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The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

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Proceedings AT Ordinary General Meeting, April 22, 1911.

The Ordinary General Meeting of the Society was held in the Lecture Theatre of the South African School of Mines, on Saturday evening, April 22nd, Dr. James Moir (President) in the chair. There were also present :—

58 Members: Messrs. W. R. Dowling, R. Allen, Tom Johnson, E. J. Laschinger, O. P. Powell, A. Whitby, H. A. White, J. A. Wilkinson, James Littlejohn, A. F. Crosse, W. A. Caldecott, A. McA. Johnston (Members of Council), A. J. R. Atkin, J. W. S. Beatty, J. H. Brown, J. Chilton, F. W. Cindel, W. M. Coulter, W. J. Creasey, T. D. Delprat, E. A. Furner, H. Goodwin, James Gray, Noel Griffin, B. C. Gullachsen, J. H. Harris, G. G. Hewitt, A. B. Inglis, G. A. Lawson, Henry Lea, J. Lea, A. Lilley, L. Marks, T. G. Martyn, G. Melvill, C. E. Meyer, S. Newton, H. W. Pidsley, J. F. Pyles, Alex. Purser, W. Russell, G. A. Robertson, R. W. Robinson, O. D. Ross, A. Salkinson, C. O. Schmitt, A. Schwarz, A. M. Sim, G. Hildick Smith, A. L. Spoor, C. T. Stephens, J. A. Taylor, A. Thomas, G. R. Thompson, F. W. Watson, John Watson and C. F. Webb.

16 Associates and Students: Dr. J. L. Aymard, Messrs. E. A. Barry, J. P. Beardwood, H. G. Brickhill, C. A. Damant, F. E. Doble, H. J. Filmer, A. King, G. F. Mathews, R. A. Porter, A. G. Rusden, H. Rusden, H. Stadler, E. H. Tamplin, A. M. Thomas, and S. A. Woolf.

15 Visitors, and Fred. Rowland, Secretary.

The minutes of the previous monthly meeting, as printed in the March *Journal*, were confirmed.

Messrs. H. Rusden and R. Allen were appointed scrutineers, and after their scrutiny of the ballot papers, the President announced that all the candidates for membership had been unanimously elected, as follows :—

BELL, KENNETH SOMERSET, P. O. Box 4284, Johannesburg. Mechanical Engineer.

CLESHAM, THOMAS HENRY, Simmer East, Ltd., P. O. Box 47, Germiston. Sampler.

DAMANT, DOUGLAS EDWARD, Aurora West United G. M. Co., Ltd., P. O. Box 26, Maraisburg. Mill Manager.

GIVEN, RALPH DAVID, Messrs. H. Eckstein & Co., P. O. Box 149, Johannesburg. Engineer.

KRATZ, ARTHUR MURRAY, Messrs. H. Eckstein & Co., P. O. Box 149, Johannesburg. Foreman Draughtsman.

MORROW, GEORGE WILLIAM OFFORD, South Randfontein Deep, Ltd , P. O. Box 45, Randfontein. Foreman Timberman.

PETERSON, CHARLES, Messrs. H. Eckstein & Co., P. O. Box 149, Johannesburg. Electrical Engineer.

TESTER, WILLIAM ANDREWS, Messrs. H. Eckstein & Co., P. O. Box 149, Johannesburg. Engineer.

TOM, ISIDORE, Messrs Lewis & Marks P. O. Box 1033, Johannesburg. Mining Engineer. (*Transfer from Associate Roll.*)

WEBB, WILLIAM MORTON, Princess Estate and G. M. Co., Ltd., P. O. Box 112, Roodepoort. Mine Manager.

The Secretary: Since the last meeting of the Society the following have been admitted by the Council:—

As Associates.—

PURSER, ALEXANDER, East Rand Proprietary Mines, Ltd., P. O. Box 67, East Rand. Fitter.

RUSSELL, WILLIAM, 13, Park Circus, Ayr, Scotland (*temporary address,* Rand Club, Johannesburg.

WEEKS, ROBERT FOSTER JEFFREY, Champion Reef G. M. Co., Ltd., Mysore State, S. India. Chief Reduction Officer.

As Student.—

WOOLF, SAMUEL ADOLF, 100, Van Beek Street, Doornfontein, Johannesburg. Student, S.A. School of Mines.

The President then distributed the book prizes presented by the Society to the successful evening class students at the recent examinations conducted by the S.A School of Mines, as follows: Chemistry, Stage I., Theoretical, £1 10s., S. Stein; Practical, £1 10s., J. P. Beardwood; Stage II., Practical, £3, W. E. John. Metallurgy, Stage II. (Gold), £3, W. A. Martin. Assaying, Stage I., £1 10s., J. Ingram. No awards were made for Chemistry, Stage II. (Theoretical); Metallurgy, Stage I.; Assaying, Stage II.; and Metallography.

THE ASSAY OF USED PLUMBAGO CRUCIBLES FOR GOLD.

By JOHN WATSON, F.I.C (Member).

This matter was brought before our Society, in the pre-war days, when Mr. Andrew F. Crosse one of our earliest presidents, read a paper entitled :—"Notes on Assaying Ground Graphite Crucibles." The subject was discussed at the meeting in September 1897, and in the following month, when Mr. Crosse replied to his critics. Curiously, since the war, this matter has not again been brought forward.

Plumbago crucibles are still in general use for melting the gold before pouring into moulds; though the larger number formerly used in the reverberatory furnaces in cyanide works for smelting zinc-gold slimes have been displaced largely by the almost general adoption of the Tavener, or pan furnace, and the cupelling furnace.

The Phœnix of old was said to rise again from her own ashes, and some of us who are engaged in mine assay work are still called upon at odd intervals to assay this material which, after grinding and mixing with old cupels, "mabor" or cement, is now used as a bed, underneath the fire-brick lining of the Tavener pan furnace.

I suppose, of all the assays which the assayer on a mine is called upon to make, this material is one of the most tricky and ticklish to value with accuracy. It might be thought from the silence which has reigned during the eight or nine years of peace, that we have reached finality in this matter, and that we assayers all rest satisfied with the method of our esteemed Past-President, that in fact the last word had been said on this subject.

It recently fell to my lot to have to assay a parcel of some 2·2 tons of ground bricks from the bed of a Tavener furnace, containing a large proportion of old ground plumbago crucibles. A fair sample had been taken at the reduction works, buyer's and seller's representatives being present. This sample was properly mixed, pulverised to – 60 mesh, and divided into three portions. I used Mr. Crosse's method, working on four assay portions of ·30 assay ton each. I did *not* rely on the assurance that the lead buttons contain all the gold. Perhaps, because I am naturally somewhat sceptical, I kept the slag in each case, had it pulverised and assayed, and found quite a large proportion of the gold in the slag.

In the first portion about one-third of the gold found was in the slag; in the second portion, more than two-thirds; in the third portion, about one-third; and in the fourth portion, about two-fifths of the total gold found was in the slag.

The results of this parcel reported were as follows :—Fine gold per ton :

Seller.	Buyer.	Umpire No. 1.	Umpire No. 2.
107·38 oz.	127·2	85·85	130·00 oz. troy.

The contents were paid for on the mean between the assays of umpires No. 1. and 2, *i.e.*, 107·92 oz.

The fine gold in this material is paid for at the rate of £3 17s. per oz. troy, therefore, it is highly important that we should have accurate assays.

Mr. Crosse, I hope, will not think me unduly critical of the method he described; on the contrary, when I had to assay this material, I felt thankful to have his paper at hand as something tangible to work upon.

Having now got a sample checked by two experts on this material—I mean the assayer of the buyer and umpire No. 2—I felt myself in possession of a valuable asset. This is a case where most of you will agree, I think, that the higher assays are the more likely to be correct. Experiments were tried using potassium nitrate and chlorate, respectively, as oxidising agents, but these gave too low a result, especially the latter. Out of fairness to Mr. Crosse's method, I tried two more portions, using a smaller proportion of manganese dioxide; as his paper referred to ground graphite crucibles, not a mixture of that material with its own bulk of old cupels. These two portions, however, gave results, again, much too low from the buttons, and I did not try the slag from these.

Composition of Plumbago Crucibles—That veteran text book, *Mitchell's Manual of Practical Assaying*, edited by Sir Wm. Crookes (6th Edition, 1888) says :—"Black-lead crucibles are generally composed of 1 part of refractory clay, and from 2 to 3 of black-lead." Never having seen a published analysis of plumbago pots, I took a piece cut out of a No. 40 Salamander plumbago crucible of a well-known brand. This was pulverised to – 60 mesh and analysed. Its composition in the dry state I found to be :—

Carbon	42·95
Silica	34·68
Alumina and Ferric Oxide	18·08
Lime	·32
Magnesia	·48
Alkalies, &c., undetermined } by difference	3·48
	100·00

It is the carbon in this material which forms the bugbear of the assayer, and I would recommend :—

Proc. Chem. and Met. Soc. of S.A., Vol. II., p. 123., *et seq.*

(*a*) To work on small portions of the sample. say ·10 assay ton, in the case of a rich sample like this.

(*b*) To carry out the roasting operation with manganese dioxide in a roasting dish, the mixture being spread out in a shallow layer and roasted at a bright red temperature in the oxidising atmosphere of a muffle furnace for at least half an-hour.

(*c*) To add enough reducer to bring down a fairly large lead, say 35gm. to 40gm. in weight, and, in all cases, to keep the slag, have it pulverised to − 60 mesh and assay for gold.

The following method will be found, I think, to give reliable results when properly carried out: Place ·10 A.T. of the sample, with ·20 A.T. manganese dioxide, in a Wedgwood mortar and mix thoroughly, transfer to a 4 in. roasting dish, brushing clean the pestle and mortar, roast in muffle furnace at a bright red temperature for at least half an-hour, then withdraw and allow to cool. Scrape out the roasting dish with a small spatula, the contents being pulverised in a Wedgwood mortar, add 2 A.T. by measure of flux as used for daily routine samples; add also 1 A.T. pulverised potassium carbonate, 1 A.T. silica pulverised, and 4 gm. mealie meal or flour. Grind the whole together in a Wedgwood mortar to thoroughly mix, transfer to paper bags and add silver (according to richness of sample). Introduce into red-hot H or J pots, heating for about 20 minutes, till fusion is complete, then withdraw the pots, tap gently, allow to cool in pots, when they can be broken. Cupel the leads, keep the slags and re-flux. Working on ·10 A.T. the ·01 gm. rider will give ounces to the ton direct.

Herewith I give comparative results:—By older method, as described in *Journal*, 1897:—

From	I.	II.	III.	IV.	oz. troy
Button,	50·7 oz.	35·7	73·0	60·8	fine gold
Slag,	51 0	73·7	36·7	48·0	per ton.
Total,	101 7	109·4	109·7	108·8	

Average 107·40

By newer, modified method:—

From	I.	II.	III.	IV.	oz. troy
	Oz. troy				fine gold
Button,	126·00	128·20	130·00	126·20	per ton.
Slag,	·20	·90	·25	·40	
Total,	126·20	129·10	130·25	126·60	

Average 128·04

My thanks are due to Mr. C. Glyn, General Manager of the City and Suburban Mine, for permission to publish these results.

That great master of science and lucid English, the late Prof. Huxley, used to say that free and open discussion is the very life and soul of truth; this Society has generally acted up to that admirable maxim. We have on the Rand several assayers who have had special experience in valuing the products I have brought to your notice this evening. I hope they will come forward and give us their best method. What we mine assayers want is a method which will give accurate results in the shortest possible time. I take it, that one of the chief advantages of belonging to a scientific society is, that there exists, or *should exist*, a feeling of freemasonry among its members. In these matters it would be well to emulate the spirit indicated by the late W. K. Clifford, when he said: "Let us take hand and help, for this day we are alive together."

Mr. Andrew F. Crosse (*Past President*): In proposing a vote of thanks to the author for his paper, I would like to say that as my name has been mentioned several times by him I would mention that I altered my opinion as to my then proposed method. This fact is stated on p. 207 in the 2nd Volume of our Proceedings. The analysis of the plumbago crucible is interesting, though I expect the Morgan Crucible Co. will be interested to learn that the alkalies, etc., amount to 3·48% by difference. I would advise that the publication Committee delete this statement, of course with the author's consent. The rest of the analysis might remain.

I quite appreciate the author's remarks about free discussion, and those here to-night who have been members for many years will allow that I for one have always given way when I have been proved to be in the wrong.

As regards rich bye-products, the highest assay is not necessarily the correct one. If ten assays are made each may be correct on the given sample, though none may agree.

Mr. J. Watson (*Member*): With reference to Mr. Crosse's remark that the figure given for alkalies is too high, I must mention that the sample piece analysed had been cut out of an *old* pot, which had been used for smelting several times with borax, soda carbonate and possibly nitre as flux.

Mr. A. Whitby (*Member of Council*): Having been furnished by the courtesy of the author with an advance-proof of his paper, I think I may be entitled thus early to offer a few remarks.

The author appears to be unfortunate in his choice of title. It is not plumbago crucibles he is assaying, but Tavener furnace bottoms, mixed according to the author with graphite crucibles. Even were he correct in this respect, he still has no justification for assuming that the assayer of 1911 rests satisfied with Mr. Crosse's method of 1897. The chief points to be observed in reading this paper seem to me to be:

1. That the author has only dealt with one sample.

2. That it was probably incorrectly labelled.
3. That he makes no mention of metallics.
4. That the sample only passed the 60 linear sieve.
5. That the analysis published of Salamander crucible is beside the question.
6. That the use of MnO_2 in roasting has no justification and that with such a small quantity as ·1 A.T. direct fusion with red lead is more satisfactory using a little Na_2CO_3 and borax.

It would be manifestly unfair to the assayer to submit a sample of such complex nature without precise information as to its derivation since an analysis is not paid for. Why the author uses such an enormous excess of flux, 2 A.T. of the daily routine flux (whatever that may be) 1 A.T. of K_2CO_3 and 1 A.T. of SiO_2 in order to melt down 0·1 A.T. charges or at most 0·2 A.T. is beyond comprehension.

Setting aside any question of imperfect sampling, I think that had the various assayers concerned being supplied with correct data there would have been no necessity for this paper, and certainly I can see no reason for such unwieldy treatment, always preferring to flux direct when ·1 to ·2 A.T. charges require to be taken.

I may remark that plumbago pots themselves when properly scraped usually do not assay more than 4 oz. and present no difficulty in roasting. When not freed from adhering slag I admit they are troublesome and cannot be roasted with or without MnO_2. Personally I should not use MnO_2. One is compelled in such a case to the use of small charges and direct fusion. I would like here to make a suggestion which I fancy is novel. Expense being hardly the main point it would almost seem that there is a field in such products as plumbago pots or even rich concentrates for the use of the puce-coloured oxide of lead PbO_2 instead of the other oxides. We know that even with such a slight relative preponderance of oxygen, red lead possesses a distinct advantage over litharge, therefore why not use the dioxide in cases where the ore has reducer in excess.

One further remark I must make. No assayer having such rich material to work upon would be correct in neglecting his slags.

Mr. J. Watson: In reply to Mr. Whitby's remark that he considers the choice of the title of this paper unfortunate, I have often assayed other samples from Tavener furnaces and have agreed all right with the reduction works assayer, except when the product contains these old plumbago crucibles. It is then only that I have found differences in our results to occur. Mr. Whitby suggests that the sample was wrongly labelled. I personally was not responsible for the marking of the samples. As a matter of fact this particular sample was marked: "Brick, Lot 2." I asked our Mine Secretary to inform both the umpires, when the sample was sent, that it contained a considerable proportion of old plumbago crucibles, and he assures me that he did so, in both cases.

Mr. A. Whitby (contributed): It appears from Mr. Watson's own showing that the material could not have contained, being constituted, say, of 50% brick and 50% pot carrying 47% graphite, more than, say, ·75 gm. to 1 gm. of carbon giving a 25 gm. button at most with litharge. Therefore I must repeat that no roasting was required and there was no necessity for reducing agent or complexity of flux. His error arises from inefficient crushing, imperfect mixing and bad fluxing. The question of mesh is serious. No such material could be obtained through a 90 or 120 mesh sieve without yielding metallics, and practice indicates the use of the fine mesh in all cases where values rise above 50 oz. to the ton.

FUTURE ECONOMIES IN RAND REDUCTION PLANTS.

By C. O. Schmitt (Member.)

Introduction:—It is an acknowleged fact that with the ever increasing depth of the mines on the Witwatersrand, with a consequent increase in the cost of bringing the gold bearing ore to the surface, and accompanied by a steady but insistent decrease in the value of the ore deposits, the profit derivable from the exploitation of the mines at great depths tends to taper off and must disappear entirely when working costs plus capital charges equal the value of the gold recovered.

There is not sufficient information available to give the average screen value of the ore for the Witwatersrand for all depths, but from the published returns of the Chamber of Mines it appears reasonable to estimate it as shewn in Table I:*

At the present day the average value of the gold recovered per ton of ore milled is about 28s.

* It should be clearly understood that the screen value of the ore given in Table I. is not based on any particular section of the Rand nor obtained from any definite mines, being merely the writer's interpretation of the published returns for the whole Rand, which obviously do not make any allowance for a deliberate reduction in grade rendered possible by the low standard of working costs now prevailing. The writer, in order to more clearly show the benefits derivable from the proposed innovations, has naturally taken a low value for the ore derived from great depths which, together with the estimated increase in mining costs, emphasises the importance of reducing working costs on the surface. Apart from this, the value of the ore has no bearing on the subject of these notes.

TABLE I.

Average Depth of Workings.	Screen Value of Ore per ton Milled.	Screen Value of Ore per ton Hoisted assuming that 15% of Waste is Sorted Out.
feet	s. d.	s. d.
1,000	40 0	34 0
2,000	30 0	25 6
3,000	25 0	21 3
4,000	22 6	19 0
5,000	20 0	17 0

and working costs, including development redemption, but not including capital charges on the surface equipment. are about 17s., leaving a gross profit of 11s., of which about 9·9s. is available for distribution, after allowing for the profit tax.

It is impossible to estimate the average depth from which ore is mined at the present day, but from Table I. it would appear that it is in the neighbourhood of 2,400ft. At any rate it is known that while some mines work at a comparatively shallow depth others obtain the ore from below 3,500ft. and even 4,000ft.

If working costs remain at the present standard the end of profitable mining would be reached at or before a vertical depth of 5,000ft., and at the present rate of working the time needed to reach this point can readily be estimated. Whatever this period of time may be, it is evident that in order to lengthen it, it will be necessary to reduce operating costs and capital charges. Unfortunately the capital spent on existing plants can not be affected by any improvements to be made and, if anything, capital charges will be greater in these cases should further capital be required to give effect to necessary improvements. In other words, as far as existing plants are concerned, any benefits derivable from improvements are minimised by additional capital charges, although it will probably be seen that these benefits will more than pay for the increased capital charges. On the other hand new mines, not yet equipped on the surface, will fully share the advantages to be derived from the improvements to be indicated later on.

It will be interesting to recall at this point the position of the mining industry on the Witwatersrand in 1905, as shown by Ross E. Browne* in a paper read before the South African Association of Engineers. He gives the following (p. 290) :—

	s.
Working costs	24·0
Capital redemption ...	5·0
Total expenses	29·0
Yield	35·7
Profit	6·7
Profit tax 10%	0·7
Company's profit	6·0

At this period (September 1905) the mines were working at considerably less depth than at present, yet the profit, if we ignore the capital redemption charge of 5s. was not much greater than to-day as appears below :—

	s.
Yield	35·7
Working costs	24·0
Profit	11·7
Profit tax 10%	1·17
Company's gross profit ...	10·53

Although the yield fell from 35·7s. to 28s. the gross profit only fell from 10·53s. to 9·9s., this favourable result being due entirely to the reduction in working costs.

If the redemption of capital is taken into account the position is at the present day even more favourable. R. E. Browne gives the capital expenditure for the average plant of the Rand Mines Ltd., milling 15,654 tons per month with 131 stamps at £620,132 or £1,127 per ton milled per day, of which £356 was for the reduction plant and £771 for the remainder, including shaft sinking and development prior to starting milling operations.

Omitting the cost of development the capital expenditure was £430,000 or £782 per ton milled per day, of which £356 was for the reduction plant, leaving £426 for the remainder. Assuming that this plant represented the average for the whole Rand at that time (1905) it can be compared with the average at the present day. As a considerable number of mines have started milling since 1905, all of which were able to build the surface plant at less cost, the charge for capital redemption, which Ross E. Browne takes at 5s. can be reduced, and it remains to be seen by how much. The tonnage milled has increased from 1,000,000 tons per month in September 1905 to 1,750,000 tons per month in January 1911, and while the cost of reduction plants was £356 per ton milled per day in 1905, the cost of the additional reduction plants may be taken at £200 per ton milled per day. The total expenditure per ton milled per day would now be £426 and £200 = £686 as against £782

* Ross E. Browne "Working Costs of the Mines of the Witwatersrand," *Journal of the S. A. Association of Engineers*, Vol. XII. p. 289.

and corrected for the increased tonnage an average for the whole Rand, at the present day, of £716.

If a capital expenditure of £782 requires a redemption charge of 5s., £716 requires only 4·5s., and we can now compare the position of to-day with 1905:—

	1905.	1911.
	s.	s.
Yield	35·7	28·0
Working costs	24·0	17·0
Capital redemption ...	5·0	4·5
Total costs	29·0	21·5
Profit	6·7	6·5
Profit tax	·67	·65
Company's profit ...	6·03	5·85

Thus, although the yield per ton fell 7·7s. the profit only fell 0·18s. This result has been obtained chiefly at the expense of mining costs, and it is hardly to be expected that mining costs will be able to keep pace with the reduction in grade due to the lower value of the ore deposits at greater depths, in fact, it can safely be assumed that mining costs will go up rather than decline for many reasons, but chiefly the following:—

(*a*). Increased cost of skilled and unskilled labour.
(*b*), Do. do. explosives.
(*c*). Do. do. ventilation.
(*d*). Do. do. mine drainage,
(*e*). Do. do. hoisting rock to surface.
(*f*). Do. do. underground transport
(*g*). Do. do. power underground.
(*h*). Do. capital charges.

Labour:—The scarcity of native labour used for drilling, etc., tends to raise the cost of same apart from the fact that with the increased depth of the mines, more time is lost in reaching the working face, the latter factor also applying to skilled miners. Further, with increased depth the temperature rises, and labour is liable to become less efficient.

Explosives:—Owing to the increased hardness of the rock to be broken more explosives will be needed and the increased demand together with an increase in the price of the raw materials, particularly glycerine,* tends to raise the cost per unit.

Ventilation:—Outcrop mines and shallow deep levels have not had to provide for artificial ventilation, but the deeper mines are compelled to adopt same in order to maintain the efficiency of the labour force quite apart from general considerations of health and safety. The cost of this item alone is liable to be from 2d. to 3d. per ton hoisted.

* W. Cullen, "The World's Glycerine Supply," this *Journal*, Vol. XI., p. 302.

Mine Drainage:—Although as a rule the cost of mine drainage is not heavy on the Rand the cost must obviously increase with the depth of the workings.

Hoisting Rock to Surface:—The cost of hoisting rock will undoubtedly increase with the depth and at an accelerated rate for several reasons. It is now generally acknowledged that the most economical depth or length of lift for a single stage of hoisting is about 3,500ft., either in the vertical or on the incline, and if we take a mine with vertical shafts 3,000ft. deep, two stages of winding on the incline will be required to reach a depth of 5,000ft. vertical, making in all three stages. Although less power is required for hoisting 3,000ft. on a comparatively flat incline than in a vertical shaft 3,000ft. deep, yet the cost of hoisting per ton will be as great if not greater due to greater wear on skips, ropes and track, apart from the increased cost of power due to duplicate cables, losses in transmission, etc.

Underground Transport:—Shafts will in deep mines be farther apart than is now the case, due to the great cost of sinking same, with the result that the distances over which ore must be transported are increased.

Power:—The cost of power must increase, as already pointed out under "Hoisting." This will be most evident in the cost of compressed air, because not only will frictional losses increase due to longer pipe lines, but more air will be required for drilling holes in the harder rock.

Capital Charges:—The expenditure on winding plant, power mains, air mains, water mains, ventilating plant, shaft sinking, naturally increases with the depth of the workings and this in no small degree.

At the present date working costs average 17s. per ton milled, made up as follows:

	s.	d.
Mining costs	8	9
Reduction costs	5	0*
General expenses	1	3*
Development redemption ...	2	0

As already said (page 465) the average depth of the workings is probably 2,400ft., and estimating that mining costs to increase at the rate of 6d. per ton milled for every 1,000 feet increase of depth we obtain the data shewn on Table II. The diagram, Fig. 1, shews this graphically. It is obvious from the table that unless it is possible to reduce working costs and capital charges mining ceases to be profitable at the comparatively shallow depth of 4,000 ft., because redemption of capital alone will swallow up the profit.

* E. J. Way, Trans. Inst. M. & M., Vol. XIX., p. 120.

TABLE II.

Probable Net Profit from Mining Operations at Various Depths.

		1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.
		Shillings.	Shillings.	Shillings.	Shillings.	Shillings.
1.	Average depth of working...					
2.	Mining costs	8·0	8·5	9·0	9·5	10·0
3.	Reduction Costs	5·0	5·0	5·0	5·0	5·0
4.	General expenses ...	1·25	1·25	1·25	1·25	1·25
5.	Development redemption ..	2·0	2·0	2·0	2·0	2·0
6.	Total costs	16·25	16·75	17·25	17·75	18·25
7.	Yield	40·0	30 0	25·0	22·5	20·0
8.	Profit	23·75	13·25	7·75	4·75	1·75
9.	Profit tax 10%	2·375	1·325	·775	·475	·175
10.	Company's profit ...	21·375	11·925	6·975	4·275	1·575

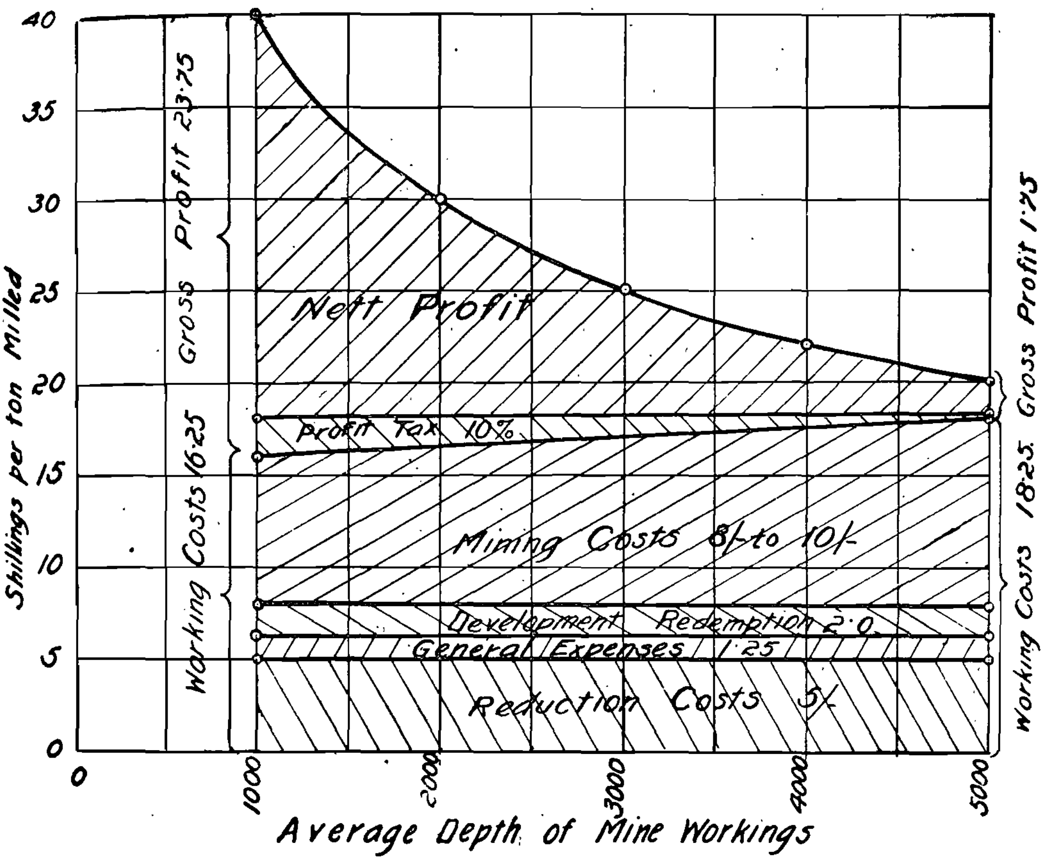


FIG. 1.—Diagram showing Screen Value of Ore, Working Costs, and Profit per Ton Milled when Working with Modified Sorting and Breaking Plant.

It might be pointed out that the assumed increase in mining costs of 6d. per 1,000 ft. is too high, and the writer hopes that this is the case, but in view of the foregoing remarks it seems reasonable to assume that 6d. per 1,000 ft. of depth is not by any means an exaggerated amount. No doubt the tendency towards increase can be counteracted to a certain extent by mining a greater tonnage, but this carries in its wake the danger of mining barren rock, which must be a real temptation to underground workers. However, as the grade would be lowered, nothing would be gained beyond distributing general expenses over a greater tonnage, and a probable loss would result from the increased quantity of waste rock sent to the reduction plant. Under the circumstances, the adoption of what is known as the big mill policy, first put to the test on the Rand by Mr. H. H. Webb on behalf of the Consolidated Gold Fields of South Africa, Ltd., was an obvious step to reduce working costs, and the results have been satisfactory. However, the successful carrying out of this policy requires a very considerable amount of advance development, for, unless the mine is well opened to conveniently supply the mill with the increased tonnage without being tempted to mine barren rock, the object in view is defeated.

At the present day the standard for comparison generally adopted on the Rand is the ton milled, but it has already been pointed out by various writers that this is not well chosen for comparing costs and efficiency of working. In the first place, the tonnage milled by no means expresses the work done underground, because the difference between the tonnage hoisted and milled, representing the waste sorted out, varies considerably in different mines, namely, from the practically nothing to over 30%. It seems fair to assume, always provided the work underground is carried out honestly and with every endeavour to reduce the quantity of barren rock sent to the surface, that the tonnage hoisted forms a much better basis for comparison, and this standard the writer proposes to use in the following investigation.

Seeing that mining costs have a tendency to increase, it will be necessary to counteract this on the surface by reducing operating costs in and capital charges for reduction plants. On p. 465 has been shown that capital expenditure for the reduction plant is a comparatively small portion of the total expenditure. Using again the figures of Ross E. Browne, we have for the average mine of the Rand Mines, Ltd., but leaving out shaft sinking and development, the following :—

Surface Equipment	...	£426 = 55%
Reduction Plant	...	£356 = 45%

It has been estimated that at the present day, for the whole Rand, the proportion would be :—

Surface Equipment	...	£426 = 60%
Reduction Plant	...	£290 = 40%

Assuming these figures as correct, any saving to be effected in the reduction plant would therefore only be a percentage of the 40%, the amount represented by the reduction plant, so that a considerable reduction must take place to materially affect the whole capital expenditure. The position is still worse if we include shaft sinking and advance development.

Referring to working costs, the position is also unfavourable if substantial reductions are to be made, because reduction costs are barely one-third of the total costs, as appears from the following:—

	Shillings.		
Mining Costs	8·75	10·75	11·5 = 68%
Development Redemption ...	2·00		
		·75	
General Charges	1·25	·50	5·5 = 32%
Reduction Costs	5·0		

Therefore, any decrease in reduction costs affect total costs only in the proportion mentioned.

Under the circumstances, the task of substantially reducing working costs and capital charges is by no means an easy one, but in view of the magnitude of the interests involved, worthy of the most serious consideration by all interested in the mining industry.

Considering an investigation of the whole subject as beyond the scope of these notes, the writer proposes to deal primarily with the sorting and breaking plant and the milling or crushing plant, merely indicating economies in other portions of the plant at the hand of data published in current papers.

I.—*Sorting and Breaking Plant.*—The problem of removing the waste or barren rock from the gold bearing ore has agitated the minds of engineers on the Rand for a considerable time, as evidenced by the papers read and discussions which have taken place before local Societies.* It might seem therefore that the subject has been considered from every point of view, making further remarks superfluous. In view of certain developments in the milling or crushing plant in the immediate past, the writer thinks that reconsideration in the light of the altered conditions will pay handsomely for the trouble taken. Members are probably familiar with the now acknowledged fact that the efficiency of the tube mill considerably increases if fed with a comparatively coarse product. Dr. Caldecott† referred to this in detail in the reply to the discussion on his paper on the development of the heavy gravitation stamp, and considerable further light has been thrown on the point by E. H. Johnson‡ in the published results of a most succesaful crushing experiment at the East Rand Proprietary Mines. Seeing that it is pos-

* Robert Dives, Ore Sorting and Sorting Appliances, *Journal of South African Association of Engineers*, Vol. III., p. 138. Wager Bradford, Some Limitations of Ore Sorting, *Journal of South African Association of Engineers*, Vol. IX., p. 61. H. S. Denny, Observations on the Metallurgical Practice of the Witwatersrand, this *Journal*, Vol. IV., p. 116. H. S. Denny, Economic Problems of Metallurgy, Report of S.A.A.A.S., 1904, p. 109. G. A. Denny, Valedictory Address, *Journal of South African Association of Engineers*, Vol. XI., p. 371. W. Calder, *Journal of Transvaal Institute of Mechanical Engineers*, Vol. VII., p. 241. C. O. Schmitt, Sorting, an Economic Problem on the Rand, *Journal of South African Association of Engineers*, Vol. XV., p. 151.

† Trans. Institution of Mining and Metallurgy, Vol. XIX., p. 57.

‡ This *Journal*, Vol. XI., p. 168.

sible to feed the tube mill with anything smaller than $\frac{3}{8}$ in., it occurred to the writer that a convenient place to obtain same was the sorting and breaking plant. The rock brought from below ground contains a considerable amount of fine particles which are not generally eliminated by screening the total rock into a + 2 in. and – 2 in. product. The latter product, however, also contains a good deal of $-\frac{3}{8}$ in., and gradings obtained by the writer from two mines showed following result :—

	Mine A.	Mine B.
$+\frac{3}{8}$ in. ...	58·3%	45·38%
$-\frac{3}{8}$ in. + 90 ..	38·3 } 41·7%	46·92 } 54·62%
– 90 ...	3·4	7·7

In these cases the average of $-\frac{3}{8}$ in. may be taken at 50% of the total – 2 in. product, in spite of the imperfect screening now taking place over stationary grizzlies, and notwithstanding the fact that the rock was not washed. As the – 2 in. product represents from 35% to 50% of the total rock hoisted, the $-\frac{3}{8}$ in. therefore equals from 17·5% to 25% of the total tonnage, the whole of which can be sent directly to the tube mill plant. If coarse breakers are in use, they naturally produce a further percentage of $-\frac{3}{8}$ in., and so will the fine breakers, the total percentage so obtained probably not falling far short of that produced underground by the explosives. G. O. Smart* found in his battery feed not less than 33% of $-\frac{1}{2}$ in., corresponding to probably 28% of $-\frac{3}{8}$ in., while W. R. Dowling found at the Knights Deep, Ltd., 26% of $-\frac{1}{2}$ in. and probably 20% of $-\frac{3}{8}$ in. This shows that in no case need less than 20% or even 25% of $-\frac{3}{8}$ in. be expected, especially seeing that we have already from 17·5% to 25% in the under-size product from the grizzlies. The present arrangements could, however, be so modified by adding more breakers that even more than 25% of the rock hoisted could be reduced to a size not exceeding $\frac{3}{8}$ in., thus still further increasing the quantity available for feeding direct to the tube mill plant.

The rock hoisted also contains a quantity passing a 90-mesh screen, and this product can be sent direct to the cyanide plant. In the two gradings previously given the average is over 5%, while G. O. Smart, at the Simmer and Jack Proprietary Mines, found 4·38% in the mill feed, and W. R. Dowling, at the Knights Deep, Ltd., 3·44%. Naturally this product is not wanted in either stamp-mill or tube-mill plant.

Before describing the proposed modifications of the sorting and breaking plant, it will be as well to shortly state the present practice. The rock mined is sent to the surface after passing through grizzlies spaced about 8 in. On arrival in the head frame, it is automatically dumped upon a grizzley, the bars of which are generally spaced $1\frac{3}{4}$ in., where it is divided into a coarse product ($+1\frac{3}{4}$ in.) and a fine product ($-1\frac{3}{4}$ in.), called "fines." These "fines" are by no means cubical or spherical in shape, as, owing to the design of the screening device, long flat pieces, the bulk of which considerably exceeds a $1\frac{3}{4}$ in. cube, are passed through. The "fines" so produced are invariably taken direct to the battery, it having been taken for granted that it is impossible to remove any waste rock therefrom. The quantity of "fines" so produced varies considerably in different mines—partly due to the different spacing of the grizzley bars, but also due to different methods of mining—and may be as high as 50% and as low as 30% of the total rock hoisted.

The coarse rock remaining on the grizzley bars, after having been washed in a more or less summary manner, is spread out upon a sorting belt or table, with the object of facilitating a close scrutiny for detecting and discarding the waste rock. The waste so discarded varies from under 10% to over 30% of the total hoisted, the average for the Rand being about 16%. The rock or ore remaining on the sorting belt is then broken to a size not exceeding 2 in., and is sent to the battery. The complete operations involved are shown on the volume and flow diagram Fig. 2, while a schematic illustration of a typical plant is given in Fig. 3.

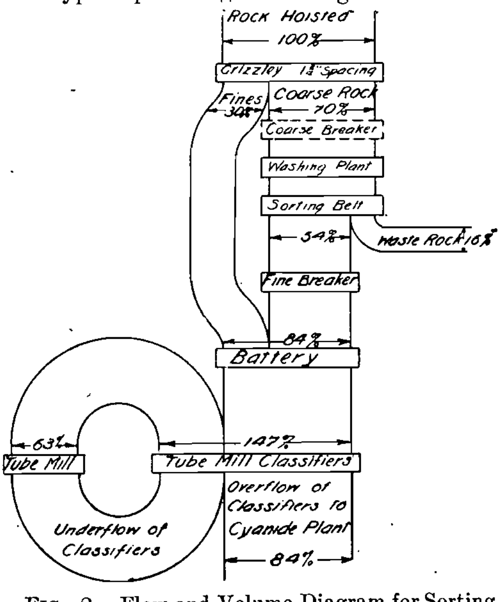


Fig. 2.—Flow and Volume Diagram for Sorting and Breaking Plant, Present Day Practice.

* This *Journal*, Vol. XI., p. 325.

In some plants coarse breakers are used prior to sorting and the "fines" so created are generally added to the undersize product from the grizzleys. This type of plant is shewn in Fig. 4.

A small quantity of ore is sent direct to the tube mill plant in the shape of pebbles and these are picked on the sorting appliance, but as the quantity is very small it is ignored in the volume diagram.

As may be seen the arrangements are very simple in character, and although in isolated

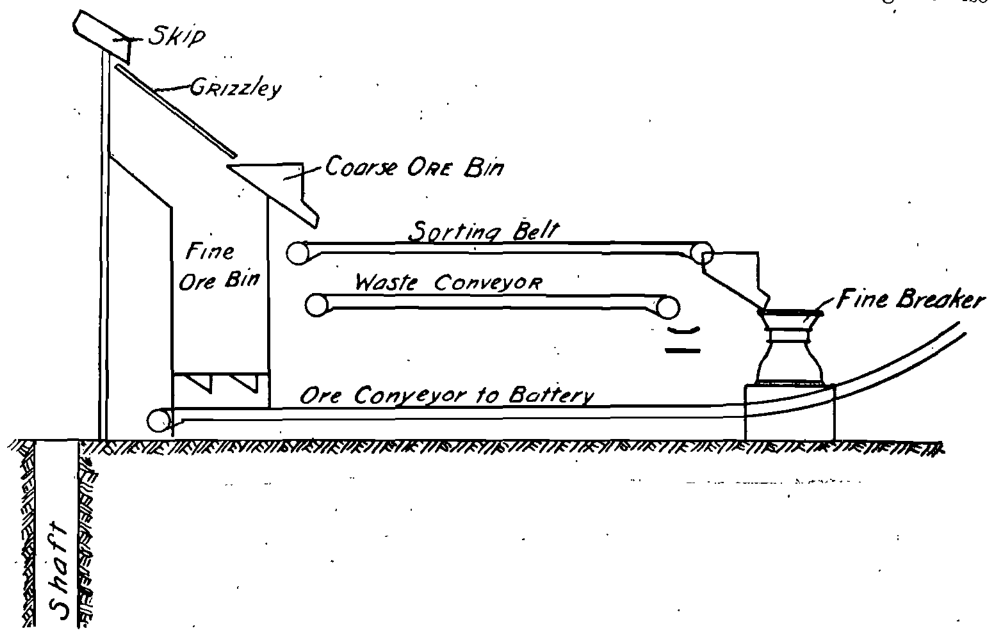


FIG. 3.—Present Type of Sorting and Breaking Plant.

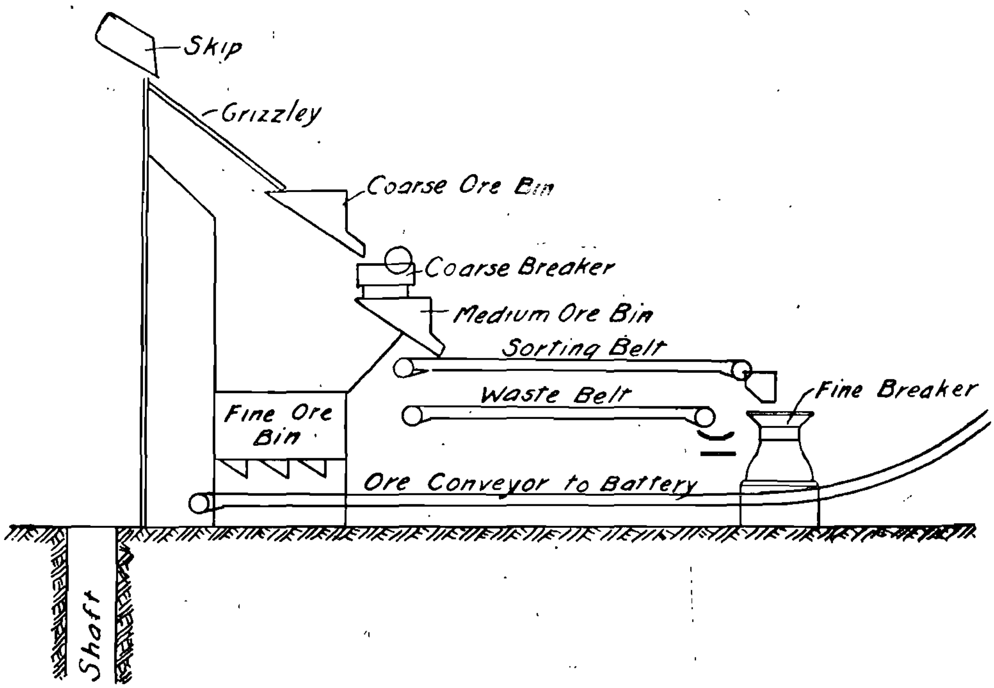


FIG. 4.—Present Type of Sorting and Breaking with Coarse Breaker.

cases more elaborate installations are found, the benefit which might be derived therefrom is altogether negatived by inefficient labour. It is notorious that only those natives who are physically unfit for other work are used for sorting purposes, although it would appear that, in view of the importance of the work and its subsequent influence upon the economy of the whole reduction plant, the work should be done by competent men. Further, the task is made still more difficult by too much crowding of the rock on sorting belt or table and by insufficient cleaning. Yet, under these distinctly unfavourable conditions an average of 16% of the rock hoisted is sorted out, and as no protest is made regarding the value of the waste dump, it is to be presumed that only waste rock is discarded. Now, provided that better labour is employed, that the rock is properly spread out and, above all, thoroughly cleaned, it does not seem impossible to raise the percentage of waste rock discarded to 20% or only 4% more than the average, always presuming that the quantity of waste rock mined and hoisted remains as before. The total waste in the rock hoisted may be estimated at from 35% to 40% on the average, but in many cases, when very small reefs are dealt with, it is much greater.

The rock hoisted is separated into a coarse and fine product, as has been stated, by stationary grizzleys when flowing at a great velocity down an incline of 38°. That the screening under these conditions is and must be imperfect is obvious and can at any time be seen by inspecting the "coarse" product upon the sorting belt or table. To improve this it would seem necessary to adopt a better screening device which may be either a shaking screen or a revolving screen, called trommel, the main object being to allow sufficient time to effect the separation and, incidentally, to permit of thoroughly cleaning the rock from all impurities and finely crushed particles. The time factor has so far been entirely ignored, except in rare cases, seeing that the time occupied by the rock in flowing over the grizzley never exceeds two seconds, while actually from 1½ to two minutes are available between the arrival of two succeeding skip loads. It would seem possible, therefore, to obtain a better separation into two products, say a coarse or +2 in. and a fine or −2 in. product and yielding, each, say 50% of the total rock hoisted, especially seeing that with the primitive arrangements now in use this is already done in many cases.

Having thus obtained the two products, the coarse or +2 in can be sent to the sorting appliance where, as already stated, 20% of the total hoisted will be removed as waste rock, the balance of 30% to be broken ready for the reduction plant.

The fine or −2 in. product, which contains proportionately as much waste rock as the coarse product must now be prepared to allow of eliminating as much as possible of the waste. To do this it is proposed to immediately screen out all particles too small to allow of conveniently detecting and discarding waste rock. It will therefore, be necessary to provide another screening trommel or other equally efficient device which will remove all particles ⅜ in. and smaller, thus giving a fine product ready for the tube mill plant. In view of the gradings given on page 9 it seems that the −⅜ in. product will equal fully 15% of the total rock hoisted, thus leaving 35% of (−2 in. +⅜ in.) The coarser product (−2 in. +⅜ in.) can now be again washed and then subjected to a close scrutiny for detecting and eliminating the waste rock. Seeing the much greater facility of removing waste rock from this material without also discarding ore than is the case when dealing with coarse rock, it would seem possible that waste rock equal to 10% of the total quantity hoisted can be so removed, thus making the total waste discarded equal to 30% of the rock hoisted. With these modifications the flow and volume diagram would now be as shewn in Fig. 5.

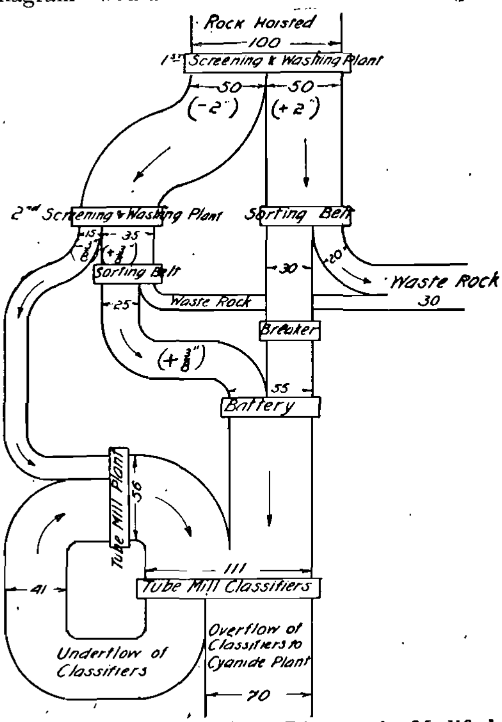


FIG. 5.—Flow and Volume Diagram for Modified Sorting and Breaking Plant on Basis of 30% Waste Rock.

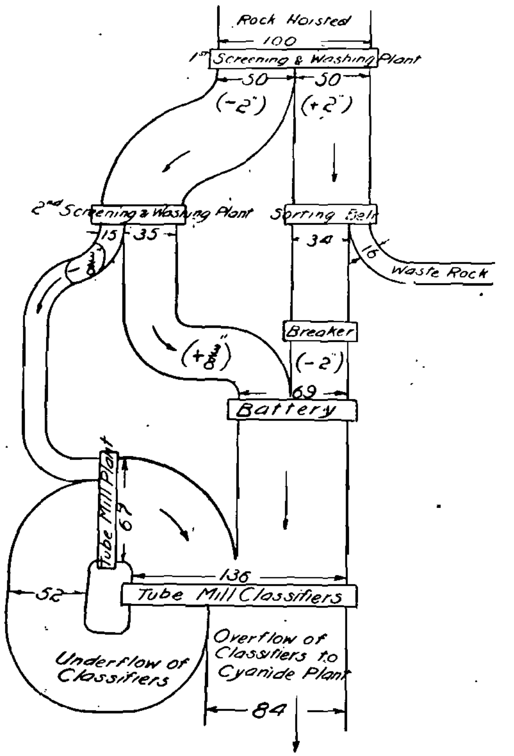


FIG. 5A.—Flow and Volume Diagram for Modified Sorting and Breaking Plant on Basis of 16% Waste Rock.

Comparing Fig. 5 with Fig. 2 it will at once be seen that of the total rock hoisted the battery now has to deal with only 55% as against 84% previously and that the tube mill plant only deals with 56% as against 63%, while the cyanide plant need only treat 70% as against 84%,

Although the battery has now been considerably relieved, yet a further reduction in its duty can be made by eliminating all the $-\frac{3}{8}$ in. product resulting from the operation of the fine breaker on the coarse rock, after sorting. The $-\frac{3}{8}$ in. product so obtained, and which may be estimated at 3% of the total hoisted would also be sent direct to the tube mill plant as shewn in the diagram Fig. 6. The work of the battery is now limited to 46% of the total rock hoisted and that of the tube mill plant rises only by 2·5% to 58·5%,

If it should be thought that the (-2 in. $+\frac{3}{8}$ in.) product from the fine breaker could with advantage be again subjected to sorting it could easily be added to the similar product from the first screening plant and the plant resulting would be represented by the flow diagram shown in Fig. 7. Compared with Fig. 6 there will be two screening plants, thus making a simpler arrangement, and while all the (-2 in. $+\frac{3}{8}$ in.) pro-

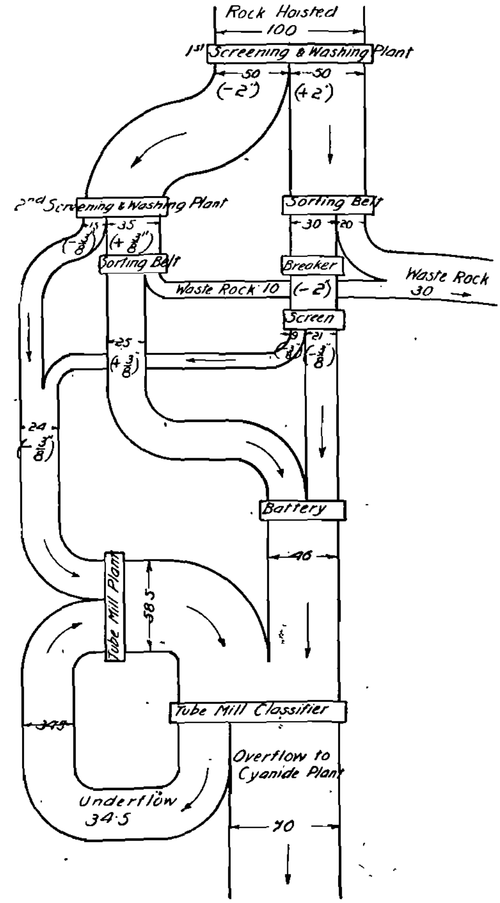


FIG. 6.—Flow and Volume Diagram for Modified Sorting and Breaking Plant with Additional Screening after Fine Breaking, on Basis of 30% Waste Rock.

duct is sorted in one place the product resulting from the 30% passed through the fine breaker is sorted twice.

If, as in some plants now in operation, it should be thought advisable to use a coarse breaker it becomes necessary to eliminate the fine product so created and to particularly see that the $-\frac{3}{8}$ in. product is sent direct to the tube mill plant. The diagrams Figs. 5, 6 and 7 would then have to be altered as shewn in Figs. 8, 9 and 10, the assumption having been made that the coarse breaker produces 10% of the total rock hoisted in a size smaller than 2 in. of which 4% again would be $-\frac{3}{8}$ in.

The diagrams shew all operations up to and including stamp milling and tube milling thus clearly expressing where the work is reduced as compared with present-day practice. In explanation of the duty allotted to the tube mill plant other than crushing the $-\frac{3}{8}$ in. product obtained direct from the sorting plant, it may be stated

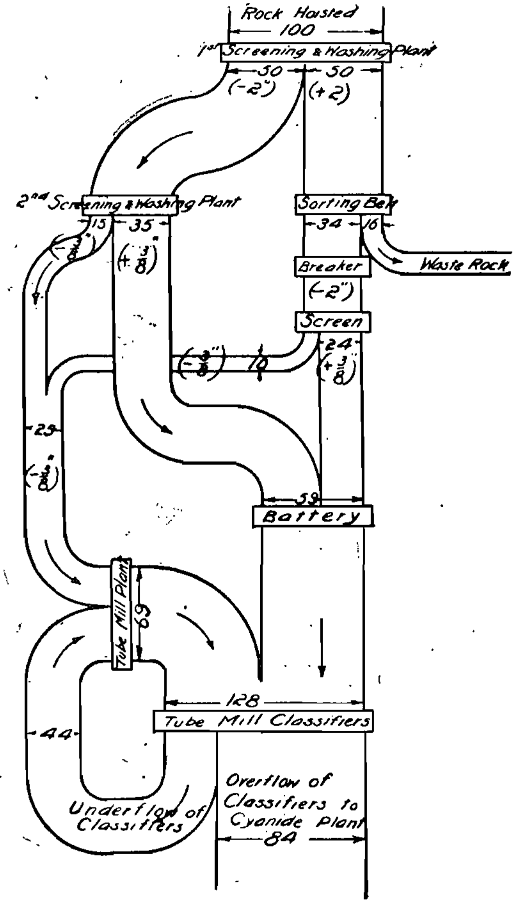


FIG. 6A.—Flow and Volume Diagram for Modified Sorting and Breaking Plant with Additional Screening after Fine Breaking on Basis of 16% Waste Rock.

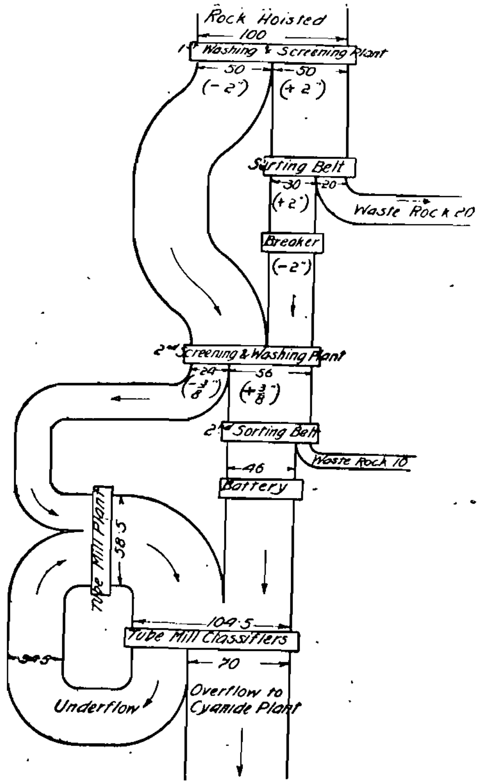


FIG. 7.—Flow and Volume Diagram for Modified Sorting and Breaking Plant with Double Screening and Double Sorting, on Basis of 30% Waste Rock

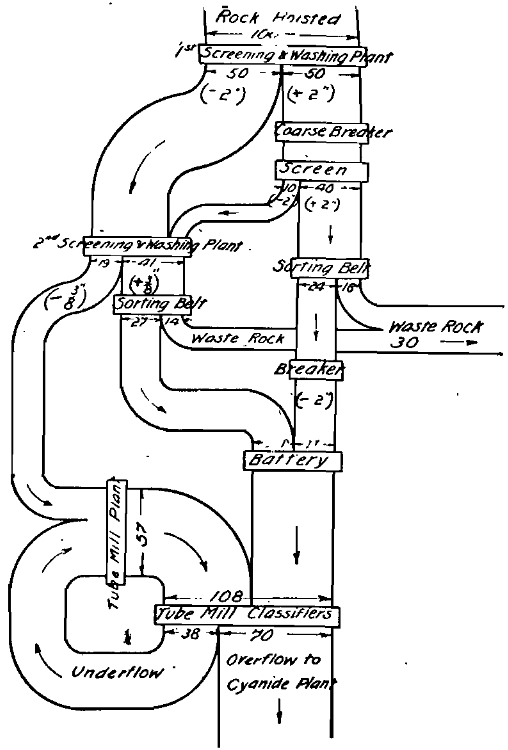


FIG. 8.—Flow and Volume Diagram for Modified Sorting and Breaking Plant as in Fig. V, on Basis of 30% Waste Rock but with Coarse Breaker

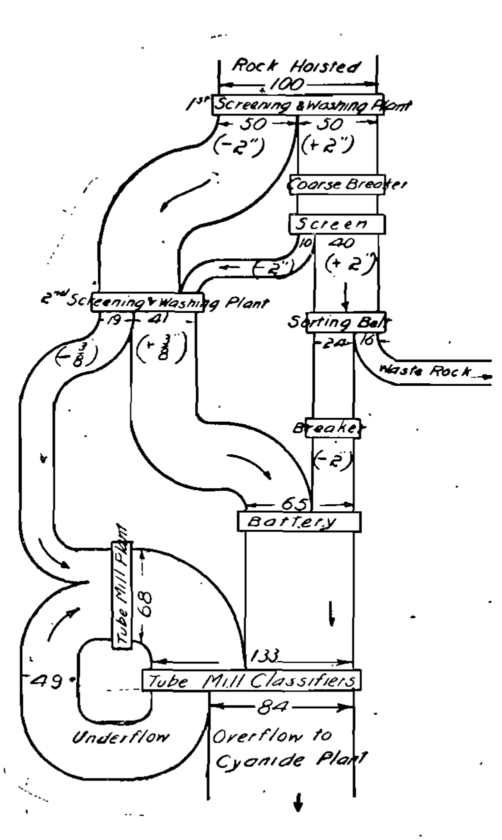


FIG. 8A.—Flow and Volume Diagram for Modified Sorting and Breaking Plant, on Basis of 16% Waste Rock, as in Fig. VA., but with Coarse Breaker.

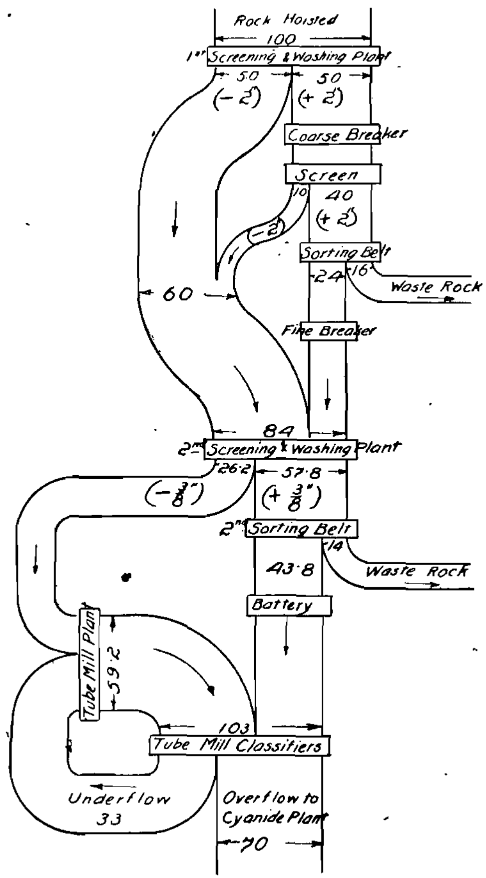


FIG. 9.—Flow and Volume Diagram for Modified Sorting and Breaking Plant, as in Fig. 6., on Basis of 30% Waste Rock, but with Coarse Breaker.

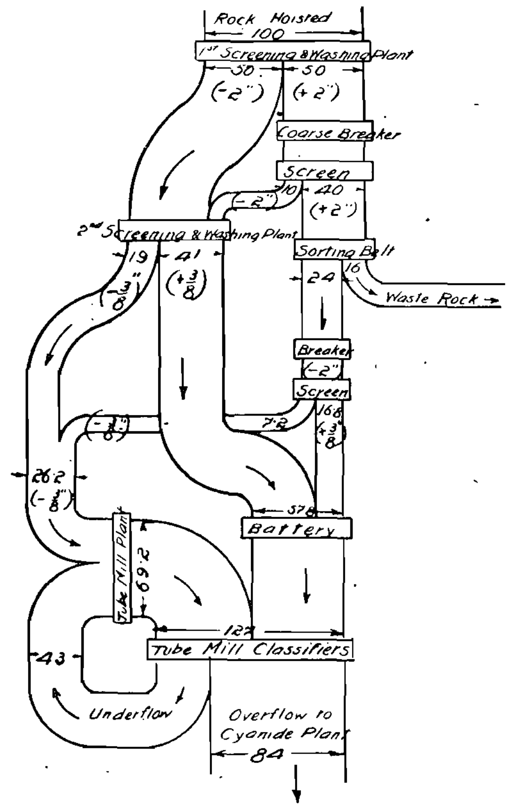


FIG. 9A.—Flow and Volume Diagram for Modified Sorting and Breaking Plant on Basis of 16% Waste Rock as in Fig. 6A., but with Coarse Breaker.

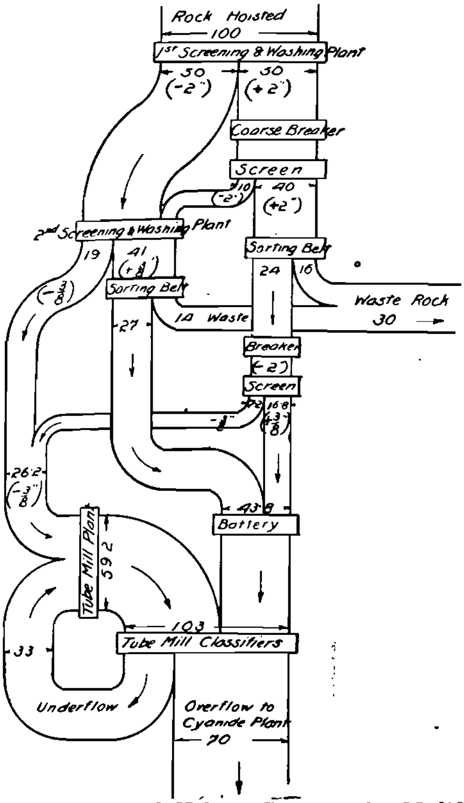


FIG. 10.—Flow and Volume Diagram for Modified Sorting and Breaking Plant as in Fig. 7, but with Coarse Breaker.

that the percentage of the ore crushed in the battery and requiring further crushing in the tube mill plant is taken at 75% which corresponds closely with actual practice in many of the later plants now at work.

For the purpose of permitting a more ready comparison between the present type of sorting plant with any of the six different forms proposed in the foregoing remarks certain data expressive of the work done have been collected in the Table III. As will be seen the basis of comparison is the quantity of rock dealt with in the various operations and expressed, as a percentage of the tonnage hoisted. This obviously eliminates the usual basis for comparison—the tonnage milled as this naturally does not readily express the work done anywhere but in the stamp mill.

It appears from Table III that while the duty of the various portions of the sorting plant is increased with the exception of that of the fine breaker, the work of which is considerably reduced, the duty of the stamp battery is in the most favourable case almost halved, while that of the cyanide and tube mill plants is also reduced. With the aid of the table it will now be possible to make an estimate of the probable increase and decrease in both capital expenditure and operating costs brought about by the proposed modifications of the sorting and breaking plant.

TABLE III.–Comparative statement of duties of various operations with existing and proposed methods

Type of Plant.	Existing Method.	Proposed Methods on basis of 30 per cent. waste rock.					
	Fig. 2.	Fig. 5.	Fig. 8.	Fig. 6.	Fig. 9.	Fig. 7.	Fig. 10.
Number of Column.	1	2	3	4	5	6	7
1. Rock Hoisted	100	100	100	100	100	100	100
2. Waste Rock sorted out ...	16	30	30	30	30	30	30
3. Ore Milled and Treated in Cyanide Plant	84	70	70	70	70	70	70
4. Ore passed through Stamp Battery...	84	55	51	46	43·8	46	43·8
5. Ore passed through Tube Mills ...	63	56	57	58·5	59·2	58·5	59·2
6. Ore direct from Sorting Plant to Tube Mills	—	15	19	24	26·2	24	26·2
7. Rock Sorted	70	85	81	85	81	106	97·8
8. Rock Screened	100	150	210	180	234	180	234
9. Duty of Coarse Breaker ...	70	—	50	—	50	—	50
10. Duty of Fine Breaker	54	30	24	30	24	30	24
11. Ore passed through Tube Mill Classifiers	147	111	108	104·5	103	104·5	103
12. Ore passed through Tube Mill Classifiers if (—⅜) product from sorting plant is also passed through Tube Mill Classifiers.		126	137	128·5	129·2	128·5	129·2

TABLE IIIA.

Comparative Statement of duties of various Operations with existing and proposed Methods.

	Type of Plant.	Existing Methods.	Proposed Methods on basis of 16% Waste Rock.					
		Fig. 2.	Fig. 5A.	Fig. 8A.	Fig. 6A.	Fig. 9A.	Fig. 7A.	Fig. 10A.
	Number of Column.	1	2	3	4	5	6	7
1	Rock hoisted	100	100	100	100	100	100	100
2	Waste Rock sorted out	16	16	16	16	16	16	16
3	Ore milled and treated in cyanide plant	84	84	84	84	84	84	84
4	Ore passed through stamp battery ...	84	69	65	59	57·8	59	57·8
5	Ore passed through tube mills ...	63	67	68	69	69·2	69	69·2
6	Ore direct from sorting plant to tube mills	—	15	19	25	26·2	25	26·2
7	Rock sorted	70	50	40	50	40	50	40
8	Rock screened	100	150	210	184	234	184	234
9	Duty of coarse breaker	70	—	50	—	50	—	50
10	Duty of fine breaker	54	34	24	34	24	34	24
11	Ore passed through tube mill classifiers	147	136	133	128	127	128	127
12	Ore passed through tube mill classifiers if $(-\frac{3}{8})$ product from sorting plant is also passed through tube mill classifiers	—	151	152	153	153·2	153	153·2

Ross E. Browne* in the paper already mentioned furnishes the following data regarding the average plant of the Rand Mines, Ltd. :—

		Tons.	
1.	Rock hoisted per month ...	17,779	
2.	Waste discarded per month...	2,125	= 12%
3.	Milling ore per month ...	15,654	
		s.	
4.	Cost of sorting per ton of waste discarded ...	1·433	
5.	Cost of conveying per ton of waste discarded ...	·334	
6.	Total cost per ton of waste discarded	1·767	
7.	Total cost per ton milled ...	·264	
8.	Total cost per ton hoisted ...	·211	
9.	Cost of breaking per ton broken	·339	
10.	Cost of breaking per ton milled	·279	
11.	Cost of breaking per ton hoisted	·246	
12.	Cost of sorting and breaking per ton milled ...	·543	
13.	Cost of sorting and breaking per ton hoisted ...	·457	

It may be gathered from these figures that sorting and breaking each represented practically half of the total cost in the type of plant then in use by the Rand Mines, Ltd. Since then there has been little change, if any, in the design of the sorting and breaking plants so that it may be assumed that at present the ratio is the same. With increased tonnages the cost per ton has, however, been considerably reduced and varies in different plants from 2·5d. to 5d. per ton milled. If we assume the comparatively high figure of 3·75d. per ton milled for the cost of sorting and breaking, the cost of sorting alone will then be 1·875d. per ton milled, which on the basis of the present percentage of waste discarded would be 2·24d. per ton hoisted (16% of waste rock) or 14d. per ton of waste removed, say 1s. 2d.

The cost of sorting also includes the cost of screening, however as the actual cost of screening has not been separately kept it will be necessary to assume a figure. Considering the very small attention paid to screening in the past the only clue we have the cost of operating a trommel, including maintenance and power, and water for washing purposes. If we assume this to be 2d. per ton sorted we have the following :—

	s.	d.
Screening per ton sorted ...	0	2
Sorting per ton sorted ...	1	0

As this is not a good basis we have to find the cost per ton screened, and as in the existing plants all the rock hoisted is screened, we have on the basis of 30% being "fines":

Cost of screening per ton screened $\frac{2 \times 16}{70} =$ ·5d.

* Working Costs of the Mines of the Witwatersrand, *Journal of the South African Association of Engineers*, Vol. XII., p. 289.

As the cost of breaking the rock is a little more than half the total sorting and breaking costs, we have 2d. as the cost of breaking per ton milled, or on the basis of 30% "fines" and 16% waste discarded:—

$$\frac{2{\cdot}0 \times 84}{54} = 3{\cdot}11\text{d. per ton broken or say 4d.}$$

which is practically the figure given by Ross E. Browne. The cost of coarse breaking is considerably less and may be taken at 2d. per ton broken. We now have the following operating costs:

	s.	d.
Sorting per ton of waste discarded	1	0
Screening per ton screened ...	0	0·5
Fine breaking per ton broken ...	0	4·0
Coarse breaking per ton broken ...	0	2·0

To complete the comparison we also need the cost of stamp milling, tube milling and cyaniding. These vary considerably in various plants, and although the figures published by E. J. Way* and used on page 466, show the average reduction costs at 5s. per ton milled, it is proposed to use the lower figures actually obtaining in a number of large plants, especially as by so doing the result obtained by the modifications suggested is adversely affected. The following will therefore be taken as a basis:

	s.	d.
Crushing in stamp batteries per ton milled	1	6
Cyaniding per ton treated ...	1	9
Tube milling per ton milled ...	0	6·75
Tube milling per ton passed through tube mill ...	0	9

or a total of 3s. 9·75d. to per ton milled. It will be admitted that these figures are low, and therefore distinctly unfavourable to the point to be brought out, and it is hoped that this will be taken into account if any of the statements made should appear too favourable. With the aid of tabulated statement of duties (table III) operating costs of the modified plant as well as of the present type of plant can be calculated. The result is shewn in table IV. It appears from table IV. that there will be a saving in working costs varying from 8·16d. to 10·32d. per ton hoisted, or per unit of gold recovered, it being assumed that the mining is carefully and efficiently done in both cases.

Naturally a comparison on the basis of the tonnage milled is not possible, as owing to the reduced quantity of milling ore, due to the increased percentage of waste rock discarded, such a comparison would yield misleading results.

It now remains to be seen what the saving in capital expenditure will be under the altered conditions. However, before comparisons can be

* Trans. Inst. M. and M., Vol. xix., p. 12.

TABLE IV.—Comparative Statement of Operating Costs in Existing Plant and Proposed New Plants.

Type of Plant	Rate per Ton.	Existing Plant Fig. 2.		Proposed Plants on Basis of 30 per cent. Waste Rock. Fig. 5.		Fig. 8.		Fig. 6.		Fig. 9.		Fig. 7.		Fig. 10.	
Number of Columns		1		2		3		4		5		6		7	
	Shillings	Tons	Shillings	Tons	Shillings	Tons	Shillings	Tons	Shillings	Tons	Shillings	Tons	Shillings	Tons	Shillings
1 Milling	1·5	84	126	55	82·5	51	76·5	46	69	43·8	65·75	46	69	43·8	65·75
2 Tube milling ...	·75	63	47·25	56	42	57	42·75	58·5	43·75	59·2	44·25	58·5	43·75	59·2	44·25
3 Cyaniding ...	1·75	84	147	70	122·5	70	122·5	70	122·5	70	122·5	70	122·5	70	122·5
4 Screening	·0416	100	4·16	150	6·24	210	8·74	180	7·49	234	9·73	180	7·49	234	9·73
5 Sorting	1·0	70	70	85	85	81	81	85	85	81	81	106	106	97·8	97·83
6 Coarse breaking ...	·167	70	11·67	—	—	50	8·33	—	—	50	8·33	—	—	50	8·33
7 Fine breaking ...	·334	54	18	30	10	24	8	30	10	24	8	30	10	24	8
8 Total costs ...			424·08		348·24		347·77		337·74		339·56		358·74		356·36
9 Costs per ton hoisted			4·24		3·48		3·48		3·38		3·40		3·59		3·56
10 Saving per ton hoisted					·76		·76		·86		·84		·65		·68
11 Saving per ton hoisted					9·12d.		9·12d		10·32d.		10·08d.		7·8d.		8·16d.
12 Saving in per cent. ...					17·9%		17·9%		20·2%		19·8%		15·3%		16·0%

Table IVa.

Comparative Statement of Operating Costs in Existing Plant and Proposed New Plants.

Type of Plant.	Rate per ton.	Existing Plant. Fig. 2.		Proposed Plants on Basis of 16 per cent. Waste Rock. Fig. 5a.		Fig. 8a.		Fig. 6a.		Fig. 9a.	
Number of Columns.		1		2		3		4		5	
	Shillings	Tons	Shillings	Tons	Shillings	Tons	Shillings	Tons	Shillings	Tons	Shillings
1. Milling	1·5	84	126·00	69	103·50	65	97·5	59	88·50	57·2	85·8
2. Tube Milling ...	·75	63	47·25	67	50·25	68	51·0	69	51·75	69·2	51·9
3. Cyaniding ...	1·75	84	147·00	84	147·00	84	147·00	84	147·00	84	147·00
4. Screening ...	·0416	100	4·16	150	6·24	210	8·74	184	7·65	234	9·73
5. Sorting ...	1·0	70	70·00	50	50·00	40	40·00	50	50·00	40	40·00
6. Coarse Breaking ...	·167	70	11·67	—	—	50	8·33	—	—	50	8·33
7. Fine Breaking ...	·334	54	18·00	34	11·33	24	8·00	34	11·33	24	8·00
8. Total Costs ...			424·08		368·32		360·57		356·23		350·76
9. Costs per ton hoisted			4·24		3·68		3·61		3·56		3·51
10. Saving p. ton hoisted					·56		·63		·68		·73
11. Saving p. ton hoisted					6·72d.		7·56d.		8·16d.		8·76d.
12. Saving in per cent....					15·8%		17·8%		19·2%		20·6%

made, it will be necessary to shortly describe how far the modified method of working will affect the design of the plant.

The present type of plant may shortly be described as follows:—In most mines there are one or more storage bins underground varying considerably in size, there are also one or more storage bins in the sorting and breaking plant and finally there is a large bin attached to the stamp battery. The last mentioned has so far been of a capacity to hold a three days supply of ore. However, with the great stamp duties now being reached it will be impossible without unduly increasing the cost of the mill bin to comply with the rule. The combined capacity of the storage bins in the sorting plant may be taken as equivalent at from 12 to 24 hours supply to the battery. In view of the fact that hoisting and surface transport is not permitted on Sundays, the storage underground and in the sorting plant is of no avail for supplying the battery on that day. This has already been taken into account in some plants where storage bins in the sorting plant have been omitted, arrangements having been made for continually transferring the ore from the sorting plant to the battery. Therefore, except in the case of intermittent transport of the ore to the battery, these bins are of no use and for our purpose can be omitted. We have then only the mill bin to consider and it is proposed, in the new plant, to allow for a bin giving three full days storage capacity. Hence, the battery will remain as before, except as regards the number of stamps, and the cost per stamp will, other things being equal, remain the same.

The tube mill plant also will remain the same, except in the number of mills required, but the cost per mill will not change.

The cyanide plant will not alter in design, but the capacity will be decreased in conformity with the decreased tonnage to be handled, due to sorting out more waste rock.

The sorting plant, however, will be considerably altered from the present design. It has already been stated that in order to obtain more efficient screening the stationary grizzleys should be discarded and replaced by a more efficient device. This will also necessitate a storage bin below the tipping gear in the head frame to hold sufficient rock for equalising the flow through the first screening plant. This bin will not be very expensive, in fact some plants already have it, although it is in the wrong place, being placed after the screening device instead of before it. The chief point of difference between the old and new sorting plant will be a storage bin for the $-\frac{3}{8}$ in. product which, in future, is to be sent direct to the tube mill plant. To secure proper running and regular work this bin also should have a capacity equal to a three days supply. Perhaps it had better be erected adjoining the tube mill plant, in any case its cost must be allowed for. The sorting arrangements proper will naturally have to be augmented to deal with the increased quantity of rock handled as shewn in table III. and this also applies to the breaking plant, except that in this case it will be a decrease.

According to the writer's investigations the cost of the various parts of the reduction plant can be conveniently stated on the basis of the tonnage milled per day.

Taking a plant capable of dealing with 2,000 tons of ore per day, the cost per ton milled per day and per ton hoisted per day, on the basis of 16% waste discarded, may be taken as follows :—

	Per ton milled	Per ton hoisted.
Sorting and breaking plant	£13	£10·92
Stamp battery	25	21·00
Tube mill plant	12	10·18
Tube mill plant per ton passed through tube mills	16	
Cyanide plant	59·1	49·644
Power distribution service	5·4	4·536
Total cost per ton hoisted		£96·280

The milling or crushing plant would consist of 240 stamps of 1,500 lbs. falling weight or 200 stamps of 1,500 lbs. falling weight, augmented by 8 tube mills 22 ft. x 5 ft. 6 in. The pulp elevating plant which will also be favourably influenced by the proposed modifications has not been included as the difference is so small as not to affect the total seriously.

Again using the tabulated statement (page 475) the capital expenditure for the modified as well as the existing plant, not considering the sorting plant, has been calculated and is as shown in Table V.

In the table the figures for power distribution have been obtained as follows :—The power consumption of the reduction plant is approximately at the rate of ·8 K.W. per ton milled per day, or a total of 1,600 K.W. for the 2,000 ton plant. The plant consists of :—

200 stamps @ 4 h.p. = 800 h.p.
= 600 K.W. = 37·5%

8 tube mills @ 100 h.p. = 800 h.p.
= 600 K.W. = 37·5%

Cyanide plant, 400 K.W. = 25%

As the total cost of the power distribution service is £5 4s. per 84 tons milled, the total cost of power plant is therefore 84 × 5·4 = £453 6s. Apportioning this in the proportion of 37·5%, 37 5%, and 25%, we have :—

Mill ...	... £170	or £2·0	per ton on 84 tons
Tube Mill	... £170	,, £2·7	,, ,, ,, 63 ,,
Cyanide Plant	£113·6	,, £1·35	,, ,, ,, 84 ,,

TABLE V.—Comparative Statement of Capital Expenditure on Part of Reduction Plant with Present and Proposed Methods of Working.

Type of Plant	Rate per Ton per Day.	Existing Plant. Fig. 2.		Proposed Plants on Basis of 30 per cent. Waste Rock. Fig. 5.		Fig. 8.		Fig. 6.		Fig. 9.		Fig. 7.		Fig. 10.	
Number of Column		1		2		3		4		5		6		7	
	£	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£
1 Stamp mill	25	84	2100	55	1375	51	1275	46	1150	43·8	1095	46	1150	43·8	1095
2 Tube mill plant ...	16	63	1008	56	896	57	912	58·5	936	59·2	947·2	58·5	936	59·2	947·2
3 Cyanide plant ...	59·1	84	4964·4	70	4137	70	4137	70	4137	70	4137	70	4137	70	4137
4 Total (1 + 2 + 3) ...			8072·4		6408		6324		6223		6179·2		6223		6179·2
5 Power distribution service: Stamp mill	2·0	84	168·0	55	110	51	102	46	92	43·8	87·6	46	92	43·8	87·6
6 Power distribution service: Tube mills...	2·7	63	170·1	56	151·2	57	153·9	58·5	157·7	59·2	159·8	58·5	157·7	59·2	159·8
7 Power distribution service: Cyanide plant	1·35	84	113·4	70	94·5	70	94·5	70	94·5	70	94·5	70	94·5	70	94·5
8 Total (4 + 5 + 6 + 7) ...			8523·9		6763·7		6674·4		6567·2		6521·1		6567·2		6521·1
9 Saving due to modified plant					1760·2		1849·5		1956·7		2002·7		1956·7		2002·8
10 Saving per ton hoisted per day					17·602		18·495		19·567		20·028		19·567		20·028
11 Saving in per cent. ...					20·6%		21·6%		22·8%		23·4%		22·8%		23·4%

which are the rates used in lines 5, 6, and 7 of the table. The table shows that as far as stamp mill, tube mill plant, cyanide plant, and power distribution service are concerned a saving of from 20·6% to 23·4%, as compared with the present type of plant, can be obtained by the modifications already described.

TABLE VA.—Comparative Statement of Capital Expenditure on Part of Reduction Plant with Present and Proposed Methods of Working.

Type of Plant.	Rate per ton per day.	Existing Plant. Fig. 2.		Proposed Plants on basis of 16 per cent. Waste Rock. Fig. 5A.		Fig. 8A.		Fig. 6A.		Fig. 9A.	
Number of Columns.		1		2		3		4		5	
	£	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£
1 Stamp mill	25	84	2100	69	1725·0	65	1625·0	59	1475·0	57·2	1430·0
2 Tube mill plant ...	16	63	1008	67	1072·0	68	1088·0	69	1104·0	69·2	1107·2
3 Cyanide plant ...	59·1	84	4964·4	84	4964·4	84	4964·4	84	4964·4	84	4964·4
4 Total (1 + 2 + 3) ..			8072·4		7761·4		7677·4		7543·4		7501·6
5 Power distribution service — Stamp mill	2·0	84	168·0	69	138·0	65	130·0	59	118·0	57·2	114·4
6 Power distribution service — Tube mills	2·7	63	170·1	67	180·9	68	183·6	69	186·3	69·2	186·8
7 Power distribution service — Cyanide plant	1·35	84	113·4	84	113·4	84	113·4	84	113·4	84	113·4
8 Total (4 + 5 + 6 + 7) ...			8523·9		8193·7		8104·4		7961·1		7916·2
9 Saving due to modified plant					330·2		419·5		562·8		607·7
10 Saving per ton hoisted per day					3·30		4·2		5·63		6·08
11 Saving in per cent. ...					3·86%		4·9%		6·6%		7·1%

With regard to the sorting and breaking plant, the chief item of additional expenditure will be the cost of the storage bin for the $-\frac{3}{8}$ in. product plus the cost of a means of transport for conveying the same to the tube mill plant. For the remaining portion of the sorting plant the expected increase of cost will have to be determined in accordance with the duty, as shown in the tabulated statement on p. 475. Dealing with the new storage bin first, it is proposed to allow for a three-days' supply, as suggested on p. 478, as being in accordance with the present practice in relation to the ore bin in the stamp battery, and which is ample to tide over the period of forced idleness on Sunday. As the greatest tonnage sent from the sorting plant direct to the tube mill does not exceed 60% of the tonnage hoisted, the storage required for the 100-ton plant would be about 180 tons. Presuming that the cheapest form of storage bin is a circular steel vat set on the ground, and as the product in question can be conveniently and cheaply conveyed by pumping, it is proposed to allow for a vat with a conical bottom, having the discharge hole at the apex of the cone. This discharge hole will be connected to the suction branch of a centrifugal pump, which will deliver a steady stream to the launder entering the tube mill plant. If the $-\frac{3}{8}$ in. product is conveyed to the storage vat by gravity with the aid of the washing water, the water may be promptly returned for re-use by providing the vat with a peripheral overflow launder, as now used on the slime collecting vats.

For a plant dealing with 2,000 tons of rock hoisted per day, to take a convenient size, the capacity of the storage vat would require to be 3,600 tons, or, at 20 cub. ft. per ton, 72,000 cub. ft. This would require two vats of 50 ft. diameter by 20 ft. deep, which, together with the necessary pumping plant for ore and return water, would not cost more than £3,000, or £1 10s. per ton hoisted per day.

In order to arrive at a reliable figure regarding the cost of the various parts of the sorting plant under the altered conditions, the amount (given on p. 479) of £13 per ton milled per day, or £10·92 (say £11) per ton hoisted per day, must be sub-divided. As these figures do not allow for coarse breaking, an amount of £1 per ton hoisted per day is provided for this purpose. On the basis of the actual cost of a number of sorting and breaking plants now in successful use, the writer arrived at the figures shown on Table VI., which are also rectified to give the cost per ton of rock or ore actually dealt with in various portions of the plant. With the aid of Table III., the capital cost for the proposed new plants, as compared with the present type, can now be calculated. The result is given in Table VII. It appears from the table that the proposed modifications of the sorting and breaking plant cause an increase in the capital cost varying from 11·2% to 39%.

Now, in order to arrive at the nett saving in capital expenditure, if any, for the whole plant, it will be necessary to combine the totals of Tables V. and VII. as shown in Table VIII.

The saving on capital account due to the modifications in the total plant, *i.e.*, sorting and breaking plant, stamp mill, tube mill plant, cyanide plant, and power distribution service,

TABLE VI.

Statement of Capital Cost per ton of Rock hoisted or dealt with in various portions of Sorting and Breaking Plant.

TYPE OF PLANT.	Cost per ton Hoisted.	Tons of Ore dealt with.	Cost per ton of Ore actually dealt with.
1. Screening Plant	£ ·9	100	£ ·9 per ton screened.
2. Coarse Breaking Plant	£1·0	70	£1·425 per ton broken.
3. Washing Plant	£1·1	70	£1·57 per ton washed.
4. Sorting Plant	£2·0	70	£2·85 per ton sorted.
5. Fine Breaking Plant	£2·1	54	£3·9 per ton broken.
6. Waste Rock Disposal...	£1·0	16	£6·25 per ton of waste.
7. Building and Foundations	£2·0	70	£2·85 per ton sorted.
8. Storage Bins	£1·6	84	£1·9 per ton milled.
9. Repair Shop, Lifting Tackle, etc. ...	£ ·3	100	£ ·3 per ton hoisted.
Total	£12·0		

TABLE VII.

Comparative Statement of Capital Expenditure on Sorting and Breaking Plants, with present and proposed methods of working.

Type of Plant.	Rate per ton.	Existing Plant.		Proposed Plant on basis of 30 per cent. Waste Rock.											
		Fig. 2.		Fig. 5.		Fig. 8.		Fig. 6.		Fig. 9.		Fig. 7.		Fig. 10.	
Number of Column.		1		2		3		4		5		6		7	
	£	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£
1 Screening ..	·9	100	90	150	135	210	189	180	162	234	210·6	180	162	234	210
2 Coarse breaking	1·425	70	100	—	—	50	71·25	—	—	50	71·25	—	—	50	71
3 Washing ..	1·57	70	110	150	235·5	210	329·7	180	282·6	234	367·38	180	282·6	234	367
4 Sorting ...	2·85	70	200	85	242·35	81	230·8	85	242·25	81	230·8	106	302·1	97·8	278
5 Fine breaking...	3·9	54	210	30	117	24	93·6	30	117	24	93·6	·30	117	·24	93
6 Waste disposal	6·25	16	100	30	187·5	30	187·5	30	187·5	30	187·5	30	187·5	30	187
7 Building ...	2·85	70	200	85	242·25	81	230·8	85	242·25	81	230·8	106	302·1	97·8	278
8 Storage bins ...	1·9	84	160	—	—	—	—	—	—	—	—	—	—	—	—
9 Repair shop	·3	100	30	100	30	100	30	100	30	100	30	100	30	100	3
10 Storage for $\frac{3}{8}''$	1·5	—	—	100	150	100	150	100	150	100	150	100	150	100	15
11 Total ...			1200		1339·6		1512·65		1413·6		1571·93		1533·3		1667
12 Increase due to modified plant					133·95		312·65		241·36		371·93		333·3		467
13 Increase per ton hoisted per day					1·34		3·13		2·41		3·72		3·33		4
14 Increase in per cent. ...					11·2%		26%		20·1%		31%		27·75%		39

TABLE VIIA.—Comparative Statement of Capital Expenditure on Sorting and Breaking Plants, with Present and Proposed Methods of Working.

Type of Plant.	Rate per ton.	Existing Plant. Fig. 2.		Proposed Plants on basis of 16 per cent. Waste Rock. Fig. 5a.		Fig. 8a.		Fig. 6a.		Fig. 9a.	
Number of Column.		1.		2		3		4		5	
	£.	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£
1. Screening ...	·9	100	90	150	135·00	210	189·00	184	165·60	234	210·60
2. Coarse Breaking ...	1·425	70	100	—	—	50	71·25	—	—	50	71·25
3. Washing	1·57	70	110	150	235·50	210	329·70	184	288·88	234	367·38
4. Sorting	2·85	70	200	50	142·50	40	114·00	50	142·50	40	114·00
5. Fine Breaking	3·9	54	210	34	132·60	24	93·60	34	132·60	24	93·60
6. Waste Disposal ...	6·25	16	100	16	100·00	16	100	16	100	16	100
7. Building ...	2·85	70	200	50	142·50	40	114·00	50	142·50	40	114·00
8. Storage Bins ...	1·9	84	160	—	—	—	—	—	—	—	—
9. Repair Shop ...	·3	100	30	100	30·00	100	30·00	100	30·00	100	30·00
10. Storage for $-\frac{3}{8}$ in. ...	1·5	—	—	100	150·00	100	150·00	100	150·00	100	150·00
11. Total			1200		1068·10		1191·55		1152·08		1250·83
12. Increase or decrease					− 131·9		− 08·45		− 47·92		+ 50·83
13. Increase or decrease per ton hoisted ...					—1·32		—·085		—·48		+ ·51

TABLE VIII.

Comparative Statement of Capital Expenditure on Part of Reduction Plant and Sorting and Breaking Plant with Present and Proposed Methods of Working, being Total of Tables V. and VII.

Type of Plant	Existing Plant. Fig. 2	Proposed Plants on Basis of 30 per cent. Waste Rock. Fig. 5	Fig. 8	Fig. 6	Fig. 9	Fig. 7	Fig. 10
Number of Column.	1.	2	3	4	5	6	7
	£	£	£	£	£	£	£
1 Cost of stamp mill, tube mill and cyanide plant and power supply	8523·9	6763·7	6674·4	6567·2	6521·1	6567·2	6521·1
2 Cost of sorting and breaking plant	1200·0	1339·6	1512·65	1413·6	1571·93	1533·3	1667·79
3 Total cost (1 + 2)	9723·9	8103·3	8187·05	7980·8	8093·03	8100·5	8188·89
4 Saving due to modified plant ...	—	1620·6	1536·85	1743·1	1630·87	1623·4	1535·01
5 Saving per ton hoisted per day ...	—	16·2	15·37	17·43	16·3	16·23	15·35
6 Saving in per cent.	—	16·6%	15·8%	17·9%	16·8%	16·7%	15·8%

TABLE VIIIA.—Comparative Statement of Capital Expenditure on Part of Reduction Plant and Sorting and Breaking Plant with Present and Proposed Methods of Working being Total of Tables VA. and VIIA.

Type of Plant.	Existing Plant.	Proposed Plants on basis of 16 per cent. Waste Rock.			
	Fig. 2.	Fig. 5A.	Fig. 8A.	Fig. 6A.	Fig. 9A.
Number of Column.	1	2	3	4	5
	£	£	£	£	£
1 Cost of stamp mill, tube mill and cyanide plant and power supply. VA. ...	8523·9	8193·7	8104·4	7961·1	7916·2
2 Cost of sorting and breaking plant. VIIA.	1200·0	1068·1	1191·55	1152·08	1250·83
3 Total cost (1 + 2)	9723·90	9261·8	9295·95	9113·18	9167·03
4 Saving due to modified plant		462·1	427·95	610·72	556·87
5 Saving per ton hoisted per day		4·62	4·28	6·11	5·57
6 Saving in per cent.		4·75%	4·5%	6·25%	5·7%

therefore varies from 15·8% to 17·9%, thus showing that notwithstanding an increase in the cost of the sorting plant, amounting to nearly 40%, a very substantial saving results in the cost of the whole plant.

Assuming that the remainder of the reduction plant, viz., amalgamating plant, mill clean-up plant, pulp elevating plant, return water service, ore transport on surface, water supply, offices, workshops, and stores cost £22 per ton milled per day, or £18 10s. per ton hoisted per day, the total cost will then be as follows, taking only the best and worst cases :—(see Table IX.)

The saving in capital expenditure, as evidenced by Table VIII., will reduce capital charges to the same extent. Taking 12% per annum, made up as follows :—

Interest at	6%
Depreciation at	4%
Redemption at	2%

as the basis, the saving in capital charges due to the modified plant will be shown in Table X. Add to this the saving in operating costs, as per Table IV., the total saving will be as per Table XI.

TABLE IX.

Column (referring to previous tables).	Existing Plant. 1.	Proposed Plant. 4.	7.
	Per ton	hoisted per	day.
1. Cost of Sorting Plant, Stamp Battery, Tube Mill Plant, Cyanide Plant, Power Distribution ...	£ 97·239	£ 79·808	£ 81·8889
2. Cost of remainder ...	18·5	18·5	18·5
3. Cost of entire reduction plant	115·739	98·308	100·389
4. Saving as compared with existing plant ...		17·431	15·350
5. Saving in per cent.		15·1%	13·25%

TABLE X.

Statement of Saving in Capital Charges by adopting the proposed Methods of Working.

	Proposed Plants on basis of 30 per cent. waste rock.					
	Fig. 5.	Fig. 8.	Fig. 6.	Fig. 9.	Fig. 7.	Fig. 10.
Number of Column	2	3	4	5	6	7
Saving in Capital (Table VIII.)	£1,620	1,537	1,743	1,631	1,623	1,535
Saving in Capital Charges, per month ...	£16·2	15·37	17·43	16·31	16·23	15·35
Saving per ton hoisted (28·5 days per month)	1·37d.	1·29d	1·47d.	1·37d.	1·36d.	1·29d.

TABLE XA.—Statement of Saving in Capital Charges by Adopting the Proposed Methods of Working.

	Proposed Plants on Basis of 16 per cent. Waste Rock.			
	Fig. 5A	Fig. 8A	Fig. 6A	Fig. 9A
Number of column ...	2	3	4	5
Saving in capital (Table VIIIA.	£462·1	427·9	610·7	556·8
Saving in capital charges per month ...	£4·62	4·28	6·11	5·57
Saving per ton hoisted (28·5 days per month) d.	·39 d.	·36d.	·514d	·47d.

Reconstructing Table II. and diagram, Fig. 1, on the basis of the reduced working costs, we obtain Table XII. and diagram, Fig. 11.

The gain, while not very great if referred to mines treating high-grade ore, which is supposed to exist at shallow depths, is yet considerable for low-grade mines, or those mining at greater depths than 3,000 ft. The advantage gained by working in the manner proposed by the writer, increases the profit derivable from the 22s. 6d. ore by 21%, and that obtainable from 20s. ore by 57%.

Now that the monthly tonnage milled is reaching nearly 1,800,000 tons, an extra gross profit of 1s. would represent a monthly gain of £90,000, of which the profit tax accounts for

TABLE XI.—Statement of total saving in Working Costs (Operating Costs and Capital Charges) by adopting the proposed methods.

	Proposed Plants on basis of 30 per cent. waste rock.					
	Fig. 5.	Fig. 8.	Fig. 6.	Fig. 9.	Fig. 7.	Fig. 10.
Number of Column	2	3	4	5	6	7
Saving in Operating Costs, (Table IV.) per ton hoisted. Pence...	9·12	9·12	10·32	10·08	7·80	8·16
Saving in capital charges (Table X.) per ton hoisted	1·37	1·29	1·47	1·37	1·36	1·29
Total Saving. Pence	10·49	10·41	11·79	11·45	9·16	9·45

TABLE XIA. — Statement of Total Saving in Working Costs (Operating Costs and Capital Charges) by Adopting the Proposed Methods.

	Proposed Plants on Basis of 16 per cent. Waste Rock.			
	Fig. 5A.	Fig. 8A.	Fig. 6A.	Fig. 9A.
Number of column ...	2	3	4	5
Saving in operating costs (Table IVA.) per ton hoisted, pence ...	6·72	7·56	8·16	8·76
Saving in capital charges (Table XA.) per ton hoisted, pence ...	·39	·36	·51	·47
Total saving, pence ...	7·11	7·92	8·67	9·23

Thus the total saving per ton hoisted varies from 9·45d. to 11·79d., as compared with present-day practice.

As the saving in working costs and capital charges shown in Table XI. is referred to the tonnage hoisted, it will be necessary to rectify the figures so as to express the saving per ton milled on the old basis of sorting out 16% of waste rock. Taking the average saving from Table XI., viz., 10·46d. per ton hoisted, the saving per ton milled will be 12·6d., or say 1s.

TABLE XII.

1. Average Depth of Mine.	1,000 feet.	2,000 feet.	3,000 feet.	4,000 feet.	5,000 feet.
2. Mining Costs.	s. 8·0	s. 8·5	s. 9·0	s. 9·5	s. 10·0
3. Reduction Costs.	4·0	4·0	4·0	4·0	4·0
4. General Exp's.	1·25	1·25	1·25	1·25	1·25
5. Development Redemption	2·0	2·0	2·0	2·0	2·0
6. Total Costs.	15·25	15·75	16·25	16·75	17·25
7. Yield.	40·0	30·0	25·0	22·5	20·0
8. Profit.	24·75	14·25	8·75	5·75	2·75
9. Profit Tax.	2·475	1·425	·875	·575	·275
10. Company's Profit.	22·275	12·825	7·875	5·175	2·475

£9,000, leaving £81,000 to shareholders. Of course, existing mines with reduction plants in full swing could not benefit to the same extent as mines which have not yet reached the milling stage. Yet, in cases where an increase in the capacity is planned, considerable benefit would also fall to those mines adopting the proposed modifications. Even assuming, which the writer does not admit, that the reduction in working costs as calculated in these notes will not materalise, it is hoped that a saving of 15% in

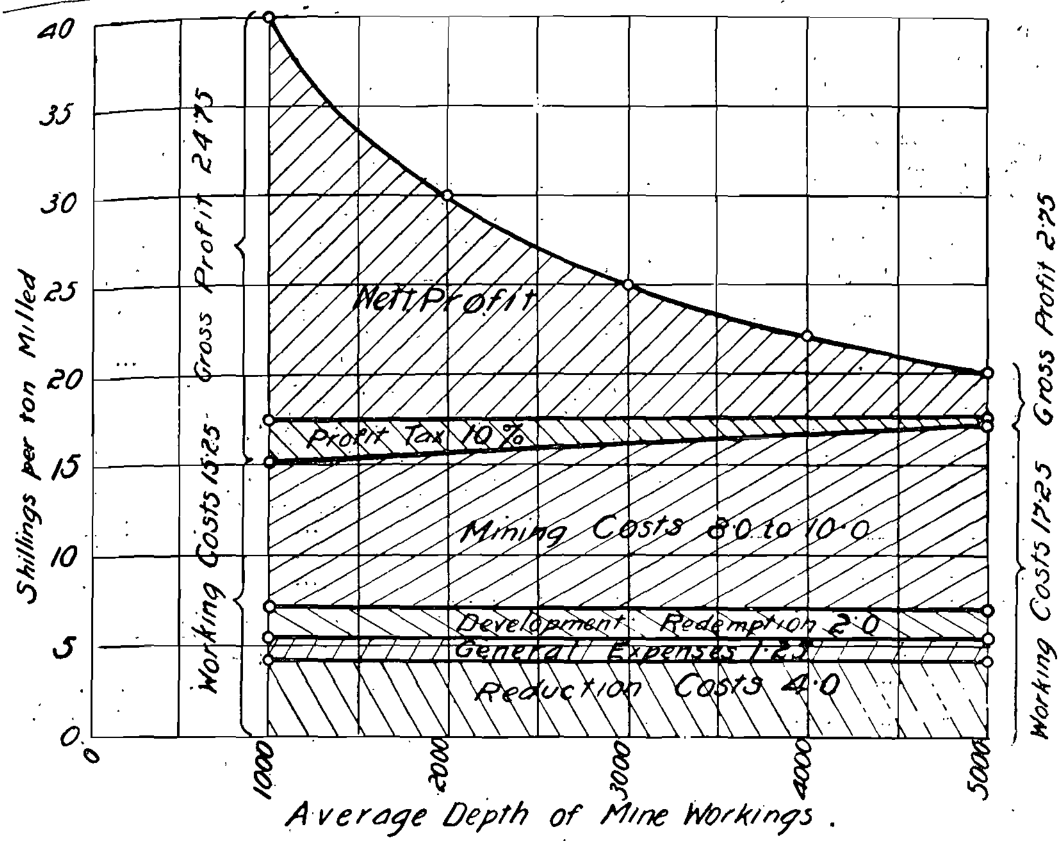


FIG. 11.—Diagram showing Screen Value of Ore, Working Costs and Profit per Ton Milled under Present Day Conditions.

the capital cost of the reduction plant is sufficiently attractive to deserve some attention, especially now when the flow of capital to the Rand is by no means as free as it used to be. In any case, it is hoped that renewed discussion, and possibly a practical demonstration of the vexed question of sorting "fines," especially the (2 in. + $\frac{3}{8}$ in.) product mentioned by the writer, will lead to some tangible result, beneficial to the mining industry and the country as a whole.

After writing the foregoing, it occurred to the author that members might object to some of the assumptions made, particularly with regard to the proposed percentage of waste rock which has to be removed in order to obtain the calculated results. Although it is thought that this percentage (30) has been justified in the reasoning already made, yet, in order to meet these objections, we will now assume that only the usual 16% of waste rock can be sorted out, and on this basis will investigate what the probable benefits may be expected to be.

From the diagrams, Figs. 5a, 6a, 8a and 9a and table III.a, which have been reconstructed on the basis of 16% of waste rock, can be seen how and where the proposed plant would be adversely affected if compared with the diagrams Figs. 5 to 10 and table III. New diagrams to correspond with Figs. 7 and 10 have not been made for reasons of economy, as it was found that these would be identical in the result with 6a and 9a.

It appears from the new diagrams and table III.a that the work to be done by the stamp battery, while considerably less than in present day plants, is more than would be the case if 30% waste were removed. Still, there is a reduction in the proportion of 84 to 57·2. The work to be done by the tube millls increases in the proportion of 63 to 69·2, and that to be done in the cyanide plant will be the same as in the present day plant. The work of the screening plant is found to be practically the same as before, and the same applies to the coarse and fine breakers. However, owing to the better separation in the first screening plant, the proportion of rock handled by the sorting belt or table decreases from 70 to 50 or 40. More work is also thrown on the tube mill classifiers.

Remodelling tables IV., V., VII., VIII. X. and XI., we obtain the tables IV.a to XI.a, and the final result (table XI.a) shows a saving in operating costs as compared with present day practice of from 7·11d. to 9·23d. per ton hoisted. This, compares with a saving varying from 9·45d. to 11·79d. previously found. It is interesting to note that the plant represented by Fig. 9a actually shows a saving greater than that obtained with the plant shown in Fig. 7, and closely approaches the plant Fig. 10.

The average saving from table XI.a, taking also into account the plants corresponding to Figs. 7 and 10, but not reproduced, is 8·47d. per ton hoisted, and on the basis of 16% sorted out, 10d. per ton milled thus decreasing reduction costs by that amount. Allowing for this in table XII. we obtain table XII.a as under :—

TABLE XII.a.

1. Average Depth.	1,000 feet.	2,000 feet.	3,000 feet.	4,000 feet.	5,000 feet.
	s.	s.	s.	s.	s.
2. Mining Costs	8·0	8·5	9·0	9·5	10·0
3. Reduction Costs ...	4·2	4·2	4·2	4·2	4·2
4. General Expenses...	1.25	1·55	1·25	1·25	1·25
5. Deve opment Redemption.	2·0	2·0	2·0	2·0	2·0
6. Total Costs...	15·45	15·95	16·45	16·95	17·45
7. Yield ...	40·0	30.0	25·0	22·5	20·0
8. Profit ...	24·55	14·05	8·55	5·55	2·55
9. Profit Tax ...	2·45	1·40	·85	·55	·25
10. Company's Profit ...	22·10	12·65	7·70	5·00	2·30

It will be admitted that even on the basis of present day practice regarding the percentage of waste rock sorted out, a considerable saving in working costs can be obtained by modifying the sorting and breaking plant on the lines proposed in these notes.

II. —*The Milling or Crushing Plant.*—From the foregoing remarks in respect of possible economies resulting from a modification of the sorting and screening plant, it appears that the greater portion of the saving effected is due to a redistribution of the work in the milling or crushing plant. As the suggested modifications of the sorting plant may or may not be adopted in practice, it remains to be seen how and where economies can be effected in the milling or crushing plant if regarded as an independent unit of the reduction plant.

Reviewing the work of the immediate past, even the casual observer cannot help being impressed by the change in the design of the milling or crushing plant At the end of 1904, about 800,000 tons were crushed per month by 6,500 stamps, while at the end of 1910 about 1,750,000 tons were crushed per month by 9,500 stamps, assisted by 200 tube-mills, which are equivalent to nearly 6,000 stamps. The average falling weight per stamp in 1904 was probably under 1,200 lbs., while in 1910 it must have been nearly 1,400 lbs., or on the basis of the nominal crushing unit introduced by Dr. Caldecott, there were in use :—

1904— 6,250 nominal crushing units.

1910—10,600 nominal crushing units in stamps ... 6,000 nominal crushing units in Tube Mills ...	Or a total of 16,600 nominal crushing units.

The duty per crushing unit in 1904 was 127·5 tons per month, and in 1910 105 tons per month. The apparent decrease in the duty is explained by the finer crushing. The grading of the average final pulp in 1904 showed probably :—

20% of	...	...	+ 60.
20% of	...	...	− 60 + 90.
60% of	...	...	− 90.

thus producing a total of 480,000 tons of − 90, and the average pulp in 1910 showed probably the following grading :—

10% of	..	...	+ 60.
15% of	...	...	− 60 + 90.
75% of	...	...	− 90.

an advance of 15% in the percentage of − 90. product, or a total of 1,312,500 tons. Further, by referring to Table I. and Fig. 1, giving the probable grade for various depths of mining, it will be seen that while in 1904 the average depth of mining was about 1,600 ft., corresponding to a grade of 34·7s., in 1910 the average depth was 2,400 ft., corresponding with a grade of 28s. The rock from the greater depth is naturally harder, requiring a greater effort to reduce it to the required fineness. Ignoring this fact, however, it is found that the tonnage of − 90 per nominal crushing unit per month in 1904 was:

77 tons, or 2·7 tons per day,

and in 1910 :

80 tons, or 2·8 tons per day,

on the basis of 28·5 working days per month. The increase in duty, ignoring the greater hardness of the rock is, therefore, not very marked, and this is undoubtedly due to the fact that many plants on the Rand are even to-day run in a very indifferent manner. This is obvious, if it is considered that in many plants the − 90 produced per nominal crushing unit is 3·5 tons, or 25% more than the calculated average for the whole Rand, and is further confirmed by the results* of the crushing trials at the New Kleinfontein, where in one case (1,680 lb. stamps) 3·27

* Trans. Inst. M. & M., Bulletin No. 75, p. 42. This *Journal*, Vol. XI., p. 248.

tons, and in the other (1,400 lb. stamps) 3·26 tons of − 90 per nominal crushing unit were produced.

Although from the crushing point of view the improvement is not very great, the net result is nevertheless considerable because, not only have operating costs being reduced, but the extra extraction due to finer crushing is equal to at least 3% or 10d. per ton milled on 28s. ore. In 1904 the crushing plant consisted of stamps only the cost of which per nominal crushing unit installed would to-day be £240, including mill bin, as against £180 per nominal crushing unit of the double stage crushing plants in use in 1910, made up as follows :

106 nominal crushing units in stamps at £240 = ...	£25,440
60 nominal crushing units in tube mills at £80	4,800
Total for 166 N.C.U. ...	£30,240

or £180 per nominal crushing unit. This represents a saving of 25%.

While the foregoing figures do not lay claim to accuracy, which is obviously impossible to attain, they do shew that better work is now done with the aid of the tube mill than was the case in 1904 besides being interesting from a historical point of view.

Possible further economies in the cost of the milling and crushing plant have been alluded to by several writers, notably Dr. Caldecott,* while the beneficial effects on the capital expenditure resulting from using a proportionately greater tube mill equipment, than is now the case, have been pointed out by the writer in 1909.† Since then a considerable advance in the right direction has been made, and it is hoped that, in the light of the following notes, some of the critics of the two stage crushing plant will repent.

While the fight between the advocates of single and double stage crushing has been waxing fast and furious, abuse masking the want of data and argument on the part of the single stage men, E. H. Johnson made some crushing trials at the East Rand Proprietary Mines the result of which must certainly be considered as sufficient to eliminate all doubt from the minds of unbiased observers. Mr. Johnson and his corporation deserve the greatest credit for their enterprise in doing such signal service for the benefit of the whole mining industry. The result of these trials, as published‡, was as follows :—

10 stamps of 1,634 lbs. falling weight, and one tube mill 22 ft. x 5 ft. 6 in., with preliminary screening into $-\frac{3}{8}$in. and $+\frac{3}{8}$in. prior to entering the mortar box, crushed 261·34 tons per 24 hours to the following grading :—

+ 90	–	·5%
− 90 + 200	–	15·5%
− 200	–	84·0%

that is 99·5% or 260 tons − 90 product or 6 tons of − 90 per nominal crushing unit, the total equipment being made up as follows :—

10 stamps = 13 nominal crushing units	a total of 43 N.C.U.
1 tube mill = 30 nominal crushing units ...	

The power consumption was 150 h.p. (approximately) so that the production of one ton of − 90 required $\frac{150 \times 24}{260} = 13{\cdot}8$ h.p.-hours. Such a result has, of course, never before been reached on similar ore, but whether this is the ultimate capacity of the double stage crushing plant or whether better results may yet be expected must remain a matter for further investigation. One thing, however, is certain namely that a very considerable reduction in capital expenditure on future crushing plants coupled with a substantial reduction in operating costs can now be depended upon. The possible saving can best be realised by comparing the work done in the foregoing crushing test with similar tests made, by using stamps only, at the Kleinfontein G. M. Co.* This is done in Table XIII. with regard to power charges.

It will be seen that on the basis of the − 90 product the power consumption of the double stage crushing plant is not much more than half of that required in the single stage crushing plant, while if compared on the basis of tonnage milled, the cost of power in the double stage plant is only 75% of that for the single stage plant or a saving of 4·32d. per ton of − 90 and 1·87d. per ton of ore milled.

Comparing the capital expenditure of the two types of plant on the basis of these experiments the following results :—

Double Stage Crushing Plant; E.R.P.M. experiment :

1.	10 stamps at £260	£2,600
2.	1 – tube mill at £2,400 ...	2,400
3.	Portion of pulp elevating plant (£1 per ton)	260
4.	Extra for trebling mill ore bin ...	600
5.	Total	£5,860

* "The introduction of the heavy gravitation stamp," Trans. Inst. M. & M., Vol. XIX., p. 57.

† *Journal of South African Association of Engineers*, Vol. XV., p. 113.

‡ This *Journal*, Vol. XI., p. 168.

* Trans Inst. M. and M., Bulletin 75, p. 42; also this *Journal*, vol, XI., p. 248.

TABLE XIII.

Test.	Ore milled per day.	– 90 product.		Power consumption. h.p.	– 90 per h.p.	Percentage.	H.P. hours. per ton of – 90.	Cost per ton of – 90 at ·4d. per h.p. hr.	Cost per ton milled.
		%.	Tons.						
East Rand Prop. Mines ...	261·34	99·5	260	150	1·734	100	13·84	5·535d.	5·5d.
New Kleinfontein I.	200·0	74·8	149·6	153	·98	56·5	24·64	9·856d.	7·37d.
New Kleinfontein II.	1320	60·7	801·54	814	·98	56·5	24·64	9·856d.	5·98d.

6. Cost per ton milled (261 tons) ... £22·45
7. Cost per ton of – 90 product (99·5%) £22·54
8. Capital charges at 12% per annum, per ton milled amount to ... 1·89d.

Single Stage Crushing Plant; New Kleinfontein experiment No. 1 :

1. 44 stamps at £260 ... ... £11,440
2. Cost per ton milled (261 tons) .. £43·8
3. Cost per ton of – 90 product (74·8%) 58·6
4. Capital charges at 12 % per annum per ton milled amount to ... 3 69d.

Saving through Double Stage Crushing £5,580

It appears from the above that the capital cost of the double stage plant, after allowing for extra mill ore bin capacity and for extra pulp elevating plant is only half of that of the single stage crushing plant, quite apart from the fact that the pulp produced by the double stage plant contains 99·5% of – 90.

The saving in capital charges at 12% per annum would be £55·80 per month, or on the basis of 28·5 working days giving a monthly duty of 7438·5 tons, $\frac{55·8 \times 240}{7438·5} = 1·8$d. per ton milled. A comparison on the basis of the tonnage of – 90 produced is naturally still more favourable to the double stage crushing plant.

In order to be fair to both types of plant when making a comparison under the heading operating or working costs it will be necessary to determine what to include. In view of the fact that costs are kept in different ways on different mines, it is impossible to take collective figures as published in the periodical returns. However, as individual items can always be obtained and easily verified, it is proposed to build up the total operating expenses in this manner. Power costs have already been dealt with and amalgamating costs will be excluded as not being part of crushing expenses. Hence, there remain :—

1. Labour charges.
2. Spare parts and stores.
3. Maintenance and repairs.
4. Sundries.

The operating costs of stamp mills per stamp per day work out as follows (Appendix I.) :—

	Pence.
1. Labour	16·44
2. Shoes and Dies	9·51
3. Screens	3·00
4. Maintenance and General Stores	25·07
5. Water and Pumping ...	9·80
6. Assaying and Sampling ...	1·21

say 5·5s., or 5s. 6d. per stamp per day.

For tube mills, operating costs per tube mill per day will be as follows (Appendix II.) :—

	s.	d.
1. Labour	22	0
2. Liners	30	0
3. Pebbles	1	6†
4. Maintenance and General Stores	24	0
5. Assaying and Sampling...	1	0
6. Pulp Elevation	9	6
	88	0 = £4 8s. 0d.

†This allows only for the transport of the pebbles from sorting plant to tube mill plant (see Appendix II.) If the cost of picking pebbles is also to be allowed for, the cost of 2 natives at 3s. per day must be allowed, which adds 6s. to the daily running expense of the tube mill, or a total of 94s. against 88s., and the saving due to the double stage plant will be reduced from 8·218d. to 7·942d.

Comparing the plants we have :—

Comparative Statement of Operating Costs for Single and Double Stage Crushing Plants, excluding Power and Amalgamating Costs.

	Single Stage.	Double Stage.
Cost of operating stamps	44 @ 5·5 = 242·0 sh.	10 @ 5·5 = 55·0 sh.
Cost of operating tube mills... ...	—	1 @ 88/- = 88 sh.
Total cost per day...	£12 2s.	£7 3s. 0d.
Cost per ton milled (261 tons) ...	0·927 sh. = 11·124d.	0·548 sh. = 6·576d.
Cost per ton of – 90	1·241 sh. = 14·892d. (195 tons)	0·55 sh. = 6·6d (260 tons)
Saving per ton milled		0·379 sh. = 4·548d.

Collecting the results so obtained, we have the following statement :—

	Single Stage Crushing. Cost per Ton Milled.	Double Stage Crushing.	Saving due to Double Stage Crushing.
	Pence.	Pence.	Pence.
1. Working Costs	11·124	6·576	4·548
2. Power Costs ...	7·37	5·5	1·87
3. Capital Charges	3·69	1·89	1·80
4. Total Costs ..	22·184	13·966	8·218

Thus a saving of about 8·2d. per ton milled results.

The above saving of 8·2d. per ton milled by no means represents the total benefits to be derived from double stage crushing, as the chief advantage lies in the better extraction which can naturally be obtained from a pulp containing 99·5% of – 90 as against 74·8% of – 90. Of course, it is quite impossible to economically produce 99·5% of — 90 when crushing with stamps only, so that if such a fine product is required the single stage crushing plant need really not be considered at all. However, to show to the full the benefits resulting from double stage crushing by a combination of stamps and tube mills, a value will be placed on the extra work done in crushing finer corresponding with the gain in extraction thus rendered possible. In order to be quite safe in his estimate, the writer submitted the following query to a number of well-known metallurgists :

"What percentage of attraction would you expect in your cyanide plant when treating ore, crushed to the three different stages of fineness shown by the gradings I. to III. hereunder :—

Pulp.	I.	II.	III.
	per cent.	per cent.	per cent.
+60 product ...	2·5	9	17
—60 + 90 product	9·5	16	22
—90 product ...	88·0	75	61

It will be seen that the gradings here given represent the final pulp resulting from the crushing tests at the East Rand Proprietary Mines and at the New Kleinfontein, already referred to.*

Members will probably remember that when these results were published a statement was made to the effect that the gain in extraction due to the finer crushing by the double stage plant "*amounts to about* 1%," and may well ask how this does compare with actual practice. In reply thereto the replies received as a result of the foregoing query are given herewith :—

Name of Mine.	Estimated Percentage of Extraction. Pulp No. I.	II.	III.
Mine A, West Rand (Roodepoort)	93·9	93·0	91·8
Mine B, ,, ,, ,,	95·9	95·5	94·8
Mine C, Middle East Rand (Germiston)	95·0	91·7	89·2
Mine D, Middle East Rand (Germiston)	95·0	92·0	90·0
Mine E, Far East Rand, Boksburg)	95·0	93·0	89·2
Average	94·96	93·4	91·0

The gain in extraction between I. and II. is therefore ......1·56%, and between I. and III. is 3·96%, say 4%.

As we are comparing crushing results which have yielded 75% and 99·5% of —90, or a difierence of 24·5%, it is safe to estimate on a gain in extraction of 3·6% when treating the finer pulp, and for a 28s. ore, which is now the average of the Rand, the gain is exactly *one shilling*.

Adding to this the saving in working costs, capital, and power charges, of 8·2d., the total gain per ton milled due to crushing by a double stage crushing plant of 10 stamps per tube mill,

* Trans. Inst. Mining and Metallurgy, Bulletin 75, p. 42.

as against crushing by stamps only, will be 1s. 8d. per ton milled, which represents a very considerable increase in the total profit.

As in the foregoing remarks, so much depends upon a correct estimate of the probable extraction, it will be as well to support the statement by a few additional data obtained from actual practice. The diagram, Fig. XII., represents the result of the ordinary work at one of the mines from 1st April, 1909, to 31st December, 1910, or 21 months, and clearly shows that an increase in the percentage of —90 product is followed by an increased extraction. In the light of these data it is hoped that the assumption of an increase of 3·6% for an increase of the —90 from 75% to 99·5% will not be seriously questioned.

That fine crushing is essential to obtain a good extraction is obvious, hence the necessity of doing this efficiently and cheaply. It must be admitted that the results obtained by E. H. Johnson will be hard to equal by any other crushing machine, except perhaps a still more effective combination of stamps and tube mills. What the ultimate possibility of this combination is going to be the writer does not care to predict, but it is hardly likely that the point now reached will be the limit.

Having established the probable saving in working costs and capital expenditure in the milling and crushing plant of the double stage type as compared with a plant using stamps only it may be as well to compare the result with that obtained by modifying the sorting and breaking plant.

It will be remembered that in dealing with the influence of the modified sorting and breaking plant upon the whole reduction plant, the type of crushing plant used as a basis consisted of a multiple of 25 stamps and one tube mill, in fact 200 stamps and eight tube mills. It was then found that in the most favourable case the stamp mill was reduced in the proportion of 84 to 43·82, or to 52% of the former capacity, while the tube mill plant remained practically as before, changing only from 63 to 59·2 a reduction to 94% of the former capacity. Hence, the crushing plant will now be constituted as follows:

25 x ·52 x ·94 = 12·22 stamps per tube mill.

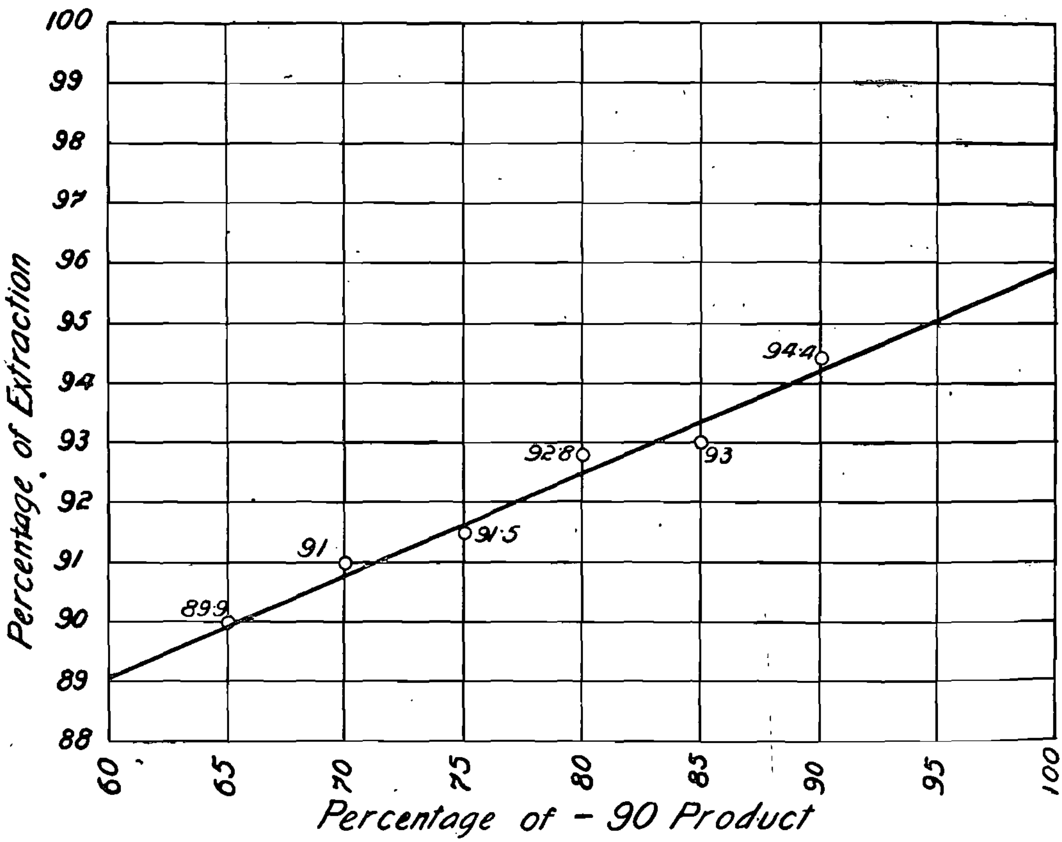


FIG. 12.—Diagram showing Probable Percentage of Extraction for Varying Percentages of —90 in Final Pulp.

It is clear, therefore, that although the milling plant on this basis is a considerable improvement on the average present day plant, it does not yet reach the standard set by the experiment at the East Rand Proprietary Mines, and used in the foregoing as the basis for comparing milling and crushing plants.

Although the saving resulting from a better design of the milling or crushing plant as such, cannot be merely added to that previously obtained by changing the design of the sorting and breaking plant, either result can be improved by a judicious combination of the two. Since the difference between the experimental plant of 10 stamps and one tube mill and the calculated plant of 12·2 stamps and one tube mill is not very great and will not change capital costs or operating expenses to any large extent, we need only consider the better extraction.

No allowance has previously, when dealing with the sorting plant, been made for the possible better extration due to finer crushing on the part of the modified plant, but in view of the result obtained by E. H. Johnson, it seems reasonable to assume that the finer crushing will result in an increase of 10% in the – 90 product, thus assuring a better extraction of probably 2%. This, on a 28s. ore is equivalent to ·56s. or 6·72d. per ton milled. Adding this to the saving of 1s. per ton milled (page 22, Table XII.) the total gain, compared with present day practice, is found to be 1·56s. per ton milled. If a comparison with a plant doing the milling in a single stage were possible, the saving would naturally appear even greater.

Considerable changes have recently been made in the amalgamating plant, as shewn in the paper by W. R. Dowling,* and by which a saving in both capital expenditure and working costs will be possible. No doubt, further information on the actual saving will be forthcoming so that there is no need to enter into a discussion of details.

Due to the efforts of Dr. Caldecott† the capital expenditure on the Sand plant can now be considerably reduced, while the introduction of the Butters Filter for the treatment of slime seems to guarantee a better extraction, if not a reduction in capital expenditure and operating costs.

The foregoing has been written not with any idea of dogmatising but in the hope that some useful discussions may arise which will help towards a solution of the one great problem in front of us—the reduction of working cost in order to increase the life of the mines on the Witwatersrand. That our old friends the stamp mill and the tube-mill have shewn such very much greater capacities when used in a more suitable manner, after being with us for a number of years, shows conclusively the enormous inertia in custom and thought on the Rand which is opposed to any change. One feels inclined to ask what would have happened if, on the advice of our self appointed critics with mysterious formulæ, tube-mills had been discarded and crushing by stamps only had been reverted to. Does it not appear likely that, far from the gravity stamp being the surviving part of the present crushing plant, it will have to go and make room for a machine capable of producing a $-\frac{3}{8}$' product more efficiently so as to still further reduce the cost of crushing. That further improvements in all departments are urgently needed a glance at Table I. will prove.

* This *Journal*, Vol, XI., p. 414.

† The Continuous Collection of Sand, this *Journal*, Vol. X., p. 43.

Concluding the writer wishes to thank you for the patient hearing and all those who have directly and indirectly assisted with the data used in these notes, a reference to the source of information having been made in each case.

Appendix No. I.

Operating Costs of Stamp Mills (excluding power)

Labour.—As a basis has been taken the labour force in an existing battery of 300 stamps, after eliminating the men doing purely amalgamating work. The number of men employed and their pay is as follows :—

6—White @ 18/6 per day,	111/-		
6—White @ 15/ ,,	90/-		
6—White @ 8/6 ,,	51/-		
28—Natives @ 3/ per day	84/-		
Per month...	£504	0s.	0d.
1—Fitter (2/3 time) @ £30 per month	20	0	0
1—Carpenter (whole time) @£30 per month...	30	0	0
1—Head Boss (half-time) @ £35 per month...	17	10	0
3—Shift Bosses (1/2 time) @ £30 per month...	45	0	0
Total labour per month ...	£616	0s.	0d.
Total labour per day ...	£20	11s.	0d.

Cost of labour per stamp per day 1·37s. = 16·44d.

Shoes and Dies.—The average cost per stamp per day of six mines, crushing over 250,000 tons, with 1,280 stamps, worked out at 9·51d.

Screens.—The average cost of this item under the same conditions, worked out at 3d. per stamp per day.

Maintenance and General Stores.—For the same six mines the average cost of this item per stamp per day was 25·07d.

Water, including pumping.—This item worked out at 9·80d. per stamp per day.

Assaying and Sampling.—This item came to 1·21d. pence per stamp per day.

APPENDIX NO. II.

Operating Costs of Tube Mills (excluding power).

Labour.—As a basis has been taken the labour force in an existing plant of 10 tube mills, after eliminating the men doing purely amalgamating work, but allowing for those engaged upon supplying pebbles of banket ore. The number of men and their pay was as follows:—

3—Whites @ 18/6 per day,	55/6				
3—Whites @ 8/6 „	25/6				
30—Natives @ 3/- „	90/-				
Total for 36 men per day	171/-				
Per month		£256	10	0	
1—Fitter (1/3 time) @ £30 per month		10	0	0	
1—Head Boss (1/2 time) @ £35 per month...		17	10	0	
3—Shift Bosses (1/2 time) @ £30 per month...		45	0	0	
Total labour per month ...		£329	0	4	
Total labour per day ...		£10	19	0	

Cost of labour per tube mill per day, 22/-

Liners.—A set of silex liners has a life of 70 days, and costs installed £105, hence the cost per tube mill per day is 30/-

Pebbles.—As pebbles ore picked in the sorting plant; only the cost of transport need be allowed for which on the basis of 6 tons of pebbles per tube mill per day and at 3d. per ton for transsport works out at 1s. 6d. The cost of feeding pebbles has already been allowed for under labour.

Maintenance and General Stores.—The average cost of this item for a number of plants has been found at 24/- per tube mill per day.

Assaying and Sampling.—Averaged under 1/- per tube mill per day.

Pulp Elevation.—The extra power required for elevating the pulp in the tube mill circuit on the basis of 400 tons of solids per tube mill per day, plus 3 to 1 of water, amounts to 120 K.W. hours, and on the basis of ·6d. per unit, this amounts to 6/- per tube mill per day. Maintenance of the pumping plant is estimated at an additional 3/6 per day, thus making the whole item 9/6 per tube mill per day.

The President: This is a great paper in more senses than one, and I am sure you will realise its importance, dealing as it does with the very life of the Rand.

Mr. E. J. Laschinger (*Member of Council*): I think Mr. Schmitt deserves the thanks of every member here and of those who will read this paper afterwards. It is a good thing to have a paper so full of references for actual use if one wishes to go into figures and criticise a paper of this kind. It is naturally a very lengthy paper, but I do not think Mr. Schmitt has drawn it out too long. It deals with a subject which has been considered by the engineers of the Rand ever since we first started to extract the gold from the ore and it will still continue to exercise our minds. I do not wish, of course, to discuss the paper to-night; that is quite impossible simply from hearing it read. It is a paper which lays itself open to a great deal of criticism, and I hope it will get the criticism it deserves. It will give everyone an opportunity of coming forward and giving us their opinions. I have much pleasure in moving a vote of thanks to Mr. Schmitt.

NATIVE FOOD SUPPLIES AND THEIR QUALITY.

(Read at January Meeting, 1911.)

BY F. W. WATSON, B.Sc. (LOND.), F.I.C., F.C.S. (Member).

DISCUSSION.

Mr. Jas. Gray, F.I.C. (*Member*): This being the first paper as far as I am aware, dealing with foodstuffs, which has been brought before the Society, I consider it incumbent on Mr. Watson's analytical brethren to come forward and show their appreciation of his efforts by contributing their quota to the discussion.

It is, I think, generally recognised that "the gentle art of sophistication" is practised on the Rand to as great an extent as elsewhere and the knowledge that an analytical control is being kept on the food supplies, as well as on other commodities supplied to the mines, will tend to check the progress of this objectionable custom. The many instances of adulteration given by Mr. Watson show that some kind of control must be exercised if a pure and unadulterated article is to be obtained, and it is satisfactory to learn from Dr. McCrae that the authorities are fully aware of the importance of the matter.

The figures given by Mr. Watson as representing the average analyses of mealies are typical, and I desire to contradict Mr. Pooler's assertion regarding the deficiency in nitrogenous principles of South African maize. If Mr. Pooler had studied the subject elsewhere and not relied solely, on Lyster's "Hygiene Advanced," his statement would never have been made.

In the *Transvaal Agricultural Journal*, Jan. 1906, pp. 359/60, H. Ingle gives the results of analyses of 10 samples of mealies grown at Potchefstroom and brings forward for comparison the mean of 154 analyses of American maize. The averages are:

	Potchefstroom Mealies. Per cent.	American Mealies. Per cent.
Moisture ...	7·18	10·95
Ash ...	1·43	1·45
Proteids ...	9·82	10·40
Fat ...	4·74	5·00
Fibre ...	1·87	1·95
Carbohydrates...	74·96	70·25

The proteids in the Potchefstroom samples varied from 9·00 to 11·62%.

The figures which Mr. Pooler produces for comparison with Mr. Watson's are the results of analysis of raw cocoa after the removal of the husk and cannot be compared with the author's which are representative of the commercial product.

In proof of this I will quote Allen's Commercial Organic Analysis Vol. III. Part II. p. 561: "The large proportion of fat in cocoa (averaging 50%) renders it impossible to manufacture a permanent preparation in the form of powder, without either removing a portion of the fat or diluting the material with some non-fatty matter, such as sugar, starch, or farina. Hence, there are two distinct types of 'cocoa' known in commerce, namely:

1. Preparations commonly called 'cocoa-essence" or 'cocoa-extract,' consisting of ground cocoa-nibs, from which a part of the fat has been removed by heat or pressure.

2. Preparations to which sugar and, generally, some starchy material have been added."

He further states p. 562: "In addition to the mechanical difficulty of manipulating undiluted cocoa containing all its natural fat, it is stated, with some probability, that the excessive proportion of fat renders the cocoa difficult of digestion. Hence the removal of a portion of the fat, and consequent concentration of the non-fatty constituents of the cocoa, appears to be distinctly advantageous." The brands of cocoa on the local market are similar in quality to those found on the home markets as a reference to any standard text book on 'Food Analysis' will show Mr. Pooler. Instead of the apparent deficiency of fat in the analysis given by the author being an example of the old saying 'Anything is good enough for the Colonies,' the deduction made by Mr. Pooler is a reflection on his own knowledge.

Notwithstanding the exception I have taken to certain of Mr. Pooler's remarks, I would like to congratulate him on a well written criticism, which deserves careful attention.

As stated by Dr. McCrae the Ordinance does not lay down the mode of expressing the percentage of alcohol in Kafir beer, whether it is to be by weight or by volume, and many of you will doubtless recall cases where the prosecution has fallen to the ground owing to the percentage of alcohol being over the limit by volume but under by weight. Personally, I am of the opinion that the practice in England of stating percentages of alcohol by weight should be adopted in this country.

The few Kafir beers I have examined at different times contained the following percentages of alcohol, and it will be noticed that only in one case would a prosecution have been successful:

	A.	B.	C.	D.	E.	F.
Alcohol, by weight ..	2·51	3·32	2·22	2·28	2·45	2·39
Do. by volume ...	3·15	4·15	2·78	2·85	3·07	2·99

It would, therefore, appear that my experience has, like Mr. Watson's, been more fortunate than Dr. McCrae's.

In closing, I would like to draw attention to the unjust manner in which the Public Health work is carried out in the Transvaal to the prejudice of the private analyst. As most of you are aware this work is carried out at the Government Laboratories and although no complaint can be made as to the manner in which the duties are performed, yet it is an instance of Government competition, and as such constitutes a serious hardship for the private analyst. The necessity for this branch of work being in the Government's hands has disappeared, as capable men can be easily obtained now; and in the second place it interferes with the satisfactory carrying out of the Food and Drugs' Act, as in the event of a private analyst appearing for the defence submitting that no adulteration has been found, the prosecution cannot proceed, whereas in the United Kingdom this is guarded against by the Government Laboratory acting as referee in cases of dispute. Here no such arrangement can be made as long as things go on as they are at present, and the third sample which is taken (supposedly for the referee) is a mere matter of form and a waste of sealing wax. To my mind this is a matter which the Council of the Society should take up, it being the only body in the Transvaal which represents analytical chemists.

I would again thank Mr. Watson for the excellence of his paper and apologise for having wandered into side issues into which, nevertheless, I have been tempted by the wide scope of his paper.

THE MINE DUST PROBLEM.

(Read at January Meeting, 1911.)

By Dr. J. L. Aymard (Associate).

DISCUSSION.

Mr. A. Purser *(Associate)*: There are a few points where the use of my "Dust Arrestor" affects the ventilation question and I would like to hear some discussion on the matter.

I will first proceed to describe it in the form in which it has come most prominently before mining men, namely, its application to drilling dry holes. In order to suspend this device from the working face in such a manner that all the dust coming from the hole must pass through it and go through treatment which separates the dust from the air, a tapered hollow cylinder, or cone, is driven into the collar of the hole. The portion of the arrestor in which the dust is treated is a downward branch leading from the hollow cone and has an opening which throws a spray of air and water within its upper end in a downward direction. This induces a current within the downward conductor and completely wets the dust before it reaches the atmosphere at the foot wall. The same water is used over and over again, thus reducing the quantity of water required.

The hollow cone is sufficiently large to allow the air to be drawn from the upper portion of the working place (as well as the dust from the hole) continually drawing fresh air into the point where the machine operators are breathing, and discharging it at the foot wall, thus assisting the natural circulation.

I may mention that catching and handling dust in its dry state will never get over the dust trouble. In any attempt to get rid of dust there are four points that ought to be aimed at:

(1). Keep the breathing line free from dust and moisture.

(2). Allow the machine man to see the hole he is drilling.

(3). Avoid a device that will compel the miner to waste time rigging it up and removing it when changing jumpers.

(4). Keep the working parts of the drill machine free from grit.

I would like to draw special attention to the latter. The life of a rock drill machine depends very largely on the care that is taken of the front head bearing, and it is a well demonstrated fact that machines working in a rise or other dusty place require reboring and new pistons more often than those drilling water holes, especially when a spray is continually used, therefore an effective dust arrestor will pay for itself in the economic maintenance of the rock drill machine.

A great deal has been said on the question of collaring holes, and my arrestor can be used for this purpose with very little rigging, but a machine will do more work with water than without it, so that as long as water can be used conveniently and without clogging the hole there does not seem to be any demand for a collaring device. But water cannot be used in a back hole after the first few inches.

Although the use of my automatic air saving cock will save a good deal of the compressed air produced on a mine, the question of economy of air is still one of the greatest importance and every mine manager looks for the greatest amount of work from the quantity of air at his disposal. My arrestor can be operated by exhaust or live air. Personally, I like the live air, because it continues to act when the machine is stopped and the jumpers are being changed, and the quantity of air used is probably less per foot drilled than in those dust catching devices which close round the jumper such as the author's and some of my own experiments. This can be illustrated by turning a small quantity of air on to the machine, and it will be found that a very slight pressure of the hand will stop the machine. Not only does the packing round the drill retard the working of the machine, but it makes it impossible for the miner to see that his drill is in line with the hole he is drilling. This leads to wearing away the sides of the drill and further retards the action of the drill, causing extra wear on the cylinder and piston.

The use of exhaust air has some advantages. There is a slight saving of air, the only drawback being that it is not continuous.

I may also mention that a test has been made with a new Butterfly valve Ingersoll drill without an arrestor and an old "Waugh" drill with a "Purser Arrestor." In the latter the air for both the machine and arrestor was taken from a $\frac{3}{8}$ in. nipple close to the machine. The Waugh finished in as short a time as the Ingersoll. I think this will prove that the amount of air used in these arrestors is hardly worth considering.

I find some difficulty in discussing the author's remarks on my device, because (contrary to arrangements made with the author) his remarks do not appear in his paper, or in any other publication, therefore I am only writing from memory and stand open to correction. He says that I told him I got my idea through seeing his collaring iron. I am sorry if any thing I may have said has led him to a conclusion which is so far removed from actual fact, inasmuch as my scheme from first to last is based on artificial circulation.

In my conversation with the author I congratulated him on his determination to press forward the advantage of allaying the dust at its source. But I had been making some little experiments in this direction long before I heard of the author, and six months before I heard of his device I made one on the same principle as his for a Mr. Perkins on the East Rand Proprietary Mines. I remember distinctly the conversation to which he referred. We talked more of construction than anything else, and I told him that I intended to make my arrestors of boiler tube expanded at one end. This scheme I have since abandoned as being too expensive, and I expect that within the next few months, with the extended use of these arrestors, we shall be able to fit up a plant which will turn them out at a price which will leave nothing to be desired.

In my device for allaying dust the draught is made to flow from the top of the drive down through a pipe until it comes out at the bottom, thus encouraging the natural tendency for the lighter and purer air to come into the working place close to the hanging wall and to return close to the foot wall. The author in his paper supports the theory, but omits to remark that this tendency is so mild that (without employing artificial means) it may easily be upset by the traffic in the working place or drive. I think it is quite reasonable to assume that a strong current of air passing through the working places of a mine will collect dust and other impurities, and will throw off those impurities wherever it slows down. In this manner a strong current will throw off its impurities at either side of its course into cross cuts where miners make up their charges, into dead ends of drives and stope benches. The main body of the air current carries very little dust with it, all the dust being in the fringe of the current. Therefore it is the duty of my device not only to separate the dust from the air at the dead ends, but also to draw a fresh supply of air from (as nearly as possible) the centre of the current so as to dilute the gas laden air in the working place.

I have read with interest Mr. Price Griffiths' discussion on the author's paper, and I was particularly interested in his remarks on spraying. A few years ago I tried some experiments for solidifying dust, using a solution of one part of unrefined molasses to about 99% water, and I find that it will go a long way towards meeting Mr.

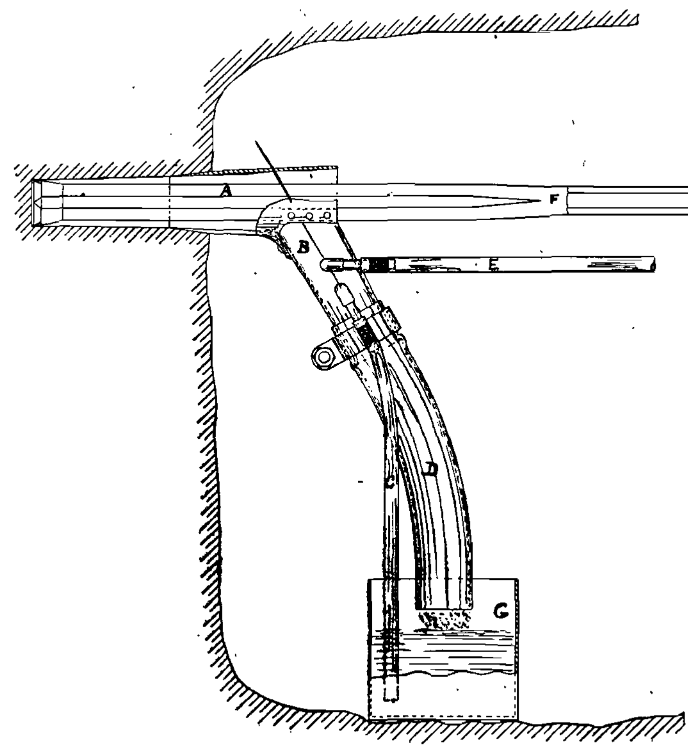


Fig 1

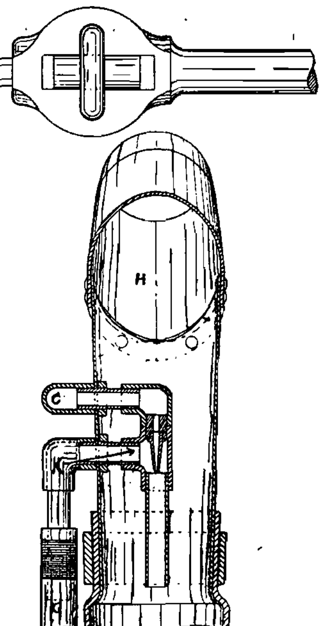


Fig 2

Price Griffiths' suggestion. I do not know what effect this mixture would have on the plates in the mill, but using it in such small quantity I do not think any bad effect would be noticeable. The mixture could be made in the tanks, or sumps, from which the water supply for the drives is taken and can be used with the "Hewitt spray" and also in connection with my dust arrestor.

Before closing, I must thank the management and officials of the East Rand Proprietary Mines not only for the opportunity they afforded for experimenting but also for their assistance in selecting the most suitable combination from the various alternatives.

The President: I am sure we must all thank Mr. Purser for coming here and giving us this very interesting demonstration of his device. Now that the Rand has two such simple devices for catching the dust we ought to hear no more about it if we can only compel the miner to use them. What we want is strict regulations.

Prof. J. A. Wilkinson (*Member of Council*): It was not my intention to say anything on the subject of this paper, but as this is the time set down for final discussion it may be better to make a few remarks now than postpone them to the period immediately preceding the author's reply. It will be remembered by many of you, that this subject, around which so much fierce discussion has raged, was first introduced to this Society by a paper read by Mr. Cullen in February 1903. Since that time very few slides of the actual dust given off by machines drilling into the banket have been shown. In October 1903 Mr. Heymann and Dr. Pakes showed specimens, the former from the actual lung of a miner who had died from the disease, the organic matter having been destroyed and the latter dust taken from a drive, the larger particles being removed by sieving. At the meeting at which the author read his paper, when it was unfortunately impossible for me to be present, your President showed you another slide of the dust taken from the author's dust captor. The slides, which I have prepared, were taken some time ago by the following method. A sample of pure glycerine, a substance which is used largely in microscopic work, was treated in such a manner as to be free from dust particles, being finally tested by the microscope to make certain that this was the case. This was enclosed in a bottle fitted with a tight rubber cork through which passed a glass rod dipping into the glycerine. Glass slides were cleaned carefully and whilst the drills were working in the ordinary manner, one was taken, a small drop of glycerine placed on it and an exposure to the dust made for a certain time. A clean glass coverslip was then pressed over the glycerine and the slide then brought into the laboratory for examination. Photographs were taken in the ordinary manner. I am sorry that we have not the lantern here this evening to show you the actual results obtained. This I hope to do at the next meeting. I may say, however, that these show the highly dangerous character of the dust, such as one would expect from a rock mass of the nature we have to deal with here, and from which any man, who has the least concern for his own life, should only be too ready to protect himself. I am indebted to Mr. J. Whitehouse, Manager of the Village Deep G. M. Co., for procuring these slides in the manner above mentioned, and also to my colleague, Professor Young, for the use of his micro-photographic apparatus.

There are one or two points furth r in the paper, to which I should like to refer. The first is the question of ventilation, and in this respect I think that air currents should not travel at too great a velocity, otherwise serious dangers are liable to arise from this cause alone, even assuming that such air is perfectly free from all dust. If not free from dust then it is obvious that the dangers, however great, would be increased due to the inhalation of dust with the air in quantities greater than is ordinarily the case. The contamination of such air in other ways is also a source of danger. Secondly the author states that "the medical aspect of the dust problem remains to-day very much as it did ten years ago." I am sorry to say that I agree with this statement and my sorrow is the more because we had hoped that some progress would have been made in this direction during the years since this question came prominently before us. Only once before have I discussed this question in this Society, and at that time I stated that there was a lack of medical research here on this matter. As far as I am aware very few histological investigations have been carried out, and hence we are not in a position to state what exactly happens to the dust when inhaled and passed below the bronchioles. How does it pass from thence to the infundibula, to the lymphatics and to the blood stream? Where is its final lodgment and how does it cause fibrosis? What is the part played by poisonous gases such as CO, NO_2, etc.? All these questions remain still a matter of conjecture apart from the conclusions which may be drawn from clinical evidence or mortality statistics. In short we may agree with the author when he states that it is quite clear that the pathology of the disease is still a matter for research, a question upon which, as a member of the medical profession, he is eminently qualified to speak. It is interesting in this connexion to observe the recent debates, which have taken place in the House of Assembly during the last few days on the Miners' Phthisis Bill now before Parliament. If memory serves aright, the Minister of Mines, in replying to the debate, stated that it was his intention to appoint medical officers for this particular work. Such a step will be heartily welcomed and will, we hope, serve to bridge the gaps mentioned above. Much of the work must, as the Minister stated, be of a confidential nature, but research into the causes and course of the disease should be open to full discussion, since otherwise the possibility of drawing erroneous conclusions cannot be avoided. It is therefore sincerely to be hoped that, during the next few years, the pathology of this disease will be considerably elucidated. One problem which calls for solution is the number and kinds of bacteria present in mine air, and a bacteriological survey of any mine would yield most valuable information, more particularly as to the prevalence of ordinary phthisis as compared with silicosis, and as to whether the dust formed a means whereby bacteria were absorbed into the body in large numbers.

Mr. A. J. R. Atkin (*Member*): Towards the end of the year, when those plants installing Butters filters are completed and in running order, a quantity of calcium chloride solution will be available for using in sprays and for damping rock before shovelling.

As this is produced as a by-product from cleaning the leaves, it will alike assist the reduction works with a credit balance and the mines with a cheap dust allayer.

PROFIT PER FATHOM.

(*Read at February Meeting, 1911.*)

By R. E. Sawyer, A.R.S.M., A.I.M.M (Associate).

DISCUSSION.

Mr. A. Richardson (*Member*): The fathomage system was so comprehensively criticised in the local press at the time of its proposed introduction that the author is to be congratulated on being able to present some of its features in a new and attractive light. The position he takes up will be considerably strengthened if he gives us in his reply some favourable data taken from actual practice, as figures compiled merely as examples, though a stimulus to discussion, lead to hypothetical conclusions foreign to the temperament of the practical mining man. The tables he gives might repay study if one had leisure enough to dissect them; but it is extremely doubtful, for the reason mentioned above, if such an analysis would be very helpful. It may be noticed in passing, however, that the compressor charges in Table I are distributed proportionately to fathoms, irrespective of stoping widths, apparently on the supposition that the drilling of a fathom consumes the same quantity of air no matter what its stoping width may be, an obviously unfair assumption. It would also be interesting to know whether the additional cost of shovelling in the narrow stopes is duly reflected in the cost per fathom; and also if 122 in. is not an extraordinarily large average stoping width for ordinary machine stopes, even after the hammer and small machine stopes have been eliminated. In Table III a stope 143 in. wide assaying 2·4 dwt. shows a profit of 24s. per fathom or 1s. 6d. per ton mined; this excellent result seems to merit a special investigation, for, if correct, it means that the potentialities of the Rand as a gold-field are not fully realized.

Regarding the value of waste, the writer once, out of curiosity and in the interests of science, took representative samples of all the partings and of the hanging and foot in every stope in a mine. The average value worked out at about 0·3 dwt. per ton, and there were no payable values shown. The band of micro-quartzite, commonly known as "black bar" or "interbedded dyke," to which the author refers, immediately underlies the Main Reef leader in the mine in question, and though, as a rule, it never carried more than 1 or 2 dwt. it, on one occasion, furnished quite a respectably sized patch which averaged 10 dwt. over a width of 18 in. This of course was stoped and sent to the mill. Occasionally also it paid to get stoping width by breaking into the black bar, so that the unsortable waste fines should carry something; but as an excellent footwall for breaking to was lost by this practice, and as the black bar was tougher than ordinary quartzite, the extra cost of breaking the ground perhaps counterbalanced the very slight increase in grade. The suggestion that the screen assays should be checked by working out the daily grade for the whole mine would, if acted upon, furnish only a rough estimate, useless as a check, as the variations in stope value are not determined by daily, but by monthly sampling: the statistical work involved would also be considerable.

Speaking generally, the square fathom principle may have its uses in certain technical estimates, but as it requires specialized knowledge to grasp its import it will never commend itself to investors, who are commonly laymen in such matters. The system does not seem to offer any advantages over the present system when employed for drawing comparisons between results obtained during different periods in the same mine, more especially if the ton mined is employed as the unit. Its range of applicability is small as it cannot be used for expressing the results obtained from diamond pipes, very wide reefs, irregular impregnations, masses, and so on. It would, however, appear to find its truest application in coal mining where the exceptional regularity of seam should lend itself admirably to the expression of results on the square fathom basis; indeed it seems strange that a principle of such supposed merit should never have been considered by the capable organisers of that old and well conducted industry. In the statement of ore reserves, again, the square fathom cannot be adopted, for, being a variable and not an absolute unit, the number of square fathoms of ore in reserve would afford no indication whatever of the life of the mine and therefore would convey no hint of its commercial possibilities. In all statistical presentation, results must, in any case, continue to be given on the tonnage principle, as a concession both to the unenlightened public and to those enlightened ones who are opposed to the suggested innovation; consequently, the new system, if adopted, would necessitate double statistical work. On the practical side, the tendency would be towards selective mining, as low grade reefs in the hanging or foot, which can be shown to produce a profit under the present system when broken with the rich leaders, would, in many cases, be allowed to remain unbroken so that the profit per fathom might be made as large as stoping conditions would permit; the grade of the ore would be raised, but the life of the mine would be considerably shortened, and this doubtful result could just as easily be brought about under the present system, if thought desirable.

PRACTICAL NOTES ON COAL.

(*Read at February Meeting, 1911.*)

By Michael Dodd (Member).

DISCUSSION.

Mr. R. Gascoyne (*Member*): It must be admitted that this paper has dealt with the subject of coal from numerous standpoints, but its value has undoubtedly to some extent been sacrificed by the general, rather than the detailed, manner in which the subject has been dealt with.

For instance, the author begins by saying that in his young days it was estimated "that a colliery might be expected to consume in its own boilers about 10% of its output, but in less than a generation an enormous change has come about and the engineer of to-day is never worth his place unless he knows a great deal more about the character, source and cost of his power supplies, than the colleges were in the habit of teaching five and twenty years ago." Now a statement like this might be perfectly true of a few isolated collieries in Northumberland and Durham, where they use antiquated boilers and equipment and perhaps handle in an expensive way fair bodies of water, but outside Northumberland and Durham, to which the author probably refers, no engineer who allows 10% of the output to be used for colliery consumption would be considered worth his place even thirty or forty years ago. But then Northumberland is the cradle of coal mining, and up to a few years ago, at all events, several prehistoric mining equipments were in regular use, which no doubt would tend to a high consumption, whilst likewise, several collieries do considerable pumping still, but to make a statement that say thirty or forty years ago a colliery might be expected to consume 10% of its output ought certainly to be qualified and made to apply in a few instances where unusual conditions prevail. Then again it ought to be pointed out that in the author's young days as to-day, the English collieries only consume under their own boilers the inferior portion of their output which it is impossible to sell, which, of course, will add to the percentage of the output consumed. The fine coal such as that generally consigned to the waste heap in the Transvaal and the refuse from the washery is generally used under the colliery boilers, but even then any decently equipped colliery, even twenty or thirty years ago, would not use anything like 5% of its output, and in most instances the consumption would be in the neighbourhood of 3% where the output was anything like a thousand tons a day and for a greater output the consumption might be less. In the Transvaal the colliery consumption runs from 1% to 5% of the output, the latter covering unusual conditions such as do not ordinarily prevail at local collieries.

With regard to coke it is generally admitted that, whilst nearly all coals will make coke, it requires a coal much less in ash than the best Transvaal coal yet found, to make a really first class coke, and besides, a coal that will coke readily ought to contain about 4% of free hydrogen. Roughly, we may consider that coking a coal doubles the percentage of ash, so that any coal from which it is desired to make a saleable coke ought to have less than 5% of ash before being put into the oven, and it is doubtful whether even after washing the best coals of the Transvaal they can be sufficiently reduced in ash contents so as to make a really first class coke, even if the other necessary conditions were present.

The author's statement on p. 362, that Middelburg coals with volatile contents from 22% to 24% may be expected to give the best results as steam coals, is too vague and loose to be taken as a good definition of a steam coal as there are other constituents besides ash and volatile contents to be considered. There is, for instance, the coal this side of Oogies in the Middelburg district with 22% of volatile matter but so inferior for steam or heating purposes that its evaporative value is only 8 as against 12 for the best steam coal in the Transvaal. To be able to judge the quality of coal for any purpose it is necessary to know the whole of its contents, not ash and volatile only—a coal may carry 15% ash and 23% volatile matter according to the author's standard of what a good Witbank steam coal ought to be and then be so lignitic in quality as to be worthless as a steam coal. There are numerous instances of this even in the Transvaal. For an ideal steam coal in the Transvaal the following rough composition would be better: Fixed carbon 70·%, volatile matter 20·%, ash 10·%.

The author, at the conclusion of his paper, recommends the American system of making contracts for the purchase of coal by which payments are made on the ash factor plus calorific value, and says "that such conditions appear sound and are certainly effective." Now, as a matter of fact, such conditions of making a coal contract are neither sound nor effective, unless they include a minimum clause, a recent instance having occurred where such conditions were embodied in a contract and enabled the seller to dispose of the whole of his dump and waste heap at an excellent price, thanks to the adoption of the American practice, although under the ordinary conditions of contract the coal was unsaleable and had gone to the dump for the last two or three years.

THE AMALGAMATION OF GOLD IN BANKET ORE.

(*Read at March Meeting, 1911.*)

By W. R. Dowling, M.I.M.M. (Vice-President).

DISCUSSION.

Mr. E. J. Laschinger (*Member of Council*): I will open my remarks on this paper by a few carping criticisms, and trust the author will not take them amiss.

Referring to line 1, amalgamation is a method or means of gold recovery and not a "source."

In paragraph 2 the author seems to speak of a minimum of simplification being necessary in plant and operations—he surely does not advocate a maximum of complication.

In paragraph 3, the author in referring to Rand gold ore milling practice before cyaniding came in says that the screens mostly in use were from 800 to 1,000 holes per square inch; my own recollection is that they were more commonly from 1,000 to 1,600 mesh.

Regarding the author's remarks on pulp elevation in relation to the various schemes of working, I am afraid that the author has missed the most important point in regard to this matter. The chief factor generally determining the number of times pulp has to be elevated and the amount of lift at each elevation is the surface contour on the site of the plant. That the process of ore reduction and gold extraction adopted will to some extent influence the pulp elevation is, of course, admitted. All known methods require some kind of scheme of flow, and the simplest sequence of processes will, as a rule, require the least pulp elevation, other things being equal. My point will perhaps be best illustrated by referring to the author's diagrams. It is evident that if in arrangement A the first elevation were higher so that the pulp could flow to the point of delivery of the second elevator its flow diagram would be similar to B. Or if the author had drawn in on B the second pulp elevator to the cyanide plant as it actually exists at the Simmer and Jack, he would have had the same flow system as the Randfontein Central.

Again, if in arrangement C, which represents the City Deep plant, the first elevator were slightly lowered the return from the tube mill plates could gravitate to it, and the second elevation would disappear and be similar to arrangement B (Simmer and Jack). In point of fact this scheme C thus modified represents the arrangement at the Bantjes Consolidated Mines. The arrangement at the City Deep was made different from the Bantjes, because in the former case the ground is very flat whereas in the latter there is a rapid fall. It was solely this difference which influenced the design at the City Deep. If a single elevation had been decided on, the lift would have been so great as to cause most undue wear and tear on the pumps and much trouble all round. As it is, the elevation was purposely split in two, with the lift in the second pump higher than in the first. It is interesting to note as the result of the experience in actual operation, that with the first pump elevating coarser particles at lower lift, and the second handling a finer product at greater lift, the combination is so well balanced that the liners in both pumps last for equal lengths of time.

In the author's proposed arrangement E he has very conveniently placed his stamp mill high up in the air, or else sunk his tube mills and plates deep into the ground, thereby saving one pulp elevation. His scheme, as applied to almost any mine on the Rand, would involve a pulp elevation from the stamps to the tube mills, or else very expensive excavations or foundations.

In considering pulp elevation one must not forget two other things, the elevation of the ore to the mill bins and the re-elevation of return water from the tail to the head of the plant. The whole flow scheme, as far as the engineers' designs for mechanical handling in ore reduction plants are concerned, commences at the pit mouth and ends at the residue dumps. Enough has been said to show that Mr. Dowling has made rather too much of saving in pulp elevation as affected by methods of amalgamation of gold.

From the standpoint of obtaining ideal conditions in ore reduction, which ideal I think could and should be attained, all the schemes outlined by the author are at fault. I refer more particularly to the reclassification of tube mill pulp. We do not reclassify battery tails for the purpose of returning the oversize back to the mill bins to be restamped, and the principle of returning a large percentage of tube mill tails back to the mills is fundamentally wrong. The amount of returns is, I believe, very much greater than is generally realised, and unsatisfactory classification is one of the most important evils which is aggravated thereby.

Another point affecting the elevation of pulp is that in all Rand practice to date a great deal of unnecessary elevation of pulp is done because of considering the stamp mill as one unit and the battery of tube mills as another independent unit. All the pulp is gravitated to one point from 200 and more stamps, and this with steep grades of launders means a very considerable loss of height. The pulp has again to be redistributed from one point to the heads of the tube mills again at grades even steeper than in the mill launders and re-collected at the tails of the tube mill plant with more loss of height together with a return launder again to the stamp mill pulp elevator. In this matter, using the words of the author in another connection, we are also following ideas imbibed from ancient practice when ore reduction plants were small and grades of launders comparatively flat. The alternative is to treat a certain number of stamps and one tube mill as an independent unit, thus saving unnecessary pulp elevation and what is much more important making classification, what it should be, simple and effective. Such an arrangement in combination with crushing and fine grinding in one pass through the combined apparatus forms an ideal scheme, and the amalgamating plates can be placed where most desirable, whether up in the air, on the ground or in an excavation. I trust I have not wandered too far away from the subject matter of the author's paper in discussing the above points.

The author's point that fine free gold in the sand is not recovered in the same proportion as the average extraction by cyanide treatment of the whole sand charge is well taken.

The locking up of gold on amalgamating plates is not an argument in favour of cutting down the total plate area to an absolute minimum : it is only an incidental advantage or on argument in favour of not having excessive plate area. The amount of plate area should solely depend upon the capacity of the surface to catch such gold as cannot be so efficiently recovered by cyaniding.

From the author's remarks on flow over plates, as regards velocity and depth of the pulp stream it would appear that what is known as turbulent flow has as much or more to do with bringing particles of gold into contact with the amalgamating surface than the idea of giving the heavier particle of gold time to sink to the bottom of a more quiet stream. It is well known that most gold collects where there is fall or impact of the stream against the plate.

The author says he "considers that sufficient importance is not attached to launders." I think the subject has received a good deal of attention in recently erected plants. As an example with which I happen to be familiar, I might refer those of an enquiring turn of mind to the pulp launders at the City Deep. Here all main launders in the mill and from the shaking tables are formed in solid concrete, and all main overhead launders in sheet steel concrete-lined. There are a few straight distributing launders of wood, lined with bitumen sheeting. When the author recommends "cement" for lining launders it is presumed that he means fine concrete in Portland cement.

Although the author deprecates amalgam traps, the advisability of having these rests upon two grounds. In a system where there is a tube mill return the trap is not so necessary as in a system where there is no return. The trap in the latter system would of course be advisable to catch coarse amalgam which would have no chance of being caught again. But even when there is a return the so-called amalgam trap is useful in catching particles and pieces of iron and eliminating them from the circuit. This is especially important in view of the economic failure of most magnetic separators that have been tried on the Rand. In fact it is a question if an iron catching trap should not be installed in the mill launders to avoid the trouble frequently experienced owing to pieces of iron having lodged in the delivery to the tailing pumps and also choking classifiers. There is also the problem of black sand which is caught in traps. Does the author also maintain that the gold in this would be as efficiently extracted in the ordinary treatment of the main plant as in the special plant such as is referred to by Mr. Allen in his paper on Air Agitation, or does he consider that all the so-called black sand is caught on the plates when scraped when there are no traps?

With regard to shaking plates *versus* stationary plates it will be interesting to note what the results will be. It is for the metallurgist to say which is the more efficient and economical, and to thresh out the arguments as to what are the real principles underlying shaking plate amalgamation, and under what conditions they could be used with advantage over stationary plates.

Our thanks are due to the author for bringing up for discussion this subject of amalgamation plate area, and for his compilation of data on this subject. It is to be hoped that all Rand metallurgists who have conducted experiments and collected original data on this practical problem will come forward and publish their results.

Mr. Mather Smith (*Member*): Mr. Dowling's paper is just what was wanted, especially by the outside districts, in that it gives comparisons of the different methods of classification adopted by the various Rand groups of mines

On this, the Worcester G. M. Co., in the Barberton district, we require a specially good classification as the gold is silica-encased, and the +60 in the cyanide residue frequently assays over 2 dwt. Six vats which had an average charge value of 2·9 dwt. gave, after over nine days treatment, the following average values in the residues:

+60 = 1·85 dwt.
+90 = ·95 „
−90 = ·38 „

It appears to me that to try and understand the work done in a spitz, or cone, one should try and imagine oneself to be a particle of +60 struggling to get down through a mass of −60, or as a fine particle of −60 trying to squeeze up through many particles of coarser sand. The particles must have time to separate out properly, and this they cannot do in the series of spitz shown in the author's sketch D. or common arrangement.

When one of the nozzles on this Eiffel-Tower-like spitz chokes up, the first person to notice it is frequently the boy in the sand collector, and by the time the nozzle is cleared there is often quite an appreciable quantity of coarse sand in the collector. With Mr. Dowling's proposed arrangement the shiftsman will be able to see at a glance by simply examining the pulp issuing from the safety-cone, exactly what is going to the cyanide plant. At present he has to climb up a precipitous ladder, a feat which he is not likely to perform any oftener than he can help, and further, a cursory examination of the whole stream is not likely to give one much idea of the grading of the sand pulp.

One objection I have heard to the idea is this: That the +60 caught in the safety cone would accumulate in the circuit and overflow to the cyanide plant before the tube mill shiftsman had time to rectify things. To this I reply that this +60 would continue, for quite an appreciable time, to replace −60 which otherwise would unnecessarily be going through the tube.

The dewatering cone in the common arrangement I could never, with my limited experience, quite see the necessity of. It has always appeared to me that a 12 in. pipe throttled at the bottom would have done equally well. I notice that two diaphragms are now being put in cones. I would be inclined to prefer an idea of Mr. Chas. Dowsett of the Knights Central. He, I am informed, intends trying the efficiency of a plate, with a hole in the centre, in the position of the second diaphragm, and this, I should think, would make the route of the pulp more tortuous than two diaphragms would do

I have never noticed any paper or remarks on another problem, namely, at what size of screening the amalgamating plates in front of the mortar boxes cease to give efficient results, and think some such paper would be of great use to the outside mines.

AIR LIFT AGITATION OF SLIME PULP.

(*Read at March Meeting, 1911.*)

By Robert Allen, M.A., B.Sc., M.I.M.M. (Member of Council).

DISCUSSION.

Mr. E. J. Laschinger (*Member of Council*): Mr. Allen's paper is an interesting compilation of the history of and present practice in air agitation of pulp as applied to metallurgical processes.

In criticising this paper there are various points of greater or less importance that may be touched upon, but in the most important question raised—air lift versus mechanical agitation—the author has missed the real point. He has failed to differentiate between agitation as the simple aim in keeping ore particles in suspension in a fluid and agitation as a means of intimately bringing into contact ore, chemical reagents and air so as to thoroughly facilitate certain chemical reactions.

If the problem on the one hand is simply to bring particles of ore into thorough contact with cyanide solution, or to keep ore from settling in water or solution, or on the other hand to also bring air for the purpose of supplying free oxygen to this intimate mixing process, the two cases are not on a par when considering simply the most economical means of agitation. All the above cases arise in practice. If air be necessary as a chemical adjunct, it is of course self evident that subsidiary mechanical stirring is superfluous if the air itself by its method of introduction can perform the mixing at a reasonable cost without other aids.

The author has not proved his case in favour of air agitation in a satisfactory manner, because he has not even attempted to differentiate between the various cases above mentioned. Even his figures on power required for air agitation are not reliable, or perhaps one should rather say are not consistent. This I will endeavour to prove.

It requires a certain amount of power to compress air, and the amount of this power can be accurately determined. The theoretically minimum work required to compress air from atmospheric pressure to any other pressure is by isothermal compression, *i.e.*, without rise of temperature during the process. The work thus required to compress a cubic foot of air is :—

$$(1)\ \text{Work in ft. lb.} = 144\ P_a \log_e \frac{P_1}{P_a}$$

Where P_a is the absolute atmospheric pressure in lb. per sq. in., P_1 is the absolute pressure of compression, *i.e*, gauge pressure plus atmospheric pressure, say, $P_g + P_a$.

The horse power required per cub. ft. of air at atmospheric pressure compressed per minute is therefore :—

$$(2)\quad (\text{H.P.}) = \frac{144\ P_a}{33{,}000} \log_e \frac{P_1}{P_a}$$

For conditions at sea level with a barometric pressure equal to 14·7 lb. sq. in., we have :—

$$(3)\ (\text{H.P.})_S = 0{\cdot}0642 \log_e \frac{P_g + 14{\cdot}7}{14{\cdot}7}$$

For conditions on the Rand with average barometric pressure equal to 12·1 lb. sq. in. we have :—

$$(4)\ \text{H.P.})_R = 0{\cdot}053 \log_e \frac{P_g + 12{\cdot}1}{12{\cdot}1}$$

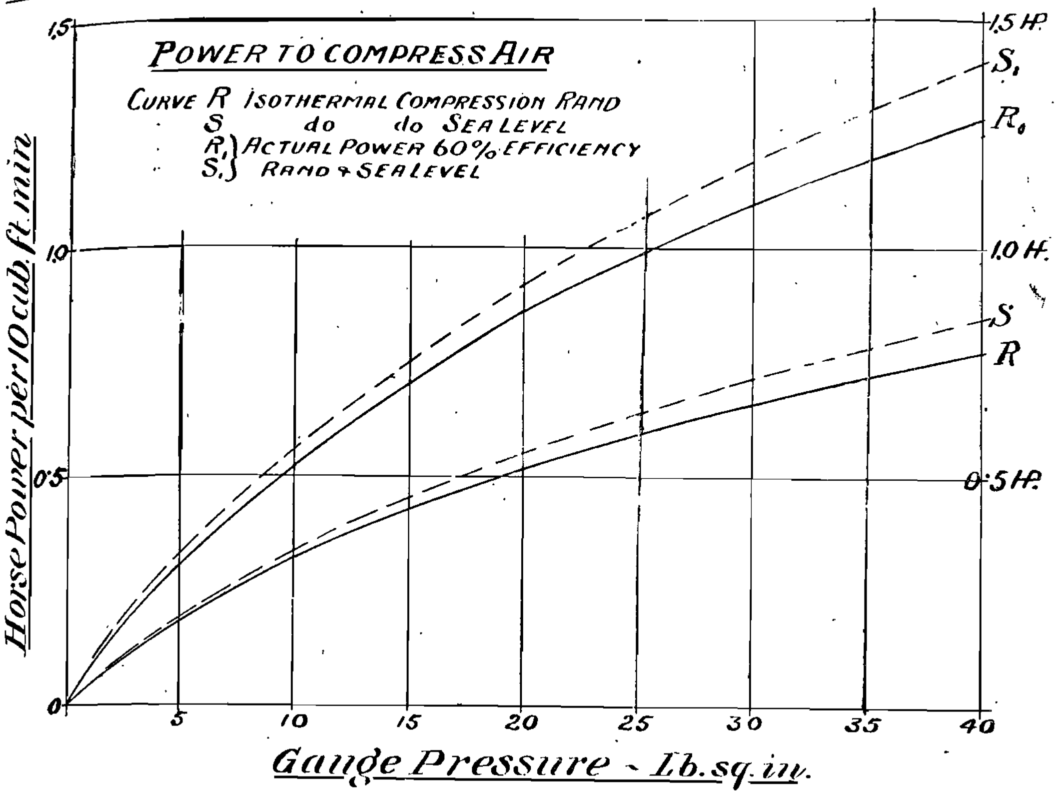
The above give the theoretically minimum figures of power required. In practice there are power losses in compression, friction losses in the motor and compressor, heat losses in compression, and leakage losses past valves and pistons. The over-all efficiency of small compressors is probably not more than 50%; even in large compressors the total efficiency will not be much greater than 65%. Assuming the favourable figure of an all-round efficiency of 60%, the actual power required will be $1\frac{2}{3}$ times the figures given by formulæ (2), (3), and (4). In the diagram herewith I have shown curves from which the power required to compress 10 cub. ft. of air per minute from atmospheric pressure to gauge pressure up to 40 lb. per sq. in. Curve S shows the theoretical horsepower required at sea level, and curve R the same for average Rand conditions; curves S_1 and R_1 the corresponding power with an over-all efficiency of 60%.

Before using this diagram to criticise certain figures quoted by Mr. Allen I crave indulgence for a digression in order to point out a few characteristics of air agitation. A glance at the diagram shows that it requires less work to compress a cubic foot of air at atmospheric pressure (generally called "free air") to any given gauge pressure on the Rand than at sea level. If we assume that the amount of work got back from the compressed air in stirring the pulp is the same percentage of the work put into it in the two cases, the conclusion is that for the same amount of agitation more volume of free air would have to be used on the Rand than at sea level to produce the same mechanical effect. The amount of air used on the Rand would have to be increased in inverse proportion as the work per cubic foot is greater at sea level than on the Rand.

If a certain amount of air be required to satisfy chemical reactions, then the air required must be measured by weight and not by volume. Since air at sea level averages 13·2 cub. ft. per lb. and on the Rand 16 cub. ft. per lb., it follows that in order to deliver the same weight of air $21\frac{1}{2}$% more volume of free air must be compressed on the Rand to furnish the weight of air that would be delivered at sea level. For this case, therefore, the amount of power required would also be greater on the Rand than at sea level. Curves of power required for equal weights of air delivered would on the diagram show the R curve above the S curve. In general the above reasoning is true for different altitudes.

It may also be of interest to discuss the point as to how much of the power put into the air is really effective as mechanical work in agitation. Air agitation in a Brown vat with the central pipe is the reverse of hydraulic air compression. In tests made on this form of compression the the over-all efficiency ranges between 70% and 80%. It may be assumed that the same ratio holds good in air agitation. The over-all efficiency of air agitation from work in the motor to agitation in the vat is therefore, say,

$$0{\cdot}60 \times 0{\cdot}75 = 0{\cdot}45 \text{ or } 45\%$$



Taking now the author's first table of average results of experiments by F. C. Brown as given, and assume for argument sea-level conditions, we have the following comparisons, taking the quantity of air used as correct:—

1st case	h.p. per table $\frac{3}{4}-1$	from diagram	1·1 – 1·4
2nd ,,	,, ,, $\frac{1}{3}-\frac{1}{2}$	,,	0·4 – 0·6
3rd ,,	,, ,, $1\frac{1}{2}-2$	,,	1·6 – 2·2
4th ,,	,, ,, $1\frac{3}{4}$	,,	3·9

In the fourth case the theoretical horse-power required works out at 2·4, therefore the amount of power quoted, namely, $1\frac{3}{4}$, may be dismissed in certain familiar words of our old friend Euclid.

In actual practical design of plant I would make even a liberal allowance on the power required as found from the diagram.

With regard to the author's question of the power required by the Pachuca system (Reference No. 8), I find on looking up this article that there is simply the bald statement that "pulp containing 100 tons of dry slime to 150 of solution can be treated with $4\frac{1}{2}$ h.p."

Figuring out the probable power consumption for the air lift agitation in the Luipaard's Vlei plant as quoted by the author, say, 85 cub. ft. of free air (presumably per minute) at between 25-30 lb. sq. in. gauge, we have from the diagram 8·3 to to 9·3 h.p., probably 9-10 h.p. in actual practice.

The above discussion proves that either the horse-powers as quoted by the author are wrong, or that the quantities of air as given are not correct. From my own experience in this matter I would judge that the quantities of air are the more correct.

In discussing the author's remarks anent mechanical stirrers, such as "clumsiest constructions," the necessity of "digging out the paddles after a short stoppage," it might be pointed out that mechanical devices need not be clumsy, and paddles need not be dug out if the machinery be designed properly.

Mr. Kniffen, in "Methods of Pulp Agitation" (author's reference No. 8), says that "if the ore only requires that fresh molecules of cyanide be brought continually to the particles of metal, and that the air which is included in the solution be sufficient for the reaction, there is no system at present better than arm agitators, raised a few feet above the bottom of the tank, and driven at 800 linear feet per minute." Presumably he means 800 ft. min. at the outer ends of the arms.

In these remarks I am not advocating mechanical stirring gear as against air agitation, but submit that in the present state of knowledge one may preserve an open mind on these questions, since there is no doubt but that mechanical devices and air agitation have each their sphere of usefulness in metallurgical processes. The author tries to make his case for air agitation so strong that he seems to have closed his eyes to any advantages of mechanical gear. While I do not wish to pose as an advocate for the other side only, I maintain that there is reasonable doubt as to the accuracy of the power figures quoted for air agitation.

Simple circulation or stirring of pulp could be carried out economically as regards power and wear by means of a centrifugal pump specially constructed and used for that purpose only. As an example, it would be possible to turn over the whole of the pulp in the Luipaard's Vlei vat every 50 minutes at a cost of no more than 6 to 8 h.p.

The trouble in the past with most centrifugal pump circulation and agitation has been that the pump has been used for other purposes beside circulation, as, for instance, in transferring charges against fairly large heads. The pump was necessarily speeded up to deal with the maximum head, and is therefore very wasteful of power when circulating. The wear and tear on the pump also increases at a more rapid rate than the increase in speed. The over-all efficiency of a low lift circulating pump, motor and piping system should be about 50%.

I am rather of opinion, however, that the whole question as regards air agitation vs. mechanical agitation will turn more on maintenance and capital cost than on power cost.

With regard to the general results found by F. C. Brown (4th paragraph), we read :—

1. "The higher the tank compared with the diameter the less the power required."

This statement is incomplete, the probable meaning being that this is true only for equal weights of pulp handled. The statement then falls into line with theoretical considerations. For if the height be doubled the same volume of free air is still only required for agitation at slightly less than double the gauge pressure. This means that the absolute pressure is not doubled, and as the work required does not increase at the same rate as increase in pressure, but only as the logarithm of the pressure ratios, considerably less power per ton of pulp treated is required.

In conclusion (2), regarding less cyanide consumption with deep than shallow vats, this result may also be expected to follow partly from the argument as in (1), but also because in a deeper vat, owing to the higher pressure of the air, chemical action between the air, the cyanide, and the pulp is more rapid, and the total time of reaction is thus also reduced. On the law that the intensity of chemical reaction is proportional to the mass density of reagents present, it follows that doubling air pressure doubles its density, and the total time is cut in half. Less total air per weight of cyanide present will be required, since only a very small proportion of the total oxygen supplied is really used up by the cyanide, and so again there will be less loss of cyanide by oil, etc., which is carried by the air supply.

There is, however a very practical point to be considered in fixing the total height of a vat, that is the expense of filling the vat by pumping, because, theoretically even, only half the work done in pumping the vat full can be regained in emptying it, and in practice generally the whole of this power is lost. There is also to be considered the extra cost of building very tall vats strong enough and furnishing suitable foundations to withstand the heavy strains, wind pressure, etc.

It may be mentioned here that a good practical rule of thumb in regard to pressure of air required is to take the figure representing the total depth of the vat in feet and divide this by two, which will give the lb. sq. in. gauge pressure required. For example, overall depth 40 ft. requires gauge pressure 20 lb. per sq. in. If air be used at a pressure much greater than that so calculated there is bound to be a serious waste of air, and probably inefficient circulation.

The maximum amount of cooling of the pulp charge due to the expansion of the air used can be readily calculated. If air be allowed to expand while doing work and no heat is added or abstracted during the process the ratios of the absolute initial and final temperatures is given by the expression.

(5) $$\frac{T_a}{T_1} = \left(\frac{P_1}{P_a}\right)^{\frac{2}{7}}.$$

T_a is the initial absolute temperature (°F + 461) and T_1 the final temperature; P_a and P_1 being the pressures as used in the formulæ for horsepower as given previously. The amount of heat abstracted in British thermal units would be for every pound weight of air used.

$$\text{BTU} = 0{\cdot}24\ (T_0 - T_1)$$

the figure for the specific heat of air being 0·24. The specific heat of water is 1, and of rock generally 0·2. Assuming that the initial air temperature to be the same as that of the pulp charge and knowing the quantity of free air per minute used, the calculation becomes simple. For the Luipardsvlei installation quoted by the author, we have the following data :—

$P_a = 12{\cdot}1$, P_1 average $27{\cdot}5 + 12{\cdot}1 = 39{\cdot}6$, T_a say 70°F = 531° abs.

Quantity of air per minute 85cf = say 5·3 lb., charge of slime 150 tons, water 300 tons.

BTU required to heat pulp 1°F = 660,000.

BTU taken by expansion of air per hour, per °F = 76.

Theoretical difference in temperature $Ta—T_1$ = 152°.

B.T.U. taken by theoretical expansion of air per hour, equivalent to heat abstracted per hour 76 × 152 = 11552.

Cooling effect on pulp per hour 0·0175°F.

It will thus be seen that this effect of cooling is absolutely negligible, and could not in practice be even measured after 10 hours of circulation. I have mentioned this point because although Mr. Allen has not touched upon it, other writers on the subject seem to have made too much of it without going into the matter thoroughly.

In this connection I might suggest that if warming up of the pulp be necessary to hasten chemical reaction and solution of gold by cyanide it would be advisable to introduce a jet of steam with the air, as the heat would then be applied in the initial stage of contact of air, cyanide, and pulp, and should thus be most effective in shortening the time of treatment.

The destruction of cyanide by carbon dioxide which the author mentions, should also be inappreciable for two reasons. First, the amount of CO_2 added by normal air is very small. Allowing 0·06% CO_2 by weight as usual in air, 100 cubic ft. per minute supplied amounts to only 0·22 lb. per hour, which would represent 0·32 lb. of potassium cyanide; Second, different authorities say that CO_2 is not a cyanicide in the presence of alkali in solution. In Rand practice, alkaline solutions are always used, quick-lime being added for the purpose.

With reference to the air agitation vats at the Geldenhuis Deep, referred to by the author, these were designed three years ago. The central pipe was made in telescopic form, so that experiments could be made on the best length of pipe to work with. The plant was finally worked with the upper telescopic pipe as far down as it would go.

Regarding the author's statement as to the Luipaard's Vlei agitation vat being probably the largest single charge vat in the world, one might be permitted to state that the probability has vanished. There are two air agitation vats installed at the City Deep, Ltd., designed in 1909. Each vat is 32 ft. in diameter, 30 ft. height of cylinder, with 8 ft. depth of cone or 38 ft. high overall, each vat treating from 250 to 300 tons of dry slime at a charge. The central pipes, 16 in. diameter, extended about two-thirds of the way up. Air for both vats is supplied by a small compressor belted to a 25 H.P. motor so as to have spare power for emergencies. An emergency air supply pipe is connected to the regular mine air service pipe.

The author has suggested that the question of turbo blowers in series to supply air might be looked into, so as to avoid atomized oil in the air. In the present state of engineering science, small blowers would not be nearly so economical as reciprocating compressors. Oil troubles can easily be avoided by proper attention to the lubrication of the compressor cylinders. Soapy water can be used at intervals for lubrication instead of oil, and the oil can be thrown down by a water spray in a suitable receiver, and the combined oil and water emulsion drained off by a suitable trap before the air is delivered to the vats.

The advantages of the shorter central pipe, which advantages are treated of in an article by A. J. Jager (Mr. Allen's reference No. 12) Oct., 1910, were realized in the City Deep design, more especially the two main points, that it is possible with the shorter pipe to commence operations before the vat is full, and that aeration is more thorough when a thick body of pulp lies over the top of the pipe. In fact, at the City Deep the air can be advantageously turned on when the vat is only one-third full. The air bubbles in the central pipe are comparatively large as they rise, but when they strike the more solid body of pulp over the mouth of the pipe the air is broken up and intimately incorporated with the pulp. With the pipe debouching at or near the surface of the pulp there is a violent disturbance in the centre and comparative quiet round the outer circles, but with the pipe opening deeper down, the whole pulp looks whipped and light, and the general appearance of the surface is like a mushroom-top, with continuous motion of the pulp from the centre to the sides.

Since air agitation is still a young process on the Rand, doubtless it will develop on lines peculiar to our local requirements, and Mr. Allen deserves the thanks of the Society and local mining circles generally for bringing this matter up for discussion at the present time.

The meeting then closed.

Annual Dinner of the Society.

The Annual Dinner of the Society was held at the Grand National Hotel on Saturday, April 29th, the President (Dr. Moir) in the chair. There were also present:—

Messrs. W. Abel, A. Aiken (Hon. Auditor), Geo. Albu, R. Allen, L. Aubourg, E. L. Bateman, R. G. Bevington (Past-President), G. Blanchard, J. Frank Brown (Member of Executive Committee of Provincial Council), R. A. K. Bruce, E. W. Buxton, W. A. Caldecott (Past-President), W. Calder, F. W. Cindel, L. Colquhoun, J. Cowie, W. M. Coulter, A. F. Crosse (Past-President), W. H. Dawe, W. R. Dowling (Vice-President), W. R. Eales, M G. Elkan, *Evening Chronicle*, J. W. Forster, W. Frecheville (Past-President, Institution of Mining and Metallurgy), K. L. Graham (Member of Council), J. Gray, T. J. Greenwood, B. C. Gullachsen, R. Hamilton (President, Johannesburg Chamber of Commerce), H. L. Harland, Hodgson, J. Irvine, E. G. Izod, E. H. Johnson (Past-President), Tom Johnson (Member of Council), A. McA. Johnston (Past-President), J. A. Jones, R. N. Kotzé, C. Lamont, E. J. Laschinger (Member of Council), G. A. Lawson, H. Lea, J. Lea, Q. J. Leitch, J. Littlejohn (Hon. Treasurer), Dr. D. Macaulay, M.L.A., A. MacDonald (President, Pharmaceutical Society of the Transvaal), H. S. Macgregor, J. McCracken, J. N. Meeser, Dr. E. T. Mellor (President, Geological Society of South Africa), G. Melvill, H. Meyer, P. T. B. Morrisby, S. J. Murphy, Dr. Temple Mursell (President, Transvaal Medical Society), S. Newton, P. N. Nissen, H. G. Nitch, E. A. Osterloh, E. Pam, S. H. Pearce (Past-President), C. Peterson, R. G. Campbell Pitt (President Rand Pioneers), R. A. Porter, H. Potter, J. F. Pyles, Frank Raleigh, *Rand Daily Mail*, J. H. Rider (President, South African Institute of Electrical Engineers), W. H. Roe, Fred. Rowland (Secretary), A. Salkinson, P. Scatterty, Courtenay Shaw, G. M. Smythe, H. Stadler, *Star*, A. W. Stockett (President, Association of Mine Managers), A. N. Stuart, W. A. Tester, J. E. Thomas (Member of Council), Professor G. R. Thompson (Principal, S.A. School of Mines), Dr. Ritchie Thomson, W. E. Thorpe, C. Toombs, M. Torrente, *Transvaal Leader*, S. T. Tregaskis, Hon. Senator W. K. Tucker, C.M.G., J. A. Vaughan (President, South African Institute of Engineers), J. F. Walker, John Watson, F. Wartenweiler, H. O'K. Webber (President, Transvaal Chamber of Mines), F. Wells, W. S. Whaley, H. A. White (Member of Council), J. Whitehouse, Professor J. Wilkinson (Member of Council) and T. Wood.

At the conclusion of the repast, the President gave the toasts of "The King" and "The Governor-General," which were received with musical honours.

Thereafter, the President announced that apologies for inability to attend the dinner had been received from the Governor-General, the Administrator, Lord de Villiers, Rear-Admiral Bush, Lord Methuen, Generals Botha, Smuts and Hertzog, the Hons. J. W. Sauer, A. Fischer, H. C. Hull, F. S. Malan, H. Burton, Dr. O'G. Gubbins, Col. Leuchars and Sir David Graaff (Members of the Cabinet), Sir George Farrar, Bt., M.L.A., Sir Percy Fitzpatrick, K.C.M.G., M.L.A., Messrs. F. D. P. Chaplin, M.L.A., P. Duncan, C.M.G., M.L.A., Lionel Phillips, M.L.A., J. G. Hamilton, M.V.O., D. Christopherson, W. Dalrymple, the Mayor of Johannesburg, S. S. Hough (President, Royal Society) and Dr. P. D. Hahn (President, South African Association for Advancement of Science).

THE SOCIETY.

The Hon. Senator W. K. Tucker, C.M.G.: The toast I have the honour to present to you to-night is that of the Chemical Metallurgical and Mining Society of South Africa. I feel that it is a great pleasure as well as an honour to be asked to propose this toast on the Witwatersrand. I say that because I have been 'in another place' lately, and there I find that small credit is given to Johannesburg for having any intelligence worth speaking about, or that at all events, if it has any intelligence at all, it is of a kind of which we have to speak with bated breath. But those of us who have been a long time in South Africa and a long time on the Witwatersrand and who know what the Rand owes to the gentlemen who form the members of this Society and what South Africa as a whole owes to these gentlemen—such of us, I say, cannot help feeling proud that we have such a body of men on the Witwatersrand as those who form the members of this Society. Now in presenting a toast of this kind one is expected to say something complimentary—(laughter). Well, it would be extraordinary if one consented to propose a toast which one did not feel one could honestly give in complimentary terms; and from the fact that I have consented to propose this toast to-night I hope you will believe that whatever remarks I have to offer in commendation of this Society are honestly meant—(Hear, hear). Now those of us who know the condition of the Rand in the early days and the difficulties which were met with in every direction, will realise that the difficulties in the extraction of gold from its ore were such as to leave little if any profit from a large section of our gold-bearing reef, and I think one may fairly say that it is to the energy of these gentlemen our friends of the Chemical Metallurgical and Mining Society that a very large portion of the credit is due for having made it possible to make our low-grade ore pay the handsome profits which lately they have been able to do. One does not forget that there are other Associations of technical men to whom very large credit is also due, I speak more particularly of the South African Institute of Engineers. It is to the indefatigable efforts of the members of these Associations, to their frequent meetings at which defects have been stated and remedies proposed and discussions take place, that a solution of many of the difficulties I have referred to is due. A large proportion of the success attained is no doubt due to the Society which is met here to-night. These are common-places no doubt to men resident on the Rand; they are matters we all know, but we perhaps do not often remember the debt South Africa owes to the efforts of the men who have so thoroughly put their best thought and much time into work of this description. Not only has your Society been concerned in trying to find more economical means of extracting gold from the ore, but it has spent many evenings in discusssing questions which bear on the relief of distressed humanity. I mean that you have spent a large portion of your time in trying to ascertain the causes and nature of dynamite fumes, the effects of these fumes and the remedies to be applied, how to make the mines healthful and in what way to combat the terrible diseases arising from inhaling such fumes. In addition to that you have paid considerable time and attention to what is called silicosis or miner's phthisis. This has also been the subject of debate in "another place." We never talk about Parliament, you know: it is always 'in another place'—(laughter)—and you would be astonished at the number of experts there are there. They are cocksure too, there is no mistake about it. In a scientific Society such as yours I am quite sure you approach a subject such as miner's phthisis knowing there are many things to be considered before you can be positive, but in "another place" you need not trouble very much about that, you can be as dogmatic as you like. My friend Dr. Macaulay will be able to tell you more about that than I can. The point I want to make in referring to this matter is that there is some good on the Witwatersrand, that there are some men who are pursuing good objects, and that there are such institutions as yours and other Associations who are trying to make not only profits better, but to make life itself better and more enjoyable to those participating in the production of gold. For this you get no credit. You have only to go a little way from Johannesburg to find that out. The friends of Johannesburg outside the radius of the Witwatersrand are very few indeed. The other people look upon the Rand as a place where illicit liquor abounds, where nearly every place which is not a canteen or gambling den, is a brothel; where the men are rushing in the hot pursuit of wealth, using means which are not the most decent. They say that some of them may become millionaires and if they do they should be ashamed of themselves; that those who have not succeeded in becoming millionaires are doing their level best to become such, and are not scrupulous as to the means by which they hope to attain their ends. You are told that you are demoralising the innocent young man from the native territories, that you bring him here and half kill him in your mines and then you try to induce him to spend his hard-earned savings in canteens or in the aforesaid brothels. That is the picture (which I assure you I have not overdrawn) of the Rand that is in the minds of many in the political world of South Africa.

It is nice to be able to come back to the Rand and reassure oneself that all these things are not true. One can only be sorry for the introductions which the gentlemen I allude to must have had when they visited the Rand last—(laughter)—and hope that when they come again they will see that their introductions are of a better class—(hear, hear). When you talk of problems surrounding such a subject as miner's phthisis considered as an industrial disease, and what it leads to in the way of compensation—you know the matter has been debated in Parliament—the questions arise: who should compensate the men, how they are to be compensated and whether the men should contribute, and whether the State should contribute—I hope you will agree with the last stage which was arrived at by the Government, namely that Parliament should set aside a sum of money for compensating hard cases which may occur during the next year. and that they should take time to fairly consider the problems which are involved in this great question of miner's phthisis. I think this was a wise step for the Government to take. I think it is generally held by all right-thinking men (whether millionaires or not) that there is a good deal to be said for making provision for persons who fall by the way in connection with any particular industry; but it is idle to think of applying certain principles on the Rand, which it is not intended to apply anywhere outside the Rand. We have just been passing large sums of money for the eradication of East Coast fever. Now if miner's phthisis is an industrial disease peculiar to mining, I should like to know whether East Coast fever is not an industrial disease peculiar to cattle-raising, and whether scab is not an industrial disease peculiar to sheep-farming; and I ask if it is sound to force an industry in which miner's phthisis is produced to be taxed on that account, whether it is not just as defensible to tax the man who owns the cattle industry to protect him from East Coast fever, or to tax the man who runs sheep in order to enable him to escape from the ravages of scab—(hear, hear). But these matters are not looked at in that light down South. As long as a question is applicable to the Witwatersrand, many politicians are perfectly willing that the principle of compensation should be applied, but they are careful that this principle shall not escape outside the ring-fence round the Rand. It makes anyone who has got to deal with these matters realise that during the time between this session and the next session of Parliament the Government will have much cause for thought, and I hope the question of compensation for industrial diseases will give other people occasion for thought also. We want to do our best for the country; we wish to help the Government and to give our best assistance if they are willing to accept it. Such institutions as yours have already devoted considerable time and attention to it; your energies have been given to the causes of the disease and to the remedies which you think may stop it. I hope that, as you have been successful in the past in solving many difficult problems, it will not be beyond your power to find the solution of this one. You may also possibly go a little further and consider the economic part of it. Is it right that only the industry should pay? Should the person liable to the disease also pay and should the Government also contribute? If it is right that the Government should find the money to combat East Coast fever, is it advisable that the Government should contribute towards a fund in connection with miner's phthisis? One does not wish to wander into many fields of political controversy, and I am sure our Chairman has something interesting to say to us, so I ask you to drink success to the Chemical Metallurgical and Mining Society of South Africa – (Applause.)

The President responding, said: I feel it a most distinguished honour indeed to rise and respond to this toast—the toast of Ourselves—so wittily and so kindly proposed by our esteemed fellow-technical and friend Mr. Tucker, on whom the Senatorial dignity sits so well. I fear we have not deserved it. He has given a most kindly presentation of our virtues, such as they are. I thank him very sincerely on your behalf therefore, but when it comes in earnest to replying, I confess I find myself in great difficulty. You know I used to be called a person prejudiced against the mining industry, sometimes quite an enemy of the mining industry, yet here I am wedged in between its leaders, and, gentlemen, the heads of the mining industry are in this case men of such unassuming modesty that really I can only imagine myself to be a lion in a den of Daniels, instead of a Daniel in a den of lions as I expected! However, this is a social occasion and there will be no gobbling up this time even if ever there were any tendency thereto.

The main excuse for these dinners is that they demonstrate that Science is not altogether inhuman and that the votaries of Science are still capable of enjoying these big feasts—although I fancy that dinners of this kind are a relic of prehistoric man and the slain mammoth, and that after-dinner speaking came in as a consequence of Noah's little adventure with the vine: I mean that speech-making was originally merely a physiological effect of diffusible stimulants on a big meal!

Speaking seriously, however, it is very good for the Society to have these feasts, if only to get away for once from technical details and to hear the wider view which we get at these affairs; and it is especially nice when the serious business of the evening is preceded by our annual pat-on-the-back. If we did not get this encouragement, we should be in danger of losing that 'gude conceit o' oorsels,' which every normal human being—and corporation too—possesses. I see that my distinguished predecessor, Mr. McArthur Johnston, was cynical on this point last year: he said when told that this is the best Society in South Africa that he was beginning to believe it himself. What I would like to say myself is this, that although we have our faults, yet for the present state of South Africa we *are* a good Society and really fulfil a most useful purpose in the State. Our motto, to parody a certain Latin one, should be that we consider nothing technical alien from us. We are a sort of combination of an Institute of Metallurgy, a Debating Society, a Chemical Society, a Surveying Institute and a Mining Journal, to say nothing of our touching on amateur medicine nor of our occasional emulation of the lighter side of the weekly Press—(Laughter). Later on we shall probably get specialised, but in the meantime we are as democratic and almost as all-embracing as Parliament—with our 'push-ons' and 'pas-ops' too. You know we do not admit politics at our ordinary meetings—which is really rather surprising seeing what we *do* admit. But the fact is that politics is ingrained in the human spirit, so we have our fling at these dinners. Perhaps it is because we can only hear, and not discuss, on these occasions, that we like it; but a better reason is that the gentlemen who come here to talk to us on politics and economics are experts in these arts, and as you see already, they give us something very good indeed, something better than the second-hand article of the local Press—(Laughter).

But to return to the Society itself, I am sorry that I was not here at its foundation. I only came in when it had—so to speak—found itself, so that I can only dimly guess at its vigorous infancy, when its controversies seem to have been conducted with chunks of old red sandstone. Now we are nearly grown up. We have reached the bashful age of 18 and yet we are not bashful, as you see. We have a wonderful supply of papers every meeting and excellent attendances to hear them. Our excursions are very successful and we have had a good many this year, and you can see how highly the generosity of those who invite us is appreciated, by the large numbers who turn up at them: in fact, I can say from Home experience that the Rand easily beats any Home Society in respect of excursions except of course the annual p cnic of the British Association. This year also we have twice broken the record as regards the size of our monthly *Journal*, a journal which I may say is highly appreciated by our 1,400 members stationed all over the world.

We meet it is true with a certain amount of criticism, which perhaps is just as well in view of the Scriptural saying about all men speaking well of you. This criticism is mainly directed at the *quality* of the matter provided; but I think these critics do not quite realise that South Africa is not yet a highly specialised country. We like to believe that the Society sets a standard of its own —which is quite in accordance with the South African spirit of independence. I am far from asserting that all South African standards are desirable ones, but I *do* say that so long as our Society gives an opportunity to everything of novelty and originality—in fact, lives up to its motto—we have nothing to fear from criticism.

There is however a fly in the ointment of self-gratulation. We have a very high proportion of silent members. I do not think I exaggerate when I say that our proceedings are carried on by less than 50 out of a membership of 1,400. It is true that these gentlemen have the 'celestial fire of enthusiasm' and amply make up for the deficiencies of the rest, fully maintaining the Society's reputation as the most free-spoken in the world. But that is not everything. It is particularly regrettable that the number of mine managers who grace our proceedings is probably less than half-a dozen. Why this apathy? Surely the life of the industry is its technical side! At least I hope and believe that the day has gone by when (as one of our critics once said) the mining industry was "merely a side show to a gambling hell." Why then this apathy? We should have been pleased to have the mine managers come forward, even if only to open their hearts to us on the technical side of the Mines Bills recently in Parliament. We could have got up a most excellent controversy on both of these Bills, a controversy which might have done some good outside, because presumably, saving the Parliamentarians who belong to our Society, *we* know more than the Parliamentarians do about these things, and also *we* do not use the closure either.

But when I have said that, I have said all. I have no sympathy whatever with the policy of drift, inertia, "all's right with the world"; nor have I any sympathy with mining on "on the stoep so long" principles. Let us open up the *arcana* of mining for discussion and improvement will surely follow. What is more, if we don't do it, there will be no Rand left for us to discuss in a comparatively short space of time, as Mr. C. O. Schmitt's able paper last week showed us. Although Mr. Schmitt's paper dealt only with metallurgy, there is a big field in the mining work proper for the economies which are to save the Rand. It may seem absurd to talk of saving the Rand at a time when, as at present, it is making a sovereign every second, but we must look to the future. The metallurgical side of gold-winning is much more highly developed than the underground work—witness the wonderful modern plants we have visited this year. I hold the opinion, and I do not think I am alone in it, that no one would tolerate on the surface-works nowadays the lack of supervision, the primitive methods of transport and the incompetent labour, which have to be put up with underground at present. We want *more light* perhaps, physical as well as metaphorical. Secondly, why do we use more explosives per ton than any other country? There has been no improvement in this respect since the war. I might go on with these Why's: there are plenty of controversial subjects in mining. There have of course been plenty of improvements, but there has been plenty of *laissez-faire*, and in this connexion there is one thing that I cannot resist mentioning, namely that I hope that in less than five years we shall no longer hear at these feasts "that blessed word Mesopotamia"—the dearth of native labour. I feel convinced that with the mechanical improvements and the ventilation schemes now in hand and the prevention of accidents this difficult question will solve itself in that time. There are certainly men who have got the impression—and this impression also exists in the kraals—that the native is being exploited and is expected (*Hibernico more*) to "come oot and get killt,"—and it will take some years to remove that impression. You will remember, gentlemen, that our accident death-rate is one of the highest in the world, at all events amongst nations that keep any record of such things. Our attitude in the past towards this question of native labour has been much the same as that of the Backveld towards pests, namely praying instead of spraying—(laughter)—and if I may pursue this vein of elephantine humour, I say the industry should adopt scientific methods, and *attract* the native instead of *contracting* for him. I expect the mining men will say it is 'like my cheek' to talk like this, but if they had not sulked in their tents, it would not have been necessary. I am really putting my views forward with due humility since, as Ben Jowett said "we are none of us infallible, not even the youngest of us." We know that the managers have plenty of worries already with poorness of grade, etc.; and they will find a good deal of sympathy too with their complaint that they are being over-regulated and grandmothered now-a-days: but things on the Rand to-day are very different from the easy job they used to be. When I read about the early days, when a proportion of the technical men seem to have been recruited from the ranks of the bricklayers and the drapers, I confess I am surprised at the good results which were undoubtedly achieved, and although I should be the last to say anything against natural abilities, in this case I am irresistibly reminded of the great Dr. Johnson's remark about the suffragettes of his day. I forget what the lady had been trying to do, but he said it reminded him of a dog walking on its hind legs, "it is not well done, but you are surprised it is done at all." The point is, gentlemen, that the Rand cannot stand the strain of rule-of-thumb nowadays. It may have been the case long ago that an ounce of practice was worth a ton of theory, but at the present time practice does not go far without theory.

Anyway, gentlemen, it is due to this Society and the Engineers that the Technics of the Rand are now so advanced as they are. They are so advanced that metallurgy proper is disappearing in favour of engineering, and (if I may be allowed one more little gibe) I wonder when our consulting metallurgists will take the hint and call themselves chemical engineers and metallurgical engineers as they do in other countries.

I want to refer to one thing more on this public occasion, namely the Seymour Library. I consider this library is one of the greatest assets of the Rand and has done inestimable good both to the reading public and to the scientific reputation of this country. In some branches of science it is nearly as good as the great library in South Kensington, and speaking for myself, I can say that more than half of any researches I have been able to do would have been impossible but for this library. The library is still incomplete although over £3,000 has been spent upon it, but the main difficulty is that its annual income is not sufficient to keep it up to date in periodicals, to say nothing of new books, of which there is a list of about £200 worth urgently required. This Society took the initiative and has been successful in obtaining some fresh support for the library from the Chamber of Mines and the Council of Education and the various Technical Societies, which have saved the library from its immediate difficulties; but if it is to be kept up to date I think that, in addition to these generous donations, we might get a small sum such as £25 a year from the richer of the mining corporations. I do not think they would feel it very much, and four or five such donations would put the matter right. I assure them that no money could be laid out to better advantage; if the Rand is to survive another 50 or 100 years, it can only be by means of scientific advances and discoveries, and these, I may say, are more likely to originate from library study than from either native or imported genius. The library also has earned the right to be considered by the founders of our Art Gallery, who displaced and disorganised it for five months, but as this is under consideration, I need only say the 'word in season.'

Gentlemen, again I thank you for drinking our healths so heartily, and you, Senator Tucker, for suggesting the idea.

"THE MINING INDUSTRY."

Dr. D. Macaulay, M.L.A.: I rise with a feeling of a distinct grievance. On arriving late when I got hold of the programme I found one of my pet quotations plagiarised. A second grievance that I have is that my friend Senator Tucker has already traversed the ground which really belongs to me. It is really a great honour to propose the toast of the Mining Industry and to ask you to drink its health. I think it is a somewhat unnecessary toast since, so far as indications go—to a layman at any rate—it never was in a better state of health than it is at the present moment, and while this Society owes its existence to the mining industry of the Witwatersrand, I think as a member of the Society I may also claim that the present healthy state of the industry owes some proportion of its vitality to the efforts of the gentlemen who compose this Society—(Hear, hear)—and it is a matter of very great regret to those of us who have been unfortunate enough—I use the word advisedly—to indulge in the luxuries of public life, to find your efforts and the efforts of the gentlemen who control this industry are so badly understood elsewhere. I would like to corroborate every word Senator Tucker has said in regard to the suspicions with which we are regarded in another place. I do not know whether "suspicions" is the right word, or whether jealousy is the right word or envy is the right word. I think I would leave it to your President's gift for phrasemaking to invent the proper word for the feelings with which we are regarded. Now I would like to impress upon you that it is our duty to dispel that feeling. Johannesburg has been described as a University of Crime. I am not very sure whether in that University you or I must consider ourselves Students or Professors, or whether we are simply lookers-on allowing our pockets to be picked by the robbers from the Stock Exchange. Anyhow we have been deliberately described as a University of Crime, and Johannesburg has been described by a leading Parliamentarian as a gigantic brothel, and I find in the Press last week our white women are described as no better than they ought to be. I really think that the time has come when if we are going to have peace in South Africa we should put an end to these calumnies directed against us. Now, Mr. President, your Society is a non-political one. In politics you are neither acid nor alkaline, but most strictly neutral—(Laughter)—but one cannot help introducing politics on an occasion like this, and I personally want to vindicate the people with whom I have been associated for the last fourteen years. One of our most delightful politicians who is partly a politician and partly a *savant*, Mr. Merriman, has, I can assure you, never got up in his place in Parliament when he has cause to refer to the mining industry without having a sneer and a jeer at the mining industry. I do think his parliamentary life ought to have taught him to view things with a little more judgment and a little more coolness. This is really an important subject. He is the spokesman of a certain section of politicians who do not belong to one particular party. I want to make that quite clear. He was the spokesman of this section of political opinion and he got up to sneer and jeer in righteous indignation about the large mortality in connection with the mines of the Witwatersrand. Now as the result of the active efforts of all those who are intimately concerned in the matter, the mortality of the mines of the Witwatersrand has been brought to within reasonable limits, somewhere about 30 or 32 per 1,000 per annum. Now rummaging through some of the archives of the Cape Parliament I discovered an opportunity of rubbing up my Right Hon. friend Mr. Merriman. I found that the mortality from chest diseases alone among the native population in Mr. Merriman's district of Victoria West amounted to 40 per 1,000 per annum. I pointed this out to my friend across the floor of the House and he was very angry and he has so little recovered from his anger that up to the present moment he has not condescended to reply—(Laughter)—because I suggested to him that before he started to find motes in the eyes of the people here, he should remove the beams and king posts from those in his own constituency. I only want to show the spirit actuating a certain section of the community towards us and to point out to you that it is the duty of every one of us to do what we can to dispel this suspicion, envy or jealousy, or whatever my friends may choose to designate it. To show you the amount of undeserved suspicion which exists, when the Minister for the Interior made an announcement which gladdened my heart, namely that the Mining Industry—it was called by him the W.N.L.A.—had come forward and offered to build here in Johannesburg a Medical Research Laboratory in order to investigate diseases peculiar to humans—animals and plants are well provided for—even that was regarded with suspicion by a certain section in another place—(Laughter). It was called "blood-money." It was called all kind of things. Now, gentlemen, a certain number of us have been advocating this for years, and I assure you gentlemen that if the Devil himself had come along with this money to build a Medical Research Laboratory, we would have had the greatest pleasure in taking it. I hope and expect from this institution the greatest benefits not only to this industry, but to the whole of South Africa and the whole of the world. We have most unique opportunities here for studying human diseases which have been steadily neglected, both by the much-abused millionaires and by the elected representatives of the people. We shall have in South Africa very soon, owing to the liberality of the Mining Industry, and I say that I have never known a case where these men have not come up to the scratch—we are going to have an institution which will be second to none in the world. Incidentally, I have not the slightest doubt, the mining industry will considerably benefit—and good luck to them too if they do—and also in conjunction with a similar institution in the north of Africa at Khartoum we are going to be enabled to have an institution which will probably make this country certainly one of the best countries in the world to live in, as many of us think it is at the present moment.

I could point out what the output has been and what we hope it is going to be: what is being done with regard to artificial ventilation on the mines and being undertaken, too, spontaneously by the authorities and under no pressure from the administration: what is being done to induce the workers on the mines to take care of themselves and also that the industry is paying its legitimate share towards the maintenance of those who fall by the way as Mr. Tucker has said. Many other things I could point out to you, I will content myself with asking you to drink to the increased prosperity of the Mining Industry of the Witwatersrand, which means also the increased prosperity of the whole of South Africa.—(Applause.)

Mr. H. O'K. Webber, responding, said: The toast of the Mining Industry has been responded to year in and year out ever since Johannesburg has been a city, and all through, many of those who sit in this room to-night have given all their energies to building up the greatest gold mining industry in the world. First came the miner, then the mechanic and lastly the chemist and metallurgist. The brilliance of America showed its light upon this country later on, and later still we had a glimmer from the light of Asia—(Laughter). But it is to the metallurgist and chemist that this industry owes its real progress. They have shown us how to extract the gold to the last decimal point of a dwt., and what is of much more importance they are showing us how to extract the gold at the lowest possible cost. The time may come when they will perhaps take over the ore from the dump and later on perhaps they will start operations at the face of the rock underground, but we have to-day among the members of this Society the finest talent in the world for the treatment of these gold problems, and although it is fortunate that the treatment of Rand ore does not contain very many difficult chemical problems, yet if it was so I feel sure the gentlemen in this room would be able to deal with any difficult problem that might come before them. Gentlemen, this industry has always been before the eyes of the world, and you have heard to-night that it is also very much before the eyes of our friends the legislators of the Cape. The pastoral portion of South Africa you have heard to-night looks upon us with a good deal of suspicion. We have been called all sorts of names. You have heard to-night that this place has even been called a school of crime, but the gentleman who called it by this name I think really means well. He is really a kind old gentleman—(Laughter). He is the son of a Bishop too—(Laughter)—and I believe if he was here to-night sitting and enjoying our dinner, I believe he would be discoursing to us upon the subject of the possible evils which may attend the life of those who carry on the comparatively guileless occupation of agriculture—(Laughter). We have also been called millionaires. I wish we were. I think perhaps it is this very Society which attracts the envy of our friends, perhaps it is because you call it metallurgical: I expect it must sound very rich in their ears—(Laughter). They also wonder where our gold goes to. Well we all wonder where our gold goes to. But this misunderstanding will wear off. If they had paid us a visit last week they would probably have found that the only idea in our heads was how to grow mealies, cattle, sheep and horses. The times are progressing. At the present time one hears on the one hand people connected with the mining industry discussing in heated argument the subject of scab in sheep, and on the other we hear of farmers discussing the latest mining regulation brought out by my friend Mr. Kotzé: but we must get it into their heads that we have a great sense of our duty towards those who earn their daily bread in the more unhealthy occupations of this industry, be they black or white. The mining industry as you know has been legislated for and they will continue to legislate for us, but many of the laws passed at the last session and regulations that have been promulgated or will be promulgated for the mining industry, have in nearly every case been practised of their own free will by the mining industry for the amelioration of the conditions of mining. But we have lawyers in Parliament, and these lawyers must legislate. They have friends who are not in Parliament and they must bring grist to their mill. Some day when the latter get into Parliament they will return the compliment.

Gentlemen, this mining industry is a huge factory for turning out an article for sale just as any other industry is, with the one exception that the article we produce has only one fixed price in the market. Therefore the question of producing gold at the lowest possible cost and the opening up of new areas containing large quantities of low grade ore holds South Africa in its hand. It spells either constant and continuous prosperity or certain mediocrity for the country we all love and live to build up.—(Applause.)

Mr. J. Frank Brown, M.P.C., in presenting the toast of "South Africa," said: One or two things occur to me to-night. I should like to say that in future the man to be called upon to propose the toast of South Africa is the man who has been in the country about six weeks—(Laughter)—because we all know that when those who visit this country have been here six weeks they know more about our problems than ourselves. I know that when I arrived here about eleven years ago and had been in the country about two months I felt I knew more than I do to-day. Apropos of the remarks of previous speakers, I heard the other day a prominent Dutchman in the Lower House, a member of the Nationalist party, ask a puzzling question. Why are there three parties? The man said "I do not know that there are three parties, who are they?" The other replied "Well, there are the

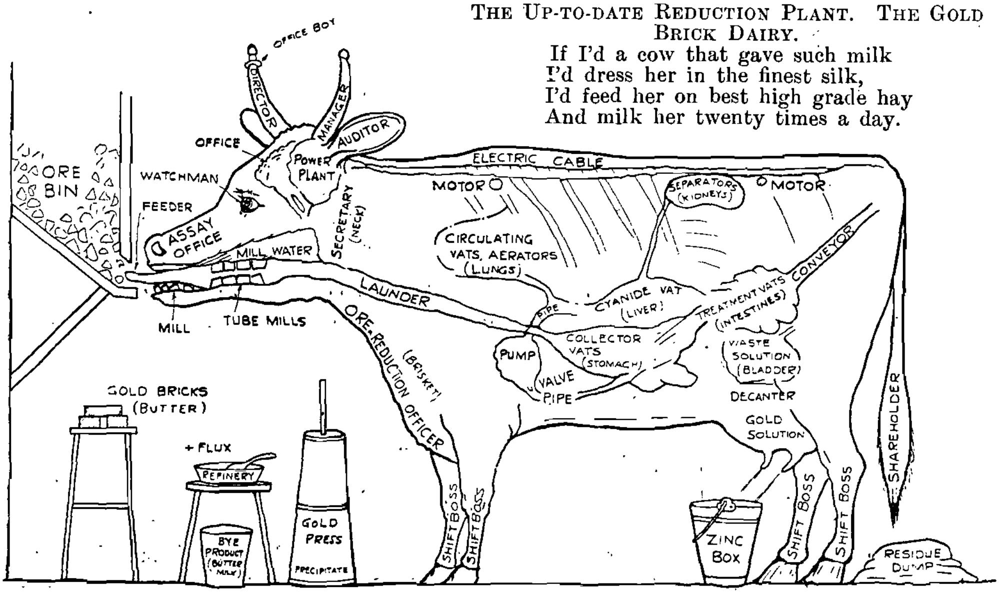
Unionist members who are progressives and the others reactionaries, there are the Nationalist members who are progressives and the others reactionaries, and the Cape Peninsula." It seemed to me that this very readily explained why in a certain place we here on the Rand are looked upon as such scoundrels. I ask you to look upon two pictures, one of ten years ago and one of to-day. Ten years ago we were in the midst of a very bitter war, a war which more or less devastated this country. Look at the picture to-day. What do we see? We see that in these few years we have brought about a union of the Provinces of this country. Any other country in the world would have taken 50 years to have recovered from a war like that and have arrived at the position we are in to-day. And in thinking of that, let us give credit where credit is due. Let us give credit to Lord Milner and those who worked with him for having laid the foundations and laid them truly and well—(Applause). Lord Milner has been criticised for his extravagant ideas, with having laid these foundations on too big a scale, but to-day I believe his most bitter critics of those days are beginning to see that he was right—(Hear, hear). Let us also give credit to the Government which has succeeded his, to those who came with the idea not to destroy but to fulfil, to those who have built up steadily on the foundations laid by Lord Milner. During the ten years that have elapsed we have seen an enormous stride in the mining industry, we have seen attention given to the base metals of the country and are beginning to realise that the country has only been scratched and that possibly the next ten years will see still greater developments. In agriculture you had only to go to the Show last week to see the enormous strides made. To-day agriculture is in a far more flourishing state than before the war. I do not know whether the prize bull of this year is better than the prize bull of last year, but I do know that when one went into the produce shed one could see that enormous strides had been made in various things which have been produced from the land. That is to the credit of Lord Milner's administration and to the present Government. It appears to me that we of the different Provinces are inclined to be a little parochial, a little provincial. The way we are regarded on the Rand from elsewhere shows that there is a good deal of provincialism. We on the Rand are big enough to take a broader view and we here should do what we can first of all for our immediate neighbourhood, but equally for South Africa. Gentlemen, let us end all this petty spirit of jealousy and envy. Let us take the lead with regard to South Africa as a whole. There are many important things we have to deal with in front of us to-day. I put education first. We have all sorts of problems to decide, but I put education first. I do not think you can over-estimate its importance, and I do not think you can over-estimate the importance of what you brainy men can do in helping on the education of the youth of this country. Take the recent education question—I may call it the bi-lingual question. Well we have seen that by a compromise a certain result has been arrived at and I think the best I can say of that compromise is that nobody is satisfied with it. Neither side is satisfied. It shows that neither side had all its own way, and yet I believe the outcome will be a fair and practical working scheme, but I will say this—it all depends on the spirit in which the compromise is carried out. I for one would say that we in the Transvaal, both British and Dutch, are fairly satisfied with our Education Act, and I do not think we should be the first to alter our Act until we find that in a certain other Province their Act is altered. There is an interesting experiment in Government going on in South Africa, namely, by means of Provincial Councils. These Councils were elected on party lines, by the same electorate as for the the Union Parliament. There is the Nationalist party and the Unionist party in the Council here. The difference from our ordinary Parliament is this. We have an Executive Committee which corresponds with the Cabinet of Parliament, but whereas the Cabinet is composed of men belonging solely to the Government party, here we have an Executive composed of two men from each side of the House, and I can only say from my own personal experience that everything has gone so far perfectly smoothly. There has been no conflict, which appears to me to indicate that the present political division is a purely artificial one. It is largely racial but ought not to be racial. If two Englishmen and two Dutchmen, representing opposite political parties, can sit round a table and discuss and carry on the public affairs of the Province without friction or ill-feeling, it seems to me to show the present division is artificial and is bound to break down. We are all here, British and Dutch, for good and all and one race cannot blot out the other. So let us try to conduct the affairs of the country on business lines and not have too much party and not too much politics. I will briefly touch on another and a lighter matter—the matter of sport. We have seen our South African boys, British and Dutch, holding their own on the cricket fields and football fields of England, Australia and out here. I for one believe that sport will do as much to break down this absurd division which exists to-day as anything else. I look around and I see men getting old like myself, men who I am sure have taken their part on the cricket and football fields, and I put it to you where have you made the best friendships? In the field of science or on the cricket and football fields? Sport is going to do more than anything else in this country to break down what I call this absurd racial division. This is a land of sunshine, let us try to make it a land of hope and glory. The charm of this country is as the Irishman said, that our future is before us. We are building up—possibly building up a big empire, doing more than we could possibly do in the older countries of Europe. We are building up an empire and each one in his own sphere can do something towards that. Let us determine to do what we can to make this country worthy to stand side by side with the other great dominions of the Empire.—(Applause).

Mr. Geo. Albu, responding, said: I have often attended these little dinner parties given by your Society, but to night the reply to a far more charming toast than usual has been allotted to me. I have to thank you, gentlemen, for drinking prosperity to South Africa. It is a subject which I adore very much, because having lived nearly all my life in this country, I love it as dearly as if it were the land of my birth. What I have been able to achieve I have achieved in South Africa.

South Africa in one word has made me what I am to-day—(Hear, hear). I am so imbued with my gratitude to this country that I have come to love it most dearly as the country which is nearest to my heart of all countries. Would I were a painter, an artist! In what glorious colours I would paint the magnificent scenes and landscapes which so few of us observe when travelling through the country. I have heard men speak of it when travelling through the Karroo, as a lonely veld. These men have no imagination and have never seen its sunrise and its sunsets. South Africa should be able to produce the greatest artists in the world. Have you seen the glorious sunshine in the Karroo, the colour of it, which, I make bold to say, you do not see even in a country like Italy? We do not appreciate sufficiently the beauties of this country and were I an artist I would be able to paint the most glorious pictures. Were I a poet I could sing of the glories of this country, but alas! I must say I am neither. I am sorry to say I am only just a poor mining man—(Laughter)—and a poor mining man of course looks upon these things sometimes with the eye of a materialist. To-night we have heard about the Agricultural Show, about prize bulls and calves and there is on the back of your bill of fare a prize cow munching raw quartz. It does not state how many ounces to the ton, but it goes through the usual process. I have been connected with the mining industry a great many years, and if all the predictions of our scientists, chemists and metallurgists and mining experts were realised, I think we should be working today at a few pence per ton. They have not all been realised and we are still working at a fairly high cost. However, that is a subject which has still to be thrashed out at some other dinner of a similar nature. But (looking again at the menu) here I see the crushed ore, and below the cow's tail I see the poor shareholders pulling at it with-

THE UP-TO-DATE REDUCTION PLANT. THE GOLD BRICK DAIRY.

If I'd a cow that gave such milk
I'd dress her in the finest silk,
I'd feed her on best high grade hay
And milk her twenty times a day.



With acknowledgments to Mr. E. A. Julian (Nevada). E. J. L.

out the slightest gratitude—(Laughter). Of course we are very desirous of paying high dividends and possibly no one is more disappointed if results do not come up to expectation than your humble servant. It is not a question of amassing fortunes as some gentlemen seem to have mentioned in another place. We are not simply bent on making money. We are anxious to give those who have put capital into this Industry a fair return for their money—(Hear, hear). As usual the cow has two horns. Well I have never been impaled on the horns of a cow or bull, but I have often been on the horns of a dilemma as to how to realise the promises I have made at my shareholders' meetings. Much as I enjoy a dinner of this kind, it is a different pleasure to have to eat my own words, a process which has hurt my digestive organs very much.

I again say South Africa is a glorious country with a far more glorious future. It will take years to make this country really proud of its beauty, as some of us may have noticed, when we go through the streets of Johannesburg and see those little black buckets on the wayside which seem to invite you to a quiet *tête-à-tête* or *dos-à-dos*—(Laughter). But the time will come when our Municipality will gradually alter the conditions of this town. You know that Sunday labour has been prohibited in this town; well it is very near Sunday now so you will excuse me if I do not delay you any longer. I thank you on behalf of South Africa.

Mr. W. R. Dowling (*Vice-President*): We have not met here this evening to listen to speeches by members of the Society, so I will not detain you long. At our annual dinner we try to get those who do not attend the regular meetings of members to make the speeches and change the subject from the dry matter we deal with at our meetings.

I wish to welcome on your behalf Principal Thompson, the new Principal of the South African School of Mines and Technology and Professor of Mining. Principal Thompson has undertaken a great work in which we wish him every success. He has made a good start by becoming a member of our Society.

We have also present to-night as one of our guests Mr. William Frecheville, a Past-President of our Sister Society, The Institution of Mining and Metallurgy in London, whom I wish to welcome. We have an arrangement with the Institution for the joint reading and discussion of papers, which arrangement is appreciated out here and we hope is, as well in London.

Gentlemen, I give you the toast of "Our Guests and Kindred Societies," coupled with the names of Principal G. R. Thompson and Mr. William Frecheville.

Principal G. R. Thompson: I believe I am called upon to respond to this toast because of my connection with education, not because of my six weeks sojourn in this land. I am not so precocious as Mr. Brown and do not feel that I can analyse the problems of South Africa, though I feel that I am learning very quickly about them. As a guest you justified my invitation from the fact that I had not paid my subscription to the Society. But, gentlemen, that is rectified. I have already paid it so that next year I shall not be in this position. I noticed that two years ago our President said the guests were jolly good fellows. They were not really guests. They belonged to the Society. I have shown my good sense by joining the Society. In fact I had no alternative, I had to join. I began to be rather distressed on account of some of the remarks I have heard this evening, because I was thinking you had so many speakers in this Society that I should be able to sit in a nice easy chair and remain silent. I did not expect that you wanted every member to speak at your meetings, and I should think from your volumes of proceedings that you have quite enough speakers. Mr. Dowling referred to the guests as being members. I hope in my sojourn here I shall always show my good sense by being in at every good thing. I notice that the President in his address made an appeal for the Seymour Library. I should like to extend what he said as to the importance of such a library, because coming from the Old Country where one has a series of good libraries in London, the want of books is not felt to the same extent as out here. I think any library in this country of a technical nature, should give a member who is working out a problem a chance of getting it solved. When I was in Leeds I did not trouble about our library being incomplete, because I conld easily go up to London and get any information I required from the British Museum, the Patent Office, or the South Kensington Library. Now to go to these libraries from here would be a serious business so that we should undoubtedly make our technical library as complete as possible. I am certain the trustees of the library and the committee who are managing it will receive with gratitude any support whatever which will tend to the improvement of the library, As one of the guests of the evening and representing others, I thank you very heartily for the reception you have given us and for the very fine entertainment both of body and mind to which we have been treated.—(Applause).

Mr. W. Frecheville, responding, said: It is my duty to express thanks on behalf of the Kindred Societies, and especially for the appreciative remarks about the Institution of Mining and Metallurgy in London. The members of that institution really appreciate the work which has been done and is being done by the Society here in this great centre of gold mining. You have many keen members working on the problems of improving the technical process for extracting the ore and cheapening costs. A very favourable feature of the Rand has always been the absence of any kind of secrecy as regards methods of working—(Hear, hear)—and the Chemical and Metallurgical Society has done excellent work in helping and stimulating further effort. During the last 12 or 15 years I have on three or four occasions had the privilege of coming here and seeing the work that is going on. The visits I have paid have been all too short, but they have all been exceedingly interesting and instructive. Over and above the technical side, there has also been the added interest of seeing the growth of the place and country. The last time I was here the great topic of conversation was the Union of South Africa, and now it it is an accomplished fact. To you who live on the spot that which has been accomplished may seem ordinary, but to us who live at a distance, it appears most wonderful to find that people who only a few years ago were shooting each other, are now pulling together to make a great country of South Africa. I regard the Rand as an excellent place for you, gentlemen, to exercise your special skill. The mines are good and the climate is good, two exceedingly important factors. Of course you know—the point has been spoken of to-night—there are drawbacks. For instance there is the unhealthiness of the mines to which allusion has been made, but I firmly believe that the difficulties can, to a great extent, be got over and in getting over these difficulties I feel confident that not only are you doing good to the worker, but you are doing an enormous amount of good to the industry itself. It is getting late, gentlemen, and I will not detain you with more remarks, but I will thank you for the very cordial way in which you have responded to the toast of the Kindred Societies, and for your very enjoyable entertainment to-night. —(Applause).

Mr. R. N. Kotze: Before we disperse to-night, there is one more toast that remains to us, I have been asked to propose the health of "Our Chairman"—(applause)—not only as representing the whole of your institution and also for the way in which he has fulfilled his duties as Chairman and entertained us to-night.—(Applause).

The President: I thank you very much for your great cordiality in drinking this toast which is a sort of extra turn, though I think it is absurd to say that I am a good chairman, or a jolly good fellow, for I am really rather a cantankerous sort of individual; but there is something to be said for the toast, namely, that it gives you an excuse for a *doch an doruis*. I'll tell you something about that! It was originally a stirrup-cup, a parting glass on the threshold, and it was not charged for. Now just try that on with the waiters—(laughter). I am sorry the Ministers were not able to come this evening, but after all it has been a good affair. Although we have not had any of the Ministers with us, we have had several very eminent politicians and I think our meeting has not been less interesting than usual. I certainly ought not to forget to mention that if there has been any success, the whole of the credit lies with Mr. Rowland who organised the thing. I thank you very much.—(Applause.)

Mr. Fred. Rowland, in response to repeated calls, said: I am not a talker, but I thank you very much. This work falls to my share and I am very pleased to do it. It is now half-past eleven and I think it is time we all went home.

Contributions and Correspondence.

A WORD ON PRECIPITATION.

In Mr. J. Hayward Johnson's contribution to the discussion on Mr. F. D. Phillip's paper* he says: "During the discussion of the paper no mention has been made of any of these bad effects, one of which is to cause the zinc to be covered with an apparently white metallic deposit giving the zinc the appearance of being newly cut or cleaned of all other deposits, whereas on examination it is found to be a coating, and all action ceases."

What is usually done is to stuff the lower compartments with new zinc, and the coated zinc is left lying dormant until it goes into the acid tub.

I take it out and soak it in a weak solution of sulphuric acid for about five minutes. The solution must be sufficiently strong to give a brisk action on the zinc. Then, with, and often without, another wash in clean water, it is returned to the heads of the boxes, and it starts doing its work straight away. I sometimes give it a little extra lead acetate.

On a big plant this could be done by running sufficient water through the box to replace the cyanide solution, and then adding a strong dip of sulphuric acid to the compartments containing the "dead" zinc.

The reverse action Mr. Hayward Johnson speaks of, seems, when it starts, to infect the

* See this *Journal*, Vol. XI., Oct., 1910, p. —.

whole of the zinc in the box. It may be that the adverse conditions which have started it, have also affected in a lesser degree the lower compartments, but it seems to me to be a reverse action, which starting in the first compartment, soon spreads right down through the box.

The following may be of interest :—We have here three slime precipitation boxes; two are of wood and the other of iron. They run under identically similar conditions, but we get better results from the iron one. On cold mornings the tails of the wooden boxes occasionally show a trace of gold by coloration test, but the iron one has never given any trouble.

MATHER SMITH.

Barberton, April 1911.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

THE WORK OF THE CHEMICAL LABORATORIES OF THE BUREAU OF MINES.—"This work is divided among a number of separate laboratories, each carrying on its own lines of work under the direction of its own chief, the whole forming a group of more or less independent units. The relation of the work of the several chemical laboratories to that of the other departments of the bureau varies with individual cases. In general, however, the problems of the chemists are closely connected with those of the mining and mechanical engineers.

The fuel testing laboratory is occupied mainly with the analysis and calorimetric testing of fuels, including coal, coke, lignite and peat. In addition to analyzing samples of all fuels used in the boiler and gas producer tests of the bureau, ultimate analyses and calorific value determinations are made on mine samples of coal collected at various places. The data on these latter tests are of value in establishing the composition and heating value of the coals in connection with the classification of the coal fields of the United States.

In addition to the laboratory at Pittsburg, there is located in Washington, D. C., a laboratory in which are tested samples of coal, delivered to the various buildings, arsenals, navy yards and military posts within the District of Columbia and in various parts of the country, and of the coal purchased by the Panama Railroad.

Fusibility and Clinkering of Coal Ash.—In the use of coal under steam boilers, the property next in importance to its calorific value is perhaps the fusibility of its ash. Indeed, some coals, which have a high heating value, are worthless for making steam on account of their tendency to clinker and adhere to the grate bars. The relation between the fusibility and clinkering properties of coal ash and its chemical and mineralogical composition is now being investigated.

It is interesting to note that TiO_2 was found in all the clinkers examined in amounts varying from 1% to 3%. Determinations of the fusion point of various ashes give values ranging from 1,150° C. to 1,400° C.

Chemistry of Petroleum Technology.—The bureau is making a study of the commercial bodies contained in the crude petroleums of the United States; of the methods for their separation and purification and of their economic uses. The California fields, because of their showing at this time the greater promise of a large and continued production, their proximity to naval stations and the peculiar adaptability of their product as a maritime and a locomotive fuel, have been selected for first study. Besides the determination of the properties and uses of the various products of the petroleums of the country, an investigation is being made of the processes of distillation and of the methods of refining.

Combustion Investigations.—The processes of combustion in the boiler furnaces are being investigated in a furnace specially designed for the purpose. By taking simultaneous samples of the combustion gases, the progress of the reactions may be followed and the time or space necessary for the complete combustion of various coals and under varying conditions of operation may be determined.

The process of producer gas formation is being studied from a physico-chemical standpoint, and an attempt will be made to apply on a commercial scale the results of laboratory experiments on the rate of formation of carbon monoxide and water gas.

The Composition of Coal.—Our scientific knowledge of the chemical character of coal is limited almost entirely to its chemical analysis and its adaptation to certain industrial operations. The object of one of the investigations of the bureau is the isolation and identification of some of the constituents of coal. By the use of inert solvents it has been found possible to extract as much as 35% of the original coal. A number of different substances have been isolated and the analysis and molecular weights of some of these substances have been determined. In a few cases it is believed that the materials are practically pure substances.

The Volatile Matter of Coal.—The quantity and composition of the gases evolved from various coals, when heated to temperatures of from 400° to 1,000° C., have been determined. In the experiments which are now in progress particular attention will be given to the influence of the rate of heating on the character of the gases produced: to the initial composition of the gases at the instant of liberation and to the thermal decomposition of these gases during passage over heated surfaces.

Weathering and Deterioration of Coal.—In co-operation with the Navy Department, the Panama Railroad Company and the University of Michigan, the Bureau is conducting an extensive series of tests on the deterioration of various coals in storage both in the open air and when submerged in fresh water and sea water.

The Accumulation of Gas from Coal,—The quantity and rate of formation of inflammable gas from freshly mined coal, at ordinary temperatures, and the rate of absorption of oxygen by the coal have been determined.

The Spontaneous Combustion of Coal is being investigated by the Bureau. Statistical information will be combined with the results obtained in the laboratory.

The Burning of Coal in Mines under a Diminished Supply of Oxygen.—The factors governing the propagation or extinguishing of fires in mines are being investigated. Chief among these are variations in temperature and in the oxygen content of the surrounding atmosphere.

Examination of Mine Gases.—Examination is made of samples from normal mine air, from the after-damp following explosions, from stagnant areas and from burning areas during mine fires. Particular attention has been given to the detection of small amounts of carbon monoxide. By analyzing samples during the progress of mine fires, the chemist has assisted in combating fires. The effect of variations of barometric pressure on the exudation of methane and the influence of carbon dioxide on the explosibility of mine gases are being investigated.

The Chemistry of Explosives.—Chemical analyses are made of all explosives submitted to the Bureau for test, of the products of combustion of explosives and of electric detonators, blasting caps and fuses. All explosives, blasting caps, electric detonators and fuses purchased by the Isthmian Canal Commission are inspected by representatives of the Bureau, and all shipments of such explosives are sampled and analyzed.

Coal Dust Explosions.—The two greatest sources of danger encountered in mining operations are the explosive gases given off by the coal, and the finely divided coal dust which exists throughout most coal mines. The first danger can be overcome by increasing the ventilation in the mines. Unfortunately, this increases the danger from the coal dust by the removal of its moisture.

A laboratory method has been devised to test the inflammable character of samples of coal dust, and to classify them according to their inflammability. This method is based on determining the amount of combustion which takes place when clouds of dust of the same density are ignited under the same conditions, the amount of combustion being determined by the pressure developed within the explosion vessel. In this way it is possible to obtain results on any one sample of coal dust which agree to 3·5% of the total pressure developed.

One of the proposed means of lessening the inflammable character of coal dust is to add a non-inflammable dust. The laboratory method used to investigate the inflammability of coal dust has been extended to various percentages of coal dust and finely ground shale in order to determine to what extent the combustion is limited by the presence of the inert dust. The experiments indicate that a marked diminution of pressure is not obtained until about 25% of inert dust is added, the pressure then falling off rapidly with a further increase in the amount of shale dust added."—D. J. K. CLEMENT, *Metallurgical and Chemical Engineering*, Vol. 9, No. 2, 90, Feb. 1911. (J. A. W.)

METALLURGY.

COMMERCIAL CLASSIFICATION OF FUELS.—"Fuels in their natural state may be classed as (1) gaseous, (2) liquid, and (3) solid. Under the third class, coal only will be considered in this paper.

Coal is technically classified as anthracite, semi-bituminous, bituminous, and lignite.

In the commercial classification of fuels, coals are known as (1) steam, (2) by-product coking, (3) producer gas, (4) illuminating gas, (5) cement, and (6) domestic.

Steam coal constitutes more than 50 per cent. of all coals mined, and covers a wide range in quality. For steam production all kinds of coal are used, with the following range in analytical values :—

Volatile matter, from 15% to 42%.

Ash, from 4% to 18%.

Sulphur, from ·8% to 5%.

British thermal units, from 9,000 to 14,800.

Anthracite is not included and will be eliminated from further consideration, as its use is confined principally to the large cities and densely populated districts along the eastern seaboard of the United States, where local conditions determine almost entirely the fuel to be used.

Steam coals may be subdivided into locomotive, steamship, and stationary power plant fuels.

Locomotive fuel is required to meet rapidly the maximum variations in demand for steam, and a coal which will deliver a considerable portion of its total heating value in the shortest possible time is the most satisfactory. This requirement is best met by gas coal, as it will give up about one-third of its total heat within two minutes after firing, due to the liberation and combustion of the volatile matter. The remaining fixed carbon maintains a constant temperature by its practically uniform rate of combustion.

That the manner of firing and the condition of the locomotive are the ruling factors in 'smoky' or 'smoke-less' operation of locomotives with gas coal has been proved by some of the leading railroads. In such cases three-quarter gas coal is used with very satisfactory results, and almost smokeless combustion.

To avoid excessive smoke, low volatile coals of high heating value are often used, but they do not burn as quickly as gas coals, a shortcoming compensated for by the reduction in smoke.

Aside from regions where low-volatile coal is the most available fuel and localities where strict smoke laws prevail, low volatile coal is used by some railroads on certain passenger runs in order that the quantity of smoke may be more easily kept at a minimum.

While high-ash coal is not especially desirable in locomotive fuel it is used with very satisfactory results, due to the readiness with which the ashes can be removed from the firebox as well as to the increased grate surface with which recent locomotives are provided. For locomotive fuel, sulphur in coal need be given no serious consideration. The belief that locomotive coal must be lumpy or screened is gradually disappearing.

Owing to the strong draught in a locomotive firebox a large proportion of fine coal is objectionable, as considerable of it may be carried through the flues without combustion. The tendency to exaggerate the extent of such loss is due largely to prejudice against any but lumpy coals for locomotive use.

Steamship fuel is required to meet a steady demand for steam, as the boiler load remains practically constant once the vessel is under way. For such service a fuel high in heat units and having a practically uniform rate of delivery of its heat units is best adapted. Low-volatile coals are most desirable for steamship fuel, and nearly all vessels of the trans-Atlantic trade and of the United States navy have adopted such fuel.

Practically the entire tonnage of low volatile coal reaches the market as run-of-mine, consequently the percentage of small coal is considerably in excess of that in a similar quantity of run-of-mine bituminous coals; but this is not objectionable in steamship operation, because, with the draught much less than in locomotive operation, the loss due to unburned coal is small.

On some freight vessels sailing the Great Lakes mechanical stokers have been installed that use slack of bituminous coals with satisfactory results, as far as can be learned.

The chemical analysis for steamship fuel would be within the range of percentage values given for locomotive fuel—specifications usually requiring ash under 10%, sulphur about 2% or under, volatile matter approaching the lower limit, and British thermal units near the upper limits. Sulphur content is of no importance, and the requirement of 2% or under must be met to satisfy the purchaser rather than because of any detrimental effect the sulphur may have on the fuel value of the coal.

The load of large central power stations usually varies greatly, and to meet the peak loads the fuel must generate steam quickly. The advantages of meeting this demand by using a coal which will give up a large portion of its heat units in the least time after firing becomes more apparent as the boiler load and capacity approach an equality.

The selection of coal for large power plants in densely populated districts is influenced by the smoke laws operative in such localities, and to comply with the law low-volatile coals are given preference.

In boiler plants fired by mechanical stokers in the eastern United States, low-volatile run-of-mine coal is used, crushed so that no piece exceeds 3 in. in size.

In the central section the prevailing practice in large plants is stoker-fired boilers, using slack or screenings of bituminous coal. Fuel of this size avoids the necessity of crushing, and, for the greater portion of the time, affords practically smokeless operation. Bituminous slack is capable of meeting sudden changes in load more readily than low-volatile coal, and allows more uniform operation under widely varying plant loads.

Where freight is the larger part of fuel cost, the highest quality of coal is the best investment for the purchaser, as the cost of transporting coals of any quality for the same distance would be identical. For this reason principally, the eastern United States is the great market for the best grades of low-volatile coal. In the central section slack is the cheapest fuel obtainable.

If the use of low-volatile coal is advantageous in large boiler plants equipped with mechanical stokers, the peak loads are usually provided for by having ample boiler capacity. In small power plants with hand firing, the size of coal is considered of importance. In rare instances do such plants have the variations in load commonly found in large power stations. Taking into consideration steam fuels used in the various regions, it is found that they cover the entire range of chemical values, but in some small plants a coal low in ash is desirable on account of furnace-grate arrangement.

Smoke prevention is frequently of much importance. Care in manner of firing and selection of coal will usually permit of operation within the requirements of the smoke laws.

For by-product coking, requirements as to quality are far more strict than for steam coal, the range for sulphur being confined to rather narrow limits. In the by-product process coal is coked in such a manner that the gas, tar, and ammonia are recovered. Gas is sometimes the principal product and the ammonia, tar, and coke are the by-products.

A satisfactory by-product coal must be rich in gas, and meet certain requirements as to quantity of some of its constituent elements, the limits of which are determined largely by the purposes for which the coke is to be used. This means that gas coals are most desirable for such use. While many low-volatile coals will yield a satisfactory coke, their yield of gas is low, and bituminous coals other than gas coals are unsuited, because they are non-coking and their gas lacks the rich illuminant found in strictly 'gas' coals.

Where illuminating gas is the principal feature and the coke is not intended for use in iron manufacture, limits of sulphur are not so closely drawn, although it is difficult to purify gas made from high-sulphur coal. 2% or over of sulphur in coal has been used in such plants, the coke being used for steam and domestic purposes.

For by-product operation in connection with steel plants, sulphur limits in coal are ordinarily placed at 1·50 % as a maximum, with an average value of about 1 % to 1·25 %.

The standard range for coal for by-product use is 6% to 7·50% ash, which produces a coke ranging from 9% to 11% in ash. Ash is objectionable in coke for iron making, as its final appearance is in the form of slag, which requires heat for its production, representing so much loss of heating value and in part explaining why limits have been established.

In general, the range of analytical values for by-product coals would be represented by:

Volatile matter, from 28% to 38%.

Ash, from 6% to 7·50%.

Sulphur, from minimum to 1·50% for coke used for metallurgical purposes. From minimum to 2·50% for coke not intended for metallurgical purposes.

Fuel for producer gas covers a wide range in values, especially since gas engines are meeting with increased favour as prime movers.

Producer gas found favor by supplying the demand for cheaper fuel, and is used principally for metallurgical and power purposes, although it is applicable for kiln-burning of clay products, lime cement, and firing steam boilers. The principal use of producer gas is in the manufacture of steel, which requires a coal ranging from a minimum to 1·5 % in sulphur content.

All coals will produce about the same quantity of producer gas, but in metallurgical processes gas coal is preferred, for the reason that its gas burns with a long flame, giving more uniform distribution of heat at high temperature.

Other bituminous coal from which the demand could be supplied, and satisfactory temperatures obtained, have a prohibitive sulphur content. The selection of fuel for producer gas is limited by the use to be made of the gas and the type of producer.

Producers are classified according to their method of operation as, (1) suction, (2) pressure, and (3) down draft.

The suction producer has found application in small plants operated by gas engines, and the fuel has been limited almost exclusively to charcoal, anthracite, and coke, or fuels whose gas is free from tar, which is very objectionable in gas-engine operation.

Pressure producers are operated under a low pressure produced by a blast of steam and air. This is the type generally used for metallurgical purposes where the gas is used direct from the producers and tar is not objectionable.

For gas-engine use the gas is stored and the tar removed before passing to the engine, and lignite, peat, and bituminous coals, as well as charcoal, coke, and anthracite, may be satisfactorily used in this type of producer.

Tests with a pressure producer conducted by the United States Geological Survey at the various government testing plants have shown satisfactory results with fuels ranging widely in analytical values, as follows;

Moisture, 1·40 to 39·60%; volatile matter, from 9·70 to 42·50%; fixed carbon, from 23·80 to 73·70%; ash, from 2·70 to 23·40%; sulphur from ·30 to 7·40%.

It is reported that bone coal containing 44% of ash produced a gas affording economical gas-engine operation, and that any coal of commercial value can be successfully used.

Down-draft producers made their appearance after the pressure producers. These fix the tar as a permanent gas, thus making use of all the volatile matter and preparing it for immediate gas-engine use.

Gas producers are utilizing more and more the inferior grades of fuel, and at present are operated with fuels covering the range from anthracite to charcoal and peat.

In illuminating gas manufacture, practically all plants specify a screened gas coal of low sulphur content.

Three-quarter-inch screened coal is specified for several reasons:

1. It can be gasified in less time than run-of-mine coal.
2. It is lower in sulphur than run-of-mine coal.
3. Charging of retorts by hand is readily accomplished.

Low sulphur is required that the gas may be purified to meet the requirements of the law.

The commonly accepted standard of analytical values for illuminating gas coal would be approximately represented by the following: Volatile matter, from 32 to 37%; ash, from 6 to 8%; sulphur, not to exceed 1·50%.

The usual standard for yield of gas is an average of 10,000 cubic feet per ton of 2,000 lb. of coal, with an average candle power of 18.

Coal for cement burning is reduced to a powder before being used, hence slack coal is generally used because of its low price and the readiness with which it can be reduced. The essential requirements are that the fuel be: (1) Sufficiently high in volatile combustible matter to insure quick ignition; (2) sufficiently high in heating power.

While the maximum sulphur content of cement is definitely fixed, the sulphur in the coal has not been closely limited, as it does not enter into combination with the cement as long as proper kiln temperatures are maintained. As the impurities of some coals are approximately of the same composition as the cement, no strict limits have been placed on the amount of ash in such coals, but high ash percentages reduce the heating power, and, for this reason only, a low ash content is desired.

Gas coals have been found to give best results in cement burning, as they are high in volatile matter, which has a high heating value with long flame of quick ignition and maximum temperature at a short distance within the kiln.

If coal which ignites slowly is used, ignition takes place too far inside the kiln, giving the zone of maximum temperature at such a distance from the firing end that difficulties are encountered in securing proper clinking of the cement, besides increasing loss of heat due to the waste gases leaving the kiln at a high temperature. While gas coals are considered the best for cement burning, other high-volatile bituminous coals are used satisfactorily.

Domestic coal must meet consumers' requirements as to size, and is prepared as lump, egg, and nut. Coal firm in structure and suffering the minimum amount of breakage in handling will meet domestic requirements most satisfactorily. It should be non-coking or free burning, so that its heat is given off readily. The ash should be small in quantity and free from clinker.

Export bituminous coal must be in large sizes and of firm tough structure, that it may reach its destination in large sizes with minimum amount of breakage. This coal is usually passed over 1½ in. screens before shipment from mines.

With the low volatile or semibituminous coals which produce a large amount of fine coal in mining, size of coal for domestic purposes is obtained by screening. For export these coals are usually shipped as run-of-mine.

In general, the preparation of coal for market by the removal of slate, bone and sulphur balls, is of importance to the producer as well as the purchaser. It is of importance to the producer in extending his market by maintaining the reputation of the coal he produces at a high standard, and to the purchaser that he may receive the greatest fuel value for the money expended.

Sulphur balls produce about one-third as much heat in burning as the same weight of coal, and on this basis alone are not so objectionable as other impurities, which have no heating value whatever. They are objectionable on account of difficulty in handling the clinker they produce.

The impurities without heating value go to increase the amount of ash, and represent so much worthless material at the same price and freight rate as the coal. As transportation is usually the greater portion of cost of coal to the consumer, the importance of removing as much free impurities as possible is readily apparent.

The selection of coal to be used for any particular purpose is dependent upon, cost to the consumer, limitations imposed by smoke laws, and fuel value. The fuel value is greatly influenced by the readiness with which clinker is formed from the ash, the greater the freedom from clinker the greater is the recoverable 'fuel value.'"—R. E. RIGHTMIRE, West Virginian Mining Institute.—*Mines and Minerals*, Feb., 1911, p. 397. (A. R.)

AN EARLY CYANIDE PLANT.—"One of the first plants, if not actually the pioneer plant to treat ore on a commercial scale by the cyanide process was built near the Calumet Mine in Shasta County, California, in 1891, by A. B. Paul. It was thus described in the *Mining and Scientific Press*, in the issue of October 3, 1891:—

'The plant is intended solely for the working of the McArthur-Forrest process, not alone on the ores of the three counties for which the company owns patent rights, but for all the ores that may be shipped from all portions of the coast. The plant will treat 10 tons of ore every 24 hours, and is so arranged that different lots of ore can be treated at the same time. In the treatment of the ore, the first operation is drying. It is then passed through a rock-breaker and into bins, from which it is fed into a Paul barrel-pulverizer, and when powdered the ore is placed in agitators and a 1% solution of cyanide of potassium added. After an agitation of 6 to 12 hours, the liquor is drawn off into filtering tubs. These filters are of wash-gravel covered with canvas. The liquor passes through the filter and into storage tanks. From this the solution is drawn into a chest of zinc filters, each filled with zinc shavings. The liquor flows down through the first (box), up through the second, down through the third, and so on, to the end of the eight filters. The gold is precipitated upon the zinc shavings in the form of a brown powder. When desired, the chest is unlocked and the zinc shavings washed in clear water, which separates the gold. When it has settled, the water is drawn off, and the gold, in the form of brown powder, melted into bars. The liquor from the filtering tank is pumped back to the first tank, and sufficient cyanide of potassium added to bring the solution up to the original 1%. As will be seen, the process is very simple; no roasting of ores is needed, and no high-priced chemicals required, with a very small loss of materials used. As numerous parties have failed in making small working tests of this process, it may not be amiss to state that very often cyanide of potassium is not more than one-half to two-thirds full strength, and it is therefore necessary to know the exact percentage of cyanide as well as to follow the company's method of treatment.'

This is one of the first articles descriptive of the cyanide process ever published in a technical journal. The details given are sufficiently comprehensive to make the operation of the process easily understood, as far as knowledge of it went, but subsequent development of the process proved it to be far from the simple application of a long recognised fact—that a weak solution of potassium cyanide would dissolve gold. Since that time, the autumn of 1891, tons of literature of the highest type of classical contributions to metallurgy have been published, and experimenters are still earnestly engaged in the study of methods by means of which the process may be still further improved and its commercial application successfully extended to the treatment of those ores which are still refractory."—*Mining and Scientific Press*, January 21, 1911, p. 137. (W. R. D.)

SCREENING VERSUS CLASSIFICATION PRIOR TO CONCENTRATION.—"As to the comparative advantages of screen sizing and hydraulic classification for table feeds, there is room for intelligent difference of opinion. In some cases, an unwarranted prejudice may be due to failure to recognize a fundamental difference in tables. In jigging practice, sized feeds are particularly favorable to making clean gate-discharge products while classified feeds are favorable to making clean hutch products. For vanners, the evidence is in favour of classified feeds, owing to the sizing action of water flowing over smooth surfaces. In the case of reciprocating tables, conditions are more complex. The material on the table is subjected to a combined stratifying action, due to agitation, and a sizing action, due to the water flow. These influences together determine the course of the various mineral particles over the table and the grouping of these mineral particles varies according to the relative activity of the two influences. This relative activity differs on different tables (and on different parts of the same table), according to the number, depth and form of the riffles. Numerous, deep, full length riffles give the stratifying action its maximum importance, and 'sized' feeds are better adapted to making high extraction and clean products. On smooth surfaces, the sizing action of the water flow predominates, and classified feeds are preferable. Between these two extremes can doubtless be found tables which will do equally good work on either class of feed, if properly adjusted. When it is considered, however, that the relative importance of the two influences at work varies on most tables with the slope, the rate of feed, and amount of water used, it is not surprising that contradictory experience is reported, where from superficial data, general agreement might be expected.

The Scope of Classifiers and Sizers.—One other factor, which must be given due weight in any comparison, is the efficiency of the 'classifying' and 'sizing' operation in each case. The results attainable by either method improve as the classification or sizing approaches theoretical perfection.

In the end, either method must stand the test of economic utility. Probably mechanical considerations bearing directly on costs, more often control the choice than any direct advantage in extraction or degree of concentration. But for this fact, some general principles might be evolved, which would tend to standardize mill work in this respect. For installations where the largest capacity compatible with clean products is desired, close screen sizing seems to have the strongest claim to consideration. In low-grade milling operations the tendency to over-load tables is very strong, while, at the same time, the low grade of the ore urges extreme simplicity of plant. The number of instances in which hydraulic classification is favoured under these conditions, therefore, serve to emphasize the preponderant importance of the economic side of every concentrating problem."—J. R. BLAKE, *The Engineering and Mining Journal* (New York), p. 256, 4th Feb., 1911. (W. A. C.)

GOLD FROM CLAY DEPOSITS.—"A new method of winning gold from clay deposits is due to J. J. W. H. van der Toorn (German patent 225,810). The processes now employed treat clay with water whereby a good deal of the gold is lost, as the separation of gold from clay is very difficult on account of the great cohesion of the clay. The new process tries to remove this cohesion. The gold-containing clay is spread over a large area, dried and kneaded. Then it is heated in a furnace similar to a brick kiln, till it assumes the hardness of stone. The rocklike masses are then broken in a stamp mill and the gold separated in the usual manner."—J. J. W. H. VAN DER TOORN, *Metallurgie*, Dec. 8, 1910.—*Metallurgical and Chemical Engineering*, ix., 2, 106. (J. A. W.)

PROGRESSIVE MILL PRACTICE.—"California is often referred to as the cradle of gold mining, and such, indeed, it really is, but it is a matter of general surprise that there is a tendency in some directions in California to remain in the cradle. Particularly is this noticeable in the treatment of gold ores of the State. Other gold-mining regions throughout the world have in their early history, almost without exception, adopted California mill practices, but in many cases the newer countries have promptly drifted away from the 'time-honoured customs' of California's mill-men and evolved newer and better methods through experimentation, or have applied those already tried out in other new regions. In no district is this departure from traditional methods more radical than on the Rand. The ores of the Rand are relatively simple—a quartzose gangue with metallic gold and auriferous pyrite. The ore yields its gold readily to amalgamation and cyanidation. As concentration is not considered necessary on the Rand, the engineers, to reduce cost, years ago began to seek for methods of milling which would permit an increase of stamp duty. Year after year saw the stamp duty increased by various ingenious means, until now, by coarse crushing and re-grinding, the capacity per stamp, as at the East Rand mills, for instance, has reached 20 tons daily, and even a higher rate is anticipated, as compared with that of 4 to 6 tons per stamp in the average California mill. That the gold ores of California are mostly readily amenable to the simple methods of recovery practised on the Rand is well known, and why California mill-men do not make an effort to increase mill capacity along lines similar to those that have been successfully evolved on the Rand is one of the things not easy to understand. An increase of stamp duty without any material increase in the cost of power will certainly result in a decrease of milling cost per ton. At many California mines, by adopting the re-grinding methods of the Rand, employing Chilian or tube-mills after coarse-crushing in the stamp battery, the capacity could be raised from 4 to 5 tons per stamp to 10 and possibly to 15 tons per stamp daily, while making as large a saving as by present methods. It seems well worth the effort, at any rate, and if the attempt be successful it would permit a stated capacity at a much lower capital expense for equipment."—*Mining and Scientific Press*, Jan. 21, 1911, p. 129. (W. R. D.)

MILLING AT COBALT.—"An interesting feature of ore dressing at Cobalt, Canada, is that the methods in use had to be devised especially for the ores of the district. No precedent could be referred to by the metallurgist and it is greatly to his credit that he has succeeded so well. At present thirteen mills are in operation by electric power, and three more are in course of erection. Wet methods of dressing are adopted, and in some cases hydrometallurgy is practiced to the extent of the final recovery of the metals at the mill.

No two mills are exactly alike, but are the same in general principle. For illustration, the equipment and practice of the Coniagas mill may be taken as typical. The ore is crushed in Blake and gyratory crushers to 1½ in., then rolled to ¾ in. and screened in trommels. The coarse is concentrated in Harz jigs and the fine on Wilfley tables. The residue from these is crushed in 30 stamps, following which the pulp is thickened and treated on Deister and Wilfley tables, followed by a canvas slime plant.

Considerable difficulty was experienced in the early work in saving values from the tailings, owing to the escape of small scales of metallic silver and smaltite which seemed to have a great tendency to float away. By paying more attention to the slime recovery this loss has been largely averted. The average extraction in the district is probably 82%. During 1909 the ratio of concentration was 39 to 1. The cost of milling was higher in 1909 than in 1910 owing to the use of cheaper electric power in the latter year. The cost of the work at the McKinley-Darragh mill was $1.98 in 1909, and is reported to be about $1.30 in 1910. Power formerly cost in the neighbourhood of $150 per hp-year, and is now obtainable at about $50.

At three plants—the O'Brien, Buffalo and Nova Scotia—cyanide plants are operated in connection with the concentration. Dr. Mandy considers the success of this process as yet problematical. The Nova Scotia plant uses pan amalgamation and cyanidation, but no figures are available on the success of this system.

The concentrating plants all treat what is known as the low grade ore, containing 10 to 40 oz. silver.

The high grade ore, varying from 100 to 3000 oz. silver, is treated in smelters. The smelting ore is further divided into low and high grade; the first carrying from 100 to 600 oz. silver and the last from 800 to 3000 oz. The purchasers pay a sliding scale according to the silver content, and have various schedules for the arsenic content. United States smelters treated ⅝ of the tonnage in 1910, and Canadian plants treated about 32%, the balance going to England and Germany.

The ores are silicious and make a good fluxing ore in silver lead smelting. They also may be used for converter lining, but for this purpose there are several objections, viz., the arsenic fails to volatilize completely, and practically not at all after the first 10 min. of blowing, causing about 1·5% of arsenic to appear in the copper; the slag is inclined to be thick; the charge effervesces owing to carbonates in the ore, causing high copper slags, sometimes as high as 15%; alumina frequently has to be added to the ore for binding; and finally, the lime and iron in the ore tend to rob the lining of active silica, leaving less to do the work of slag production."—Dr. JOSEPH T. MANDY, *London Mining Journal*, Dec., 1910.—*Metallurgical and Chemical Engineering*, February, 1911, p. 105. (J.A.W.)

MILLING NATIVE SILVER ORE IN MEXICO.—"The following is a description of a combination of amalgamation and cyanidation for silver ore. The ores of the Batopilas silver mines are peculiar in that the clean base minerals, galena, blende and pyrite, seldom carry more than 4 oz. silver per ton. The values occur mostly as native silver, argentite and sometimes arsenical silver.

The ore is sorted into two classes, the high grade native silver ore which is treated without concentration, and the low grade milling ore which is concentrated.

The high grade ore is stamped through a fine screen. Some coarse native silver accumulates in the mortar and is removed and washed by hand prior to smelting and refining. The screened material is amalgamated in pans by the following process: The charge for a 4 ft. pan is 1000 lb. ore, 15 to 17 lb. mercury, 4·5 lb. cyanide of sodium, about 4 oz. lead acetate, 3·5 lb. lime, and 1 to 1 of stock solution. The solution in the pan then runs from 40 to 48 lb. cyanide per ton, and never below 33 lb. The ore is first ground for six hours without mercury, when it is added and grinding continued for 10 hours. The charge is then run into a settler where it is leached and agitated, mechanically and by air, for 12 hours. The settler is then washed four hours, and the amalgam and residues removed and washed by hand. The former is properly retorted, and the latter is sent to percolating tanks, referred to later.

The slime washings from the settler are thickened in a Dorr machine, the clear overflow of which goes to strong solution sumps, and the thickened underflow to Pachuca tanks. One of the latter is filling while the other is being agitated and drawn off. Blaisdell filters are used, four charges being put through in 8 hours. The tailings from the filter run about 9 oz. silver per ton.

The low grade ore is concentrated 50 into 1. The concentrate consists of pyrite, galena and blende, with native silver and argentite. It is reconcentrated into two classes, high and low grade. The high grade is amalgamated in a pan, adding mercury pound for pound of silver contained, and a slight excess. Grinding proceeds for 14 hours before amalgamation is started, this being continued for 2 to 5 days. Cyanide, lime and lead acetate also form a part of the charge, and the pan is decanted twice daily into the rich solution sump, the solution being made up again with stock solution holding 10 lb. KCN per ton. After 6 days the pan is discharged into a settler, where it is agitated mechanically and by air for six days, the solution being decanted once a day. The tailings from the settler go to the Dorr thickener, and thence to the Pachuca tanks.

The low grade concentrate, which forms the bulk of the product treated, is leached in the percolating tanks referred to above. The charge consists of from 35 to 60 tons of ore; the chemicals added being lead acetate, lime and cyanide. The latter is added in sufficient quantity to make 50 lb. KCN per ton. The solution is left on 24 hours, then drawn off and the tank allowed to aerate for 48 hours. Stock solution of 10 lb. KCN per ton is then run on and allowed to stand for 12 hours, after which it is withdrawn and the tank allowed to stand dry for 24 hours. This process is continued with 12 hour periods of percolation and aeration for two months when 95 to 96% of the value has been leached from the concentrate. The precipitated silver assays about 800 fine, and the refined product about 990 fine."—W. M. Brodie, *Mexican Mining Journal*, Jan., 1911.—*Metallurgical and Chemical Engineering*, Feb., 1911, p. 105. (J. A. W.)

MINING.

Transvaal Stope Drill Competition.—"The following is a summary of the report of the Underground Manager of the Stope Drill Competition, Mr. Tom Johnson, which gives the practical results of the trials in a concise form:

Machines.—I think all the percussive machines are too light in weight for general work. They should be at least 130 lbs. for the smallest of them, say, a 2¼ in. machine. They all require larger feed screws, steel wearing washers between the shoulder of the feed screw and feed screw bridge, and chucks to carry 1 in. diameter shanks. The nuts on the valve chests ought to be more accessible for the use of a spanner, and the cradles should be longer.

Chersen.—This machine proved itself at the elimination trials, and on the testing blocks, to be a fast driller, but in general work in the various stopes it failed to accomplish anything like the work that might have been expected from it. It does fair work in a leader stope where the holes can be put under and over the reef, but when it had to drill in reef there was trouble, as the machine failed on the back stroke. Another drawback was that a very small bit of grit stuck the valve, but this might be overcome with a good type of air strainer.

Holman 2⅛ in.—This machine, next to the Siskol, is the one most favoured by the miners, for its freedom from trouble. This type allows the miners to drill their holes as they want them, and can put down 5 ft. holes with ease. With a free running machine like this, a miner has a better chance of breaking rock than with a machine which has not a sufficiently powerful back stroke, and through this cause loses holes or has to leave them short in length. The spares costs on this machine are fairly low, which puts it in a good position under the Rules of the Competition—i.e., footage costs.

Holman 2¾ in. This machine has the same fault as the Chersen and the New Century in not being able to run freely for long periods. It drills faster than the Holman 2⅛ in. when actually running, but cannot make the same drilling time during the shift. A very small piece of grit no larger than a pin-head getting into the valve stops the machine from working. If this valve were arranged that the entrance to the valve was the smallest part, a little grit getting in would go away with the air instead of sticking the valve. The use of a good strainer would prevent a lot of trouble.

Siskol.—This machine is one of the most favoured by the miners, for one reason—that when a hole is started there is more certainty of getting the hole down, and also to a greater depth, than with the other machines. This machine often drilled 6 ft. holes in reef in the stope at 2,600 level, Robinson Deep, and I think could drill 7 ft. holes comfortably. This and the Holman 2⅛ in. are the best machines for all-round work It has a sufficiently powerful back stroke, and does not get stuck up with every grain of dirt that gets into the valve chest. This machine must have been badly handled during its run on the Village Deep and the Crown Deep E.F.—e.g., on the Crown Deep E.F. the footage per shift was 43·9 and on the W.F. 79·5 in practically the same ground, as it was practically a new stope at the time. The air pressures were 80·5 and 80·18 respectively. This machine is lowest in labour and air costs, but highest in spares, much of the latter being due to the competitors sending out a machine for the use of hollow steel, and having to use these unsuitable spares under the Rules of the Competition. It should be provided with a half chuck bush instead of a full one, as at present, and provision should also be made for wearing strips for taking up the wear in the cradle.

Running Conditions.—Supply of Drills.—Steel handling on two of the mines gave very little trouble, due in a great measure to the stopes being close to the shaft. On the other two mines quite an amount of time has been lost on account of the poor system of handling the steel, There have been times when 200 drills per machine have not been sufficient to keep the machines going, a very large amount of steel having been lost on the various mines. Where the drills could get to no one seems to know. It is true starters easily get buried and the other drills easily mixed with hand drills, and all trace of them is thus lost; but, taking everything into account, the loss is very much more than it ought to have been.

Air Pressure.—The running of the machines was suspended at the Cason mine on November 5, 1909, owing to the prevailing low pressure. It was not resumed, and the footage drilled in this mine was disregarded. At the Crown Deep we have lost time since the beginning of December until about the end of February, owing to low pressure. In the fore part of the competition the Crown Deep provided the highest pressure of air, and in the latter part of the run of the Holman 2⅛ in. (the last machine to run there) the pressure has again been good. The Village Deep and the Robinson Deep have provided a good and fairly continuous supply at good pressure, particularly the Robinson Deep.

Boys.—The boys supplied on the various mines have usually been up to the average of mine boys. There have, of course, being odd shifts with poor boys, as will always happen at times on all mines. The only time the supply of boys has caused unusual loss was during the run on the Siskol machine in the 2,700 stope of the Robinson Deep. Miner Brown had bad boys for 16½ shifts, as reported by me on December 15, which undoubtedly handicapped the machine. The reason that Brown did not have better boys was that during the time he was at the Village Deep two of his boys died and another went home, and when the Siskol started at the Robinson Deep the company was troubled with a sudden sickness that attacked their boys, and consequently was not able to do better for us.

Holes per Bench.—It has not been possible to go thoroughly into the merits of two-hole versus four-hole benches. What little has been done in this matter and my own experience leads me to believe that with these light machines, which can be so quickly unrigged and rigged up again, two-hole benches with ordinary miners would without doubt be much the best as regards cost per ton of rock broken. With the present heavy machines in ordinary use, I do not think that there would be any gain in using two-hole benches, as the time lost in moving would wipe out the gain. The only way that I can see to be advantageous by two-hole benches with heavy machines is to keep a spare machine in addition to bars so that the machine boys after finishing their two holes move to a fresh machine already rigged up. The machine that had completed its two holes would then be taken down and rigged on a fresh bench ready for the next pair of boys who had got their bench finished, and so on in rotation. I think it is better to give manufacturers encouragement to build a 3 in. or 3⅛ in. machine weighing not more than 200 lbs. for wide stopes, as a machine of this weight, with rigging gear in proportion, would no doubt pay for use on two-hole benches, 200 lbs. not being a prohibitive weight in stopes over 4 ft. wide.

Work Done.—It will be noticed from the attached table that there is quite a difference between the footage drilled per hour per machine during the competition proper and during the elimination trials and air tests. During the elimination trials the guage of the bits was less. One white man was on one machine; machines were supposed to be in the best of order, and it was pure competition work for the three days. The same thing obtained at the air tests, smaller bits, machines in apple-pie order, special men, and everything handy. Some of the competitors have built too much on the air test figures. A curious fact of the air tests is that of the finishing machines the Holman 2⅛ in. has the smallest average inches per minute, yet stands so well in work done in the mine. In the competition proper there has not been much actual competition work done during my time, whatever may have been the case during the early part when the work was fresh. Machines could not always be at their best, parts must wear and be replaced, the change in personnel, loss of enthusiasm, and a hundred and one little things that must happen on a long run, but not on a three days' run, help to account for the difference in footage drilled.

Machine.	Footage per Hour at Underground Elimination Tests per Single Machine.	Footage per Hour Competition per Single Machine.
Holman 1⅞ in. ...	... 6 ft. 5 in. ...	3 ft. 8·5 in.
Holman 2¾ in. ...	... 7 ft. 0 in. ...	3 ft. 5 in.
Chersen ...	... 8 ft. 3 in. ...	3 ft. 4·3 in.
Siskol	... 4 ft. 8 in. ...	4 ft. 0·7 in.

Machine v. Hammer Boys.—Costs.—In the competition two sets of machines, the Holman 2⅛ in. and the Siskol, have cost approximately 8·3d. per foot drilled plus cost of steel and drill sharpening, which should come to at the most 1·5d. per foot, making 9·8d. per foot. But it has taken 1·282 mine shifts to make one 8-hour shift; therefore the wage cost must be increased in that ratio. Further, instead of assuming 10s. per shift for two machines as the white wage, I have taken 25s. per shift for four machines. This alteration means an increase of ½d. per foot drilled, making the total cost per foot for these two sets of machines practically 11·8d. per foot, this being as near as I can get to the actual cost per foot for 28,528 ft. drilled by these machines. This includes the footage drilled with low air pressure. The loss of air in transmission and depreciation of compressors are not charged in these costs. This cost of 11·8d. per foot compares favourably with the cost by native labour, for which 1s. 1d. per foot would be an exceedingly low figure. The tonnage broken should be as 6 to 5 in favour of the machines; the cost of explosives would be as 6 to 5 in favour of native labour. The tendency is for natives' wages and costs to increase, and this is the heavy item (10d. per foot) in hammer work, but a much smaller item (only 3d.) per foot in machine work.

Depth of Holes.—With a proper size of bit a hole 4 ft. 8 in. or 5 feet deep is much better as regards tonnage than the ordinary boy's hole, for it will carry more explosive, and so a greater burden. A man automatically puts a greater burden on long holes than short ones. For these several reasons I think that even if machine drilling cost us as much per foot drilled as the hammer boys, which I have shown they do not, the extra tonnage from the machine holes would more than pay for the expense of extra compressors—cheaper cost per ton being the true comparison.

Stoping Width.—As to stoping width, these machines have run in stopes of an average width of 30 in., while sometimes the width was as low as 24 in. in S.W. 1 W. at the Cason. There were two periods done at 43 shifts at an average stoping width of 30 in., three others at an average width of 35 in. to 36 in., and seven at an average width of 36 in. to 40 in.. showing that the machines are capable of narrow stoping if the mine authorities will insist on narrow stoping, as 12 out of 28 runs have therefore been done at less than 40 in., the last run at the Crown Deep will also be under 40 in., and making 13 out of 30. It has not been the fault of the machine that the whole of the stoping was not done at less than 40 in. In one stope, the reef being in two portions, it was necessary to stope wider; in other places carelessness on the part of the miners and the mine officials was the cause of the greater stope widths. The average width for the total work is 44 in. to 45 in. I know that there is an idea prevailing that these machines cannot stope narrow, but this competition has proved that 43% of the work done has been in stopes 40in. and under. With 15% of the work it was necessary to carry over 40 in., leaving 42% over 40 in., most of which was due to the mine officials not wishing to interfere with the competion men.

Hammer Drill Machines.—There is little I can say with respect to hammer drill machines during the competition trials, for there was only one hammer drill machine (Climax Imperial) running at the time I joined the competition staff. From what I can gather the troubles were steels sticking in the holes, water flying about, and steels breaking at the shanks. This will always be a trouble in drilling down holes of greater depth than 40 in. or so, as there are sure to be fluctuations in the supply of water to the bits on account of the hole in the steel choking with dirt, or a soft bit getting burred and the hole closed that way, or water getting shut off. Outside the competition it is being proved that the hammer type of drill is capable of doing good work drilling dry uppers. There is no reason why it could not do stoping. A separate jet can be used to allay the dust, and solid steel used as at present in the rises, although, personally, I think a water fed hollow steel arrangement will yet be got out that will not throw the water about, but send it up the hole where it is wanted. If it could be proved that the hammer type of drill could drill the ground cheaper than hammer boys, there is no one who would not be ready to start the stope to the rise instead of to the dip. I do not mean back stoping in a blind stope, but starting from the corner of a winze on the lower face of the block of ground.

Boys.—The number of boys used per two machines was, as usual, five, and this number is necessary to get the best work from the machines, and to reduce the number would, in my opinion, increase the cost per foot. As it is best under the circumstances to use five boys per two machines, there is no reason why the machines should not be made a little heavier than that demanded by the rules under which the competition was held, and so enable them to stand up to their work better and last longer, and thus reduce the cost of maintenance.

Maintenance of Machines.—The maintenance costs show great diversity, ranging from 1·6d. to 3·3d., including depreciation of machines. This is excessive, as spares have been sacrificed at times with the idea of getting greater footage. In ordinary work the spares cost should come below the smaller figure, for some of the above waste will be cut out, and known improvements that will be and are now being effected will lower the costs.

Explosives.—The amount of explosives used compares very well with ordinary work, coming out at over three fathoms per case. I had a mixture of gelatine and gelignite tried, and found that it was cheaper than gelatine alone, but with holes drilled of the diameter suggested hereafter in the 'Recommendations on size of bits.' Gelignite would be best for the ordinary run of miners, although good miners might make gelatine pay by increasing the burden on the holes. The best explosive to use depends on three things—the miner, the depth of the hole, and the diameter of the hole at the bottom.

Skill.—The mining work done during the competition leaves room for improvement. With the four machines left in the competition the average footage required to break a fathom of ground was 51·9 ft. I think it should have been kept down, to, say, 45 ft. and with the Siskol to 42 ft. per fathom. The reason that it has taken a greater footage than I deem necessary is due to the low average length of hole drilled. On some of the runs good work has been done, whilst at other times the work was unsatisfactory. During my time the miners have been what any manager would class as good men, but the hope of winning prizes was more or less dead, as the competition had lasted too long and the men had lost enthusiasm. In my opinion it would have been much better to have had monthly prizes, and I think in this respect the fathomage bonus system, introduced in October, cheapened costs somewhat. The length of hole drilled on the average has been very low for all machines when taking into account the capabilities of the machines, and the size of bits in use. This in a great measure is due to the shape of the bits used, as there has been too great a clearance and too little metal in the bits. The steel used stood up to its work very well, but I think deeper holes would have been drilled with a better shaped bit.

Drills.—In my opinion the shape of the bit is a very important matter, and it is not always the best steel, as steel, that is the best for cutting rock, as the gauge wears off the drills very quickly, because there is too little metal provided for the wear. Large machine drills of ordinary steel can run with only 3-16 in. difference or gauge of bits. A set of 5 drills can start with a 2 in. bit with a finishing bit of 1¼ in., depth of hole 8 ft. 6 in., and 1¼ in. cartridge will go to the bottom. For the small machines run in the competition ⅛ in. should have been sufficient difference in gauge. All the competitors used too large a guage on the drills, starting with a 1⅞ in. bit where they should not have gone above 1½ in. bit for a starter. With this gauge five drills could have been used, and still finish large enough to meet the condition of 15-16 in. at the bottom of a hole 6 ft. deep. Many feet of drilling are being lost for the sake of paying a little more in the drill sharpening shop. This shop is one of the main points to commence increasing the efficiency of rock drilling machines, then the machine fitter, then the mine captain and shift bosses, and, lastly, the miner, instead of commencing with the miner. If these four points are properly looked after, small machines should surpass hammer boys easily, and all machines do much better work.

Machine Handling.—The case of handling these machines can be judged when a boy could, without disconnecting the hose from his machine, lift it off the arm of one bar, carry it away, place it on the arm of another bar ready rigged, and be ready to drill in from 15 to 20 minutes.

Recommendations—I would recommend the lightest reciprocating machines to weigh 120 to 130 lbs. The extra weight is wanted in feed screw, longer cradles, slides and cylinder liner. (Only the Holman 2⅛ in. has a liner.)

The same size bars and fittings will do for stoping widths up to 4 ft. A heavier machine—say 150 lbs. could be used, if desired, in stopes between 3 ft. and 4 ft., but to take the same fittings as the lighter machines:

In stopes over 4 ft., a machine weighing 180 to 200 lbs. would be heavy enough—but not too heavy for two-hole bench work—and of sufficient diameter (3 in. or 3⅛ in.) for any of our work. The standard bar for these machines would be, say, 3½ in. diameter.

The bits should be parallel at the sides and flat for about an inch from the cutting edge. The sizes for the smaller machines should be :—

No.	Size of bit.	Size and shape of steel.	Length.
1	1⅞ in.	1½ in. Cruciform.	2 ft. 0 in.
2	1 11-16 in.	1½ in. ,,	3 ft. 3 in.
3	1½ in.	1 in. Octagon.	4 ft. 9 in. (1¼ in. grooved.)
4	1/5-16 in.	⅞ in. ,,	6 ft. 3 in.
5	1⅛ in.	⅞ in. ,,	7 ft. 9 in.

1 in. diameter explosives to be used.

Large Machines.—

No.	Size of bit.	Alternate.	Size and shape of steel.	Length.
1	2 in.	2¼ in.	1¾ in. Cruciform.	2 ft. 6 in.*
2	1 13-16 in.	2 in.	1½ in.	4 ft. 0 in.
3	1⅝ in.	1¾ in.	1¼ in. Octagon.	5 ft. 9 in.
4	1 7-16 in.	1⅓ in.	1⅛ in. ,,	7 ft. 6 in.
5	1¼ in.	1¼ in.	1 in.	9 ft. 3 in.

1¼ in. diameter explosives to be used.

* Shanks included."

—*Mining Journal*, Feb. 18th, 1911, p. 177. (A. R.)

Prospecting for Silver.—"Silver, once called a precious metal, is now an ordinary commercial substance, whose intrinsic value is so low, about 20 cents per ounce, that it is not sought so eagerly as formerly.

It would be folly on the part of the prospector to pass it by simply because it is so common a substance, for there are possibilities that it may be in large quantities or associated with other metals which will enhance its value. While silver is found occasionally in metallic form, it is more frequently found associated with other metal minerals, for instance, copper, lead, and gold. When native it resembles the silver in coin, although possibly a little brighter or darker in colour. It can readily be distinguished in this form, but if there is doubt it can be melted with a blow-pipe on charcoal, or if that useful little instrument is not available it will dissolve in nitric acid. If a little salt be added to a silver nitrate solution white silver chloride will be precipitated. If a few drops of hydrochloric acid be added to a silver nitrate solution silver chloride will be precipitated, which is soluble in ammonia, while lead chloride is not. Silver chloride is insoluble in hot water, while lead chloride is soluble, but will precipitate on the solution becoming cold.

With these few simple tests the novice can distinguish lead from silver, although frequently the two are associated in nature; in fact it is a rather rare occurrence to find lead sulphide free from silver.

The greater part of the silver produced in the United States is obtained when smelting lead and copper ores.

The greater part of the silver produced in Mexico comes from lead-silver ores. These ores also carry some gold, which oftentimes is sufficient to pay for their treatment, although not in such quantity that they could be classed as gold ores.

The greater part of the silver produced in Ontario, Canada, is almost native, although associated with cobalt and nickel minerals.

The first large silver deposit found in this country was the celebrated Comstock lode, in Nevada. The black sulphide of silver was at first thrown away by those who were washing for gold, and even broken up to obtain the free gold in the lumps. As soon, however, as an assay disclosed its nature mining commenced in earnest. The gangue in this deposit was mostly quartz and the vein has been worked to a depth of 3,100 feet, making it evident that the solutions forming the vein came from great depths. Argentite, or silver sulphide, contains 87·1% of silver and 12·9% of sulphur. It occurs in cubes and octahedrons, massive; as scales, coatings, and tree-like markings. It has a blackish lead-gray colour. Its streak on porcelain has a lead-gray colour and a shining metallic luster. It is partly soluble in nitric acid, and when in solution will silver-plate a copper strip. The mineral is as readily cut as lead; will flatten under the hammer, and is easily melted.

Other silver deposits were found in Nevada, although they were not remarkable, and it was not until 1878 that any bonanza silver deposits attracted attention. These were at Leadville, Colo., where the lead sulphides and carbonates were found in limestone adjacent to porphyry. In places very rich silver ore was found and often associated with it was gold. Closely following this were the Butte, Mont., deposits, which were in granite that had been cut by intrusive dykes, forming fissures that were afterwards filled by solutions carrying copper sulphides, gold, and silver. The copper sulphides were weathered, leaving the gold and silver in great masses near the surface. The gangue in this instance is quartz, indicating that the mineral solutions came from below.

Following this discovery came the Mollie Gibson and Aspen silver deposits in Colorado. These mines were in limestone adjacent to porphyry, and like the Leadville mines, were contact deposits. Probably the next most noted silver deposit was found by a burro in the Couer d'Alene district at Wardner, Idaho. The silver-bearing galena seems to be as rich in the Bunker Hill and Sullivan Mine at a depth of 2,100 feet, as at the surface. The mine is said to have paid over $7,000,000 in dividends since its discovery in 1885. It is at present the richest silver mine in the United States, and other silver-lead deposits are being discovered in the same district almost every year. The deposits are in a mineralized zone, having quartzite foot wall and an impregnated hanging wall of brecciated quartzite. The rocks in this section are quartzite and schists that have been folded and otherwise distorted.

In the Colbalt district in Canada there are some exceedingly rich silver veins in diabase. The outcrop of these veins is coloured pink by cobalt bloom, and if nickel be present a greenish tinge is observed. The silver in this district is almost native and is associated with calcite gangue showing that the ascending solutions carrying silver were met by descending solutions carrying carbonate of lime.

While silver is found in the older formations in quartz veins, and in the Cobalt district with calcite gangue, the largest deposits are found in limestone adjacent to porphyry. It seems remarkable at first that this should be the case until the same phenomenon is noticed in the case of copper sulphides and galena,

Both copper and galena when in sulphide form are associated almost invariably with silver. If they become weathered or taken in solution they leave the silver to be absorbed by some other solution, and this travelling along crevices in limestone eventually finds some mineral or solution which precipitates the silver.

For example, silver sulphate in solution, could be precipated by a salt solution forming insoluble silver chloride, known as horn silver or cerargyrite. Large deposits of this mineral are rare, but it is found associated with other silver minerals. It is soluble in ammonia, but not in nitric acid. Being soft and waxy it is readily melted, and will, when wet and placed on zinc, turn black, swell up, and show metallic luster if pressed with the point of a knife. It is usually found near the surface, but also in some depth in deposits formed from other minerals, being oxidized and taken into solution. Horn silver contains 75% silver and 25% chlorine. It is whitish with other shades of colour at times.

Should the silver be in solution and meet another solution containing antimony, ruby silver would be formed. Ruby silver is a black mineral with a dark red tinge. It generally looks massive, but under the glass it is seen to be finely crystallized. It gives a dark red streak on porcelain; is easily melted, giving off sulphur fumes, and is soluble in nitric acid. It might be mistaken for proustite or light red silver, but to tbe prospector this makes little difference. Light red silver contains sulphur and arsenic instead of sulphur and antimony. It is soft, gives a bright red streak and has a bright red colour. It is decomposed by nitric acid and melts easily. Both minerals are associated and at times carry considerable gold. Several other silver minerals are known, but usually are associated with other metals or nonmetals to such an extent as to be unrecognizable, although at times they can be determined by tests.

Limestone is generally bluish-gray or drab, but cannot always be recognised with the eye; however, a drop of acid will cause it to froth. Silicious limestone will not effervesce, and in all probability silver deposits will not be found in it. Porphyry weathers more or less at the surface unless highly silicious, and is generally white or gray with crystals of some other minerals prominent in a fine mass. It is an intrusive rock that often forms great dykes. It is presumed that solutions bearing minerals accompany the intrusion, and these, finding their way into limestone, deposit their mineral constituents. Another reasonable supposition is that the mineral in porphyry weathers and is carried down by surface waters and is then deposited."—*Mines and Minerals*, Dec., 1910, p. 289. (A.R.)

PREVENTION OF EXPLOSIONS.—"In the course of an interview, Professor Cadman, of the Birmingham University, said that 'in a modern mine you have all the main roads receiving deposits of the very finest coal dust, which, when intimately mixed with the air, is highly explosive. The whole process of mining nowadays tends to produce this dust in large quantities. At present the Government is devoting considerable attention to mine rescue work, but we must go further back than that. We want to devote much more attention to the prevention of explosions, and, it having been absolutely established that coal dust alone can cause an explosion, the obvious remedy is either to remove the dust or render it innocuous. Removal is totally impossible, and, turning to the alternative, we find that the coal-owners are exerting every effort to discover a remedy. During the past two years they have spent £10,000 in experiments to this end. Mr. W. E. Garforth has been acting as chairman and Dr. Wheeler as scientist to a commission appointed by the Mining Association of Great Britain, which has already done admirable experimental work. Their final report is awaited with keen interest. At present their suggested remedy is the use of stone dust, by the introduction of which the explosive coal dust is rendered both inert and innocuous. I only know of one colliery where this remedy has yet been tried, even as an experiment. I feel convinced that it will prove the ultimate solution of the terrible problem, but, if it does, it can never be successfully applied until every one engaged in a mine has realised that coal dust is the chief source of danger."—*Science and Art of Mining*, Jan. 21, 1911, p. 265. (W. R. D.)

VACUUM CLEANERS.—"A Wigan gentleman, who holds a mining appointment at Delagua, Colorado, U.S.A., sends a cutting from the *Denver Post*, which makes an interesting contribution to the present di cussion on the coal dust question. The journal says that within the next week or ten days the experiment of removing dust from a coal mine with a vacuum cleaner, just as carpets and tapestries are cleaned in a private dwelling-house, will be tried by the Victor-American Fuel Company in its coal mines at Delagua. Two suction machines of special design, adapted to the peculiar conditions existing in a mine, are being built, and before they are shipped to Delagua they will be tried in the presence of experts and representatives of the Victor Fuel Company. In this advance experiment the machines will be turned on a pile of slack coal to discover if their suction power is great enough to draw up coal refuse at that degree of coarseness. As they will be used in the coal mines, the machines will consist of large fans working in tubes, from which radiate vacuum devices fashioned after those used in hotels and residences, but of much larger size. These vacuum machines will be taken on trolley cars to the extreme limit of an entry and stationed at a suitable distance from the place of operation. Two men, each holding one of the 'suction cleaners,' will then go over that part of the mine, drawing the dust from top, ribs, and roadway through the hose back into the car. When a car is full it will be taken to the outside of the mine and dumped. Expert mechanics who have studied the matter estimate that with one such device, manned by two operators in addition to the trolley pilot, a half-mile of entries could be cleaned in a night. 'With two of these machines we could have our sixteen miles of entries made as clean as the floor of my office twice a month,' declared Senator Frank E. Cove, chief attorney of the Victor Company. 'If these machines work successfully,' he continued, 'there isn't a coal mine in the State of Colorado that ought not to have a half-dozen of them.' The cost of one of the machines being built for the Victor Company is $500."—*The Science and Art of Mining*, Jan. 21, 1911, p. 266. (W. R. D.)

REINFORCED CONCRETE IN MINES.—"The use of reinforced concrete in mines is of comparatively recent date. The difficulties in placing concrete and the lack of authoritative figures and estimates for the strengths needed kept this construction out of mines, according to a writer in *Beton u. Eisen*. In 1898 the Wiemelshausen mine was the first one to timber its ventilating shafts with concrete. The reinforced concrete is especially well adapted for ventilator funnels, as the concrete does not transmit the mine noises as do the iron ventilators. Where earth pressure is very great reinforced concrete is far ahead of any other construction for timbering. To obtain final perfection, a strong false work is of necessity, as this has to sustain and resist all the forces till the concrete is hard and firm enough to take up the load. False work of iron construction, made of angle irons and I-beams is by far the best in spite of its greater cost. Lately it has been tried to use ready-made reinforced concrete temporary work in place of the iron. In the Ruhr district where the pressure is enormous and the earth shifts a good deal, the space between the outer mountain wall and the inner shaft wall was tamped in concrete reinforced by iron and old rails. There is a rather interesting construction of a flushing chamber which is to store the material used for flushing the mine, and is in form of a bin. It consists of a storage space with funnel shaped exhaust, and the flushing chamber with washing plant. The chamber is 13 ft. high and topped by a concrete dome. To relieve the dome of pressure and at the same time get greater distribution of load, steel rails were built into walls for reinforcements. The temporary timbering of heavy oak timber connected by iron bars was removed in circular rings so that never more than 4 feet of shaft was without timbering. The thickness of the walls is 12 in. and is reinforced by double vertical and horizontal 0·3 in. round iron rods, the meshes of the network formed being 40 sq. in. Numerous iron loops prevent breaking of reinforcement towards shaft side. The entire timbering is covered with a coat of water-proof mortar. A second interesting piece of work is the completion of supply-space in the Rheinelbe mine. On account of the poor condition of the earth (brittle slate) reinforced concrete had to be used and the shaft had to be enclosed all round as the pressure was exerted from all sides. Even the temporary false work had to be made extra strong. The supports and uprights were let into the ground to depth of 12 in. and connected with the upper ceiling beams by clamps and pins. To prevent earth from pressing against the walls of mine, separate timbers and supports were used and a double temporary timber wall constructed. When filling concrete the timbering was removed for a distance of 4 ft. and tamped. Iron reinforcements were led into the roof and to a short distance into the sides of the mountain, thus insuring great strength. Between the inside chamber wall and outside shaft wall, a space 8 in. wide was left, so that in case of possible settling of shaft the chamber would not be injured. Another construction was that of a small sub-station platform, where only vertical pressure needed to be figured, and reinforcements were made accordingly."—*Mining World*, Jan. 14th, 1911, p. 62. (A. R.)

MISCELLANEOUS.

PRODUCTS OF CRUDE PETROLEUM.—"There are at present nine products, or classes of products, obtained from petroleum. The names of these are given in the accompanying tabulation :—

Kind of product.	Per cent. yield.	Amount Bbl.
1. Kerosene	20·50	15,000,000
2. Lubricating oils of all kinds, including greases	10·00	7,000,000
3. Naphthas, all grades ..	15·00	11,250,000
4. Gas oil, used for enriching water gas in large cities	30·00	22,000,000
5. Paraffin wax	1·50	1,125,000
6. Roofing pitch	2·50	1,875,000
7. Paving pitch and road-making oils	2·00	1,500,000 tons.
8. Coke...	3·00	300,000 bbl.
9. Fuel oil	14·00	1,050,000
	98·50	
Loss in manufacturing ...	1.50	
Total...	100·00	

together with the yield of each class in percentages and the total production in the United States for 1909, stated in barrels."—*Journal of the Society of Chemical Industry.—Australian Mining and Engineering Review*, Dec. 5, 1910, p. 123. (A. R.)

LIQUID FUEL FOR AERONAUTICS.—Aviation is only made possible with the aid of petroleum products, so that it is largely in the control of the petroleum industrialists, who should endeavour still further to improve their products. Motor fuel should be chemically pure, of the lowest possible specific gravity, of the highest possible heat productivity, free of constituents with a high boiling point, and should not deposit any soot in the mechanism. The higher the heating power the smaller the cylinder of the motor. The specific gravity and heat productivity are inter-related. The lower the former the higher the latter, and the aeromobile can travel further in proportion as its fuel excels in these respects. The new petroleum product, aerobenzine, is of exceptional value. Its specific gravity should be 0·620 to 0·590; or alternatively it should boil with the heat of the hand. Its specific gravity must be under that of benzine, its heat productivity over that of benzine, and should be distinguished by these lightest hydro-carbons, which in the process of producing benzine evaporate and are lost. The lower its specific gravity the purer it is; and the higher its heat productivity the more power it will develop in the motor cylinders. The use of aerobenzine will reduce the weight of the motors, simplify their construction, and lessen their cost.

Aerobenzine must be kept in thick-walled hermetically-sealed vessels that can stand great pressure. It may be used for refrigeration and illumination. It is considered that in the summer the petroleum loses its aerobenzine and part of its benzine by evaporatioon n the way between the well and the factory, so that condensers and refrigerators should be constructed near the derricks. It can be seen that valuable material is now being lost from the light Maikop oil in the open reservoirs there. Refrigeration should be employed in the process.

A remarkable recommendation for aerobenzine besides its high market value to the producers is that its production constitutes a safeguard against fire; for the gaseous hydro-carbons, usually lost in Russian distilleries, issuing from the factory apparatus and mixing with the atmosphere make an explosive mixture easily ignited, whereas their capture would obviate this risk.—E. DE HAUTPICK.—*The Mining Journal*, Jan. 21, 1911, p. 64. (R. A.)

FIRST AID TO INJURED IN MINING ACCIDENTS.—"Sir H. H. Cunynghame, K.C.B., Under Secretary at the Home Office, in response to an enquiry, and as the result of visits he has paid to a considerable number of mines and quarries, has drawn up the following recommendations in connection with mining accidents.

The form of first-aid box for the treatment of simple cuts which I would suggest is as follows :—

For five men the size of the box is $5 \times 3\frac{3}{4} \times 1\frac{1}{2}$ in.; made of tin, with a lid or cover. It contains a 2 oz. bottle labelled "poison," with a cork which has been dipped in melted paraffin wax. Another bottle labelled "poison," 2 in. high, by $\frac{5}{8}$ in. in diameter, contains a dozen pellets each about $\frac{3}{8}$ in. diameter, containing salt, one-third of a grain of perchloride of mercury and any substance, such as a trace of gum, to bind the material together. In fact, the perchloride of mercury may be made into soluble pills or pellets by any practicable method.

The box also contains a paper package, $1\frac{1}{2}$ in. $\times$ 2 in. $\times$ $3\frac{1}{2}$ in., of tufts of blue wool which have been rendered antiseptic by means of perchloride of mercury and zinc in the usual manner. The box further contains a piece of pink boric lint, 6 in. $\times$ 8 in., folded in four, and put into a separate envelope just the size of the box, six or eight safety pins, and a small pair of scissors.

In a small tin pill-box, $1\frac{1}{4}$ in. in diameter, is contained a roll of adhesive indiarubber plaster, 2 yards long by $\frac{1}{4}$ in. wide, of the kind usually employed by surgeons. Finally, there are about 12 yards of good tape 1 in. wide.

The method of use is as follows :—First put one of the mercury pills into the 2 oz. bottle, fill up with water, and shake till dissolved. This makes a solution of strength about 1 in 3,000. With this wash the cut well. The salt will have the effect of preventing the solution from smarting.

It is an interesting fact that if even a little baby's wound is washed with weak salt and water, the child feels no smart and will not shrink. The smarting caused by the use of ordinary water is due, I believe, to the fact that the non-saline water passes by endosmosis into the tissue and swells it, whereas salted water or saliva, being more akin to the liquids of the body, has no such effect. This is the reason why a cut does not smart if sucked, as it does if washed with water. The amount of salt necessary to add to water in order to produce a liquid of the same density as blood-serum is 0·85%.

As soon as the cut has been washed it should be dried with another tuft of blue wool, and both tufts thrown away. On no account should a handkerchief or any other rag be brought near the cut. If the cut yawns, its edges may be brought together and secured by a bit of the sticky adhesive plaster (electricians often use a bit of rubber tape for the purpose). This tape will adhere upon a cut if the blood be wiped off, and the tape quickly put on and held for a little time. Once it has stuck, wet on the top will not affect it. Then a piece of boric lint should be cut and put on the wound and fixed in place with two or three bits of adhesive plaster. Finally, the place should be bound up with a bit of tape and secured by a safety-pin, and then the man may handle his pick again. In two days the wound should be examined and re-dressed; but most small cuts will be well in that time. The great thing to remember is that everything—tools, clothes, handkerchiefs and skin, are all full of microbes, and cause wounds to fester. The object to be obtained is to poison the microbes and then shut up the wound in an anti-microbe dressing.

These cases can be got from Mr. Jacobson, the agent for the Draegar rescue apparatus, 70, Shoe Lane, London, E.C.

The above quantities of contents of the box can, of course, be increased. Thus, for 100 men a box containing about ten times the above-mentioned quantities would be sufficient.

The box is also good for domestic use or for factories, stables or other places. For home use, if perchloride of mercury is considered dangerous, pellets of permanganate of potash may be used—but it is not so effective as perchloride of mercury."—*Iron and Coal Trades Review*, Feb. 17, 1911, p. 243. (A. R.)

TRANSVAAL TOBACCO. — Three bundles of "bright" tobacco leaves in good condition were submitted in February, 1910, to the Imperial Institute, London, by the Department of Agriculture, Transvaal, and were found on analysis to give the following results :—

	Per cent.
Moisture ...	6·9
Nicotine ...	1·2
Total Nitrogen	1·6
Ash	7·5

The ash on analysis was found to consist chiefly of :—

	Per cent.
K_2O	27·87
Na_2O	0·27
CaO	21·98
MgO	10·69
SO_3	2.35
Cl	0.17

Bulletin of the Imperial Institute, viii, 4, 404, 1910. (J. A. W.)

A NEW CAPE THERMAL CHALYBEATE SPRING.— In 1906 boring for oil was started in the neighbourhood of Port Elizabeth, but on the 29th May, 1909, at a depth of 3,400 ft. a spring of hot water was struck. Boring was stopped at 3,460 ft. and the spring was found to yield 250,000 gallons per diem at a temperature of 128·5° F., the chemical composition being:

	gr. per gal.
Sodium Chloride, NaCl.	25·71
Magnesium Sulphate, $MgSO_4$	3 07
Do. Carbonate, $MgCO_3$	2·10
Calcium Carbonate, $CaCO_3$	2·06
Iron Bicarbonate ...	1·66
Alumina, Al_2O_3	0·02
Silica, SiO_2	1·60

Gases in solution, analyzed by Sir James Dewar, were found to consist of :

Carbon Dioxide, CO_2	3·43%
Oxygen, O_2	11·54%
N_2, H_2, He., Ne.	85·03%

In 1,000,000 parts of gas from Zwartkops the hydrogen, helium and neon are 741 parts, while at King's Well, Bath, England, they form 1,516 parts of the gas in solution. The amount of ferrous carbonate at first seemed to vary from 0·8 to 3·78 gr. per gallon, but now seems to remain constant at 1·7 gr. per gallon. H_2S has also been noticed, but other springs were tapped in the course of the work, some of which reach the surface outside the casing, and it seems most probable that the gas in question comes from one of these. As a table water when charged with CO_2 the water of the spring is very palatable, and baths have been erected so as to take advantage of the medicinal qualities of the waters.—*The South African Journal of Science*, Vol. VII., 5, 202, March 1911. (J. A. W.)

Reviews and New Books.

(We shall be pleased to review any Scientific or Technical Work sent to us for that purpose.)

Lafar, Franz. Technical Mycology. Vol. 2. Eumycetic Fermentation. 8vo, pp. 568. *C. Griffin.* Net 24s.

Hill, Claude W. Electric Crane Construction. 8vo, pp. 334. *C. Griffin.* Net 25s.

Campbell, M. Contributions to Economic Geology. Part 2, Mineral Fuels. (U. S. Geological Survey Bulletin 381), 24 Plates. 8vo. pp. 559. *W. Wesley.* Net 10s.

Duffield, W. G. The Effect of Pressure Upon Arc Spectra. No. 3, Silver, 4,000 to 4,600. No. 4,600. No. 4, Gold. With 4 Plates. 4to, sd. *Dulau.* Net. 2s. 6d.

Hayes, C. and Lindgren, W. Contributions to Economic Geology. Part 1, Metals and Non-Metals, except Fuel. (U. S. Geol. Survey Bulletin 430). 14 Plates and Engravings. 8vo, pp. 653. *W. Wesley.* Net 6s.

Rice, G. The Explosibility of Coal Dust. (U. S. Geol. Survey Bulletin 433). 16 Plates and Engravings. 8vo, pp. 234. *W. Wesley.* Net 4s.

Home Office. Pamphlet. How to Test for Fire Damp. 1½d.

Fowler, Gilbert J. An Introduction to Bacteriological and Enzyme Chemistry. Cr 8vo, pp. 336. *E. Arnold.* Net 7s. 6d.

O'Shea, L. T. Elementary Chemistry for Coal-Mining Students. 8vo, pp. 332. *Longmans.* Net 6s.

Duncan, W. Galloway. The Modern Motor Car; its Management, Mechanism, and Maintenance. Illustrated. Cr 8vo, pp. 124. *C. Lockwood.* Net 2s. 6d.

Senter, G. Outlines of Physical Chemistry. 2nd Edition, revised. Cr 8vo, pp, 406. *Methuen.* 5s.

Jackson, William. Dictionary of English and Spanish Technical and Commercial Terms used principally in the Iron, Steel, Hardware and Engineering Trades. 12mo, pp. 164. *Spon.* Net 2s. 6d.

Horner, D. W. Weather Instruments and How to Use Them. Cr 8vo. sewed, pp. 48. *Witherby.* Net 6d.

Callendar, H. L. and Moss H. On the Absolute Expansion of Mercury. 4to, sd. *Dulau.* Net 2s.

Hilditch, T. P. A Concise History of Chemistry. Cr 8vo, pp. 274. *Methuen.* 2s. 6d.

Sherman, H. C. Chemistry of Food and Nutrition. Cr 8vo. *Macmillan.* Net 6s. 6d.

Tutton, A. E. H. Crystals. (The Internal Scientific Series). Cr 8vo, pp. 312: *K. Paul.* 5s.

Moor, C. G. and Partridge, William. Aids to Bacteriology. 2nd Edition. (The Student's Series). 12mo. *Bailliere.* Net 3s. 6d., sewed Net 3s.

Abstracts of Patent Applications.

(C.) 22/11. William Watts Bonson. Process for dry ore separation. 13.1.11.

This application relates to a process of dry ore separation, which consists of delivering the mass to a moving surface with air pressure thence through, then forming a bed of ore (mineral) which is maintained while the varying percentage of mineral is being delivered on this bed and drawn off as collected.

As a method of achieving this process, an appartus is described consisting of a reciprocating table, floored with a fine mesh to allow the air to be distributed and passed through the mass and provided with diagonal slots over which the gangue is passed while the mineral is led towards a series of gates in which the ore bed referred to is formed by retardation.

(C.) 23/11. William Watts Bonson. Improvements in dry ore separators. 13.1.11.

This application should be taken in conjunction with No. 22/11, by the same applicant. The former application is for the process of maintaining an ore bed in the dry separation of ore from gangue, whereas the present application relates to a particular device based on the same principle.

The device similarly consists of a reciprocating table, floored with fine mesh fabric to distribute air pressure from beneath and providing parallel diagonal slots, super-imposed at an angle; the upper series to guide the gangue to the tail of the table and the lower series to guide the ore to longitudinal division, consisting of gates wherein is maintained an ore bed from the bottom of which the pure concentrated ore is drawn at the same rate that it is collected, and thereby maintaining an efficient separation.

(C.) 31/11. Eduardo Jose Maria Madero. Novel rotary engine. 19.1.11.

This relates to a form of rotary engine to be driven by a working fluid. It consists essentially of a plug or piston running in a circular path and transferring its motion to the driving shaft by an arm. A system of levers operate gates which divide the circular path of the piston in two and also valves which serve to admit and exhaust the working fluid.

(C.) 35/11. Jacobus Jan Willem Hendrik van der Toorn. A process for the extraction of gold from clay. 21.1.11.

This application relates to a process for extracting gold from clay, and is intended to prevent losses that occur when such material is treated with water.

The applicant claims that by kneeding and beating this clay, stone-like lumps are obtained, which may be broken up and the gold extracted.

(C.) 48/11. Frederick Ringrose. Improvements in automatic lubricators. 27.1.11.

This application refers to an automatic lubricator arranged in connection with a mixing tank for mixing graphite or other solid lubricant with liquid lubricant.

(C.) 66/11. Lewis Condict Bayles. Improvements in combined throttle valves and oilers. 3.2.11.

This is a device for admitting a small quantity of oil to a steam or air pipe at each time of opening the supply cock.

(C.) 169/10. Frederick Johnson Knight. Improvements in the preparation of sodium cyanide. 15.4.10.

This refers to the preparation of sodium cyanide by the fusion of a mixture of sodium ferro-cyanide, sodium carbonate and carbon.

(C.) 196/10. Tullio Bubola. Improvements in apparatus for electro-chemical treatment of ores. 28.4.10.

This patent deals with an apparatus for the electro-chemical treatment of ores :—

It consists in a combination of a vat (coated internally with non-conducting material), to contain the ore and treatment liquid, an electrode placed in the lower part of the vat, movable rod-like electrodes depending into the upper part of the vat, the mechanism required to move the upper electrodes, and a few other details consistent with the working of the apparatus. The electrode in the bottom of the vat constitues the anode and the movable electrodes in the upper part of the vat the cathodes. The solution is injected below the filter floor.

The combination further includes the means for passing the electric current through the ore and liquid in the vat, a precipitation box, and the means of circulating the solution.

(C.) 202/10. Bertram Gray. Improvements in pipe linings. 29.4.10.

This application consists of lining metal pipes with woven fabric treated with anti-corrosive substance, such as a bituminous composition.

(C.) 632/10. Bertie Gray Moorcroft Edwards. An improvement tappet. 24.12.10.

This application is for improvements in tappets for stamps consisting of two wedges arranged parallel with the stem.

Selected Transvaal Patent Applications.

Relating to Chemistry, Metallurgy and Mining.

Compiled by C. H. M. Kisch, F.M.Chart.Inst.P.A. (London), Johannesburg (Member).

(N.B.—In this list (P) *means provisional specification, and* (C) *complete specification. The number given is that of the specification, the name that of the applicant, and the date that of filing.)*

(P.) 107/11. Josiah Phillips. Improvements in barrows. 17.2.18.

(P.) 109/11. John Denyer. Improvements in furnaces for heating drills and the like. 20.2.11

(P.) 110/11. George Warren (1), Joseph Gribble (2). Telescopic rock drill bar. 21.2.11.

(C.) 111/11. Jacob Wilkinson (1), Albert Edward Payne (2). An improved apparatus for regulating the pressure of the current in an electric circuit. 21.2.11.

(P.) 112/11. Alexander Purser. A new and improved device for regulating the flow of compressed air and the like. 22.2.11.

(P.) 113/11. George Harold Leeney. A new and improved roofing for houses and the like. 22.2.11.

(C.) 114/11. Sydney Russell Barrett. Improvements in and relating to pipe joints. 22.2.11.

(P.) 115/11. Charles William Dowsett. Device for maintaining an even flow of pulp from a centrifugal pump. 22.2.11.

(P.) 116/11. Robert Blyth (1), Thomas Connolly (2). Improvements in means for protecting miners from dust produced in rock drilling, also applicable to other occupations. 23.2.11.

(C.) 117/11. Henry Bell. Improvements in switches for electrical mine signalling apparatus. 23.2.11.

(P.) 118/11. G. H. Rotherham (1), Vernon D. J. Hoar (2). Segmental disk filter. 23.2.11.

(C.) 119/11. Jehn Berry. Improvements pertaining to winding and hauling engines. 24.2.11.

(C.) 120/11. Hermann Wolf. Improvements in the spraying matter in suspension and in spraying nozzles therefor. 24.2.11.

(C.) 121/11. Marcellin Mallet (1), Joseph Hubert Puthod (2). Improvements in or relating to blasting charges. 24.2.11.

(C.) 122/11. Henry Squarebrig Mackay. Process and apparatus for extracting metals from their ores. 24.2.11.

(P.) 123/11. Allan Thomas Cocking (1). Kynoch, Ltd. (2). Improvements in and relating to the manufacture of explosives. 24.2.11.

(P.) 127/11. Alexander Edward Kressmann (1), John Hart (2). Improvements applicable to acetylene lamps. 25.2.11.

(C.) 129/11. Fritz Deimel. An igniter acting through a spark produced by friction. 25.2.11.

(C.) 130/11. Carl Nitschke. Telescopic lifting gear. 27.2.11.

(P.) 131/11. John Law Aymard (1), Arthur Payne (2). A new and improved foot leg guard. 28.2.11.

(P.) 132/11. Bertram Poidevin Richardson. Improvements in pipe and similar couplings. 28.2.11.

(P.) 133/11. Lewis Watkins. Pulp or tailings separator. 28.2.11.

(P.) 135/11. William Jamieson (1), Andrew Francois Brink (2). Improvements in spraying nozzles. 2.3.11.

(C.) 138/11. Peter Mommertz (1), Gewerkschaft Deutscher Kaiser (2). Improvements in linings for pipes. 3.3.11.

(C.) 139/11. Peter Mommertz (1), Gewerkschaft Deutscher Kaiser (2). Improvements in linings for disintegrating machines. 3.3.11.

(P.) 142/11. Edmond Ernest Johnson. Improvements in extracting metals from their ores, and apparatus therefor. 1.3.11.

(C.) 143/11. Emil Schranz. Improvements in jigging machines for separating minerals. 7.3.11.

(C.) 144/11. Oscar Horace Schuller. Improvements in vibratory sifting machines. 7.3.11.

(P.) 145/11. George Rodd. An adjustable scraper. 7.3.11.

(P.) 147/11. Charles Henry Wilkins (1), James Wilshir (2). Improvements in rock drill chucks. 7.3.11.

(P.) 148/11. Geo. H. Rotherham (1), Vernon D. J. Hoar (2). Segmental revolving disc filter. 8.3.11.

(P.) 149/11. William York. A new and improved method, instrument, or machine for scooping or dredging dams, drains, etc. 8.3.11.

(P.) 150/11. Samuel Alford. Improvements in means for consuming smoke applicable to domestic fire grates, the furnaces of steam generators and the like. 9.3.11.

(C.) 151/11. Emanuel Rosenberg (1), John Sedgwick Peck (2). Improvements in braking induction motors. 10.3.11.

(P.) 152/11. Edward James Rule (1), James Ferguson (2). Improvements in chucks or tool holders for rock drilling machines. 10.3.11.

(C.) 153/11. Hermann Georg Spengel. Improvements in conveying apparatus. 10.3.11.

(P.) 155/11. Hermann Stadler. Improvements in sifting apparatus. 14.3.11.

(P.) 156/11. John Pitkethly Smith. Improvements in dust collecting attachments for rock-drilling machines. 15.3.11.

(P.) 157/11. Arthur Dixon Arnold. Improvements in shaft and haulage rollers. 15.3.11.

(P.) 158/11. Charles William Dowsett (1), Frank Gowyne Alfred Robert (2). Improvements in tube mill linings. 16.3.11.

(P.) 159/11. Martin Wagner. An improved apparatus for the spraying of solutions and the like. 16.3.11.

(P.) 160/11. John van Nostrand Dorr. Improvements in settling apparatus. 17.3.11.

(P.) 161/11. Richard Nicholson (1), Carl Davenport (2). Improvements in or relating to percussive rock drills and the like. 17.3.11.

(C.) 162/11. Victor Nightingall. Improvements in electric cooking appliances and water heaters. 17.3.11.

(C.) 163/11. Harry Pauling. Improved electric furnace for treating gases. 17.3.11.

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(P.) 167/11. Jacques Berthold Schlesinger. Improvements in rock drills. 23.3.11.

(P.) 168/11. Adolf Reichenberg. Pneumatoplane. 23.3.11.

(C.) 169/11. Stewart Woodford Young. Fume destroying composition. 24.3.11.

(C.) 171/11. Jacobus Matthias Lofthouse (1) and Emily Rosalie Booty (2). Improved carburetter for air gases. 24.3.11.

(C.) 172/11. Edmund Seal Donisthorpe. Improvements in or relating to apparatus for synchronising the working of machinery. 24.3.11.

(C.) 173/11. Stephen Ware (1) and Charles Ware (2). An improved rail joint and fish plate fastening therefor. 24.3.11.

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(C.) 175/11. John Joseph Keppel (1) and Samuel Alexander Lyttle (2). Improvements in wire strainers. 24.3.11.

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(P.) 182/11. Frederick Pattersen (1), Thomas Evan James (2) and Williams Bradwin Varian. A device for the prevention of railway accidents through collision of trains; the automatic stopping of opposing trains; and the ringing of alarm bells at level crossings or elsewhere. 28.3.11.

(P). 183/11. John Kenneth Addie. Rope jockey attachment. 30.3.11.

(C.) 184/11. Thomas Nogier. Apparatus for sterilizing water by means of the ultraviolet rays.

(C.) 185/11. Charles Francois (1) and Alfred Chapitel (2). Improvements in breaking machines. 31.3.11.

(C.(186/11. Clemens Graaff. Improvements in a method and an apparatus for extinguishing fires. 31.3.11.

(P.) 187/11. Hans Charles Behr. Improvements relating to pneumatic stamps. 31.3.11.

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(C.) 206/11. William Hardie Cheyne (1) and George Richmond Newburn (2). Improvements in or connected with rapid action of steam hammers, more especially intended for use with tools for scaling boiler tubes. 8.4.11.

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(P.) 208/11. Thomas Graham Martyn. Improvements in or relating to apparatus for separating suspended solids from liquid or gases; mixed liquids from each other and gases from liquids. 11.4.11.

(C.) 209/11. Edward A. Blanton. Improvements in nut locks. 11.4.11.

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(P.) 213/11. John Murdoch Skelley (1), Rollo Bowman Ballantine (2) and Norman David Penny (3). An improved apparatus or means of preventing radiation of heat from steam pipes. 12.4.11.

(P.) 214/11. William Frederick Keatingstock. An improved fertiliser, insecticide and fungicide. 13.4.11.

(P.) 215/11. Charles Graham Stone. Improvements in stamp mills. 13.4.11.

(C.) 216/11. Oscar Clarence Beach (1) and Arthur Judson Hodge (2). Improvements in disc pulverizers. 13.4.11.

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GRAHAM, H. W., *l/o* London; P. O. Box 1,155, Johannesburg.

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MARQUARD, J. D., *l/o* Rose Deep, Ltd.; Inspector of Mines Office, Boksburg.

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PHILLIPS, F. D., *l/o* Germiston; Bwlch R. S. O., Breconshire, South Wales, Great Britain.

SCAER, V. E., *l/o* Bulawayo; Arcturus Mines, Salisbury, Rhodesia.

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