THE RAND LEASES PLANE TABLE

By T. Zadkin*

INTRODUCTION

In presenting yet another contribution to the study of methods of concentration, I have no desire to re-open the discussions on the value of mill concentration. This Society has been privileged to hear views on the subject in the past, and members are no doubt well aware of all the advantages claimed by those who favour all-cyanidation for gold extraction. To those who seek to improve their methods of gold recovery in the mill, I know that the plane table is worthy of attention. I submit further that the views of the protagonists of all-cyanidation may need to be revised.

Before describing the plane table I wish to explain that on my arrival at the Rand Leases Gold Mine in August 1953, I was so greatly impressed with the performance of the plane tables in operation there, that I sought to learn the history of their installation. I found that credit is due to the late Mr Donald McLean, who originally conceived the idea of applying this concentrating device to present-day large-scale practice, to Mr S. K. de Kok, now of the Anglo-Transvaal Consolidated Investment Company, Limited's Metallurgical Department, to Mr R. V. Guthrie, now Reduction Officer, Village Main Reef Gold Mining Company Limited, and to my predecessor, Mr M. J. Dennehy, who directed the development and installation of the table. I am indebted to Mr de Kok for much of the following information.

PREVIOUS CONCENTRATION PRACTICE

The Rand Leases reduction plant includes two 9′ × 10′ primary ball mills, eight primary tube mills, 6′ 6″ × 20′, and eleven secondary tube mills 6′ 6″ × 20′. The original flowsheet included straking for the recovery of free gold by means of corduroy cloth in both the primary and secondary milling circuits. Substitution of corrugated rubber mats for cloth in the primary circuit resulted in a slight decrease in mill gold extracted. Subsequently, tests revealed that of the total gold recovered by concentration, 76 per cent was actually being recovered in the secondary circuit. Concentration in the primary circuit was then abandoned, and although this change resulted in a further slight reduction in mill gold recovery, no detrimental effect on total extraction was observed. The use of corduroy cloth in the secondary circuit only, facilitated more frequent washing of the cloths as well as better supervision. This then, was the practice immediately prior to the introduction of the plane tables. Each of the corduroy tables had an effective straking area of 42 sq.ft., treating approximately 1,800 tons of solids per 24 hour day at a slope of 20 per cent (dilution 41 per cent moisture). One European supervisor and six Natives were employed on each shift to remove and wash the corduroy cloths at two-hourly intervals. The washings were pumped by two 2″ centrifugal pumps to collecting tanks in the recovery house. The daily yield of concentrate, about 8 tons, was then reduced to approximately 900 lb on a shaking table, and this richer product was delivered to the amalgam barrel while the tailing was pumped back into the milling circuit. After amalgamation, the batea residue was run over a small corduroy launder and a shaking table (for osmiridium recovery) and then returned to the milling circuit.

Because of the intermittent nature of the operation of the corduroy tables, and the decline in efficiency with clogging and wear, close supervision and frequent washing are essential. The plane table, on the other hand, achieves the continuous removal of concentrate without any handling whatsoever.

DESCRIPTION OF THE PLANE TABLE

The plane table consists essentially of a suitably inclined table equipped with longitudinal riffles running down the table,

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H—Launder. I—B

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parallel to its sides, and to the direction of flow of the pulp. At a certain distance from the head of the table, the surface is stepped down and a slot runs transversely across the table, the width of the slot being sufficient to allow the lighter upper portion of the pulp stream to cascade over it while the heavier and slower moving portion falls through the gap into a receptacle, thus achieving concentration. The riffles are provided by laying a corrugated rubber mat on the upper surface of the table. Use is made of the differential velocity of layers at different depths in a sheet of ore pulp flowing over a substantially smooth surface to produce differences in the rate of movement of solid particles of varying sizes and, particularly of varying specific gravities, over that surface. The riffles afford protection to the heavier particles, which have settled, from the streaming action of larger particles of lower specific gravity which might entrain them in the faster moving upper portion of the pulp and carry them over the slot.

Fig. 1

A—Head of frame. B—Frame. C—Holes. D—Edge-boards. E—Stools. F—Scrubber. G—Trough. H—Launder. I—Bowl.

At this stage it is interesting to refer to Agricola's description of the frame[1] (Fig. 1): '. . . The frame is made of two planks joined together, and is twelve feet long, and three feet wide, and is full of holes large enough for a pea to pass. To prevent the ore or sand with which the gold is mixed from falling out at the sides, small projecting edge-boards are fixed to it. This frame is set upon two stools, the first of which is higher than the second, in order that the gravel and small stones can roll down it. The washer throws the ore or sand into the head of the frame which is higher and opening the small launder, lets the water into it and then agitates it with a wooden scrubber. In this way the gravel and small stones roll down the frame on to the ground, while the particles or concentrates of gold, together with the sand, pass through the holes into the trough which is placed under the frame, and after being collected, are washed in the bowl.'

Obviously no new principle can be claimed for the plane table. But its successful application to modern large-scale practice is novel—in this case, to a mill treating more than two million tons of ore per year, which, taking circulating loads into account, means an even greater tonnage over the plane tables.

The Rand Leases plane table (Fig. 2) consists of an inclined table, slope 20 per cent, width 3′ 6″, with a step $2\frac{1}{2}''$ deep and 1″ wide, situated 4′ 6″ from the top and 5′ from the bottom. A feed box and distributing blocks are situated at the head, and a launder is provided underneath the step and at the lower end, as a receptacle for concentrate drippings. The deck is constructed of $\frac{5}{16}''$ Masonite tempered hardboard or concrete formboard and is covered with two sections of rubber riffled matting of the same type previously used as a substitute for corduroy cloth. The riffles are spaced $\frac{1}{4}''$ apart, and are $\frac{1}{8}''$ deep, but investigation on the most efficient shape of riffle remains to carried out. Turbulent and uneven flow of the pulp tend to decrease efficiency. The feed box and distributor have been found adequate for ensuring even distribution over the table. A slightly diverging flow is produced and to reduce eddy currents to a minimum, the two sections of rubber are laid with the saw teeth facing outwards. The framework is of wooden construction and the slope can, if desired, be varied. The table is brushed down with a wire brush, usually once or twice per shift, mainly for the removal of fine iron.

THE DEVELOPMENT OF THE PLANE TABLE

In July 1949, the first test table was installed in one of the secondary mill-ancillary classifier circuits. The initial results were not too promising, as it was found that the table was too narrow for the tonnage to be handled, but the principle was found to be sound.

Accordingly, a 4′ 3″ wide table was installed with the rubber riffles running at 60° upwards and outwards from the centre of the slot. Tonnage and assay figures showed an improvement on the prototype but not to the extent to justify adoption. While excellent concentration obtained at the centre of the table, the concentrate at the sides tended to be low-grade. The next table installed was essentially the one in use to-day, i.e. 3′ 6″ wide, with the slot at a distance of 4′ 6″ from the head and the riffles set to run parallel to the sides of the table.

Without going too deeply into the mechanics of pulp flow, it is obvious that the efficiency of the table, assuming sufficient liberation of the gold particles, will depend largely on the time available for settlement of those particles. Hence for a table of definite length and width, there are two variables which may be altered within fairly wide limits, viz. the dilution of the pulp and the slope of the table.

It was found that the 3′ 6″ × 4′ 6″ tables worked well over the range of 34–42 per cent moisture in the pulp and 12½–20 per cent inclination when treating 1 200–1 800 tons of solids per day in the secondary mill effluent.

Table I shows the results obtained from a number of samples of the concentrate from this test table.

Following the encouraging results obtained from the single test table, two more tables were installed, making a total of three plane tables, and eight corduroy

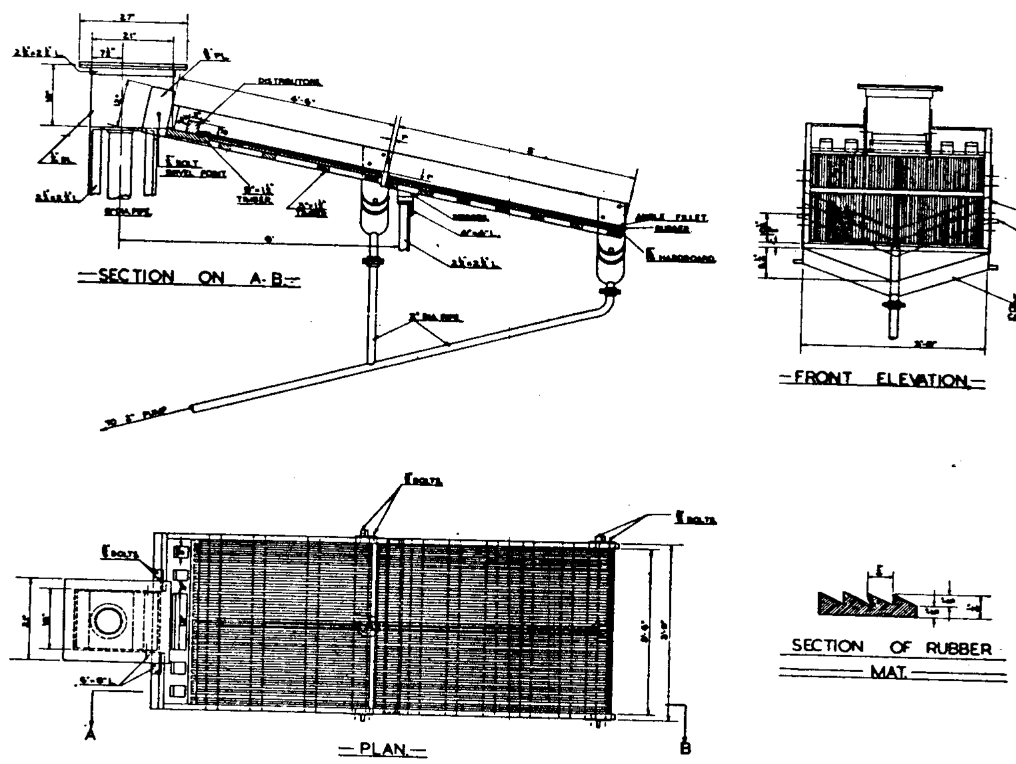

Fig. 2—Details of plane table

tables in the secondary circuit. Tests were conducted to confirm the previous results and to obtain data on the main variables for efficient operation.

Table II gives the results of four tests, each of three days duration, the concentrate from the three plane tables being reconcentrated, amalgamated and retorted separately from the current corduroy concentrate, the figures for which are also given.

It is seen that the corduroy recovery was slightly higher than that of the plane tables, but corduroy extraction had never averaged 47 oz. per mill per day, the slight rise being due to the more frequent washing made possible by the replacement of three corduroy tables. It was concluded that at the worst the plane tables would give only a slightly lower recovery than the corduroys and would make very little difference to the final pulp value.

Fig. 3 indicates that by varying the slope of the table and the specific gravity of the feed, a wide range of concentrate tonnages may be obtained. In general, it may be

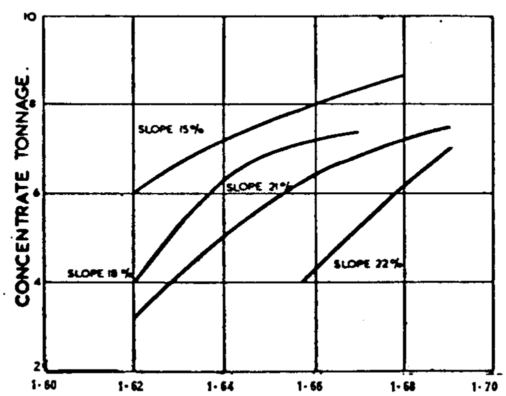

Fig. 3—Effect of slope and dilution on concentrate tonnage

said that the flatter the table, and the higher the specific gravity, the higher the tonnage of the concentrate.

The next step was the complete replacement of corduroy cloth by plane tables; this was done over a period of a few weeks, three tables being installed at a time, until the change-over was complete. The slight reduction in mill gold recovered was not considered serious, as no detrimental effects were reflected in the residues.

Tests showed that it was possible to remove a second concentrate from the end of the plane table, the second concentrate assaying about 8 oz. of gold per ton. All the tables were then equipped to collect these 'second series' drippings.

Subsequently one of the secondary tube mills was set aside and the circuit modified to provide a special re-grinding circuit for the shaking table tailing; the tube mill was in closed circuit with a plane table, and rake classifier, the returns from which assayed

TABLE I

	Concentrate tons per 24 hrs.	*Oz. gold/ton*	*% FeS_2*
	4·24	16·40	15·40
	4·80	14·60	15·66
	6·80	18·54	—
	6·56	11·83	12·27
	6·28	9·72	15·58
	5·52	15·48	13·88
	5·36	10·44	11·66
	4·64	17·64	16·36
	5·80	6·75	13·49
	5·60	16·29	—
Average	5·64	13·77	14·29

TABLE II

Average tons per 24 hrs.	Plane table concentrate: Average assays oz./ton — No. 1 table	No. 2 table	No. 3 table	Actual recovery: Oz. fine gold per mill per 24 hrs. — Plane tables	Corduroys
22	16·8	12·2	14·0	44	45
17	20·2	11·2	13·3	41	48
18	17·4	13·6	10·9	43	47
23	19·4	14·4	6·9	47	49
Av. 20	18·4	12·8	11·3	44	47

up to 40 per cent FeS_2. The circuit was further modified by feeding the combined concentrate from ten plane tables (approximately 150 tons per day) to the bowl classifier of the re-grinding unit, and re-concentrating on the plane table in this circuit; the concentrate so obtained is pumped to the recovery house as already described. The final overflow product from the re-grinding unit joins the current final pulp for further treatment.

A subsequent development was the installation of cyclones in place of classifiers. Thus, the bowl classifier in the re-grinding unit was replaced by a 24″ cyclone. In addition, a 14″ cyclone was installed to provide supplementary feed to the re-grinding tube mill from the pulp feed to the final cyclone classifiers. A third slot was added to one table to see if pyrite extraction could be increased. Visual inspection suggested that this was successful, but further test-work will be required to determine whether any advantage is to be gained by removing a greater weight of concentrate for separate grinding. It seems to be the consensus of opinion on the Witwatersrand that the preferential grinding obtained with

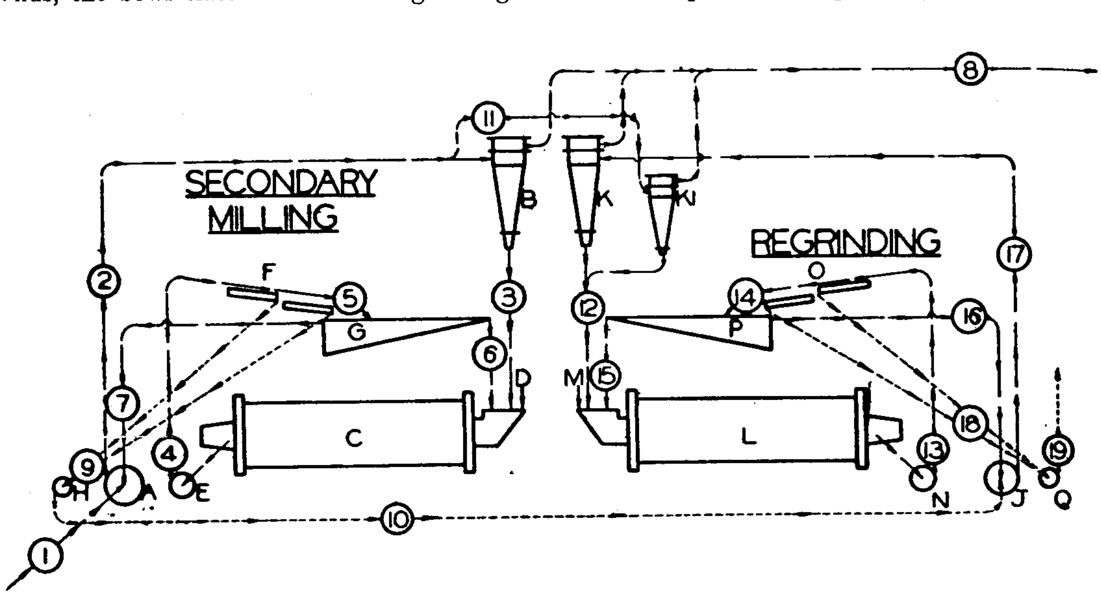

Fig. 4—Concentration and regrinding flowsheet

A. 4 12″ Main circuit pumps (2 spare)
B. 10 27″ 20° cyclone classifiers
C. 10 Tube mills 20′ × 6′ 6″
D. 10 Pebble pockets
E. 10 5″ Centrifugal pumps
F. 10 Plane tables
G. 10 Duplex rake classifiers 18′ × 8′
H. 4 2″ Centrifugal pumps
J. 1 6″ Centrifugal pump
K. 1 24″ 20° Cyclone classifier
K1. 1 14″ 20° Auxiliary cyclone classifier
L. 1 Tube mill 6′ 6″ × 20′
M. 1 Pebble pocket
N. 1 5″ Centrifugal pump
O. 1 Plane table
P. 1 Duplex rake classifier 18′ × 8′
Q. 1 2″ Centrifugal pump

1. Pulp from primary milling
2. Total pulp to final classifiers
3. Final classifier return
4. Mill effluent
5. Plane table tailing
6. Ancillary classifier return
7. Ancillary classifier overflow
8. Final pulp
9. Plane table concentrate
10. Plane table concentrate
11. Auxiliary cyclone classifier feed
12. Cyclone classifier return
13. Mill effluent
14. Plane table tailing
15. Ancillary classifier return
16. Ancillary classifier overflow
17. Concentrate and classifier overflow
18. Final concentrate
19. Concentrate to recovery house

stage grinding and adequate classification is sufficient assurance that no totally encased gold is delivered to the cyanide plant.

PRESENT CONCENTRATION PRACTICE

Effluent pulp from each secondary mill, diluted to a specific gravity of approximately 1·66, is fed to its table feed box. The table overflows to a classifier while the concentrate drippings are washed down the launders provided with water sprays to 2″ rubber-lined pumps (two or three tables per pump) whence they are delivered to a common sump. This is illustrated in Fig. 4 where it will be observed that the table concentrate, after classification in a 24″ cyclone, enters a re-grinding circuit which includes a re-concentrating plane table operating at a specific gravity of 1·82. The concentrate drippings (8 to 10 tons per day) are pumped from this table to the recovery house, the recovery house tailing being returned to the re-grinding circuit.

CONCLUSIONS

Mr A. Clemes has listed the points to be considered in investigating concentrating devices.[2] It is submitted that the plane table answers to these requirements :—

(a) Capital cost. The plane table can be constructed in mine workshops at a very low cost.

(b) Maintenance cost. Wear is negligible, the only real attention required being the fixing of the rubber riffled mats to their base.

(c) Security. There is no handling of concentrate and the final re-concentrating plane table can be completely enclosed.

(d) Saving in labour. No labour is required, other than the mill shiftsman's attention.

(e) Applicability to existing plants. As in the case of Rand Leases, it should not be difficult to fit the plane table into existing plants, even into all-cyanidation plants.

(f) Control of moisture. This has not presented any new problem, in spite of the daily variations brought about by the frequent fluctuations in milling rate, due to power shortages.

(g) Efficiency. For the period of operation of corduroy cloths in the secondary circuit only, the gold recovered by concentration was 38·02 per cent of the total recovery. For the last four months of 1953, the corresponding figure was 43·75 per cent.

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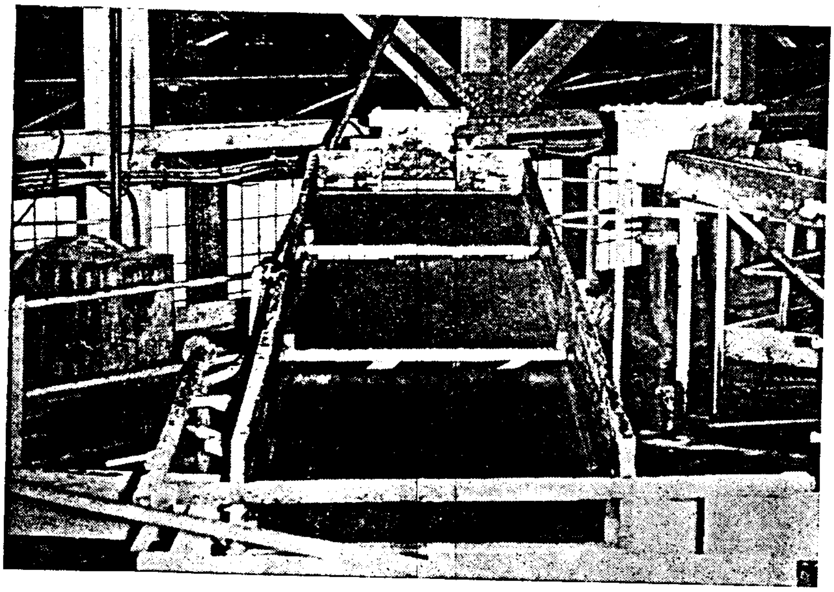
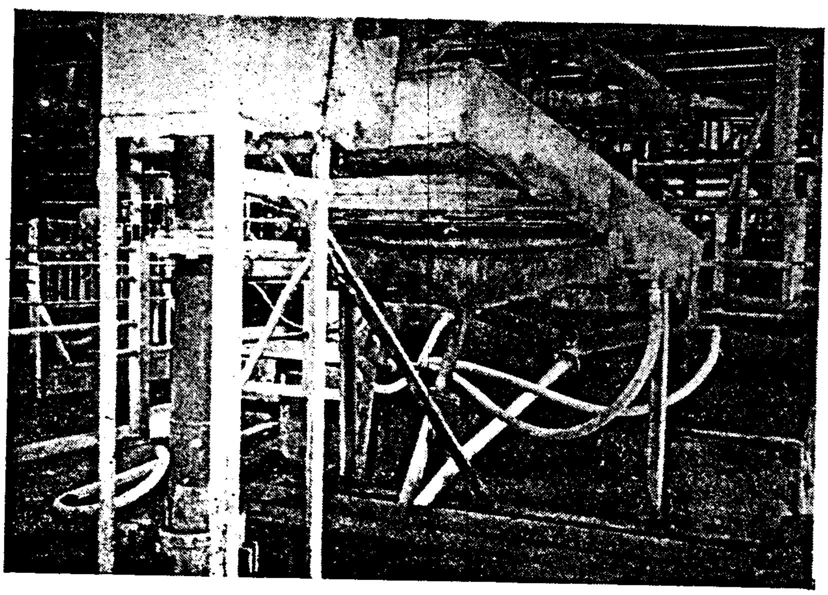
2. A. Clemes. Contribution to discussion on 'Gold concentration at the amalgamated banket areas reduction plant,' by G. Chad. Norris. *Journal Chemical, Metallurgical, Mining Society of South Africa* (January 1950), page 163.



An experimental three-deck plane table



Underside of a double-deck plane table