inaccessible clear-water sumps and giving rise to problems of sump cleaning, solids in suspension promote pump wear, which is influenced by

(1) the direct linear proportionality between pump wear and water turbidity,
(2) the hardness of the particles relative to that of the metal from which the pump components are manufactured,
(3) the head against which the pump is operating, packing ring wear being proportional to 3/2 the power of the seal pressure provided the particle size is less than 37 μm, and
(4) the particle mass and size, there being an increase in wear rate when the particle size reaches 40 per cent of the gap clearance.

Where the settled water is to be suitable for human consumption underground and in refrigeration circuits, the particles in suspension can adversely affect the chlorination process and cause the scaling of condenser and evaporator tubes. Under these conditions, water clarity approaching Rand Water Board (R.W.B.) standards (5 p.p.m.) is desirable but difficult to achieve without secondary filtering. An effluent with a turbidity of approximately 10 p.p.m. is considered practical.

Tables I and II list acceptable levels of turbidity for the service water used in underground drilling and cleaning operations, the requirements for potable water according to S.A.B.S. 241-1951, and particle-size counts of underground water samples taken at West Driefontein and Doornfontein Gold Mines.

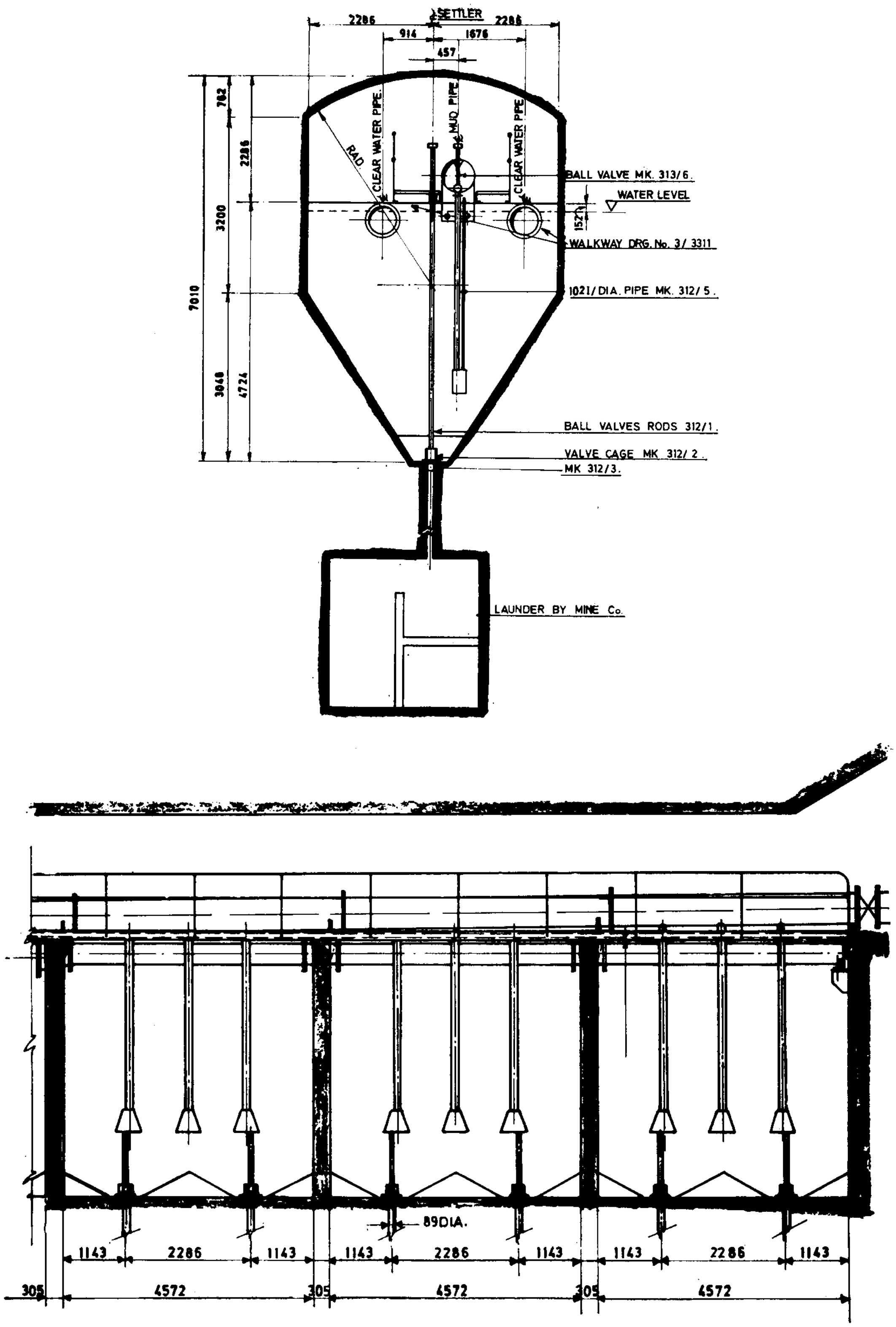

Fig. 5—Settler of No. 2B tertiary shaft, 26 level at Venterspost

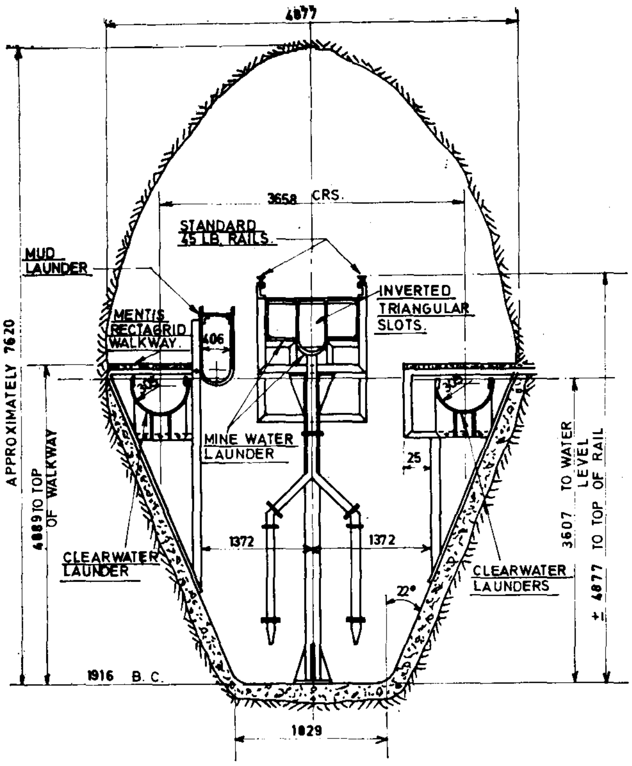

Fig. 6—No. 1 settler of No. 1 main shaft, 23 minus 60 level at Kloof

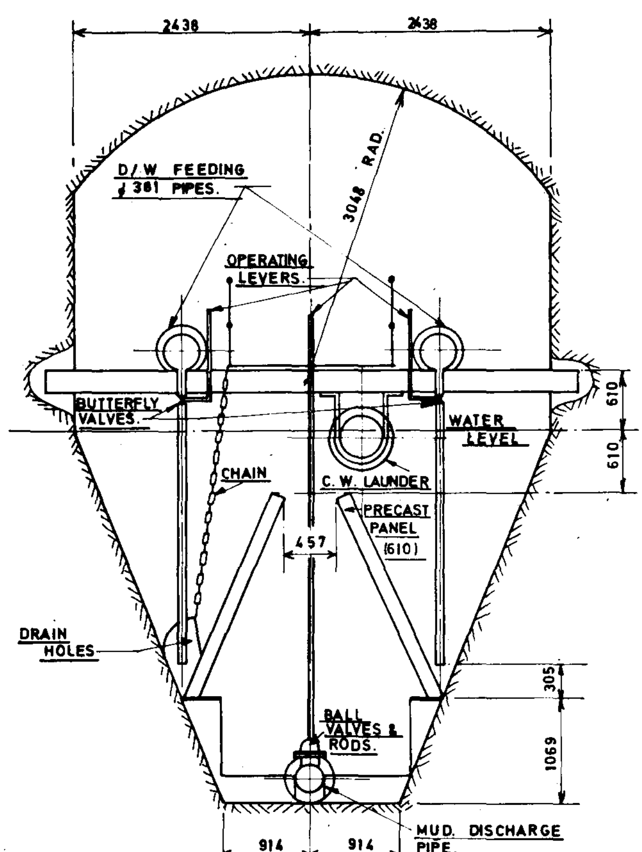

Fig. 7—No. 2 settler of No. 1 main shaft, 23 minus 60 level at Kloof

TABLE I

SPECIFICATIONS FOR WATER

A. Service water in mines

Turbidity 10⁶ particles per cm³	Remarks
10	Maximum acceptable
5	Fair
2	Good

B. Potable water[2]

Max. turbidity (expressed in silica scale) p.p.m.	Remarks
Class A 5	R.W.B. requirement
Class B 50	R.W.B. requirement

C. Industrial effluent

Max. suspended solids mg/l	Remarks
10	R.W.B. requirement[3]

TABLE II

PARTICLE-SIZE COUNTS OF WATER FEED TO SETTLERS

Particle size μm	Doornfontein %		West Drie. %	
0 to 1*	16	87	22	84
1 to 2*	27		40	
2 to 3*	22		9	
3 to 4*	15		9	
4 to 5*	7		4	
5 to 7,5	6		4	
7,5 to 10	3		4	
10 to 12,5	2,0		2	
12,5 to 15	1,5		2	
>15	0,5		4	

*Particle sizes requiring flocculating agents to aid settling rates.

Grit Collectors

It was the practice in the past to provide some means of removing the coarser particles from the influent before it reaches the settler system, and grit traps, which are generally shallow sumps cleaned mechanically or by hand-lashing, were provided. In the latest installations, grit traps have largely been dispensed with, the idea being that the larger particles will settle out in the drains before the water reaches the settlers (Table III). It may, however, be necessary to provide grit traps in installations where, owing to ventilation considerations, water is pumped back from the workings. Fig. 8 shows a grit trap that is cleaned mechanically by means of a flight conveyor.

Flocculation of Influent

The settling rate of particles of the size that is encountered in underground settling (about 5 μm) is so low (about 1,65 mm/min) that it is inconceivable to operate a vertical-flow settler without the use of flocculating agents to cause the fine suspended particles to coagulate into 'flocs', thereby increasing the effective particle size and also the settling rate.

When a flocculent is used, three distinct stages should be allowed for:

(i) mixing of the flocculent with the water,
(ii) formation of 'flocs',
(iii) conditioning of 'flocs'.

TABLE III

PARTICLE-SIZE COUNTS OF A SAMPLE OF DRAIN WATER AT WEST DRIEFONTEIN

Size μm	% of sample	% size distribution
> 147	8,6	99,2
> 104	1,0	90,6
> 74	5,5	89,6
> 43	6,4	84,1
> 37	3,4	77,7
> 31	1,1	74,3
> 25	2,5	73,2
> 18	5,6	70,7
> 13	9,7	65,1
> 5	32,2	55,4
< 5	23,2	23,2

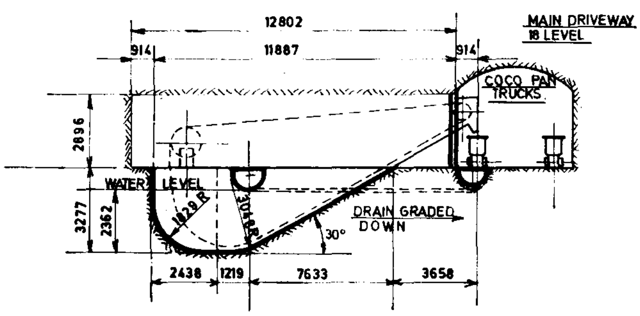

Fig. 8—Grit collector of No. 2 shaft, 18½ level at West Driefontein

The mixing of the flocculent with the effluent is achieved by the introduction of the flocculent at a point of high turbulence caused possibly by compressed-air agitation, and by cascading of the influent down two or three steps or the use of baffles in the inlet launder. The formation of 'flocs' requires a further period of turbulent flow to encourage the growth of particles or 'flocs' through collisions between colloidal particles. It must be noted, however, that excessive turbulence tends to break up the 'flocs' that have formed. Conditioning of 'flocs' is the growth of small 'floc' particles through collisions to form larger ones with high settling velocities. A settler should be designed to allow for this 'floc'-conditioning stage to take place in the vertical feed pipes and after discharge at the bottom of the inlet compartment.

The time taken for the three stages varies with the different flocculents commercially available, and it is generally necessary to establish these times before the inlet system to the settler is designed.

Pumping and Settling Capacity

The design of the pumping system comprising settlers, storage sumps, and pumping plant depends on the service-water requirements, the quantity of fissure water encountered in the mine, and the permitted pumping times, which are usually influenced by power control considerations.

In a mine where no fissure water is encountered, the

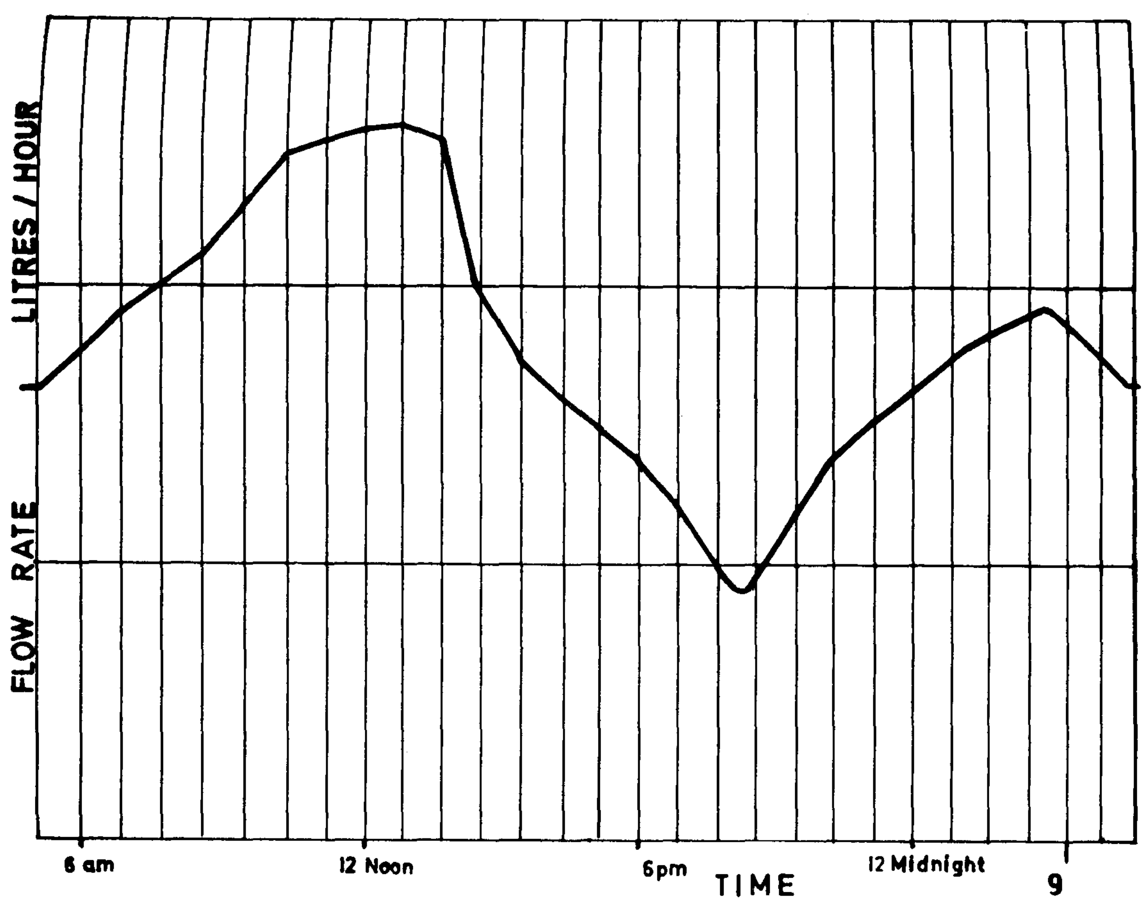

Fig. 9—Typical curve showing water flow rate for 24 hours

pumping system will be required to handle only the service water that is used in the mining operations. The quantity of service water used will vary from mine to mine, depending on the drilling and cleaning techniques, The water feed to the system varies considerably throughout the day in respect of flow rate and turbidity. A figure of 2 t of water per 1 t of rock mined with a peak flow rate equal to between 70 and 80 per cent of the water handled per day being pumped in an 8-hour shift are figures used by Gold Fields in the basic design of settling systems.

Fig. 9 shows a typical curve of the variation in water flow rate over 24 hours.

Withdrawal of Sludge

Experience has shown that sludge left in a settler for any length of time becomes solid and cannot easily be removed from a settler by means other than sluicing with high-pressure water or hand-lashing, whereas fresh sludge behaves like a viscous fluid and can easily be discharged from the bottom of the settler by means of a pipe at the bottom of the sloping walls of the settler or by means of a pump travelling above the settler as shown in Fig. 3.

Tests on No. 2 Settler

The tests and modifications were carried out on one 4,57 m by 4,57 m cell of the No. 2 Settler (shown in Fig. 7), which comprises six 4,57 m cells.

The effects of modifications on the clarity of the effluent and on the cell flow rate were compared with those of the other unmodified cells of the settler. The initial observations indicated a very unstable 'floc' bed owing to the relatively high flow rate in the down feed pipes.

Various feed arrangements with the divergent brattice walls at various heights were tested. It was found that the original spacing of down pipes at approximately 900 mm centres was too great, and that mud built up on the brattice walls between these pipes creating a channelling condition, which caused the unstable 'floc' bed. It was also established that the feed pipes (50 mm diameter) were too large, and with the 1,22 m head available a flow of 4,54 l/s (60 ft/min) was achieved. With this high flow rate, strong upward flow currents were created that caused extreme agitation for two-thirds to three-quarters of the depth of the 'floc' bed, leaving only one-third to one-quarter of the bed depth for filtering. A reduction in the diameter of the down pipes to 38 mm and an increase in the number of down pipes (spacing them at approximately 300 mm centres) created a more stable condition, even at flow rates of up to 2,73 l/s at an inlet head of 1,22 m.

Once suitable feed arrangements had been established, further tests were carried out on the height of the divergent brattice walls, which basically control the height of the 'floc' bed. An optimum height of between 990 mm and 1220 mm for an inflow of 30,3 l/s per side was established.

After the above optimum conditions had been proved and a further series of tests conducted, it was noticed that there was certain instability in the 'floc' bed because of the formation of high-velocity channels that tended to drag mud particles into the effluent launders. This channelling was attributed to insufficient length of the effluent launder. The ratio of launder lip length to settler surface area was increased from 4,37 m to 50 m per 100 m², and immediate improvement was observed.

In the initial tests on the settler (influent flow rate of

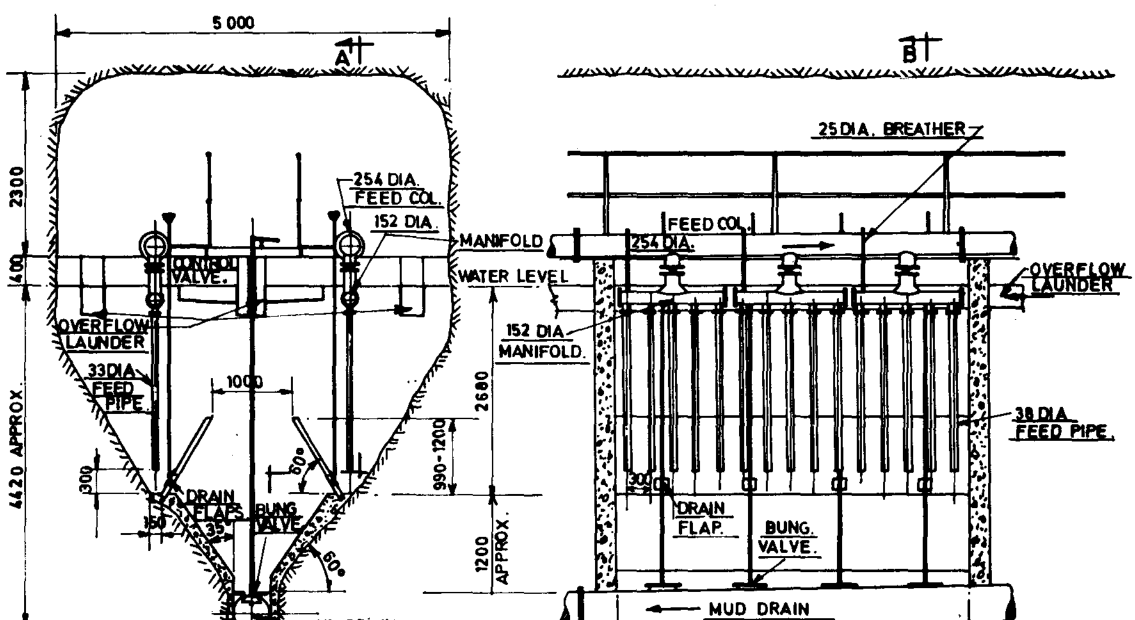

Fig. 10—Recommended layout of settler cell for an influent flow of 60,6 l/s

30,3 l/s per side or 2,9 l/s per square metre of surface area, and a 50/50 mixture of Seperan and Magnafloc as flocculating agent), the following results were obtained:

Pulp density in 'floc' bed 1,03 (4,64 per cent dry solids for solids of 2,7 specific gravity)

Turbidity of effluent 3,0 million particles per cubic centimetre.

The rough as-mined side walls and surface finish of the cell walls and divergent brattice walls had no effect on the performance of the settler, but it was noticed that it was necessary to have relatively leak-proof joints between the planks forming the divergent brattice walls, and that the distance between the brattice wall and the side wall at the apex of the divergent section at which point the down pipes discharge should be as small as possible and not exceed 150 mm; also, the joint between the lowest plank and the concrete landing should be adequately sealed.

Recommendations

From the above results and from observations made of the operation of the settlers at Kloof Gold Mining Co. Ltd, the following recommendations for the design and operation of a standard double-V compartment vertical-flow settler can be made.

Design

(1) Optimum flow rate 2,92 to 3,0 l/s per square metre of surface area.

(2) Influent velocity in inlet launder 0,534 m/s.

(3) Velocity in vertical downward feed pipes 2,38 m/s, i.e. 2,73 l/s in a pipe of 38 mm diameter.

(4) Centre distance between down pipes 300 mm maximum.

(5) The influent should be fed to the down pipes via a manifold situated below the inlet launder, and the manifold should be provided with a valve or flange at each end for flushing. An air-release pipe of 25 mm diameter should also be fitted to the manifold.

(6) Ratio of total launder lip length to surface area of settler 50 m per 100 m^2 minimum. A notched lip launder should be used in preference to a straight lip launder to eliminate variations in flow due to incorrect levelling.

(7) The down feed pipes should reach to within 300 mm of the apex of the divergent chamber.

(8) The distance between the side wall and the brattice wall at the apex of the divergent chamber should not exceed 150 mm.

(9) The height of the divergent brattice walls should not exceed 1220 mm from the apex.

(10) The joints between the planks forming the brattice wall should be adequately sealed to prevent leakage of the 'floc' bed.

(11) Arrangements for the discharge of mud should comprise an open-ended pipe provided with bung-type valves, and should be situated at the bottom of the quiescent chamber formed by the two divergent compartments. The bottom of this compartment should be V-shaped with the outlet pipe situated at the bottom or apex of the V.

(12) The cross-section of the settler should be in accordance with the excavation shown in Fig. 10.

(13) The settler should be divided into cells approxi-

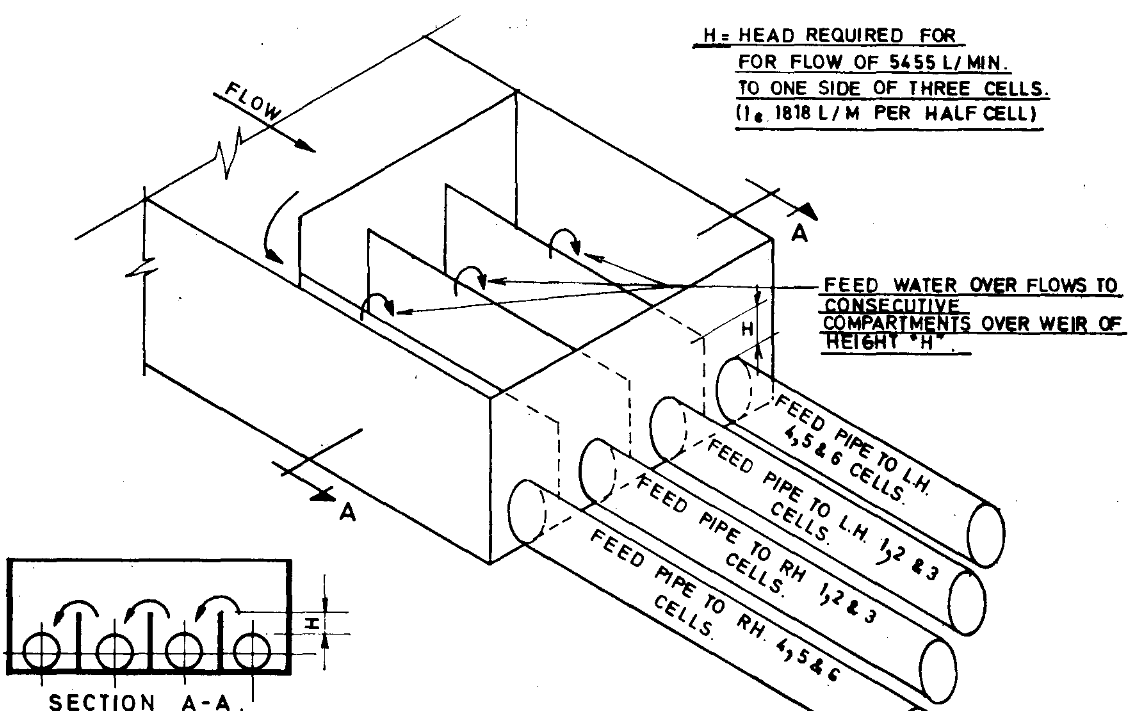

Fig. 11—Feed launder for constant feed to the cell

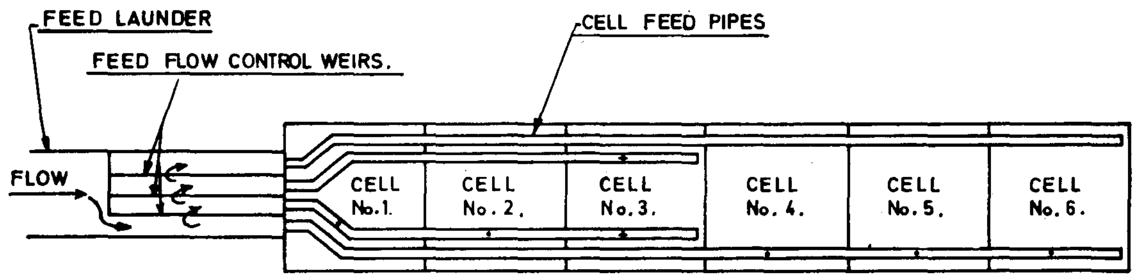

Fig. 12—Plan of feed launder and pipes for a six-cell settler, each pipe being designed to accommodate the feed to three half-cells

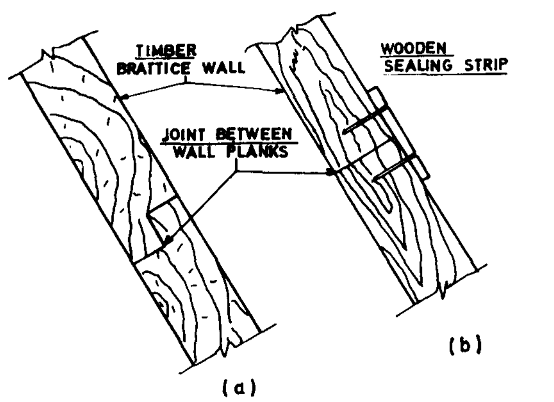

Fig. 13—Recommended joint between the planks forming the brattice walls

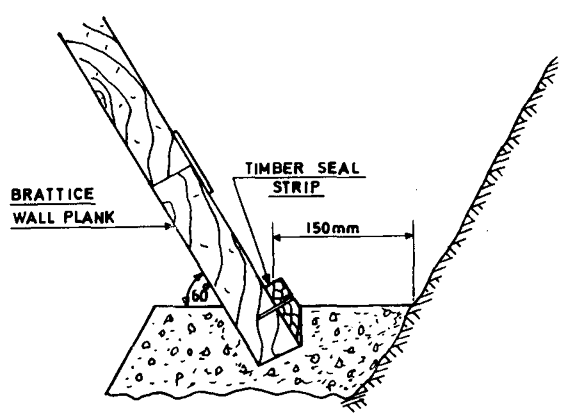

Fig. 14—Detailed view of the bottom of the brattice wall

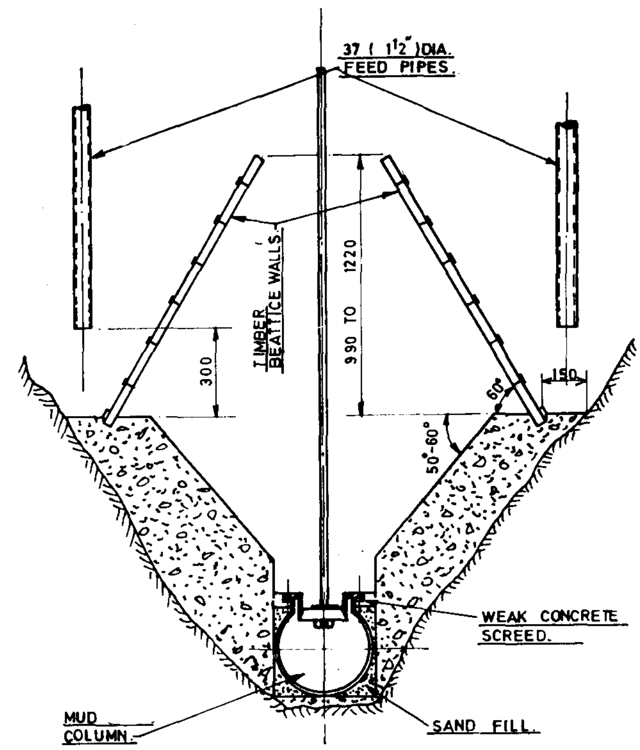

Fig. 15—Recommended arrangement for the mud outlet

mately 4 m in length to facilitate cleaning of individual cells without interruption of the settler operation.

(14) If the nature of the ground prohibits excavations of the width shown in Fig. 10, a settler comprising one half of the unit can be successfully employed provided the parameters specified above are adhered to.

Figs. 11 to 15 serve to illustrate the main parameters specified above, Fig. 10 showing the general arrangement with salient dimensions of the recommended standard settler for use with flocculated underground industrial water.

Operation of the Settler

The inflow to any settler underground varies widely from a minimum during the night to a maximum during the day shift. By use of cellular construction, the flow to each cell can be kept reasonably close to the optimum. The layout of feed launders shown in Fig. 11 illustrates a method for utilization of the settler in three half-cell increments. This progressive inflow arrangement would provide constant use of the left-hand side of cells 4, 5, 6 and intermittent use of the left-hand sides of cells 1, 2, 3. The right-hand sides of all these cells would be used only during the peak period.

If this feed arrangement were adopted, the operators could easily be trained to control the flow into the cells by maintaining the inlet valves to the cells in the open position. The specific gravity of the mud drawn off is generally fixed by the means of delivering the mud to the surface. If reciprocating pumps are employed, a specific gravity of 1,1 is the limit for the mud, but, if the mud is delivered to the surface by means of the hydraulic displacement system, a specific gravity of up to 1,5 could be tolerated.

It was found at Kloof Gold Mining Co. Ltd, where reciprocating pumps are employed for the mud, that, if the mud is drawn off the settler by dropping of the

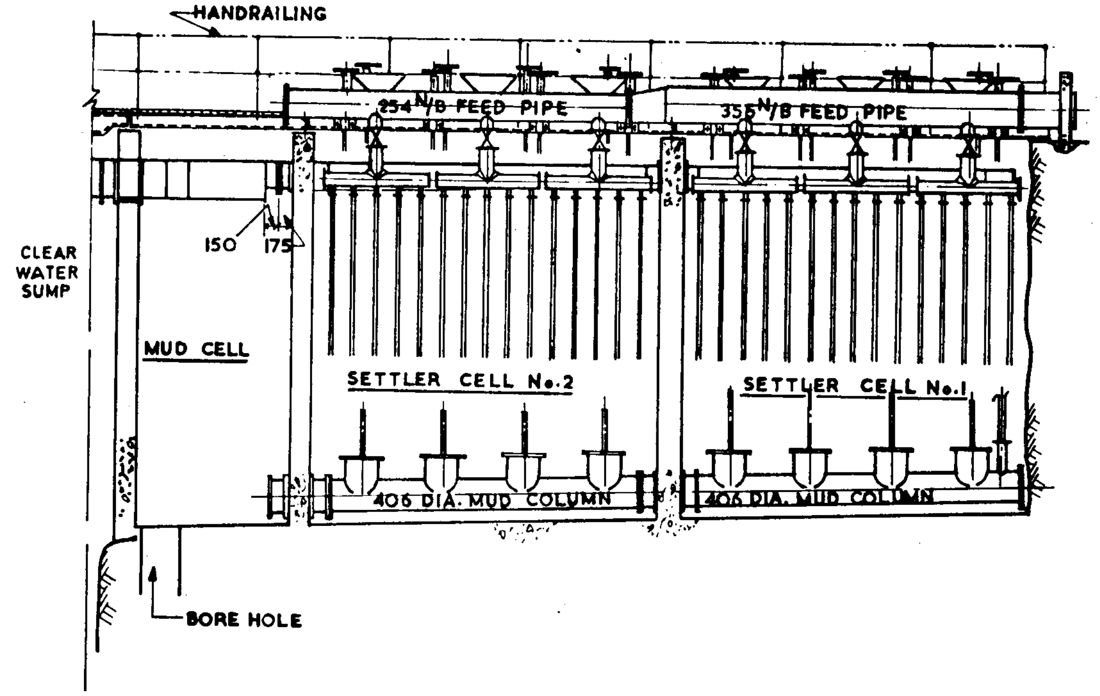

Fig. 16—Elevation showing the settlers of No. 2 shaft at East Driefontein

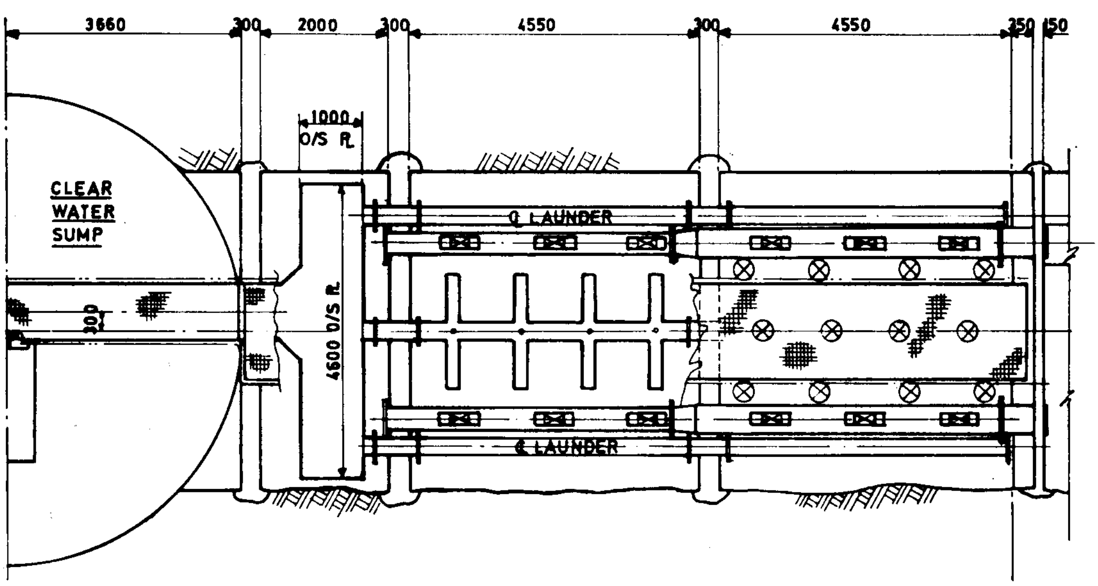

Fig. 17—Settlers of No. 2 shaft at East Driefontein

water level between 0,6 m and 0,9 m twice during the shift, the specific gravity of the mud can effectively be maintained at 1,06 to 1,07.

Based on the above observations, the following recommendations are made.

(1) The feed system and feed control should be such that each cell is operated as close to the optimum flow rate of 2,92 l/s per square metre of settler surface area by bringing it onto load in stages as the load increases during the day.

(2) The mud should be drained from each cell at regular intervals, the period between each draw-off operation being dictated by the mud specific gravity suitable for the mud-pumping system.

(3) Each cell should be operated with a solids concentration of between 4,7 and 7 per cent in the 'floc' bed.

(4) With extreme variations of flow and influent turbidity over a 24-hour period, a small accumulation of mud within the divergent compartments will be experienced. This build up should be flushed out once a week or once every two weeks, depending on the rate of build up and the incidence of channelling, which causes instability in the 'floc' bed owing to this build up.

(5) The influent to the settler should be effectively flocculated by the mixing of the intake with the flocculent and its conditioning before entering the settler. The mixing of flocculent and the agitation should be carried out in accordance with recommendations made by the suppliers of the flocculent. Arrangements should be made for variation in the feed rate of the stock solution in accordance with the variation in the inflow and turbidity of the influent. The mixing of the stock flocculent solution with the influent water should be done by cascading in preference to agitation by compressed air. After agitation, the growth of 'floc' particles should be encouraged by the passing of influent through the launder at a flow rate of 0,6 to 0,9 m/s for a distance of approximately 6 m before it enters the launders above the settler.

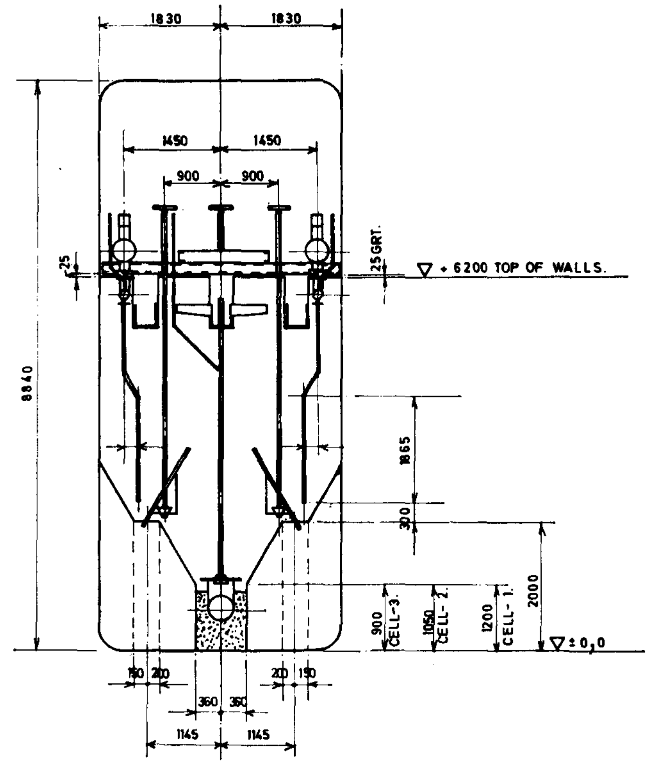

Fig. 18—Arrangement of mud settlers, 24 level No. 1 shaft, Venterspost

Present Arrangements

The general arrangement for the settlers of No. 2 Shaft at East Driefontein G.M. Co. and a redesigned settler recently commissioned on 24 level No. 1 Shaft, Venterspost G.M. Co., are shown in Figs. 16 to 19. Table IV is a comparison of the performance of the settlers in operation at present.

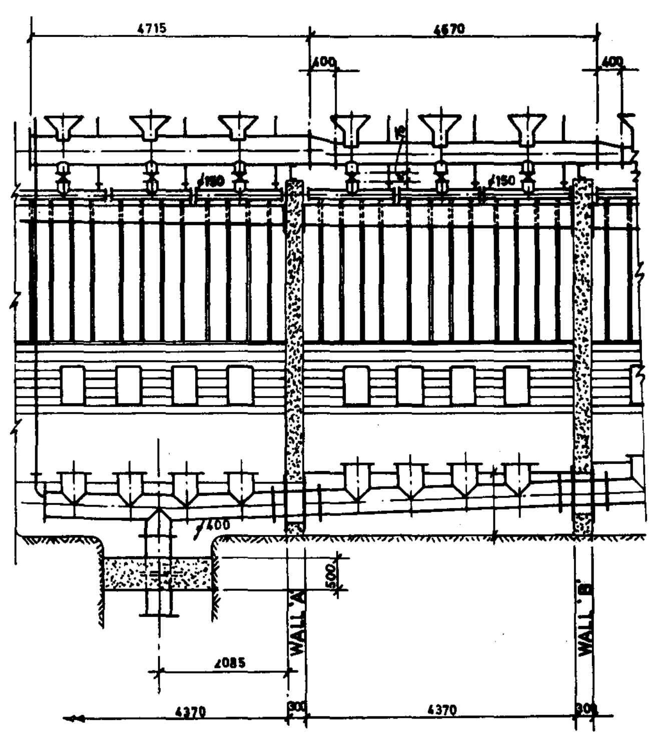

Fig. 19—Arrangement of mud settlers, 24 level No. 1 shaft, Venterspost

References

1. De Villiers, J. W. An investigation into the design of underground settlers. *J. S. Afr. Inst. Min. Metall.*, Jun. 1961.
2. South African Bureau of Standards. *Specification of water for domestic supplies.* S.A.B.S. 241—1951. Pretoria, the Bureau.
3. *Regional standards for industrial effluents*, no. R. 553.

Bibliography

Johnson, F. C. The settlement of the underground mine waters of the Witwatersrand. *J. Chem. Metall. Min. Soc. S. Afr.*, Oct. 1952.

Symposium of papers on pumping, vol. 1. *J. Instn Certif. Engrs S. Afr.*, Jun. 1952 to Jan. 1955.

TABLE IV

SETTLERS AT PRESENT IN OPERATION

Mine	Shaft and level	Type of settler flow	Length and width of settler, mm	No. of cells and cell dimension	Cross-section	Feed rate per cell l/h	Solids in feed water p.p.m.	Solids in effluent p.p.m.	pH of water	Mud discharge rate, l/d sp. gr.	Flow rate per unit surface area l/s/m²
Venterspost	2 shaft 20 level	Cross	15×6	1	Rectangle	20 800	43 180	18	7,8	136 200 1,255	0,64
Venterspost	28 tert. shaft 26¼ level	Vertical	27,4×4,5	6 4,5×4,5	V	41 500	22 095	10,3	7,0	476 700 1,078	0,57
Venterspost	3 tert. shaft 32 level	Vertical	27,4×4,5	6 4,5×4,5	V	28 050	1 475	84	6,8	227 000 1,071	0,83
Venterspost	1 shaft 24 level	Vertical	45×5,5	3 15×3,5	Rectangle	66 000	1 500	8,8	7,3	50 967 1,275	0,35
Venterspost	1 shaft 24 level	Vertical	15,9×3,6	3 4,37×3,6	V	111 000	1 500	8,2	7,3	84 945 1,283	1,96
Venterspost	2 shaft 20 level	Cross	15×6	1 15×6	Rectangle	208 000	43 180	18	7,8	136 200 1,255	0,64
Venterspost	3 S.V. shaft 32 level	Vertical	27,4×4,5	6 4,5×4,5	V	21 520	1 475	84	6,8	227 000 1,071	0,73
Doornfontein	No. 1 shaft 15 level	Cross	118,8×3,88	20 5,54×3,88	Rectangle	30 555	678	11	6,9	109 000 1,12	0,39
Doornfontein	No. 1a S.V. shaft 35 level	Vertical	98×2,75	18 5,5×2,75	V	20 000	850	16	5,5	220 000 1,07	0,37
Doornfontein	No. 2 S.V. shaft 33 level	Vertical	70×3,7	15 4,6×3,7	Rectangle	23 5C0	750	9	7,0	100 000 1,1	0,38
Kloof	Main shaft No. 2 settler 23-60 level	Vertical	30,48×4,88	6 5,49×4,88	V	187 500	1 625,6	7	8,0	123 000 1,24	1,94
Kloof	No. 1 S.V. shaft 31 level	Vertical	29,1×5	6 4,85×5	V	59 000	719,4	17,2	8,0	350 000 1,317	0,68
East Drie.	No. 1 shaft 14 level	Vertical	27×5	6 4,5×5	V	90 600	10 128	74,8	7,5	120 000 1,099	1,12
East Drie.	No. 2 shaft 24 level	Vertical	22,75×5	5 4,55×5	V	58 500	10 109	71,6	7,3	120 000 1,035	0,71
Libanon	No. 1 shaft 12 level	Cross	45,72×4,57	1	V	540 000	10 000	16,4	7,8	3 350 1,05	0,72
Libanon	No. 1 S.V. shaft 27 level	Cross	33,53×4,57	1	V	160 000	5 454	15,8	7,8	3 550 1,05	0,29
Libanon	Harvie Watt shaft 23 level	Vertical	30,48×4,57	3 9,754×4,57	V	160 000	4 458	18,2	7,8	236 400 1,07	0,32
West Drie.	No. 2 shaft 18½ level No. 1 settler	Cross	34,3×5,2	2 3,5×5,2 30,8×5,2	V		3 392	24	7,85	31 004 1,1	
West Drie.	No. 2 shaft 18½ level No. 2 settler	Cross	34,5×5	2 3,5×5 31×5	V		3 392	24	7,85	109 810 1,1	
West Drie.	No. 2 shaft 18½ level No. 3 settler	Cross	34,5×4,8	2 3,5×4,8 31×4,8	V		3 392	24	7,85	64 593 1,1	
West Drie.	No. 2 shaft 18½ level No. 4 settler	Cross	47,7×6,1	2 3,5×6,1 31×6,1	V		3 392	24	7,85	64 593 1,1	
West drie.	No. 5a S.V. shaft 32 level No. 1 settler	Vertical	41,4×4,58	13 3,05×4,58	V		6 992	50	7,45	480 000 1,216	
West Drie.	No. 5a S.V. shaft 32 level No. 2 settler	Vertical	41,5×4,58	12 3,94×4,58	V		6 992	78	7,45	480 000 1,216	

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