much methane at a depth of 7,000 feet. He could not find CO, but as this was of great importance, Dr. Moir kindly tested the sample and confirmed the absence of CO.

This seemed contradictory to the test in the previous sample quoted in the paper, in which CO was said to be present. He did not know where this gas was analysed; perhaps Mr. Cooper could tell them as he (the speaker) was in England at that time.

Mr. H. A. White said he would just like to know if Mr. Cooper was responsible! There was carbonmonoxide in the first sample.

Mr. R. A. Cooper replied that this gas was not analysed at the Rand Mines Laboratory and that he had no knowledge of it.

The President: Is this gas still being given off?

Mr. C. J. Gray: I understand it is still giving off. It is bubbling up with the water, but considerably more slowly than it was at first. The probability is that more will be struck in that vicinity of the mines. They have got it in two different places.

CONCENTRATION AND SELECTIVE REGRINDING.

By E. H. Johnson.

The literature of the subject of selective regrinding, with a view to the beneficiation of extraction by cyanide, is so complete and authoritative that it would appear almost unnecessary to recapitulate the theoretical grounds for these measures, but there are three published papers that have a special bearing on the subject to which I should wish to draw your special attention. These are, the late Dr. Caldecott's paper in 1905 (I.M.M. Transactions, Vol. XIV.), F. Wartenweiler's paper, "Distribution of Gold in Banket Ore Classified Products" (*Journal of the Chemical, Metallurgical and Mining Society of S.A.*, Vol. XXI., page 217), and Messrs. Graham and Wartenweiler on the "Size of Gold Particles" (*Ibid*, Vol. XXIV., page 285). Dr. Caldecott's paper, written at the time of the local introduction of the tube mill, states the case of the limitations of stamp mill comminution and the benefit anticipated from classification and tube milling, which has since been realised. F. Wartenweiler's paper, written 16 years later, indicates that we have reached somewhat near the limitations of classification and bulk regrinding, and the following quotation from this paper points to the need of selective regrinding. "All the information under 'distribution of gold extraction' and 'extraction on pyritic portion' points to the great importance of grinding the maximum amount of pyrite and gold as fine as possible." Graham and Wartenweiler's paper carried the information a stage further by demonstrating the practicability of grinding the metallic gold, and the time factor required for dissolution of the gold in cyanide solution in the various grades.

Of the practical efforts in this direction, Messrs. Denny's experiment at the New Goch with Frue-Vanners, and Mr. Fred. Hellman's with Wilfley Tables at the East Rand Proprietary Mines, Limited, followed by tube milling of the concentrate, were unsuccessful owing to the running cost of concentration by these mechanical tables neutralising the benefit obtained. The flotation experiments at the Modderfontein Deep suffered from similar economic causes.

The following notes record an effort to overcome the economic difficulties by using a device of simple construction and automatic operation to effect the concentration. This device has been under experimental trials at the East Rand Proprietary Mines since May, 1925.

A suggestion by Mr. Winterton, Mill Manager, Eastern Mill, East Rand Proprietary Mines, of the possibility of effecting a rough concentration internally of a slowly revolving cylinder, led me to design the machine (Fig. 1) with which the experiments have been carried out. It consists of a cylinder, 12 feet long by 3 feet diameter, lined internally with a specially made corrugated rubber. An externally supported stationary launder passes through the cylinder and serves to collect the concentrate which is washed off the rubber by a spray pipe over the launder. The corrugations of the rubber are set at an angle, being higher, in the direction of the rotation, at the discharge end than at the feed end of the cylinder. The cylinder is set at an inclination of 6% and revolves 7 revolutions per minute. Approximately one-half H.P. is required for its operation. The action

during revolution is that of continuously passing a corrugated belt beneath the pulp stream. The riffles serve, not only to provide the necessary impediment to cause settlement of the heavy constituents of the pulp, but also to carry the concentrate out of the stream adhering to the corrugations until met by the spray of water over the launder where it is washed off. A side spray on the rising side serves to govern the cleanliness of the concentrate.

The experiments have been carried out in three stages :—

(1) Testing out a single unit, taking proportions of the effluent of one tube mill to determine capacity.

(2) Installation of one concentrator per tube mill and isolating one tube mill for regrinding, using the ordinary pebble load as grinding medium.

(3) Erection of 5′ x 22′ ball mill, using an iron grinding medium.

Summarizing the results of Stage 1. of the experiment, the results obtained with one concentrator were as follows :—

Tons Fed Per 24 Hours.	Concentrate % of original feed (by weight).
220	4.01

Ratio liquid to solid in feed.	% Extraction on head value.	
	Gold.	FeS_2.
.84 to 1	58.14	51.39

Stage 2 gave the opportunity of testing the device under working conditions over a period of 9 months. This was useful in providing experience, but the only modification of the machine found desirable was the flattening of the angle of the currugations from 30° to 15°. The necessity of obtaining clean water for the spray-pipes became very evident, and the steadyhead was converted into a crude leaf-filter, using cocoa-nut matting as filtering medium to remove the candle grease and fibrous matter so prevalent in mill circuit water. The continuous effectiveness and operation of the spray water service is essential to prevent concentrate being carried past the collecting launder and

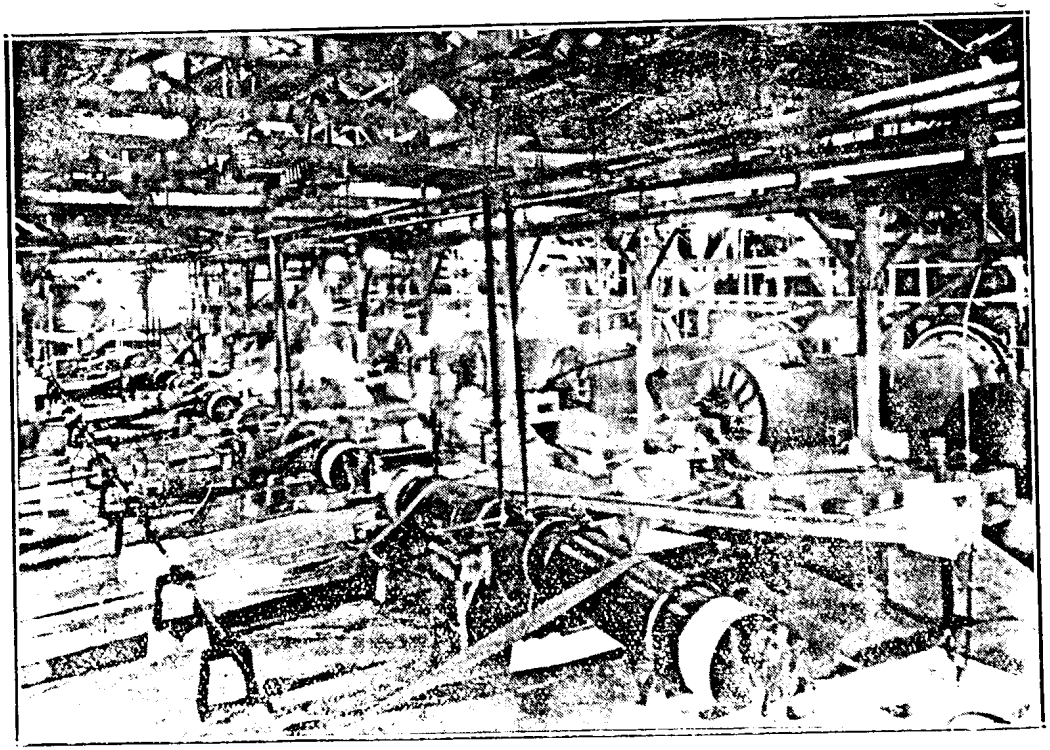

Fig. III.—General layout of Concentrators in the Tubemill House, showing air-lifts which convey the concentrates to the regrinding plant.

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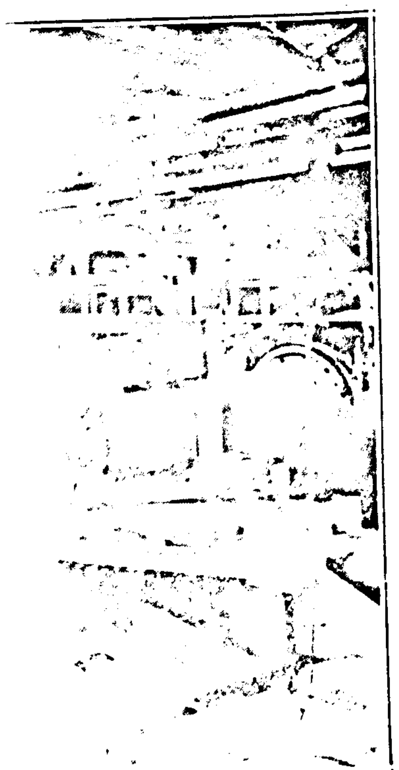

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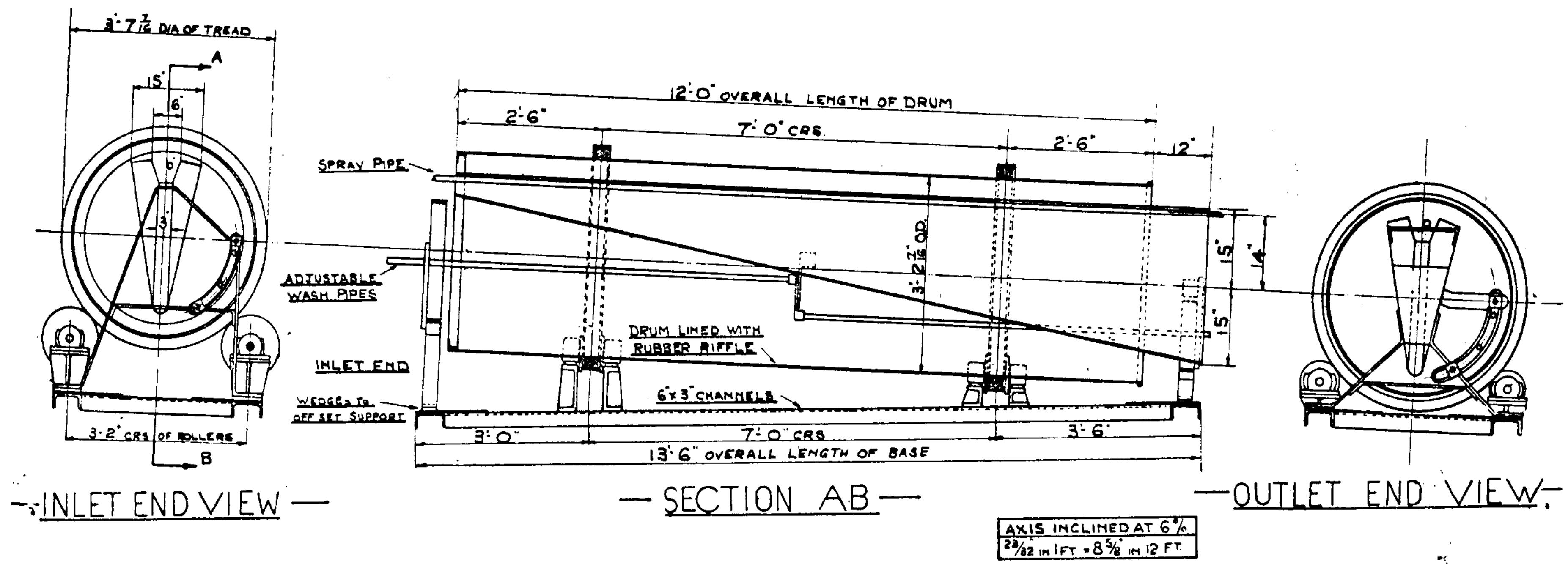

FIG. I.—THE NEW CONCENTRATOR.

again entering the pulp stream. The results obtained during this period are given later.

Stage 3 commenced with the installation of the regrinding ball mill and Fig. II. gives the flow sheet as at present existing. It also tabulates the results obtained at the different stages of concentration and regrinding. It will be noted there are two continuous circuits in which "A" is the primary tube mill circuit from which the concentrate "B" is withdrawn passing over four Corduroy Tables on its route to "C", the regrinding circuit. The ball mill effluent also passes over two Corduroy Tables, the combined product of the six tables yielding approximately one ton of concentrate for barrel amalgamation. The combined tailings pass into the regrinding closed circuit, the overflow of ball mill cone rejoining the main pulp stream from the tube mill and passing to the cyanide plant.

It will be noted that the grading of the ball mill cone overflow is somewhat coarser than the ball mill effluent. This is due to a large proportion of the lighter silica in the primary concentrate being separated at the cone and not entering the grinding circuit.

In regard to the retention of the 6 Corduroy Tables in the circuit, these are needed to reduce the bulk concentrate to the small quantity consistent with amalgam room practice. Where amalgamation is not practised, as in some of the more modern plants, these tables would be omitted with consequent simplification of the circuit. I might mention, in passing, that experiments are at present being carried out to eliminate the corduroy and substitute a redressing apparatus of simple manipulation. I hope to refer to this at a later date.

In tabulating the results obtained, I have shown, for comparison, the results obtained on the same plant for the year 1925, prior to the introduction of the concentrator. The 1925 residues were the lowest previously recorded from this plant.

	Average Monthly Tonnage.	Screen Value Dwts.	Sand Residue Dwts.	Sand Residue Pence.	Total Residue Dwts.	Total Residue Pence.
1925	72,700	4.934	.442	22.1	.262	13.1
		With concentration and pebble regrinding. Stage II. of experiment.				
1926	72,900	5.348	.370	18.5	.233	11.65
		Stage III. Concentration and iron regrinding.				
1927 Jan.	74,500	4.974	.300	15.0	.185	9.25
Feb.	69,700	4.594	.289	14.45	.181	9.05
Mar.	75,300	5.273	.283	14.15	.177	8.85

There has been a slight decrease in slime residue during the latter period, but other causes have also entered into this, so it is preferable to judge of the effects of the concentration and regrinding on sand residue only. The sand constitutes 44% and the slime 56% of the total pulp.

Based on sand residue reduction in value, taking the March results as compared with 1925, there is a decrease of practically 8d. per ton.

The cost of concentration and regrinding has worked out at :—

	£	s.	d.
Water pumping and air power (Pohle lifts) ..	54	15	0
Regrinding (including power, iron balls, liners and maintenance)	305	18	0
Concentrator maintenance ..	6	17	6
	£367	10	6

From this amount the saving in native labour and corduroy should be deducted, viz.: £73 15s. 0d., leaving the nett cost over corduroy at £293 19s. 6d., or 0.940 pence per ton milled on a basis of 75,000 tons per month (the average milling). The nett saving, therefore, is 2.58 pence per ton—say, 2½d. per ton, or £780 per month.

It may be noted that whereas in the initial experiment (Stage 1) the tonnage capacity of the concentrator was estimated at 220 tons, the installation only provided for one concentrator per tube, although the daily effluent of each tube mill is 310 to 320 tons. It was considered that, for the experimental stage this would be sufficient to demonstrate whether benefit was to be obtained. An opportunity occurred later, owing to a tube mill being under repair for a few days, to make a short experiment on reduced feed by dividing the effluent of one tube mill through two concentrators. The results gave an extraction of 59% gold and 45% FeS_2 by the concentrator. The concentrate produced was also cleaner, containing 52 dwts. gold and 23% FeS_2 compared with 31.74 dwts. and 12.11% FeS_2 as shewn in the flow sheet (Fig. II.) from 310 tons per tube. For a higher grade proposition than the East Rand Proprietary Mines provision of two concentrators per tube mill would be desirable.

A brief experiment was recently carried out to determine to what extent the bulk concentrate could be reconcentrated by passing the product of the ten machines through one machine of the same construction. From 196 tons primary concentrate 22 tons secondary concentrate was obtained, containing 224 dwts. and 41.84% FeS_2 per ton. The purpose of the experiment was to determine how far corduroy practice could be imitated in retaining the free gold and eliminating the pyrite. The result shewed an extraction of 80 % of the gold and 40 % of the pyrite. The 22 tons, however, was far too large a bulk for amalgam room practice.

The photograph (Fig. III.) shows the general lay-out, and the method of conveying continuously by a series of short air-lifts to the regrinding plant. The photograph

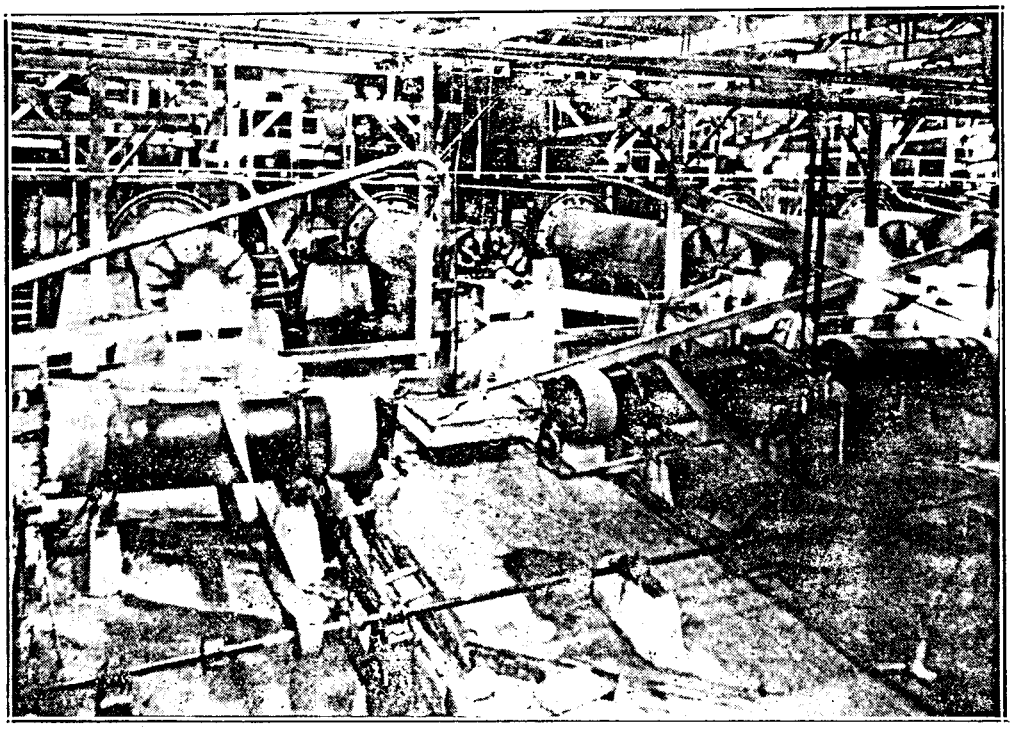

Fig. IV.—Close-up view of two Concentrators.

Fig. II.) from 310 tons per
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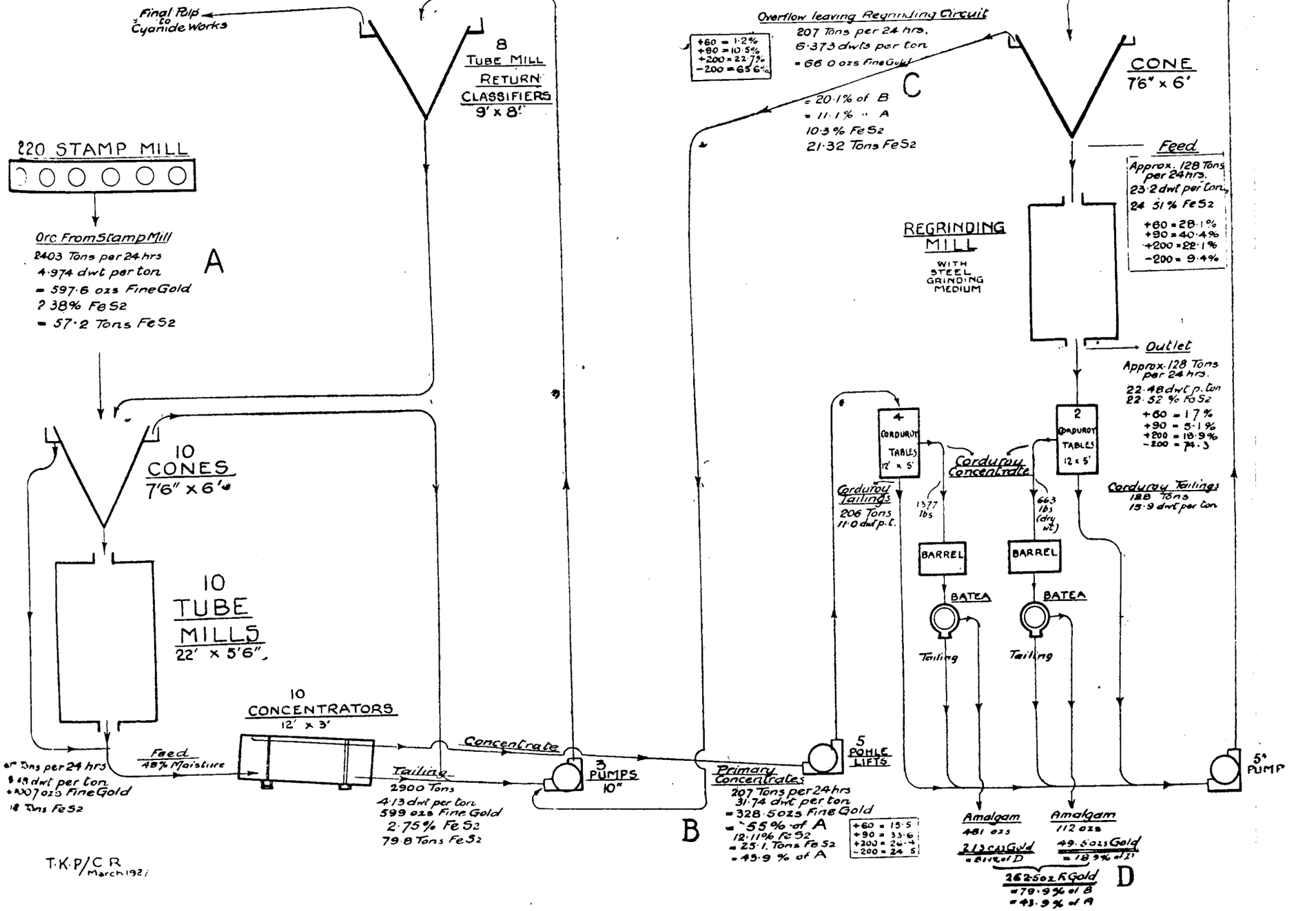

Fig. II.—CONCENTRATOR FLOW SHEET

Cason Mill, E.R.P.M., January, 1927.—Data given refer to a period of 24 hours.

(Fig. IV.) gives a closer view of two concentrators.

In conclusion, I have to thank the Chairman, Mr. Raleigh, and Mr. A. H. Krynauw, Manager of the East Rand Proprietary Mines, Limited, for permission to publish these notes and more particularly for their great encouragement during the progress of the experiments. I am also greatly indebted to Mr. K. L. Graham, Consulting Metallurgist, for much valuable assistance and advice. To Mr. T. K. Prentice for collecting the data and preparing the flow sheet, also to Messrs. Winterton, Elder, and Reynolds, of the Cason Mill Staff, for their practical work and interest I wish to express my keen appreciation.

Mr. J. M. Dixon : The Society will, I am sure, be pleased to accord Mr. Johnson a hearty welcome in again entering into active membership, and to vote him a generous vote of thanks for the very interesting paper he has given us.

For many years now we have had the problem of economically separating for selective regrinding and treatment the pyritic content of the ore, and Mr. Johnson is to be congratulated on the able manner in which he has followed this up. The machine which he has described to-night is simplicity itself and is a very definite advance on the way to lowering very materially sand residues.

In recent years a great advance has been made in slime treatment, and it is certainly a matter of congratulation to learn that at reasonable cost fairly substantial reductions can be made in the sand residue.

The results indicated by Mr. Johnson come at a very opportune moment, as there are a number of old more or less low grade mines operating on old-fashioned plants, and a substantial saving, as is indicated, of £700 per month, is a most important one.

Mr. Johnson has based his figures on sand alone, but I think it must follow that there should be some effect on the slime residue too.

It was generally realised when corduroy was introduced, crude as it is, that some mechanical device would soon take its place, and any machine which assists in the elimination of, or reduction in the number of, tables in a plant will be welcomed.

It would be interesting to know if Mr. Johnson has done any work on the selective cyaniding of the concentrate, as it seems to me that once this has been separated from the ore, the logical sequence would be to give it selective treatment right through.

In an investigation of sand residue lately, it was found that in about 3 per cent. concentration a product containing from 12 to 20 dwt. was obtained ; this, on being reground to —200 and re-cyanided yielded some 90% of its value, but the time taken on ordinary sand treatment lines was excessive and it may be that this material requires air agitation to recover the maximum economically.

Mr. H. A. White had very much pleasure in seconding the vote of thanks to Mr. Johnson, for more than one reason. For one thing, he echoed Mr. Dixon's sentiments in welcoming Mr. Johnson back to their ranks of active contributors. Another thing ; he was glad to be able to give an example of the fact that, in the scientific world, a prophet was not without honour amongst his own kin. He had greater reason for stating that, because, in a recent speech by one of the leaders of the Mining Industry, reviewing the metallurgical practice in the last year and the progress that had been made, the curious thing was there was no mention whatsoever made of that success of Mr. Johnson's. It seemed that the metallurgist was certainly not without honour save on his own mine and amongst those of his own group. There was no doubt whatsoever, he thought, in the minds of them all that the paper just read recorded a real success and a real improvement in metallurgical practice. The practical success that had been gained had been one of very great importance, especially to the mine on which Mr. Johnson was carrying out the experiments ; and the success was not only metallurgical, it was financial. Therefore, as a description of a successful process, nothing could be said against that paper in any way whatsoever. All they could do was to echo the encomiums of Mr. Dixon, and state that undoubtedly they were satisfied that a financial success had been achieved. Besides that practical aspect—man did not live by bread alone—there was the theoretical aspect to be considered. He did not think that Mr. Johnson had, by any means, made it clear that his contribution—on the side, he might say, of that school amongst them which had rather advocated closer concentration, as against the other school which

went in for the whole hog of finer grinding—had demonstrated the fact, if it be a fact, that his method of concentration and separate grinding of the concentrate was better, financially or practically, than the method which was now being adopted, say, on the Far East Rand of wholesale fine grinding. For instance, at the West Springs, Modder East, and elsewhere they practised the so-called all-sliming method: but, of course, the percentage of —200 being made was well below 80%; and, he thought, the general consensus of opinion would be that unless one had a percentage of 90% of —200, all-sliming was rather a misnomer.

The point was, with the plants that they were using on the Far East Rand, especially, for example, with the more modern classification apparatus that they now employed, they did a certain amount of preferential grinding of the pyrite, simply incidental to that method; he meant, they could not separate and classify by water without giving preference to the pyrite, as well as to the coarser particles. Therefore, it naturally re-entered the circuit and did not leave until finely comminuted. Was it necessary to go beyond that? That was a point Mr. Johnson might reply to. What percentage of minus 200 was he getting before he introduced that concentrating appliance? By means of it he added 3% or 4% of minus 200. What percentage was he now getting? If he had adopted the modern classification methods, would he have got that extra percentage of minus 200, followed by the lower residue, at a higher or lower cost? Curiously enough, Mr. Johnson spoke of his machine as a concentrator, and, in the flow-sheet of the West Rand Consolidated Mines, which had recently been published, it was called Mr. Johnson's *Classifier*. Perhaps Mr. Johnson was in between the two schools, and all he was after was the best way of increasing profit. Whichever theory was right, he had much pleasure in seconding the vote of thanks to Mr. Johnson.

The President said the paper was now open for discussion. It was one of very great interest to many of their members, and he he trusted it would receive the adequate discussion it deserved.

IRON AND STEEL IN SOUTH AFRICA.

INFORMAL DISCUSSION.

Professor G. H. Stanley: In connection with this discussion a brief statement of the position in India will no doubt be of interest; extracted, I may say, from the "Metal Industry" of March 25th last.

There are four concerns manufacturing pig-iron, and in 1926 the aggregate output was 902,000 tons.

The Tata Iron and Steel Company produces two-thirds of the pig-iron and nearly all the steel, and it is situated about 155 miles west of Calcutta.

The coal field from which the coal is drawn is about 115 miles north of the works but the coking is done at the works. Sources of ore supplies are nearer at hand, being situated from 50 to 80 miles away. Dolomite and limestone are obtained about 115 miles away.

The major part of the output—522,000 tons in 1926—is converted into steel, partly by seven basic open-hearth furnaces of up to 70 tons capacity, and partly by a duplex process combining the use of acid converters with final refining in 200 ton basic tilting open-hearth furnaces.

The output consists of rails, fish-plates, steel sleepers, beams, channels, angles, tees, bars, plates, tin bars, black sheets and galvanised sheets.

The Indian Iron and Steel Company has two blast furnaces situated about 140 miles north-west of Calcutta and capable of making 400 and 600 tons per day respectively. None of this output is converted to steel and the bulk is exported.

This works is situated on a coalfield and makes its own coke from purchased coal. Ore and limestone appear to be drawn from some of the sources supplying the Tata works, and about 160 miles distant.

The Bengal Iron Company has its works about 10 miles distant from those of the previous Company mentioned, being similarly situated on a coalfield and producing its own coke.

Ore is brought from about 150 miles away.

It has five blast furnaces and makes only foundry iron. The capacity of the works is 200,000 tons per year, but in 1926, owing to market conditions, the output was only 20,000 tons of pig-iron and 71,000 tons of castings.

The Mysore Iron Works has been established since the war and is operated by the Mysore Government.

There are large forests, but no coal, in Mysore, and consequently the plant consists of one charcoal blast furnace of 60 tons daily