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Proceedings AT Ordinary General Meeting, April 20, 1907.

The Ordinary General Meeting of the Society was held in the Chamber of Mines, on Saturday, April 20th, Mr. Wager Bradford presiding. There were also present :—

37 Members: Dr. J. Moir, Prof. J. Yates, Messrs. R. G. Bevington, T. L. Carter, W. R. Dowling, K. L. Graham, A. McA. Johnston, Dr. D. Macaulay, M.L.A., M. Torrente, A. Whitby, H. A. White, Prof. J. A. Wilkinson, J. Littlejohn, W. A. Caldecott, W. Cullen, F. Alexander, S. G. Bartlett, W. Beaver, F. T. Chapman, A. A. Coaton, G. Goodwin, W. H. Jollyman, J. A. Jones, J. Kennedy, G. A. Lawson, Hy. Lea, J Lea, W. W. Louttitt, W. P. O. Macqueen, J. McLennan, T. T. Nichol, S. S. Osborn, A. Richardson, C. B. Saner, G. O. Smart and F. W. Watson.

The following members were represented by proxy, Messrs. E. H. Johnson, A. Heymann and J. Thomas.

9 Associates: Messrs. J. Chilton, Wm. M. Coulter, W. J. Dunnachie, J. A. P. Gibb, R. W. Leng, R. W. Maxwell, C. Toombs, I. Tom and W. Waters.

8 Visitors (including Mr. R. T. A. Innes, Director of the Meteorological Department), and Fred. Rowland, Secretary.

The Chairman: Gentlemen, I have to express regret that Mr. Johnson is not able to be present to-night on account of illness, for which reason I am in the chair. I move that the minutes of the last ordinary general meeting, as published in the *Journal*, be accepted. This was seconded and agreed to.

NEW MEMBERS.

Messrs. Alexander and Beaver were elected scrutineers, and after their scrutiny of the ballot papers, the Chairman announced that all the candidates for membership had been duly elected, as follows :—

FORD, M., Meyer and Charlton G. M. Co., Ltd., P. O. Box 1127, Johannesburg. General Manager.

JEFFERY, ARTHUR RUFFORD, Gaika Mine, Queque, Rhodesia. Cyanide Manager.

THOMAS, H. MUSSON, Jumpers Deep, Ltd., Cleveland. Mine Manager.

It was announced that the Council had admitted Mr. W. H. JOHNSTON as a Student Member.

GENERAL BUSINESS.

The Chairman: I should like to suggest in the way of general business, the possibility of organising this year as was done last year, an excursion to the Victoria Falls. Mr. Littlejohn and myself discussed the matter with Mr. Hoy a fortnight ago and he told us that the C.S.A.R. would make a rate of £20 for the round trip, which is practically the same rate as last year. The excursion last year was so successful that it certainly ought to be repeated, and I shall bring the matter before the Council at the next meeting.

Mr. H. A. White: I think it is usual on this occasion to make some reference to the annual dinner. I should like to move a vote of thanks to all the gentlemen responsible for carrying it out, and to the Secretary for the able and efficient way the matter was dealt with.

The vote of thanks was carried unanimously.

NOTES ON SOME RECENT IMPROVEMENTS IN TUBE MILL PRACTICE.

By KENNETH L. GRAHAM, M.I.M.M. (Member).

It was originally my intention to have contributed anything I had to say on the subject of tube milling to the correspondence columns of our *Journal*, as being the proper place for it; but, as this would have precluded discussion of a subject well worth further attention from the members of this Society, I must claim your indulgence for having glorified under the title of notes a description of a few improvements in tube mill practice which have occurred to me since Mr. Dowling, in his excellent paper, brought the subject up to date some twelve months ago. Moreover, there was a lack of papers of any description, seriously threatening the hitherto irreproachable reputation of the Publications Committee. In stepping into the breach I felt that to a certain extent I came to their rescue.

During the interval the computation of the work done in our tube mills was dealt with by Messrs. Pearce and Caldecott from a mathematical standpoint and aroused much interest; yet the subject is by no means exhausted, and data are required bearing on various points in our practice, which directly affect the economics of tube milling. As many of us have had the opportunity during the last year of gaining considerable experience in this very important branch of our metallurgy, these data should not be difficult to obtain, and if, as I hope, some of our members who have hitherto kept aloof from the discussions will come forward with their experiences, the best practice will gradually be evolved.

The experiences of metallurgists in New Zealand, Australia and America have benefited us but little here, for, so far as I know, on no other goldfields are the conditions comparable with those existing on the Rand, the short life of our liners, for instance, being particularly noticeable compared with elsewhere.

Although Mr. Dowling advocated the use of banket as a useful adjunct to pebbles, no figures have been advanced bearing on the relative efficiencies of these grinding agents where used separately. In some quarters doubts were expressed as to the possibility of making this change without affecting the efficiency of the tube mill: further, it was suggested that the banket would prove to be more severe on the lining than pebbles. This latter view I did not share, as it seemed to me probable that the irregular shape of the quartz lumps would tend to decrease sliding, with beneficial results both to the lining and to the efficiency of the mill. Having the opportunity I was able to convince myself on these points by practical test.

Two tube mills, No. 1, an Allis Chalmers, and No. 2, a Fraser and Chalmers, both 22 ft. x 5 ft. 6 in., were lined with silex blocks, 6 in. x 6 in. x 4 in., laid on edge, the joints being staggered to prevent wear in circumferential corrugations. No. 1 was loaded with quartz, No. 2 with Danish pebbles, all other conditions, including revolutions per minute, weight of solids fed per 24 hours, percentage of water to solids, being kept as nearly as possible the same. The efficiency was taken as being the increase in -90 between the inlets and outlets of the tube mills, a sufficiently accurate method for the purpose under consideration. The size of apertures in the two sieves used for grading, after all not very important in this particular case, were measured as carefully as possible and gave ·0098 in. and ·0063 in. respectively. The results for the month of January were as follows:—

No. 1 Mill. Quartz fed 171·5 tons. No. 2 Mill. Pebbles fed 10 tons.

	Entering Tube Mill.	Leaving Tube Mill.		Entering Tube Mill.	Leaving Tube Mill
+60	68·68	9·73	+60	68·68	11·32
+90	19·57	26·28	+90	19·57	27·24
−90	11·75	63·99	−90	11·75	61·44

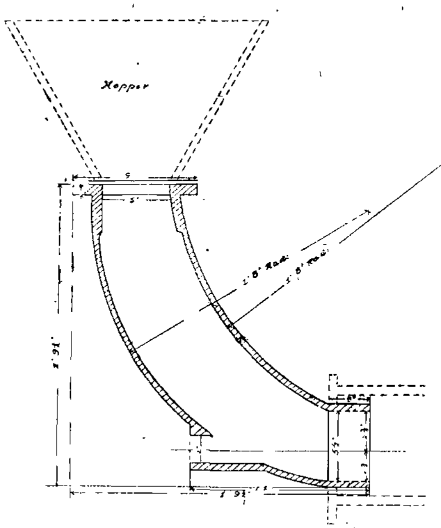
It will be seen from these figures that No. 1 mill, running on quartz, showed the highest efficiency; this was maintained throughout the entire run of 81 days. The reason for this result is not immediately apparent; to theorise, it might be that a higher percentage of the work done is by impact rather than by grinding, the quartz lumps, owing to their irregular shape, being lifted higher in the mill, there being less sliding amongst themselves and on the liner than in the case of the smoother and rounder pebbles. Should the elucidation of the point open up a fresh field for the many accomplished mathematicians we have amongst our members, these notes will not have been written in vain.

Unfortunately at the expiration of the 81 days No. 2 mill had to be stopped owing to mechanical defects, so that I was unable to carry the second part of the test, namely, the question of wear of liners, to a conclusion. However, as No. 1 mill running under these conditions gave a life of 140 days, whereas a similar lining where pebbles had been used gave only 124, I am convinced that any fears on this score are groundless.

The saving in cost when using reef is very considerable. In the case under review, in No. 2 mill 10 tons of pebbles costing £60 were used. In No. 1, 171·5 tons of reef had to be sorted, trammed and fed at a cost of approximately 2s. per ton or a total of £17, thus showing a net saving of £43 per tube mill per month. The economy becomes still more marked when the profit on the additional tons crushed is taken into consideration.

Where three tube mills are in use requiring an aggregate of 15 tons a day of quartz (and it is pertinent for me to point out here that this is equivalent to three extra stamps), the Kafir labour required to do the feeding becomes quite an item unless a mechanical device capable of handling, (say) 2 tons per hour is installed. Such an arrangement is in daily use at the Geldenhuis Deep, Ltd., and as a saving of 5 to 6 boys a day has resulted I will venture to describe it. The feeder itself is simply a cast iron bend made with a long radius 5 in. in internal diameter at its narrowest point, the inner and outer curves not being concentric so as to give a maximum diameter at its centre. The upper end which is flanged is made ½ in. less than the lower end as a precaution against choking, the latter being entered 3 in. into the hollow trunnion of the tube mill. The method of preventing back-flow can be seen from the sketch on the following page.

The pulp from the dewaterer is passed in through a 1½ in. orifice in the back of the casting, situated centrally as regards the outlet end of the bend. A hopper of whatever shape is required is bolted to the flange, an 8 in. or 9 in. belt being used to



carry the quartz from a feed hopper on the ground level to whatever number of tube mills are in use, a plough to direct it into the hopper, removable at will, being fixed on the belt opposite each feed. This arrangement, which is simple and effective, can take quartz lumps up to $4\frac{1}{2}$ in. diameter without fear of choking, there being little or no back-flow or splash from the inflowing pulp, with a load maintained well over the centre of the mill. As the nozzle on the dewaterer approaches to within an inch of the orifice in the feed pipe, some other than the ordinary method of ascertaining the tonnage passing through the tube mill by diverting the pulp with an elbow and hose attached, had to be resorted to. To overcome this difficulty I had five-way pieces cast, these take the place of the usual four-way fitting in use under the dewatering separators on the Rand mines plants, the fifth branch being at right angles to the other four. Into this a nipple, maincock and nozzle, the latter the same size as that in use on the branch feeding the tube mill, are screwed. By temporarily closing off the inflow to the mill and opening the maincock the pulp can be diverted rather more conveniently than by the method previously in vogue. Tonnage computation on these lines is only an approximation under any circumstances, at the same time it is a useful guide, until the capacity of whatever size of nozzle which will give the best results for a known set of conditions has been ascertained by experience.

From what I have seen there is evidently some divergence of opinion as to what this should be, the percentage of water to solids, the tonnage reground, the feed of pebbles or quartz required, all varying over a wide field. Personally, I am inclined to think that with one tube mill for every 350 to 400 tons milled per 24 hours, using 100 to 300 screening with apertures between ·07 and ·03 in., $1\frac{1}{8}$ in. is the most suitable size. Working under a head of 6 ft. this will pass 250 to 270 tons per day with water to solids at 1 to 1, the tonnage sent to each tube mill being varied of course to suit the conditions of the lining if maximum efficiency is to be secured.

It would be interesting to construct curves showing the relation between the tonnage tube-milled and the final pulp for different sets of conditions. Data on these lines are difficult to obtain however, except on an experimental plant, owing to the different factors continually varying independently of one another. I make this remark feelingly from actual experience.

Before leaving the subject of quartz *versus* pebbles, I should like to point out that where the former is in use some automatic contrivance for catching the particles discharged through the holes in the outlet plate of the tube mill is absolutely necessary. This may amount to a quarter of a ton per mill per day, or over, and if allowed to go to the shaking tables, chokes up the distributing launders, detaches amalgam from the plates, and causes endless trouble. A device, the invention of Mr. B. Chew of the Crown Deep, is in use on our mills, and is perfectly effective in its action. It consists of a perforated trommel fixed to and revolving with the tube mill, buckets being attached to the inside of the periphery which elevate the quartz particles and discharges them down a chute provided for the purpose, from whence they pass by means of a pipe through the bottom of the launder to a bucket or other receptacle, to be returned to the battery for further crushing.

Hydraulic classification, although a well-worn subject, will still stand discussion before we condemn it as thread bare, for with the advent of tube mills this part of our work immediately assumed a magnified importance. As far as arrangement is concerned I think it is generally admitted, that, given a certain number of classifiers of similar dimensions, they will do better work in pairs abreast than in series, but the question of the use of water remains unsettled. I use it myself on all six classifiers, having them arranged in three rows of two abreast; my reason for doing so is, that where the tube mills at our disposal are admittedly too few to grind down to that economic limit which is the desideratum in this direction, it is absurd to impair their efficiency by passing through them material which will already pass a 150 mesh sieve. This can be prevented by the judicious use of an upward stream of water, the effect of which can be seen in the overflow of the dewatering separator which should be cloudy without being turbid; this fine distinction will, I am sure, be understood by practical men.

While on the subject of classification I take the opportunity of including a few figures, which may be interesting in this connection, being the averages of the results obtained by assay from the graded products of a large number of sands residues from which the slimes were not completely eliminated, the screens used being 60, 90 and 150, the first two having apertures as previously given. A rough coefficient of extraction was obtained for each product as follows:—

	per cent.		per cent.		per cent.		per cent.
+60	75·5,	+90	81,	+150	87·5,	−150	91·3

I do not want to attach any undue importance to these figures: too many known and unknown factors of error enter into the methods employed in obtaining them to allow anything of the kind. I give them merely for what they are worth with the object of accentuating the importance of getting as high a percentage of −90 into our final pulp as possible if a uniformly high extraction is to be obtained.

Mr. Dowling in his reply to the discussion on his paper predicted that silex as a lining had come to stay. So far, his prediction has been a true one, although it seems probable that even this may be replaced with something cheaper in the near future. The average cost of three linings of this material put into our 22 ft. x 5 ft. mills, the blocks being 6 in. x 6 in. x 4 in. on edge, works out at £155, including labour, cement, etc., which taking the life of four months is a little over £1 5s. a day. So far I think no local chert has proved quite so satisfactory.

As to the time occupied in relining, a Davidson mill, 20 ft. x 5 ft. on the Geldenhuis Deep, Ltd., stopped for this purpose at 8 a.m. on a Monday was running again at 11 a.m. on the following Wednesday morning, the duration of the stop being 2 days 3 hours, constituting a record I believe for this size of tube mill on the Rand. To do this, diamond quick setting cement was used throughout, no steaming being required, the reloading being commenced immediately on the masons finishing their work. The cost, owing to the price of the cement (about £55 a ton) was very high, the total being increased roughly by one-third. This would be justified however in cases where it was essential that a certain daily tonnage should be maintained, as the extra expenditure would be more than set off by the loss in reduced extraction through coarse crushing, should the tube mill be out of action for the period required to reline it in the ordinary way. When we consider that only recently in California four weeks was the time given to a Silex liner to set, I think we may take a certain amount of credit to ourselves for the expedition with which the work is done here. Were similar periods required we would long ere this have had to face either lowered extraction or lessened tonnage, or have added to our already inadequate tube mill equipments. It is the absolute necessity of getting a high running time out of the machines at our disposal that has helped to bring about this result.

Before concluding I might touch on one more point that requires clearing up, that is, the question of peripheral discharge, which in the "early days" of tube milling was recommended by Mr. Laschinger and others as a means of increasing efficiency and reducing wear on liners. So far as I know the opposite has proved to be the case; the majority of mills built originally on this principle, having been converted to central discharge with beneficial results; theory in this instance as in many others not being borne out in practice. Personally I am not at all convinced that peripheral discharge has gone for good. Tube milling is still in its infancy, and some slight improvement in the original design, as introduced here, might enable these mills to do all that was claimed for them. I commend this suggestion to any of our members who have the plant to experiment with.

The Chairman: This tube mill question is one which must appeal to all of us because we are gradually getting our residues down, and our extractions up, by the influence of the tube mill.

The system of carrying these mills is entirely different, and I think the consensus of opinion here is that tube mills carried on end bearings are the best. All the mills of the Fraser and Chalmers' type, with which I am familiar, that is, supported on rings attached to the barrel, have worked satisfactorily for a certain time and have then given a great deal of trouble. As an illustration of that, I started three mills, one of them carried on rings, and the others on end bearings, and for several months the former did most excellent work; but finally the rings began to elongate and this resulted in shearing off many of the rivets which attach the rings to the barrel of the mill, leakage set in through the rivet holes, and ultimately we had to stop the mill. The other mills have given no trouble. This shearing off of the rivets may be due to faults of construction and not of principle. The wearing rings as originally designed were too light, the barrel of the mill at the points where these rings were attached was out of round, and there being no provision for taking up the elongation of the rings, shearing of the rivets was inevitable. Certainly, if you can carry a tube mill on rings it is more advantageous than to have end bearings, because it is more easily accessible. At present we are putting on heavy new rings, designed by Fraser and Chalmers, to allow for taking up any elongation. First of all a plate 1 in. × 8 in. was riveted around the mill just at the point where the ring goes, and these plates are then turned perfectly true with a slight taper, the mill was found to be ½ in. out of round. On this plate was then fitted and firmly riveted a ring tapered inside to match the taper of the plate, and outside to fit a second ring. This last is the wearing ring, or tyre, and being tapered inside to match the first ring, it can be forced further on from time to time by lateral bolts, to take up any elongation. The wearing ring is carried on wheels supported on bearings in the usual way. These rings were made very heavy, much heavier than the original rings, and if this experiment proves satisfactory (and I am slightly in doubt that it will over a long period of work), it will establish a very important principle in tube mill practice. I must quarrel a little bit with Mr. Graham's classification of quartz. Would it not be better to call it banket? When he first said quartz I thought he was alluding to local quartz pebbles which are very different from banket. The former disintegrates much less readily than the latter. To feed gold bearing rock into a tube mill instead of perfectly barren rock tends to economy and profit. A mill manager ought to be thankful to the cyanide manager who feeds banket into his mill because it increases his nominal duty per stamp and certainly increases the output. Just a word about silex liners: I have experimented with local and silex liners, and also with some imported liners which are not silex. The average run of the tube mills at the Langlaagte Deep was about 180 days with the best imported silex liners, against 60 days with local liners. Any comparison of the cost of a liner does not cut much figure, when you consider the cost of having to hang up the mill. As an illustration of the difference I might say that we were running on a 200 mesh screen with three tube mills, and when one of these mills has to hang up, it means going back to a 400 or 600 mesh, and that means a considerable decrease in the tonnage milled, and more or less trouble in the cyanide plant. The question of tube mill practice is one that is of special interest to all of us and papers on the subject are most welcome. I must also ask you to extend a hearty vote of thanks to Mr. Graham for his paper.

NOTES ON THE USE OF THE FILTER PRESS FOR CLARIFYING SOLUTIONS.

(Read at July Meeting, 1906.)

By S. J. Truscott and A. Yates (Members).

REPLY TO DISCUSSION.

Prof. J. Yates read the reply of the authors as follows:—In our paper, as printed in the July *Journal*, two errors appear which we wish to correct:—On p. 4, col. 1, line 16, instead of "Zinc gold slimes filter presses" read "Ore slimes filter presses," and at line 20, instead of "The precipitate became clear and was easily reduced," read "The precipitate became clean and was easily reduced."

Mr. W. R. Dowling, in his remarks on our paper, gives as his opinion that we should have included sand filters in the original construction scheme. That some clarifying process was necessary we fully realised, and in our completed plant designs we allowed for the use of the filter presses mentioned in the paper, but pending the arrival of the remainder of the plant we used the tanks, which we happened to have by us, as clarifiers. The exceptionally fine and tight slime we were working on would, with sand filters, have necessitated constant cleaning of tanks of the size proposed by Mr. Dowling, as you may judge from the fact that 1½ in. cakes in the ore slime presses take upwards of two hours to make.

We cannot show Mr. Dowling any improvement in precipitation or a reduction in the zinc consumption, as owing to a careful daily dressing of the boxes the zinc was always kept fairly clean. With a flow of 1·61 tons of solution per cubic foot of zinc space per 24 hours, the precipitation at that time averaged 95·4 per cent. of the gold value. With the present flow of 1·27 tons of solution per cubic foot of zinc space the solutions are leaving the boxes showing traces only.

We are pleased that Mr. K. L. Graham acknowledges the superiority of the filter press over the sand filters as used on the Rand, and we regret that he has not read our remarks touching their capacity more carefully; he would make us say that for the 300 tons of solution per day clarified here two presses were absolutely necessary. We mentioned that the presses were opened twice a week and cleaned; now, if they were opened four times per week they would have a capacity equivalent to 600 tons, or, with only one press and a daily cleaning—occupying about two hours—you would have a capacity for some 500 tons of solution per day. We put the two presses in commission because they were both available, and by so doing we reduced the frequency of opening them for cleaning.

The above figures refer to Redjang-Lebong slimes; elsewhere it is possible that such a press may have a larger capacity. Mr. J. Acheson Jones of the Meyer and Charlton plant, in his useful contribution to the discussion, mentions that a press of similar filtering area, viz., 425 sq. ft., has a capacity of 500 tons a day with a head of 24 ft., and that it was cleaned once every ten days only. A safe working figure in the installing of presses for filtering solution from slime plants would be 1 sq. ft. of filtering area per ton of solution to be clarified.

Figuring on the above capacity and accepting Mr. Graham's statement of cost, two presses, costing altogether £400, would clarify 950 tons of solution per day, whereas a tank of the same price would only clarify 600 to 700 tons; the presses occupy less floor space, cost less, have a larger capacity, do their work far more efficiently than the sand filter tank, and require much less labour to clean them.

Mr. Graham objects to the comparison of costs on a basis of fine ounces recovered on account of the difference in the value of the two months (January and December, 1905) returns, but we would point out that allowing the same gold and silver to January as is given for December the costs still differ very materially, viz., cost of smelting per ounce recovered:—

	January.	December.	January in terms of December.
Fine Gold	27·2d.	6·01d.	18·52d.
Fine Metal	3·07d.	0·87d.	2·75d.

The extra amount of short zinc treated in January had no marked effect on the cost figures, as this short zinc was quite clean and easily reduced; all the trouble arose from the precipitate being highly charged with ore slimes, which necessitated increased quantities of flux and which could only be slowly reduced in our charcoal fires. We had tried coke *versus* charcoal fires in the pot furnaces, but found that the great cost of the former fuel was not justified by the results obtained with it. Anyone working with pot furnaces will know how hot and uncomfortable are the operations of charging, removing and pouring; with tilting furnaces these troubles practically disappear; the material, mixed with its flux, is charged into the projecting mouth of the retort without discomfort, and the pouring is done by the smelter turning a hand wheel which operates the worm and pinion, tilts the furnace and runs off the slag into pots and afterwards the bullion into ingot moulds, the operations being very simple, and the working atmosphere comparatively cool, hence our remark "absence of effort in smelting."

We were pleased to read in connection with the Meyer and Charlton Mine of the success attendant on the introduction of filter presses for clarifying solutions, and of their marked superiority over the sand filter tanks previously in use there, a point mentioned by Mr. J. Acheson Jones, and we believe that similar results will be obtained wherever the two methods are tested against each other.

MINING EDUCATION.

(*Read at August Meeting, 1906.*)

By Prof. J. A. Wilkinson, M.A. (Member).

REPLY TO DISCUSSION.

Prof. J. A. Wilkinson: In placing before you my views on the subject of the education of students destined for careers in the mining industry, I had ventured to hope that such a subject would have elicited from amongst the many members of our Society a wide discussion, such as its importance in my humble opinion deserved. The views expressed in my paper are the results of a careful study of this subject during the last few years, and that the subject is by no means an unimportant one has been shown recently by the number of papers which have appeared in various scientific journals in different parts of the world, dealing exclusively with this matter.

In reply to Mr. Rusden, who reminded me of the King Edward mine, worked entirely by the students of the Camborne Mining School, I should like to state that as this school is a separate, distinct and individual foundation, not attached to any university or institution of university rank, it was excluded from the category as I was dealing solely with institutions of this standing. In this connection I find in the prospectus for 1904-5, "The curriculum is therefore that of a technical institution, and as such the school is recognised by the Board of Education." Now as such terms are used in England, a technical institution is of a somewhat lower grade than institutions such as those mentioned in my paper, and the differences are so well known to all that it is not necessary to repeat them here. I cannot, however, allow this opportunity to pass without a few remarks on the school in question. Since its establishment, in 1877, Camborne has indeed done a great work, and at the time when universities had not heard or dreamt of such a thing as mining as a subject for serious study; and no one who takes the trouble to peruse its prospectus can indeed deny that its period of usefulness and, I hope prosperity, is but more than beginning. The Rand, possibly more than many other mining areas of the world, owes to this school a great debt for the numbers of miners who have turned to good account here the lessons they have learnt there. The utility and advantages of having such a mine as the King Edward for the students must be great indeed, but this subject is one which I feel is more pertinent for mining engineers than for myself. On general grounds, however, in a university curriculum, as stated, I would oppose the intrusion of work of too technical or practical a character in the earlier stages of a student's career.

In reply to Mr. Lee, who accuses me of having dealt with the few rather than with the many, I venture to state that I purposely avoided this subject, which in itself is worthy of a separate contribution. As, however, he asks for my opinion on this, I feel constrained to make a few general remarks. It is obvious that the instruction received by a student who is fortunate enough to be able to devote four whole years of his after school life to its attainment must be somewhat different to that which a man, who spends most of the day in earning his daily bread, can obtain by spending a few hours per week after a hard day's work within the precincts of a school or college. Furthermore it must be remembered that the day student before being allowed to enter upon his course is compelled to pass a matriculation examination in general subjects. Now my own experience tells me that the evening student generally begins from a much lower level than this. The question therefore arises, to what extent will a student be able to benefit himself by attendance at such classes or by taking correspondence classes such as Mr. Lee suggests? It is impossible to answer such a question in a few words, but if the studies are rightly directed and properly undertaken the advantages will be great. As a teacher, however, I have been often sorely afflicted by encountering the wrong attitude of mind on the part of a student at the commencement of such a course of study. The personality of the student has in these cases to be reckoned with, and this factor is possibly the most important one. I could quote many instances of such students who, without any knowledge of the subject they desired to study, have wished to begin in the advanced classes, and when told that such a course was impossible have left in distress. Further, as education is one of the few subjects on which most people are authorities, such people do not generally seek advice from those who might be expected to have some small knowledge of the subject, but on the contrary are generally prepared to give it. This is another of the small difficulties which educationalists have to encounter.

Again, if such a student has in view a specific object he generally desires to attain that object in the least possible time. This, I opine, is a very praiseworthy ideal. But here again the student and teacher are in conflict. The latter, if he be a true educationalist, informs the student that certain preliminary courses are necessary before he can possibly take up with advantage, what may be supposed to be a professional or technical subject. Such a course is generally obnoxious to the student whose idea of the "least possible time" extends at the most to one academic year instead of the longer period which the teacher suggests. And the end is generally that he employs the short cut and seeks the aid of "a correspondence school" towards which he is lured by a specious and glowing advertisement.

Concerning these schoosl, at the outset I wish to make it quite clear that they exist for the same reasons as gold mining and other companies, namely, to make profits. That this is more than possible is shown by the vast progress that many have made during the last 20 years. Huge teaching staffs, large buildings, an expensive system of clerks and offices, wide and attractive schemes of advertisements, district agents, and a complete and thoroughly up-to-date office administration, cost money. Whence does that money arise? And how are students attracted? By the offer of complete courses within a very short space of time. These so-called complete courses are very often a snare, and it is a matter of great regret that it should be so, since the work is generally made attractive to the student, and to accomplish this object many, in fact almost all, of the difficulties which a student should be made to realise are left without comment, not mentioned at all or placed in such perspective that the real difficulty is hidden away.

That this is good policy from the strictly commercial point of view, no one will for a moment doubt, but I ask, is it true education? And is a man so trained the more fitted to solve the difficulties which may arise in actual practice? I venture to think that but one answer can be given to such a question. Half a loaf is better than none, however, is an adage which is applicable here. In fact I would go farther and state that such correspondence classes in that they reach the many who either from force of circumstances or for other reasons are unable to attend a properly staffed and equipped educational institution, are doing a great work, and it is a work which cannot be ignored by educationalists. They fill a distinct gap and in such wise are commendable. But I would warn those who have used, are using, or intend to use this method, that there are many blanks left which require filling in before a student can pride himself on a complete mastery of his subject. As far as practical subjects are concerned correspondence work can never take the place of instruction in a well-equipped laboratory under the personal supervision of the teacher.

Concerning Mr. Lee's criticism of the defects of modern instruction in that too much detail is given I am in hearty sympathy in so far that I consider the recapitulation of obsolete methods is a useless mental worry. I would go further and say that, if the principles of the subjects studied are ignored, then such instruction is sadly defective, and teachers who indulge in these methods are unworthy of their calling. I cannot agree with Mr. Lee in his remarks on teaching by suggestion since a student's time is generally very limited and he is unable to discover everything for himself. He must therefore be gently led along the paths of discovery, the courses being so arranged that the first phase leads up to the second and so on, each being interwoven so as to form one connected and harmonious whole. If, however, my critic suggests that too much spoon-feeding is practised, the student not being allowed or asked to think for himself, my only comment is that circumstances are so various and the mental abilities of students so varied that the necessary diet for a particular group or class must be left to the decision of the individual teacher, whose educational experience should enable him to diagnose the case and administer the proper remedy.

Above all things, however, the student must be taught the why and the wherefore, which should precede the how, as the latter naturally follows the former in true sequence. If this be true, then our students will be thinking and reasoning beings, able to use to the full their creative and deductive faculties, as Mr. Lee puts it, and we shall not engage ourselves in the manufacture of his walking encyclopædias. Concerning the sequence of practical and theoretical mining I am not able to give an opinion. In this connection I had hoped for criticism from some of our mining members. I am sorry to find that the description given of a graduate entering upon his life's work is corroborated by Mr. Lee's South African experiences, as I had indulged in the hope that South African graduates were not so much to blame in this respect.

As regards the division of the year into academic terms and vacation, I should like to state that we have tried various arrangements here at the University College, and the general consensus of opinion seems to be in favour of our present scheme, which consists of two terms of four months each separated by one month's break in winter and three months in summer. As far as mining students are concerned these vacations are spent as far as is possible in actual working in mines during the latter two years of the four years' course. To split the year into two periods of six months each I would not deem good policy, for the simple reason that neither students nor teachers would be able to withstand the mental strain of a continuous six months' academic work.

I thank Mr. Edwards for having amplified and confirmed from his practical experience many of the points which I mentioned.

In answer to Mr. Bawden I must repeat that I do most strongly affirm that cramming is not education, and my remarks in reply to Mr. Lee are equally applicable here. If the facts which a student necessarily learns in the study of his subjects have been properly correlated by the teacher, understood and learnt by the student as merely part of a comprehensive study, then they will not be readily forgotten. On this matter Thomas Carlyle, in an address to the students of the University of Edinburgh, just forty-one years ago, said, "By diligence, I mean among other things—and very chiefly—honesty in all your inquiries and what you are about. Pursue your studies in the way your conscience calls honest. More and more endeavour to do that. Keep, I mean to say, an accurate separation of what you have really come to know in your own minds, and what is still unknown. Count a thing known only when is is stamped on your mind, so that you may survey it on all sides with intelligence. There is such a thing as a man endeavouring to persuade himself, and endeavouring to persuade others, that he knows about things when he does not know more than the outside skin of them, and he goes flourishing about with them. There is also a process called cramming in some universities—that is, getting up such points of things as the examiner is likely to put questions about. Avoid all that as entirely unworthy of an honourable habit."

Since writing my paper I have been much gratified by finding that the views therein expressed as the independent results of my own experiences have been confirmed by writers on this subject all over the world. In this connection I wish to quote from a letter which I received a short time ago from Dr. Bonsall Porter, Professor of Mining at McGill University, Montreal, in which he says:—"I have had great pleasure in noting that in most respects you and I have almost identical opinions." These are amplified in a paper which Professor Porter read last year before the Canadian Mining Institute* entitled

* See Journal Canadian Mining Institute, Vol. IX., 1906, page 143.

"The Education of Mining and Metallurgical Engineers." I desire to thank my critics, Messrs. Lee, Edwards and Bawden, for their kindly reception of my paper. In conclusion it is my sincere hope that with the advance of mining and metallurgical progress in South Africa, in the rush to open up new industries, that the important subject of how to train young men to the best advantage will not be forgotten by those who will have to make use of their services. In this to a large extent lies the future welfare of this country.

The Chairman: We will now pass on to the paper by Mr. Richardson on "Mine Subsidence," as there are several members here to-night who desire to speak on this subject.

MINE SUBSIDENCE.

(Read at March Meeting, 1907.)

By Alex. Richardson, A.I.M.M. (Member).

DISCUSSION.

Mr. R. T. A. Innes: It is very kind of Mr. Richardson to have brought me here, but I am afraid I cannot say anything of value because it is a subject on which I know nothing. Mr. Richardson thought that to a certain extent mine subsidences might be influenced by meteorological factors. I have considered the question since he mentioned it to me, but I do not think that meteorology plays any part in the subsidences here. It is true that explosions in coal mines in England are generally associated with high barometers, but the absence of gas here puts such a thing out of question. The dryness of the Rand mines would also eliminate the damp factor which it is quite possible in time would, under other circumstances, disintegrate the rock. As far as that factor is present—dampness in the mines—it is not due to meteorological effects because even the damp air on the surface going into the mine gets much warmer, and its moisture carrying capacity is thereby increased. However, Mr. Richardson—and this brings me to a most practical point—asks me if we have a seismograph at the Observatory. I am sorry to say we have not. There are many instruments which the Observatory does not possess and which we would like to have, but the outcry against the cost of the civil service reacts on our scientific work, and it is difficult to get the support that is so necessary. But would a seismograph tell you anything? It is doubtful. The Witwatersrand and the whole of the High Veld, as far as I can find, has never suffered from the slightest shock of earthquake. Earthquakes, however, are not unknown to the Transvaal. Two shocks occurred a few days ago at Leydsdorp. They took place at 4 o'clock in the morning, and some months ago severe shocks occurred in the eastern part of the Ermelo district and over Piet Retief and Swazieland, which alarmed the people there to a considerable extent, but similar shocks have never been felt on the western side of the Drakensberg as far as I can gather. Of course that practically proves nothing because the Witwatersrand and the whole of the Transvaal have only been settled for a comparatively short time, say, 50 years at the outside, whereas earthquakes sometimes occur only once in 300 or 400 years, the great earthquake at Lisbon, is an example. There is another fact which makes me think that at no time has the Witwatersrand ever suffered from earthquakes or severe tremors, and that is that if there had been tremors of the earth during the last 300 or 400 years, the Rand mines instead of being amongst the coldest in the world, would be amongst the warmest, because such tremors generate an enormous quantity of heat in the rocks and that heat would take some hundreds of years to dissipate. It would seem to me that the land here has undergone no violent shaking for many thousands of years. It is quite possible that I may be arguing on too small a foundation and that the addition of a seismograph might show that considerable movements were going on. I think that the rock blasting in mines give far sharper and more important shocks than those due to distant earthquakes. If the Society considers the Observatory should instal a seismograph, any suggestion on that subject will receive careful and sympathetic consideration.

Prof. J. Yates: We are indebted to Mr. Richardson for a very readable and instructive paper on a little discussed subject, a paper which, under an unassuming title, plunges us into issues of the greatest import. In fact, such is the importance of these issues that one is chary of approaching the matter at all at the present day, when, in the absence of experience of the new conditions ahead of us, we are compelled to make so many assumptions in our attempts to look forward.

In making the foregoing remarks, I have in mind not so much the subsidences which are disturbing a few of our present mine managers, but the troublesome "creep and thrust" which will make its appearance sooner or later at very great depths.

I purpose to-night to confine my remarks mainly to the discussion of the influence of subsidences on our methods of work, present and future, and I accept Mr. Richardson's figures for the purpose of the argument.

It is noteworthy that since the paper was read we have had a subsidence at the Great Eastern Collieries, and a minor one at the Ferreira Gold Mining Company. The author has brought to our notice the other subsidences on the Rand, and, looking abroad, we find that serious stratigraphical disturbances have occurred in the salt district of Cheshire, England, and the Mansfeld copper district of Germany, and elsewhere.

In dealing with this subject, we can conveniently classify our mines on the Rand into three groups, as follows :—

(1) Those mines which have had, or are likely to have, subsidences which have affected or will affect, both underground and surface.

(2) Those mines lying to the dip of Group 1 which have had, or are likely to have, subsidences which have affected, or will affect, only the underground working, the falls of rock occurring some time after the exploitation, on our present lines, of the areas affected.

(3) Those mines which may possibly be opened up in the future to the dip of Group 2, and at such great depths that the resultant pressure on the reef will tend to close the working places very shortly after they are opened up.

Let us take these three classes in order, and see how matters stand.

GROUP 1.—All our outcrop mines fall within this group. Few of their workings are "packed" to any extent, and the great majority have their "hanging" supported by sparsely scattered pillars of ore only. The few pillars which have been left will, sooner or later, owing to the action of the air, moisture and pressure, oxidise, soften and scale and lose their supporting power, and down will come the country rock. It may be 5 years, or it may be 10 or 20 years before this happens in certain cases; all one can say is that at some period or other they will experience a subsidence which will probably affect the surface slightly, and more or less block up the old underground workings. The surface damage will probably be of little consequence, but underground, the collapse will make it well nigh impossible to recover the standing pillars, and at the same time, the working of those low grade blocks and leaders which had been left behind as being unpayable under existing economic conditions, will, in many cases, be seriously hampered. It is therefore to be hoped that no great period will elapse before the improvement in economic conditions will enable us to mine the 100,000,000 tons of ore of 16s. recoverable value recently referred to by Mr. Reyersbach as existing in our present workings between the Wit. Deep and Roodepoort; delay in its extraction diminishes its chance of ever being worked.

It is pointed out to us that 710 ft. is, so far, the maximum vertical depth from which surface disturbance has arisen on the Rand: this occurred on the Champ d'Or, and, as Mr. Richardson says, we have some grounds for assuming that the caving of workings below 1,000 ft. vertical, will not be evinced on the surface. I may relate, in connection with surface subsidences, that in South Staffordshire, 30 ft. of coal was extracted at a depth of only 432 ft. with a resulting subsidence of $13\frac{1}{3}$ ft., or 44·4 per cent. A canal passed over the affected area, and men were constantly engaged puddling the bed of the canal and raising its banks, and the subsidence occurred so regularly and slowly that traffic was only interfered with on two occasions, and then for very short periods.

Can we prevent these subsidences on our outcrop mines? It can be done to some extent by thoroughly packing the stopes with waste, or by building numerous "chocks"; but the expense of "chocks" would be great, and we have not as a rule sufficient waste for effective "packing," and there arises the pertinent question, "is it worth our while to keep the workings open under the circumstances?"

GROUP 2.—This includes the workings located within the zone between 1,000 ft. vertical and Group 3. Like Group 1, their superposed country rock is borne in nearly all cases by pillars of reef, assisted here and there by "packs." Future years will record a more or less general subsidence of this group, for reasons identical with those already mentioned, *i.e.*, the weathering, scaling and weakening of the present pillars. But in this case only the mine workings will be affected, for, as I have already pointed out, with the reef at this depth, the surface will be practically immune from interference. Mr. Richardson has placed on record, however, a case of subsidence in Wales which arose from excavations 2,400 ft. deep, the strata being of a soft nature. It must be borne in mind that the physical characteristics of the rocks, the thickness of the reef, the angle of dip, the area of the excavations and the depth of the workings, all have a bearing on the nature and extent of the collapse and its projection towards the surface. Our reef thicknesses are small, and this limits the propagation of the wave of disturbance in the direction of the surface, for the falling strata have but little space to fill.

It is difficult to follow the reasoning of Prof. Callon and others who favour the theory that subsidences are transmitted to the surface without sensible diminution in amount, irrespective of depth. If the falling rock was one homogeneous whole, falling as one piece, one could understand such a belief, but the conditions are not such, for the falling strata are often made up of layers of all sorts and conditions of rock, which doubtless fall, not as one whole undivided mass, but individually, and, in falling, are more or less shattered and re-arranged, and consequently occupy a greater space. The lowest layer has the greatest fall, but as layer after layer descends the fall for the succeeding ones is greatly lessened, until there is ultimately no space to fall through, and the subsidence terminates. This appears to me to be a simple explanation of the observed fact that subsidences at great depths do not affect the surface. As in Group 1 the result underground is to place certain pillars beyond our reach, and to render such low grade blocks and reef as had been left behind, difficult of access in at least some cases. In view, however, of the fact that we have so little waste available for "packing," it is again questionable whether any material departure from our present practice is called for at the moment, but as Group 3 is approached, some departure from to-day's exploitation practice may have to be made.

Group 3.—As I have already stated, this group includes the properties which may possibly be opened up in the future at such great depths that the resultant pressure on the reef will tend to close the working places very shortly after they are opened up, in fact, the phenomena of "creep and thrust" will follow closely on the development faces.

In 1899 I pointed out before the South African Association of Engineers that, so far as temperature alone was concerned, our workings might possibly attain a depth of 10,000 ft. vertical. Will the resistance of our reef to pressure ever allow us to reach such a depth? I am discussing this point quite apart from financial considerations. Mr. Richardson has placed in our hands the results of some tests made on Rand quartzite, with the object of ascertaining its compressive strength, and from these he has deduced that the resisting power of our quartzite may, at great depth, be from 10,000 lb. per square inch to over 15,000 lb. per square inch. Accepting these figures as holding good for the banket also, I find that with the lower resistance it would be necessary at 8,000 ft. vertical with a dip of 25 deg. to leave approximately 88 per cent. of our reef as pillars, merely excavating about 12 per cent., and with the higher resistance—15,000 lb. per square inch—approximately 59 per cent. of the reef would have to be left intact. I need hardly say that in neither case would mining be profitable. But in working out the above figures we are taking much for granted, and I cannot for instance imagine that they correctly represent the resisting power of our rock under the natural conditions existent in our mine workings, and few of our mining men will believe that the above figures depict what would actually be experienced. At the same time the increase of pressure at very great depths may compel us to depart, more or less, from our present method of opening out and stoping, and drive us to adopt, say, a modified longwall, as Mr. Richardson mentions, or induce us to resort to the thorough filling of stopes with waste rock, sand, or such like. It is greatly in favour of longwall work that all the ore may be extracted, and the ventilation is greatly simplified.

In this connection, some views expressed by Mr. McNair, President of the Michigan College of Mines, U.S.A., in his recent Vice-presidential address before the New York meeting of the American Association for the Advance of Science, are of interest. They touch on deep mining in the Lake Superior Copper District, and as the views are doubtless based on the experience being gained in the very deep mines there, with your permission I will quote them:—

"The copper mines of the Lake Superior district are essentially low grade. Their profitable operation is made possible by the great extent of the lodes, their comparative uniformity of character and the investment of great sums of money to maintain operations on a vast scale over a long period of years.

"With but one important exception the lodes are the vesicular tops of ancient lava flows which subsequent to solidification have had the cavities wholly or partly filled by the deposition of various minerals, among which is native copper. They dip at angles varying from 38 to 70 degrees.

"The modern shafts through which the rock is hoisted are either inclined, following the plane of the lode, or are vertical. The inclined shafts are of dimensions such as to provide for two rail-roads of approximately standard gauge on which run the skips, which are operated in balance. In addition there is room for the ladder way and air pipes, usually at one side. The vertical shafts have compartments providing usually for cages and pipe and ladder way. Several of the inclined shafts are over 5,000 ft. long. One has a length of 8,100 ft. Of the vertical shafts the three deepest are respectively about 5,200, 5,000 and 4,900 ft. deep.

"Long before such depths were actually reached there arose the question as to a possible limit set by the ultimate crushing strength of the rock which is penetrated. Manifestly mining cannot go to a depth such that the weight on walls of drifts and stopes will exceed the ultimate strength of the material of which they are composed. There is a widespread impression that the lake mines are approaching such a limit. There are current statements to the effect that pieces of rock occasionally snap off the rock faces because of the great strain, and are violently projected as if propelled by an explosive.

"In this connection a few figures will be of interest. The average density of the rock of the copper-bearing series is not far from 2·87, that is, a cub. ft. weighs about 179·3 lb. Therefore a horizontal sq. ft. of area at 5,000 ft. from the surface has above it a column of rock weighing 448 tons. The ultimate crushing strength of the average rock is not well known, but since it is mostly trap this may be safely assumed as at least 1,200 tons per sq. ft. If, therefore, the sq. ft. above defined carries the entire column above it, it is loaded to much less than half the crushing strength, and only at nearly three times the assumed depth will the load reach its crushing limit. At a dip of 38 deg., the pressure normal to the plane of the lode at 5,000 ft. from surface is only 354 tons per sq. ft. It is in this direction that the crushing forces are mostly called into play. As the dip increases this normal pressure of course diminishes. At 52 deg. it is 278 tons, and at 70 deg. it is 152 tons per sq. ft.

"However, the matter does not end here. The removal of large portions of the copper zone leaves considerable areas of the roof or hanging wall to be supported by the pillars which are left for the purpose, or by the walls of the opening, or by both. The weight on pillars and walls is thus increased and may easily approach the crushing limit. Take for example a long pillar 50 ft. wide, having on either side an open space of 150 ft. Suppose it to be a lode dipping at 38 deg. Allowing for neither rigidity nor arching, and supposing the weight on the pillar evenly distributed, at 5,000 ft. depth it would be subjected to a pressure of 1,239 tons per sq. ft., a pressure under which it would fail.

"As a matter of fact in such a case the rigidity of the rock mass distributes a large part of the load out over the rock beyond the walls of the opening. That this rigidity may be considerable is illustrated in several cases where areas of hanging as wide as 200 ft. or more have no support between walls, and yet have stood up for several years. They are not, however, at maximum depth.

"In such an area a pillar when first cut out may have to carry but little more than its previous load. As the hanging wall slowly bends, the pillar must take up more and more of the extra weight. This is not applied uniformly. As the rock between pillars and walls bends downward the tendency is to concentrate the load at the edge or face of the pillar or wall, much as a beam does when supported in like manner. The outer parts of the pillar may thus become overloaded and here it will fail.

"It does so by the splitting off of pieces of rock much as may sometimes be observed with a specimen in the testing machine, though on a much greater scale. These pieces break from the base as well as the top, and, as a rule, like any hard rock under a crushing load, the pillar fails suddenly. Small pieces of rock may fly a considerable distance, and such occurrences have undoubtedly given rise to the exaggerated impression of the compressive stress to which the rock is subjected in the lowest levels.

"The hanging rock mass moves of course when the pillar crushes, and the vibration due to the sudden though slight displacement is often conveyed to the surface. The result is a miniature but perfectly genuine earthquake which may be felt over a distance several times that of the pillar from the surface. With the crushing of the pillar and the movement of the hanging, a re-adjustment of the weight takes place, and the process begins over again. Instead of the process being repeated in exactly the same manner, it is possible for the hanging to break in such a manner that the arching effect may protect this pillar and place the load on others. Eventually at great depths the hanging and foot must come together, and in one mine the final steps in the process came so rapidly as to completely wreck it.

"The pressure normal to the plane of the lode is not the only stress which may become manifest. The pillars are not as a rule separate from either foot or hanging. They are parts of the same rock mass, and it is not possible for the hanging to slide over the pillar. In consequence the readjustments which take place when a pillar falls as above described sometimes put an enormous longitudinal thrust on the foot, and in places its surface portion has buckled up under such stress. Also, at points where shaft pillars have been weak, shafts have been pinched and twisted under the same conditions so as to interfere with their operation.

"Experience seems to have shown that at the great depths recently reached it is useless to expect to hold up the hanging rock mass for a long time by any scheme of pillars unless far too much of the lode is left in place, and that the only feasible method is to cut away the entire lode and permit the hanging to cave as rapidly as it will to the point where the broken rock again fills the whole space, and redistributes the weight over the footwall. Following this plan, stoping begins at the point farthest from the shaft and progresses towards it. With a wide shaft pillar, or with the shaft in the footwall, and with some general method which avoids concentration of pressure where it can do harm, there seems no reason to anticipate serious difficulties due to crushing for a farther depth at least as great as that already attained."

These are President McNair's views, and he, at any rate, does not see any impossibility in mining to 10,000 ft. vertical.

In conclusion, I would again compliment Mr. Richardson on his paper, but I think that, like me, he will not place much reliance on the figures he has evolved, interesting though they may be. Most of us on these fields will be very well pleased if our operations are carried to 8,000 ft. vertical over any large area; few look forward to pass 10,000 ft., and to such depths as these I, for one, believe we will be able to descend without meeting with any very great technical difficulties; it is financial considerations, not technical difficulties, which will cry "Halt!"

The Chairman: This paper of Mr. Richardson's on mine subsidence has opened up a question the magnitude of which we have only lately begun to realise. It is a question which has received too little consideration on these fields up to the present time, since it has to do enormously with the future of the Rand. Mr. Reyersbach in his speech to which Prof. Yates has referred, pointed out that there are immense quantities of low grade ore on these fields which, under existing economic conditions, cannot possibly be exploited. But this vast asset should be kept available, and it rests with those of us who have to do with the management of mines, to see to it that we leave our houses in such order that when in the future it becomes an economic possibility to work the reefs which at present we cannot exploit, our successors may be able to take up that work without having to re-open caved areas. The cost and the possibility of working the Main Reef body proper in the future depends largely on this question of mine subsidence. Prof. Yates quotes Mr. McNair on the system of working a mine from its outside limits back to the shaft. By that method you may indeed exploit a reef regardless of the pressure from the hanging wall, but if in outcrop mines and the first row of deep levels we work out the Main Reef Leader at the present time without allowing enough pillars to support the roof, and leave the Main Reef body itself to be worked ten years from now, it is quite possible that such subsidences may occur as would make it impossible ever to mine that ore at a profit. It certainly is worth while in very many cases to keep stopes open where ore is left, because it is the history of every country that with its development economic conditions change. That which is impossible to-day becomes possible to-morrow and profitable next year. The conditions of this country must certainly change. The wages which are paid in new countries, as those countries develop and acquire a local population are subject to economic changes. They come down and costs come down, and that is a condition which will certainly arrive in this country. Perhaps not in your lifetime, nor in mine, but it is certain to come; just as certain as that the federation of South Africa will come. And when it does come these enormous bodies of low grade reef, which at the present time we cannot exploit, will become a profitable asset to the shareholders of our mines, and they will assist in continuing the development of this great country. So it behoves us to study this question of subsidence and see to it that so far as possible we leave the mines in such shape that ore bodies left to-day can be worked in the future.

LAST DRAININGS.

(*Read at February Meeting, 1907.*)

By H. A. White (Member).

DISCUSSION.

Mr. W. R. Dowling: After the many discussions which Mr. White and myself have had upon the subject of cyaniding sands it is a cause of special pleasure to me to read his able exposition of the subject in his very useful paper on "Last Drainings." The reasoning in his paper logically demonstrates the advisability of the practice which I have for long past found it desirable to carry out on the cyanide treatment of sands.

As the object of applying strong solution is to dissolve the gold and the weak to wash it out, it follows that the strong should be applied as early as possible in the treatment to leave the maximum amount of time for washing. The solution of the gold is not always complete at the first contact with cyanide and cases are where dissolution continues to the end of the treatment, due mostly to the gold not being sufficiently exposed by crushing. Since the conditions under which charges are collected in our present practice of cyaniding, allow for the presence of sufficient lime in the mill water to neutralise any acid in the ore, it seems to have taken us a long time to realise that the old practice of putting on a preliminary wash before the strong was not necessary. Where, however, dumps are being milled with the current ore it might be reasonable to apply a preliminary wash.

With reference to the method of applying washes, I think that as many drainings dry as possible, consistent with a sufficient tonnage of solution, should be made. Draining dry after each saturation of solution is good practice, and possible on many plants. There is not so much time lost by this method as is generally supposed, as during the time that some vats are closed for saturation or the stream weakening, others are leaching very much faster. My present practice is to drain dry after about every 100 tons of solution applied. This gives 7 drainings dry in the course of applying 800 tons and more of solution.

With reference to the strength of cyanide solution necessary, I am not yet satisfied that even ·1 per cent KCy is not too high. If as Mr. White suggests, and I think he is quite right, ·05 per cent. is strong enough for solution purposes, why use as high as ·1 per cent? ·1 per cent. strength by the way, is not commonly used. Many cyanide managers consider this too low and prefer as high as ·2 per cent. The statement that a high strong is necessary for precipitation purposes is not altogether consistent. As the weak slime boxes precipitate satisfactorily with solutions of much less strength, why should it be necessary to have so much strength for the strong, only to have that strength reduced by about 50 per cent. in the extractors? If we take as an example a 200 stamp proposition, making a sand tonnage of, say, 700 tons per day, strong solution applied 20 per cent. = 140 tons, decomposition in boxes, say, ·04 per cent. = ·8 lb. KCy per ton of solution = 112 lb. KCy per day or ·17 lb. KCy per ton of sand. Would it not be cheaper even if some of this saving had to be used on the weak boxes to maintain good precipitation, to use ·05 per cent. solution on the sands? We know that so much slime would not be made in the boxes for clean up, but acid is cheaper than cyanide. The difficulties of experiments of this nature is that no company is prepared to risk the output not being forthcoming at the end of the month.

With reference to the value of the last drainings I do not think these should be sampled at any other time than that which gives the highest assay. If the samples will stand the severest tests then there is not room for any doubt. My practice is to drain the last saturation of the sand charge into a sump. Systematic samples over months from this sump show practically no difference with the last draining samples. The last draining samples being ·131 dwt. and sump ·133. As for the cost of precipitation I think Mr. White has allowed altogether too much, at all events, for large plants. Allowing for zinc, cyanide and all the power used in the extractor house the cost per ton of solution works out at less than 3d. As it is unfair to charge precipitation with all the cyanide and power I believe that 2d. is a sufficient allowance, at least for any increases of tonnage. Thus the cost is ·04 dwt. and any solution drawn off of greater value shows a profit so long as it is derived from the sand and not from the solution pumped on. This is where, as Mr. White points out, it is so important to have sufficient capacity and good precipitation.

Coming to values of solution leached I find that Mr. White's diagrams confirm my results, so there is no reason to put the Society to the expense of publishing my diagrams. Such diagrams should be prepared on every cyanide works as they are of the greatest value in deciding how to classify the leachings. Utilising the information obtained in this way very good classification can be done, by which the maximum amount of gold can be precipitated in the minimum number of boxes, as is shown by the following figures. This leaves much less gold to be carried forward at clean up:—

Class of solution.	KCy per cent.	AlK per cent.	Tons of solution per day.	Assay value dwt. per ton.	Gold contents of solution oz.	Per cent. of gold in each class.	Zinc cubic feet for each class.	Zinc per cent. for each class.
Rich ...	0·058	0·013	350	4·565	80	64	250	23
Medium	0·017	0·007	310	2,041	32	26	220	20
Poor ...	0·019	0·010	870	0·304	13	10	620	57
Totals...	—	—	1,530	—	125	100	1,090	100

90 per cent. of the gold is delivered to 43 per cent. of the zinc.

In the table the leachings are classified into three grades—rich, medium and poor. It will be noted that the cyanide strength of the medium is much the same as the weak, the only object in separating them is for the gold. After precipitation, the medium and weak solutions go to the same sump.

Mr. F. Alexander: There is no doubt Mr. H. A. White in his paper on "Last Drainings" has opened an old sore, and a question requiring the serious attention of every cyanide manager, particularly those treating the sand after tube milling.

My experience has taught me to beware of acid pulp as one of the chief causes of high last drainings, but other causes are prevalent, of course, such as: 1. badly filled tanks, 2. too short time available for treatment, and 3. old filter mats, with shovelling slabs, forming a concrete bottom fairly water-tight, but none of these are, in my opinion, quite so bad as the bunches of acid ore that find their way through the reduction works from time to time in a most irresponsible manner.

Twenty or thirty tons of mullock cleaned up from some old working, where the rails, laid some twelve months ago, are believed still to exist, is quite sufficient to contaminate the day's crushing (unless neutralised in the mine). Such acid ore, after doing all the damage it can to the copper plates of the battery, most readily precipitates when mixed with the slightly alkaline water used for milling, forming the worst of slimy lumps possible for cyanide treatment, as they hold up a large percentage of acid with the moisture, and will, when cyanide solution is pumped on, absorb and retain more gold bearing solution than any other portion of a charge. It is only by successively draining dry that this gold is displaced, and this repeated drying of charges is not always possible.

This cause is also largely responsible for the need of using stronger solutions than are theoretically required for the solution of gold in every charge, and as cyanide is cheaper than gold, we prefer to have sufficient cyanide present at all times to cope with this and other similar bugbears.

The obvious solution of this difficulty is to have no such lumpy product, but this is more easily imagined than achieved, and if some of our inventive members will exercise their powers and perfect a less costly machine than the Blaisdell extractor, that would break up and scatter these offensive lumps, I feel sure we should obtain satisfactory results after leaching a charge for, say, five days with an equal quantity of solution to sand. I hope the discussion on Mr. White's paper will serve to elucidate the very interesting diagrams so ably brought before the members of this Society, as I know opinions on this subject are many and various.

THE SCREEN ASSAY ON THE MEYER AND CHARLTON G. M. UNDER "THE NEW METALLURGY."

(*Read at March Meeting, 1907.*)

By Chris. Toombs (Associate).

DISCUSSION.

Mr. F. T. Chapman: Mr. Toombs concludes his admirable paper by stating that, in his opinion, the screen assay will always be only very approximate wherein I quite agree with him. My experience of the same system when in charge of the assay office on the New Goch bears out his statement very closely.

In regard to his latter system of assaying the screen sample unwashed, this method, at first sight, under the new metallurgy appears to me to be the correct one, and was the first method I tried; but in practice it is most unsatisfactory to the assayer when you cannot get two results to agree, and have differences of 2 dwt. and even much more in my own experience on a grade of 7·50 dwt.

These differences must surely condemn this system. Here I would like to suggest to the assayers still working this method to try precipitating the whole of the gold in solution with cuprous chloride before drying the pulp sample and better results may possibly ensue.

On the Goch I used the method of washing the pulp very thoroughly, and was able to get remarkably close results from the washed sample, and this, at any rate, was satisfactory from the assayer's point of view. However, the washed sample was, no doubt, too low in most cases, as my experiments showed the moisture retained in the pulp would, when washed out with known quantities of water, assay as high as 6·5 dwt. per ton, whereas the solution taken off the pulp in the first place would be more like 2·20 dwt., and the numerous washings, especially the first wash, tend to dissolve gold.

On the Goch the ratio of solution to ore used in crushing was about 8 to 1, and, of course, as Mr. Toombs states, you have to add to your washed screen assay the difference between the solution going to the mill and the solution taken off the pulp multiplied by the relative tonnage of solution used. At this point I would like to ask Mr. Toombs what he did when the assay of solution going to the mill was higher than the solution taken off the pulp? Did this ever occur at the Meyer and Charlton? I have no doubt it did, since it occurred with me several times, and, further, I might say you could take samples at short periods during the day with very different results.

At times the difference between the solutions was ·2 or ·3 dwt. and even higher; this, multiplied by the number of tons of solution estimated to have been used in crushing 1 ton of ore meant 1·6 or 2·4 dwt., and more to be added to your washed pulp assay, this was possibly much too high and exceptional, for I usually found about ·1 dwt. of a difference; however these discrepancies are sufficient in themselves to condemn the method, as it is impossible to obtain a reliable result as to the actual screen value, although the assays may agree.

In the method used lately by Mr. Toombs and formerly by myself, the variation on four results must in itself condemn that method.

I would like to ask Mr. Toombs if his samples were dried on iron plates or dishes, and would not this be likely to have the effect of precipitating some of the gold? At the Goch the samples were carefully dried in large enamel dishes and a great amount of gold was, no doubt, dissolved preparatory to washing. The conclusion I have come to is, there can be no good method possible under the system of arriving at a true screen value, and I think the value of the ore milled will have to be determined at a point before contact with solution, possibly some method with automatic samplers.

We endeavoured at the Goch to arrive at a value of the ore going to the mill by taking bin and chute samples before coming in contact with solution, the bin sample taken from the tripper over the mill bins and from the chute to the mortar boxes; these results were condemned as worthless, although I venture to say probably as accurate and more so than either of the methods used for obtaining the screen result when calculating the gold called for on the value of the ore put through the mill.

The following are a few results comparing samples from:—

Bin. Dwt.	Chute. Dwt.	Screen. Dwt.
13·00	7·00	8·60
7·60	8·15	7·50
8·50	6·65	6·90
9·75	8·50	6·40
11·70	7·20	6·45
8·80	5·30	6·40
14·25	8·30	6·65

It is curious that the average of the seven chute and screen samples make the chute ·31 higher than the screen, this being the exact difference shown by Mr. Toombs in what he considers the difference between the right and wrong way of determining the true screen value.

I understand that on the Goch and Charlton mines a weighed portion of every day's screen sample is now kept, and at the end of the month is bulked and assayed, this should return a value similar to the month's average of pulp samples. Several assayers along the Reef and in town have assayed this sample, and the variation is as much as 10 per cent. between their respective results, and in some cases nearly 2 dwt.

NOTES ON THE ESTIMATION AND VALUATION OF ORE RESERVES.

(*Read at January Meeting, 1907.*)

By W. R. Tait (Associate).

DISCUSSION.

Mr. **T. Lane Carter**: When Mr. Tait speaks of the "haphazard way of estimating ore reserves," he must be only referring to a few individual mines, for on the whole the work of estimation is done with extreme care on the Rand. As a matter of fact some mines go to the other extreme, and spend large sums of money monthly in estimating the ore reserves in the mine, as if the property were for sale. It seems to me that this excessive sampling need not be done twelve times a year, but that one estimation per annum is sufficient.

I agree with Mr. Tait that 12 in. is a good maximum width to take in sampling. To get a true value of a very narrow reef is generally most difficult, on account of the variable gold contents of the ore. Very often the majority of the gold is found on the casings of the reef, and one is liable to get too much or too little of this rich portion. In sampling these narrow reefs I consider it preferable to take the sample right along the reef, for the whole distance between sections, rather than collect the sample from one spot. The reef is measured a number of times, and an average struck for its width.

Mr. Tait does not mention them, but I consider automatic samplers a great help in quartering down mine samples. It has been proved that the sample obtained from these samplers is a true one.

In dividing up his blocks into payable and unpayable I note that Mr. Tait does not discriminate between the different reefs in regard to the limit of payability. On the West Rand the south reef is far more expensive to work than the main reef, the difference in the limits of payability being about 1 dwt. The limits in this part of the Rand are roughly 5 dwt. for the main reef, and 6 dwt. for the south reef.

There is a most important point I desire to raise in connection with Mr. Tait's paper, and that is the question of the assay plan factor.

What percentage of the value of the mine, as shown by the assay plan, is recovered? We all know how violently this factor varies on different mines. On one property you find men who declare that they recover 90 per cent. of the values disclosed by their assay plan, while on a mine a few miles distant the assay factor is only 65 per cent. Mr. G. A. Denny, in his book, "The Deep Level Mines of the Rand," says, on p. 135, "Thus, of the total value the amount secured is only 63 per cent., which for safety's sake the writer reduces to 60 per cent. We may then lay down the invariable rule, that upon reefs or stoping widths of 4 ft. and under the estimated recovery value may only be taken as 60 per cent. of the assay value of the ore standing in the mine" (as shown by the assay plan).

I should like Mr. Tait to state what assay plan factor he is accustomed to take, and his experience in this line.

It is just here that many of the yearly reports made on the Rand are misleading. The chairman of a company, in a grandiloquent speech announces to the world that they have ore reserves to the extent of 900,000 tons, of a value of 33s. What does he mean? Does he mean that from 900,000 tons 33s. will be actually recovered, or does he mean that by the assay plan the value of this ore is 33s. per ton. If it is a value according to the assay plan, and the assay factor is no higher than that used by Mr. Denny, namely, 60 per cent., then the practical value of the 900,000 tons of ore is only 19·8s. It seems to me the value of ore reserves should always be stated in terms of the recovery value, and not as the value displayed by the calculations from the assay plan.

There was once a "mining expert" in London, who acted in a consulting capacity to a mine on the Rand. Taking the assay plans of the mine one day the expert worked out that the mine should be making far higher profits. A long report was written to the manager, pointing out that the profits should be greater, and proving the assertion from the assay plans. The manager studied the figures for some days and then sent this cable to London. "Your figures are wrong. You have used 90 per cent. as the assay plan factor, whereas the figure we have found from experience is only 69 per cent."

The meeting then closed.

Erratum.

Page 300, under Hydrazine Salts for Volumetric Analysis. For the second equation read :—

$$N_2H_4.H_2SO_4 + 6NaOH + 2gHCl_2 = 2Hg + 4NaCl + N_2 + Na_2SO_4 + 6H_2O.$$

Proceedings AT Special General Meeting, April 20, 1907.

A Special General Meeting of the members of the Society was also held the same evening to consider the adoption of certain amendments to the rules, and also a proposition for the incorporation of the Society, brought forward by Professor J. A. Wilkinson. Mr. Wager Bradford presided.

Mr. W. Cullen in submitting the new rules said :—I daresay it is within the recollection of most of our members that the draft rules recently approved by the Council came before us at a Special General Meeting for confirmation some two or three months ago, when the meeting as a whole decided that on one question of principle it could not see eye to eye with the Council. The whole question seemed to turn very much on the election of Vice-presidents by the Council. By the draft rules submitted to you on that occasion the election of Vice-presidents was left entirely in the hands of the Council and the meeting somehow or other differed from the Council in this finding, and as a result the whole matter was relegated back to the Council for reconsideration. I do not think I am telling any secrets out of school when I say that this matter has been the subject of frequent debate by your Council, and I am sure that the whole of the members of the Council hope that the rules submitted to you to-night will meet with your approval in every respect and in every detail. I can assure you myself, and I was formerly in opposition, I have given my best personal consideration to them, and those who were against me at that time have collaborated with me. At the end we happened to see eye to eye, and I hope that you will agree with us. Without wasting any more time I will formally move the adoption of the rules *en bloc.*

Mr. H. A. White: I have great pleasure in seconding that proposition. We were unanimous in the Council in adopting these rules, and I hope the general meeting will be with us.

The Chairman: Gentlemen, you have heard the motion that the rules as submitted should be adopted. Copies of these rules have been sent to every member, and doubtless you are familiar with them. I will ask for any discussion on the motion.

There being no response, the Chairman put the motion to the meeting and declared it carried.

The Chairman: The next item before the meeting is a resolution to be proposed by Prof. J. A. Wilkinson as follows:—

"That the time has now arrived when the Society should become incorporated under the Ordinance to provide for the Incorporation of Societies in the Transvaal (No. 56 of 1903) and that the President and Council be hereby empowered to take all the necessary steps to procure incorporation under the aforesaid Act."

Prof. J. A. Wilkinson explained the object of the Act of incorporation, pointing out by this means Societies and Associations became recognised in the laws of the realm. The Act also conferred certain privileges. Once the Society became incorporated they could sue as a Society and be sued, though he did not think such privileges would affect the Society very much. To become incorporated was quite a different thing from obtaining a Charter which would require that every member should pass a qualification test. By incorporation the Society would remain just as it was before and anyone could still join it who took sufficient interest in their proceedings to induce them to do so. With the advent of Responsible Government he thought it was time they should take this step. They were now under a different regime and were supposed to be able to look after their own affairs. He trusted the members would unanimously support his motion.

Mr. W. Cullen seconded the motion.

The Chairman said that he presumed the incorporation of the Society would mark a certain step in its progress. For a long time they had carried on very successfully without it, but the fact that they had carried on successfully under certain methods did not mean that they should not branch out and adopt others. He thought it could only improve the position of the Society.

Mr. R. G. Bevington said that at present the Society had no legal standing and no actual legal force, and if it were necessary for them as a body of scientists to make representations to the Government on some question the latter could turn round and say "Who are you?" The incorporation of the Society would only cost them a matter of about £10 and it would give them a legal status and enable them as a Society to claim to be heard if they wished to approach the Government on any question.

The resolution was then put to the meeting and carried unanimously, which brought the business of the special meeting to a close.

Annual Dinner.

The Annual Dinner of the members of the Chemical, Metallurgical and Mining Society of South Africa took place on Saturday evening, the 13th April, at the Carlton Hotel, and though not so largely attended as in some previous years the function lost none of its importance, either socially or otherwise. The guests included representatives of kindred scientific societies on the Rand, many of the leading representatives of the mining industry, and some very important speeches affecting that industry were, as is always the case at this annual gathering, delivered and attentively listened to. The President of the Society, Mr. E. H. Johnson, occupied the chair, and there were also present:—

Messrs. W. K. Tucker, C.M.G., M.L.A. (Mayor of Johannesburg), L. Reyersbach (President Transvaal Chamber of Mines), H. W. Soutter (President Chamber of Trade), S. J. Jennings (President South African Association of Engineers), H. H. Johnson (President Transvaal Institute of Mechanical Engineers), R. Q. Leeds (President Pharmaceutical Society), F. Alexander, W. Beaver, R. G. Bevington, B. V. Blundun, Dr. H. J. Bradey, W. Bradford (Vice-President), Dr. H. G. Breyer, A. F. Bruun, W. A. Caldecott (Past President), P. Carter, T. L. Carter, F. M. Cecil, R. Clarkson, M. H. Coombe, W. M. Coulter, W. Cullen (Past President), C. R. Davis, W. R. Dowling, W. M. Epton, S. Evans, M. Ferguson, J. S. Fisher, Max Francke, A. Gardner, P. C. H. Glover, W. S. Gordon, K. L. Graham, J. Gray, T. Greig, H. R. Grix, A. Heymann, C. H. Hilditch, C. B. Hilliard, S. Holmsen, W. L. Honnold, W. W. Hoy, G. J. Hunter, J. E. Lapping, J. Lea, Q. J. Leitch, J. Littlejohn (Hon. Treasurer), Dr. D. Macaulay, M.L.A., T. McKerrell, R. G. McKowen, H. Meyer, W. E. C. Mitchell, Dr. J. Moir (Vice-President), W. D. Morton, P. T. Morrisby, W. Nicklin, S. S. Osborn, E. Pam, C. F. Parry, S. H. Pearce (Past President), A. Rodger, F. Rowland (Secretary), C. E. Rusden, C. B. Saner, A. D. Scott, F. Simmonds, C. B. Simpson, Prof. Stanley, S. H. Steels, J. H. Stevens, H. Taylor, J. Telford, W. G. Walker, H. Warren, G. E. Webber, H. A. White, J. Whitehouse, Prof. J. Wilkinson, N. Wilson, D.S.O., and Prof. J. Yates.

Apologies for absence were received from His Excellency the High Commissioner (Hon. President of the Society), Hon. J. C. Smuts (Colonial Secretary), Hon. J. de Villiers (Minister of Mines), Hon. J. Rissik (Minister of Lands), Sir Percy Fitzpatrick, M.L.A., Sir George Farrar, M.L.A., F. D. P. Chaplin, M.L.A., G. Albu, Hon. W. Dalrymple, M.L.C., W. H. Dawe, H. L. L. Feltham, Lionel Phillips, C. H. Spencer (President

Association of Mine Managers), H. F. Strange and R. W. Schumacher. A congratulatory wire was also received from Mr. Clement Dixon.

The dinner was well served and greatly appreciated, and at the conclusion of the repast the President proposed the usual loyal toasts, which were received with musical honours.

The Mayor (Mr. W. K. Tucker, C.M.G., M.L.A.), who next proposed the toast of "The Society," said — The toast which I have to propose to-night is that of the Chemical, Metallurgical and Mining Society. Though most of you, I believe, are members of it, it will be none the less acceptable to you on that account. To those of us who are simply members, who receive your periodicals and read at our leisure the discussions which take place at your meetings, it is a pleasure, I think, to be invited to meet with you round the festive board and see that men of science, whose business it is to be working arduously all the year round, can set apart one evening at all events on which to have a little relaxation. I take it that your Society is composed principally of metallurgists and chemists, although you have added on the profession of mining. We are told that a very long time back a certain man was an artificer in metals, and it is evident that some one must have discovered those metals. Chemists were also known a long time back The alchemists of old were men who dug away into the mysteries of nature, mostly, I believe, with the object of trying to discover the elixir of life. They looked a very scraggy lot if we may be guided by the pictures one sees in the old books. Their laboratories were not at all efficient. A few bottles, a crucible and a table seemed to be their whole outfit, and the men themselves very often neglected their barber and allowed their hair and beards to grow long. They looked as though they did not care what happened or how soon they shuffled off this mortal coil. Well, it was strange that they should be the men above all others who were seeking the elixir of life. At all events, considerable progress has been made in the science of chemistry since those days. It made its principal advance from the time chemists gave up trying to find the nostrum that was going to provide them with perpetual youth. Since then they have tried by means of chemistry to ascertain how our lives may be made worth living on this sublunary sphere. They have entirely given up looking for the elixir of life. That is now relegated to the people generally, for if we may be guided by the number of advertisements one sees of all kinds of nostrums as being the most effective cures of all the ills to which the flesh is heir, this idea of the elixir of life is not entirely eradicated from the public mind. But I think it would be the last thing which the Chemical Society would attempt to find. Chemists now set themselves the task of trying to make a man's life upon earth, short as it is, at all events as enjoyable as they can make it. You have entirely altered the course the original alchemists set out for themselves. You do not wish to prolong life but to create in that life all the possible enjoyment an intellectual life can give. In a community such as our own, where we are dependent to a large extent on extracting from mother earth the riches which she has hidden, we are greatly indebted to the men of science who make it possible to extract at a cost which still leaves a profit, the precious metals which lay hidden. In that way the members of your Society have done a great amount of good for the Transvaal since the goldfields of the Witwatersrand were first discovered. It would be impossible for us, I think, to overestimate the value to this country of the work which these men have done for us, and I think that this town may be proud that there is such a Society as yours in our midst. You have shown by your discussions that you have the interests of this country at heart, that you have not selfishly set yourselves to make your daily bread and get out of the country as soon as you can, but by associating together you work that some good may result and by your discussions and publications you give us the result of your experience. Therefore I say that the community at large is indebted to your Society, and I congratulate the Society on the good it has already done in the country. The problems which this country still has to face in confronting nature in finding out the lines which ought to guide us in our future conduct are very great, whether you take mining, agriculture, or the means of life, or even if you come down to the question of how you are to manage a gas engine. There are problems which are still to be solved, and I think it is by means of associations such as this, and that of the allied professions, such as that of the Engineers that we may hope to see our way to meet the difficulties as the times goes on. Nature when she hid her secrets in the continent of Africa seems to have used methods different from those which she employed in other parts of the world, and therefore the experience gained by men in other parts of the world does not always hold good here, and it remains for the gentlemen who pursue science in one way or another to find out what nature has done in South Africa. You have still the key to find which will unlock the mysteries of nature; for the continent of Africa must be brought into requisition by man as well as the older and more favoured continents, and you can only arrive at it by continuing to labour in the future as you have done in the past. You have done extremely well so far but you have still much to do. I hope that your efforts will be successful in discovering what nature has hidden from us for the present. Apart from the satisfaction you take in meeting together I hope that you will regard yourselves as in a measure responsible for the education of those who are to come after. You have in the mines to-day an inefficiency of labour. The inefficiency of workers generally is one of the things which retards progress, and it is one of those things which are still to be overcome, and it rests with bodies such as yours to do it. If they will help generally in the advancement of the country they can do a good deal to remove that inefficiency as time goes on. It is not only that the men in the mines are inefficient in any particular branch, but I think that in all branches advancement may be made. One does not want to say that the miner is inefficient, or the man in the cyanide works or the battery, but we do know that a large number of men in the mines can be very much improved, and if you can improve the knowledge of your workmen you can get greater efficiency from them and reduce your working costs, and if you can reduce working costs you will be able to add many thousands of acres of land, mineral bearing land, to those which are already profitable, to work land which must lie idle to-day because under present conditions it is impossible to work it at a profit. If you can increase your mineral bearing land in this country merely by reducing working costs you will do a great thing for the country. We should all bear in mind that we have got at our feet problems which cannot be tackled because we have not yet discovered the key. I hope it will be your endeavour and that of other Societies to try and find that key, and unlock the door to the solution of these problems, and that this country may become more prosperous on what has yet to be discovered. The subject of your Society is one to which I should confine myself, but it is difficult to continue on those lines without becoming tedious to other people. The only suggestion that I should like to throw out is this. If your Society can see its way, or its members can see their way, to induce those who work daily with them, particularly those who are young, to avail themselves of the opportunities provided by the establishment of the Transvaal University College so that they may become more efficient in their work, they will do very good work for the future of this country. Gentlemen, I wish you to drink with me to the prosperity of the Chemical, Metallurgical and Mining Society of South Africa. (Applause.)

The President: I am sure we are all grateful to the Mayor for the very kind references he has made to the Society, and also deeply appreciative of the cordial reception which has been accorded to the toast. This is an annual privilege of ours —to listen to a little praise of the Society and its work—which comes as an encouragement as well as a refreshing interlude in a year otherwise mainly devoted to the cultivation of the critical habit. We used to earn a certain reputation for robust criticism in the old days when we were known as the Cyanide Club, but now that we have acquired the nickname of "Medicallurgical Society" this reputation has been materially enhanced. The innocent-looking little bubbles arising from many glasses here this evening do not appear to form a subject likely to lead to heated discussion, but I can assure you that when these bubbles get out of due proportion in mine air—or out of control in a gas engine for that matter—they wonderfully develope the critical faculty. To criticise necessarily requires a subject for criticism, therefore it argues that the Society possesses both constructive and destructive faculties, and the constructive faculties are, I am pleased to say, dominant. It is probably the constructive rather than the critical quality that has given us the honour of having a member of our Council who is a representative in the first Legislative Assembly of the Transvaal. I think this is an appropriate occasion on which to congratulate the Ward of Denver on its intelligent selection. I may mention also that the Society has nine other members in the Legislature.

I notice that both my immediate predecessors have alluded, by inference at least, to the absence of a qualification or test for admission to membership of this Society, and I am aware that there exists a feeling in some minds that the status of the Society might be raised by establishing such a test. This is a very natural view, and if it were presumed that the initials M.C.M.M.S. conferred any professional distinction (other than that of a keen interest in their work) there would be undoubted justification in demanding such a qualification. The absence of such a test is rather a matter of history and circumstances. At the time of the formation of the Society, thirteen years ago, this was a very young community. It was also confronted with all the problems incidental to the introduction of a new process of gold recovery, the exigences of which were adding a refinement to metallurgical analysis and assaying as well as to the actual practice of gold recovery that had hitherto been unknown. Grains of gold became of the importance that pennyweights had been before, and the action and composition of working solutions of the greatest interest. The number of trained metallurgists was small at that time. The industry was not competitive in the sense that a greater achievement on the part of one would reduce the value of the product of another, and no local increment in gold production was likely to produce any decrease in the value of the metal, so that it was of advantage to all that the greatest possible yield from the ore should be obtained. There was a considerable amount of local talent available and still more was there an enthusiasm which made for progress, and the need for co-operation was great in the interests of the industry. One of the first resolutions of the provisional council at the formation of the Society was proposed by our Past President, Mr. S. H. Pearce, that no limitation should be placed on the membership of this Society, and I consider that the Society owes much to Mr. Pearce for that proposition. We earnestly needed, and still need, the co-operation of the practical man—the man on whose effective carrying out of the operations success depends—and the theoretical expert. Another urgent need was the acquisition, publication and distribution of useful information to the members, and this could only be done by a Society in receipt of a fairly large income. This would have been impossible with a small select Society, but was obtainable by a large membership paying small subscriptions. It showed considerable courage that the Society started with a membership of about fifty and an annual revenue that would just about pay at present one month's printing expenses. To have excluded willing enthusiasts because they did not possess a certain scholastic degree would, I consider, have been a poor policy, whether they came to teach or to learn. One judges an institution by its accomplishment, and I think we can truly say that ours has been no mean one. An exclusive organisation would necessarily have been self-selected, and would have debarred many whose intelligent assistance was urgently needed, and whom the Society could also assist in acquiring an intelligent comprehension of operations which formed their daily occupation. My predecessor remarked "that some members had learned all the science they knew from our meetings and *Journal*," but I myself should like to add, "had also so well assimilated their lessons as to have become an economic factor of the greatest importance to this industry." That this broad democratic principle has not been unwise has been shown by the large number of highly-trained scientists who have been so willing to add themselves to the original nucleus, and who have enabled us to greatly extend the scope of the Society's usefulness. An expression that was used by an eminent mining engineer with reference to the American Institute of Mining Engineers, that it was "an Association of young men with reputations to win, rather than of old men with reputations to maintain," applies equally to this Society. To maintain a reputation means caution, whereas we wish to encourage courage and originality, for that way lies progress. That this view is worthy of encouragement is proved by the fact that there are mines profitably working to-day which a very few years ago were considered unprofitable, a result almost entirely due to the efforts of members of this Society. Let us then encourage any earnest effort whatever the early scientific training may have been, for a scientific training may be due rather to the intelligence of the parent who provided it than of the son who received it —so that all talent and energy may be able to produce its quota of benefit to the community. (Applause.)

Mr. L. Reyersbach, in proposing "Prosperity to South Africa," said—Mr. President and Gentlemen, were South Africa not a country of almost kaleidoscopic changes, it might be held to be almost ironical to talk of prosperity at the present moment whilst we are still in the throes of a depression without precedent even in this country which within the last 40 years has witnessed a series of ups and downs. If we consider that well within a decade of the siege of Ladysmith the victor of Colenso is to-day being welcomed as the first responsible Prime Minister of the Transvaal in the metropolis of the Empire by men of every shade of political opinion, if it is realised that it has taken only eight years to put an end to an unparallelled political upheaval, we may hope that the financial and commercial depression, however serious in its incidence, may be overcome in a comparatively short time. But, gentlemen, to restore confidence and to restore prosperity it behoves us seriously and dispassionately to try to discover the causes underlying the evil. There are, no doubt, differences of opinion as to these causes, both from a political and economic point of view. It is from the latter aspect only that I approach the matter to-night, and I believe I will be able to show that we are the victims of three principal underlying factors. We are suffering from instability owing to the uncertainty prevailing as regards the future of the main industry of this Colony. We are suffering from the after effects of several years of unwarrantable public and private extravagence, and we are indirectly suffering from a wave of prosperity—industrial and commercial—in other parts of the world. It is not the first time that the labour question has been touched upon at an annual dinner of this Society. It cannot be too often repeated that it has not arisen during the last quarter of a century only. Ever since the agricultural development of the Western Province, of the Cape Colony, was attempted, settlers there have complained of insufficiency of manual labour. In Natal no sufficiently strong inducement could be held out to the virile Bantu race to assist in the development of the tea and sugar plantations. It is natural that the rise of huge mineral industries, such as has taken place during the the last 40 years, should have added to the acuteness of the position. One of the main factors to be reckoned with is constantly and apparently wilfully overlooked. Given a return to normal conditions, the labour requirements of South Africa are bound to increase. It is true the number of hands required for pastoral pursuits is not very large, but if agriculture is to prosper it must have labour, and it must have cheap labour. Already this mainstay of the country is burdened in a great portion of South Africa with excessive land values, and if in addition to interest charges expensive labour has to be paid for, how can we ever expect to compete with countries where these drawbacks do not exist? Excluding some portions of Northern Rhodesia, base metal industries, excepting coal mining, have barely been touched, and if they are to be developed considerable numbers of unskilled labourers will have to be available. It is admitted that some portions of Central Africa have not yet been fully tapped, but whatever labour may be available from that source it appears to me to be robbing Peter to pay Paul to enlist the men for work away from their own homes. The country itself will develop industries—be it coffee, tobacco, or cotton. It will, as time goes on, require additional railway connections with the coast, and will not be able to assist the Southern portions of the Continent for any length of time unless it is prepared to hamper its own development. And besides it must not be forgotten that at best the labour is hardly suitable for the work. It is true that at the present moment, in consequence of stoppage of works throughout the South African Colonies, a momentary small surplus is available, and possibly this condition of affairs will continue for some months longer, owing to the unfortunate visitation of innumerable swarms of locusts which have devasted the country. But experience teaches us that it is only a passing phase. This labour cannot be considered permanent. It is fluctuating in its character and it is unreliable. We require not only here but for every existing and prospective industry a permanent and reliable source of labour, a permanent and reliable labour army to fall back upon. After mature consideration, after weighing all the pros and cons, and having due regard to the permanent welfare of the South African Colonies, and with the concurrence of the then Government, both here and in Great Britain, it was decided to have recourse to an expedient adopted in many parts of the world, and which may be said to have been universally successful.

Apart from political considerations, which I hold should not enter into the argument, I can see no reason why Chinese labour should not continue to be employed in this country. It has taken four years of continued effort to arrive at the point where we are to-day. Any policy of replacement will take as long—if not longer—and neither this Colony nor the remainder of South Africa can afford to wait.

Apart from the question of permancy, we have to consider the price of labour. Only the diamond industry appears to be ready and able to afford to pay almost any wage. I have already alluded to the cost of farm hands. It is hardly necessary to point out that for any new industry, be it base metals, cotton or tobacco, labour must be cheap. I took an opportunity a few weeks ago to point out that on the Witwatersrand we have to obtain greater efficiency from the force at our disposal. We have to attempt by every means in our power to increase the margin between cost of production and the value of the yield.

I reckon that of the Companies' contributing to the March output, those situate between Roodepoort and the Wit Deep have a reserve store of ore of considerably over 100,000,000 tons of a recovery value of about 16s. over and above the ores which can at present be profitably worked for the benefit of shareholders. If we succeed in bringing down our working costs to the figure given, it will be possible to mine the whole of this huge quantity of ore, although it may not leave any margin of profit for distribution. It may thus be considered in the light of a national asset. The gold recovered would be of benefit to the whole world, and almost its entire value would be spent within this Colony in wages, stores and materials, and would for a number of years be the means of sustaining considerable portions of the population. It must, however, become possible of treatment before the properties containing it are exhausted, for although it can and should be extracted, once any property is finally closed down and the ground allowed to settle, it will be impossible to re-open drives or stopes, and the huge value of the asset would be finally lost. By reducing working costs to this level, returns paid to shareholders from ores leaving a margin of profit would be considerably increased, and such increased returns would naturally have a tendency to improve our credit and enable us to expand.

The extravagance I have referred to has been apparent throughout. No single individual or group of individuals can tackle this all important question. We have to stand shoulder to shoulder —farmers, merchants, professional and financial men; our workmen must lend a helping hand, and above all the Governments of the various South African Colonies must assist. I remember not so very long ago the Governor of Natal—unconstitutionally it may have been, but wisely as it has turned out—sounding a note of warning to the legislators of the Garden Colony, who were seriously discussing adding to their financial burdens through the construction of a second main line of railway in order to avoid some heavy gradients which make the working of the existing line somewhat expensive. We all know that Capetown and Durban invested hard-earned savings in bricks and mortar, and unfortunately to-day a large percentage of the investment must be considered as dead capital or at least as unremunerative. Table Bay, where huge works were commenced and partially completed, and where it was expected the wharves would not suffice, even on the extended scale, for the tonnage to be handled, is to-day a sheet of water without shipping. The railway programme all over South Africa, even after some of the more important schemes had been temporarily laid aside, has been of sufficient magnitude to strain the finances of the Governments almost to breaking point, and coming nearer home, in our own Colony some of the schemes evolved for the proper Government of the country have undoubtedly been on too magnificent a scale. We have not been able to find the capital necessary to continue the railway to Delagoa Bay across Swaziland further than to the neighbourhood of Ermelo. This extravagance, however, as I have said, was by no means confined to Governments. Every individual who has lived through these years must take his share of the blame. Whatever criticisms were raised, the whole community finally acquiesced in the expenditure. Our Municipal schemes—I am not now alluding to the unfortunate failure of the power station—were far too ambitious. Newtown, and the creation of a municipality of 81 square miles show that we were over sanguine, and I cannot absolve the financial houses and their technical advisers of a share of the blame either. I recognise that the erection of sky-scrapers in Johannesburg lead people to believe that the dreamt-of population was within reasonable reach, and the estimates of huge additions to our stamping capacity, and for water requirements, though made in perfect good faith, have turned out to be beyond what we may expect to attain in the near future.

I am afraid I have already occupied too much of your time, but I must claim indulgence for a few minutes longer while I deal with the effects on South Africa of prosperity in other parts of the world. America, North, South and Central, has experienced a boom in transportation and mining industries. At the present moment cousin Jonathan is suffering from an attack of indigestion, but he is very enterprising, a man of almost unlimited resource, and will find a physician capable of curing his indisposition. In some European countries, based on the expansion of coal and iron mining and electricity, partly also owing to the creation of new industries, such as motors, large developments have taken place, and attention is being directed to the mineral resources of Asia. Canada has prospered and so has Australia. All these developments have had to be financed, and the investing public has preferred to take inducements offered elsewhere, and is showing us the cold shoulder. This state of affairs will alter, provided we succeed in redressing the errors of the past and arrive at a final and permanent solution of our main difficulties.

Given encouragement of capital on the part of all South African Governments, and particularly our own, the money markets of the world will again become available for public and private enterprise throughout the sub-Continent.

We require stability, development on sound financial and commercial lines, a broadening of the base to carry the superstructure of Government, from the Cape to the Zambesi.

Let us beware of standing still. We must go ahead or we must retrace our steps, which means that we have to reconsider the whole structure of our life—social, political and industrial; there is no middle course. Let us direct our energies steadfastly to one goal—the permanent welfare and the permanent prosperity of South Africa. But let us realise that to attain our object, we have to set aside political considerations, we have to treat economic questions on business lines and on business lines only.

Mr. H. Wallace Soutter (President of the Chamber of Trade), responding, said: Mr. President and gentlemen, will you allow me to say how highly I appreciate the compliment you have paid not only to me but to the Chamber of which I have the honour to be President in inviting me to be present to-night, and in having given me an opportunity of addressing so distinguished an Association. I have to respond to the toast which has been so ably proposed by Mr. Reyersbach, and it is with regret that we all feel that the subject of the toast is absent to-night, and that we are face to face, as Mr. Reyersbach has stated, with a period of unprecedented depression. The causes and remedies have been the subject of much discussion. The other day, when I was in a neighbouring Colony, I found on the counter of a bookseller's shop a neatly bound volume the title of which was "The Depression, its Causes and the Cure," and the price of this book was two shillings. Notwithstanding the bad times I felt that I might venture upon such an expenditure if only it would tend to lift the clouds which have unsettled us all. It was, I regret to say, like my other investments, a very bad one, for the author let himself go. He said, "that amongst the causes of depression was the exploiting of the mineral wealth of South Africa, for it created the financial vampire who sucks the riches of the country with ravenous greed, and who, having drained the last drop of blood out of the carcase, resumes his nefarious career in some other part of the globe." I read further that "the realisation of that untold wealth has only added millions of fresh tentacles to the capitalistic octopus, which held poor humanity in the iron grip of bondage and slavery." Such were some of the causes of the depression. I looked to the end of the volume to get my two shillings worth—and there I found the remedies. Amongst them, first of all, was the expulsion of the capitalists, so that the Government could work the mines for the exclusive good of the country. Another remedy was the education and civilisation of the native, "to make him a formidable competitor of the white man, for the success and prosperity of the white man will be in proportion to the difficulties placed in his way in order to obtain and retain his supremacy." Gentlemen, if we approached the problems which concern us in such a spirit as that I venture to say that they will never be solved, but such is not the attitude in which we approach our troubles. I venture to submit to you to-night that prosperity is not the fickle jade that we so often imagine her to be. Now, sir, I do not claim to be deeply versed in political economy either old or new, but I submit to you to-night that prosperity is governed by certain economic laws which are as potent and as inexorable as any of the laws of nature; and we are suffering, I verily believe, because we have too often ignored those laws. As a country advances in civilisation, so history tells us, it advances gradually from a purely agricultural to an industrial and commercial development. These spasmodic periods of what we have called prosperity in the past have been due to no such development, but they have been due to extraordinary causes. They have been due to the influx of huge sums of money to this country in consequence of wars, of the opening up of the diamond fields, of the opening up of the gold fields, and in consequence of immense speculation in building operations. It has been during the period when this influx of money, which we may call capital, was being expended that we experienced those periods of prosperity, and whilst individuals during those periods made large fortunes, I venture to say to you that the natural resources of the country and the progress of the individual inhabitants of the country did not derive anything like commensurate benefit from these periods. There was on the part of men a desire to grow rich too quickly. Men were dazzled by the fortunes which were obtained through the mineral wealth, and were drawn here in the hope of participating in those fortunes, and the result of it was that from all parts of this country as well as from countries across the sea a huge population was attracted to all the mining centres, and the development of the natural resources of the country was ignored to a very large extent. The result of that was that each period of prosperity was succeeded by a period of depression, and we to-day are suffering through just such a period of depression. Gentlemen, I have read many speeches, and I have been for a time depressed, but I am an optimist. I believe there is a great future for this country, and that if that great future is to be realised we shall, as Mr. Reyersbach has pointed out, have to readjust our ideas. We shall have to readjust our conditions. We shall have to realise this fact, and I put it with very great diffidence to this assembly that, great as the mineral wealth of this country is, great as the mining industry is, enormous as the advantages from that industry are, yet the mining industry of this country is not the *summum bonum* of the country. We shall have to realise that the mining industry is a sacred trust, that it is a stepping stone and a stimulus to the development of the other resources of the country, and therefore I look with hope to the future, because the mineral wealth of this country gives us an enormous advantage over those other countries which are without it. If we are but to develop on the lines which I have indicated it does seem to me that jealousy between the mining interests and the agricultural interests is grotesque. That it has existed we know, but we trust that it will cease, that it will depart, because a house divided against itself is sure to fall. We hope and believe that the Government, the new Government of this country, will realise that the highest interests of this country are involved in the mining industry, not only on account of the revenue which it contributes, great as that revenue is, but because it and the population it has attracted form in themselves a market which should stimulate every agricultural enterprise. In view of that fact it seems to me, sir, to be incredible that the fears which have been expressed by some should be realised, and that this Government should interfere seriously with the labour supply, on which Mr. Reyersbach has dealt so eloquently to-night. Sir, I believe that the Government will realise that it is their best interest to foster the mining industry, and I believe there is another duty which lies upon this Government, and which I think they do realise, and that is that they should, in no half-hearted way and with no niggard hand, seek to create a greater interest in the agricultural development of the country. In the past there has been an absence of scientific methods; the clinging to old habits has paralysed the agricultural life of this country, and, with all due respect to the farmers, I venture to say that the majority of them are too slow to move: they are to slow to change: they are conservative to a fault, and it is the most difficult thing in the world to convince them that there is any other road better than the road they have been accustomed to travel. This, sir, I venture to think, must all be changed. No doubt, I shall be challenged by agriculturists if there be any who have ventured into your Society with the fact that they are surrounded with phenomenal difficulties, with pests and diseases, and with "acts of God," but, excepting always the "acts of God," I do think that in this age of vigorous scientific research there is reason to believe that we may overcome the difficulties, the pests and diseases which hamper agricultural development. It has been done in other countries, and I cannot see why it should not be done in this country. Sir, to-day this country is satisfied with small herds, with samples of wheat, of mealies, of tobacco, of sugar, and of tea, with the result that during the last year we in the Transvaal imported no less than $6\frac{1}{4}$ million pounds sterling worth of food stuffs, which could have been produced and manufactured in this country. Now, sir, I am the President of the Chamber of Trade, and I imagine some of you will think I am going to indulge in statistics. I assure you that I am not, but there are certain items of that $6\frac{1}{4}$ millions which must arouse the attention of every thoughtful man. Imagine that we should have to import butter, cheese and milk to the value of £475,000, that we should have to import fruit to the value of £200,000, vegetables to the value of £150,000, and, worse still, that we should have to import eggs to the value of £125,000. These are figures which arrest the attention. These are figures which have led me to lay stress to-night upon the paramount importance of paying far more attention to agricultural development than we do, because the agricultural possibilities of this country are enormous. There are great tracts of land for pasturage or for stock rearing and for the culture of cereals. There are vast areas pre-eminently suited for the cultivation of fruit, cotton, tobacco, and rubber; and these, I say, speaking as I am to gentlemen connected with the mining industry, these, I say, are the sources of wealth, which if developed will result in permanent prosperity to this country, long after the mines, having served their day and generation, shall have fallen on sleep. And, sir, one last word, if you will pardon me. The prosperity, on the lines I have indicated, of the Transvaal can never be divorced from the prosperity of the British colonies of South Africa. We should take the wider outlook so that we can look forward to that unity of which hitherto we have only dreamed, the unity of British South Africa under the old flag; and, sir, we should see to it that we in the Transvaal do not postpone that day by any narrow, any selfish, any self-centred view. Let us realise that we are members of a great British South African family. Do not let us, for the sake of immediate advantage, take any step or do anything which would prejudice the other members of that family. Do not let us unduly favour a foreign port at the expense of the British ports of South Africa. If you adopt this wider view, we can look forward to the day when there will be a United South Africa, and when at your annual banquet someone far more competent than I am to respond to the toast of Prosperity to South Africa will rejoice in the fact that it is not something to be hoped for but something which has been attained.

Mr. Wager Bradford next proposed "Our Guests and Kindred Societies." He said: Mr. Chairman, in rising to propose the toast I shall speak to the last first. The kindred societies of Johannesburg need no eulogy from me, because the work of these societies speaks for itself daily in the life of this community. I feel, in proposing this toast, very like the man who built his own coffin, dug his own grave, and buried himself, as I belong to most of these kindred societies, and being on the inside I know that their work is very good. It is a notable thing among these institutions that they are remarkably unselfish. Information and knowledge they acquire is given freely to each other and to the public at large, and that information and knowledge is not small. As an illustration of what I mean I may cite the case of the Institute of Mechanical Engineers, which has just recently offered its expert advice free of charge to the Municipality. I venture to say, gentlemen, that there are men sitting on the Council of that Institute whose reputation as mechanical engineers is not confined to the Transvaal. I think you would look far before you found a better illustration of the liberality of the technical societies of Johannesburg. I found on going through the rules of the Pharmaceutical Society a note which appealed especially to me because it referred to indentured apprentices and to the privileges which indentured apprentices might enjoy. It will be within the recollection of all of you that last year, through the efforts of this Association and the efforts of the Mine Managers' Association, a system of indentured apprentices was introduced on these fields, which can have only the most beneficial results. In that system of apprenticeship, boys who are growing up in this country are admitted to learn the various trades on the mines, and already the effect of that system is being made manifest by the young fellows who are coming on to be ultimately the skilled workmen of this land. That system is one that should be extended, and the Mine Managers' Association at the present moment is endeavouring to put forward a scheme for the extension of this apprentice system so that not only surface and mechanical trades shall have apprentices, but that we shall possibly introduce into the mines apprentices for the study of mining as a business. The industry calls for great numbers of skilled men, and the reservoir from which that skilled labour can be drawn at the present time exists only in other countries. But there are growing up in this country, and there is every possibility that in the future their number will be increased, young men who must be provided with employment, and the greatest field for the employment of these young men are the mines—in underground labour. What we are endeavouring to do at the present time is to establish a general system of apprenticeship so that we can take on boys and put them through the various courses of mine work and make them thoroughgoing miners at the expiration of three or four years. This is one of the things one of your kindred societies is endeavouring to do at the present time, and I mention it to illustrate that the work of these societies is good. Various gentlemen have referred to-night to the depression which exists in this country, but the work of the kindred societies goes on just the same. The output and all the rest of it does not put them out. They are working along on scientific lines, and their lines are so apart from stocks and shares that they can still pursue the even tenor of their way and work out the best good of the industry. Coming to our guests, the Chemical Metallurgical and Mining Society dinners have always been notable for the guests who have honoured us with their presence, and on behalf of the Society I desire to extend to those gentlemen who are with us to-night our most cordial greeting and our thanks for their presence. I have particular pleasure in extending a welcome to Mr. Hoy. About a year ago this Society had an excursion to the Victoria Falls, and it was a most successful excursion. That success and the pleasure of a great number of its members was due in no small degree to the kindly courtesy of the gentleman who has to respond to this toast to-night. (Applause.)

Mr. W. W. Hoy, responding, said: Mr. Chairman, Mr. Bradford: I had hoped that when your Secretary asked me to respond to the toast of the "Guests" it would be a response very late in the evening and therefore necessarily brief. Since coming, however, I feel that I am not only in the midst of a distinguished gathering but an exceedingly scientific gathering. I am grateful that there is a prominent name associated with me in responding to this toast. I am somewhat in the position of a bridge player who under certain circumstances trusts to his partner. That is the course I intend to pursue. On behalf of the guests I thank you for the honour you have done us in inviting us to your annual dinner. Your Society serves two main objects, one the thoughtful aspect and the other the social. Your Society, I take it, has as its basis the stimulation of thought, the application of energy, and the promotion of research. Gentlemen, I do not flatter the reputation which you have earned when I say that the community of the Transvaal take a great interest in the work in which you are engaged. I cannot suitably reply to this toast, and I do not propose to stand between you and a more distinguished member of a kindred society, but I will say on my own behalf that while I appreciate the remarks which Mr. Bradford has made I am surprised that any man's good works should be told him in his lifetime, and if the railway has served your Society in the past, I hope we shall have many more opportunities in the future. Gentlemen, I thank you for the honour which you have done me in asking me to respond to this toast. (Applause.)

Mr. H. H. Johnson (President of the Transvaal Institute of Mechanical Engineers), who also responded, said:—Mr. Chairman, Mr. Bradford and Gentlemen, the pleasure which it gives me to respond to the toast of the kindred Societies this evening is only tempered with regret that I have not the eloquence of the previous speakers. The annual dinner of the Chemical Society is one of the landmarks of the year of the scientific societies of Johannesburg, and it is indeed a pleasure, gentlemen, for us to be invited to come here as your guests this evening and partake of your hospitality, and hear the eloquence of your members and other guests. One of the greatest pleasures it has given me this evening is to hear the very kind way in which Mr. Bradford has proposed this toast. We have heard a great deal of pessimism, a great deal of our misfortunes and about the depression, but I think that by the time we meet next year we shall have a different tale to listen to. As regards the kindred Societies I can only say, gentlemen, "Are we downhearted?" I think the scientific societies are satisfied with the progress they have made in the past, and if it lies in the power of the Societies here to help forward the great industry it will be our duty and pleasure to do so. It is, I am sure, unnecessary for me to-night to dilate upon the good work which has been done by our many Societies in Johannesburg; it is known. What is the reason, gentlemen, for the progress made by the industry here. Why is it that it has been able to make the rapid progress it has in the short time that it has been in existence? It is largely due to the exchange of ideas, to the meeting of individual members connected with the industry in their different societies, and when a new idea has been brought forward it has been discussed thoroughly. As a rule, when new things which are benefiting the industry have to be introduced it has not been an uphill task because every member connected with the industry knows from his own Society all about it. He knows the advantages of it, and does not shut his eyes to these advantages, and one and all are willing to assist and adopt the new scheme even though it may be troublesome at first. Gentlemen, I claim that the kindred Societies and the Chemical Society have done some good, and I take some credit to ourselves for it. There is only one regret I personally have, and I know it is shared by some members of the Engineering Society, and that is that although practically every branch of the mining industry is represented by its own Society on these fields, in one instance it is duplicated. I refer to the South African Association of Engineers and the Transvaal Institute of Mechanical Engineers, and, I believe I am right in saying that it would be for the benefit of both these Associations if they could see their way to an amalgamation scheme. In times of depression such as we have, every two guineas is two guineas, and it has come to my knowledge that men are severing their connection with Societies as they cannot afford the upkeep of so many, and I think it is time that we should try our hand at unity. Unity is strength, and I think it would be to the advantage of both Societies if it could be arranged. I hope that it will be talked over by some of the members who may be present here to-night, and that at our next meeting here there will be one less Society in Johannesburg and one stronger.

The Mayor: Before we part this evening there is one more duty we have to perform. We have had a most enjoyable evening, an evening of enjoyable entertainment and information, and I think that it is due to our Chairman who has conducted the proceedings to night with considerable ability that we should drink his health and wish him good luck before we part. (Applause.)

The President briefly returned thanks and the proceedings terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

THE APPLICATION OF THE ELECTRON THEORY TO ELECTROLYSIS.—" The electron theory of electricity and magnetism may be fitly described as an extension of the ionic theory of electro-chemistry to solids, gases and a vacuum, inasmuch as it postulates material carriers of all electric charges, and reduces electric phenomena to the configuration and motion of these carriers.

One of the most valuable achievements of the electron theory is the complete harmonisation of the processes of metallic and electrolytic conduction. Both processes depend upon the existence of minute charged bodies capable of threading their way through a mass of other bodies which are either uncharged or less mobile. If a body contains no such charged bodies—ions in the wider sense—or if its ions are fixed in position, it is incapable of conveying an electric current of any description. A current consists in the displacement of ions. The conductivity of a body is accurately and precisely defined by the number of ions it contains in unit volume and by their average mobility, this mobility, in its usual acceptation, excluding any measurable free path. The definition and physical interpretation of conductivity is thus the same in liquids and solids.

It is only when we consider the individual carriers themselves that a fundamental difference appears between metallic and electrolytic conduction. Compare a centimetre cube of copper with a centimetre cube of dilute hydrochloric acid, each of them conveying a current of one ampere. The copper conveys its current almost solely by its free electrons, some 400,000,000 in number, which possess a mobility some 100,000,000 times greater than that of a hydrogen ion. The hydrochloric acid conveys the current by means of its hydrogen and chlorine ions, which, in a millinormal solution, amount to about 2,000,000. Since the current is the same in each case, the electrons in the copper must move some 200 times more slowly than in the electrolyte. But this is not usually the case, for in a copper wire 1 mm. in diameter conveying one ampere the speed of the electrons is of the order of 1 cm. per second. The greatly superior mobility of the free electrons brings it about that a much lower voltage is required to maintain an ampere in a copper conductor than in a liquid conductor of the same dimensions.

Whence this difference between solids and liquids? It cannot be said that this question is anywhere near a complete solution. But since the whole range of electro-magnetic phenomena has become unified under the sway of the electron theory, much additional material has become available upon which to base our judgment. The existence of free electrons in metals is made possible by the close packing of their atoms, which brings about a frequent exchange of electrons between *one atom and another*. During the short period occupied by its change of allegiance—a period amounting to something like $\frac{1}{5000}$ of its average time of attachment to a metallic atom—the electron is free to fall along the potential gradient, and thus to constitute an electric current. When the metal expands by heat, this process of exchange naturally becomes rarer, and the metallic resistance increases. The positive atoms and neutral atoms are so *tightly packed that they* contribute nothing perceptible to the conductivity. In an insulating solid or liquid the electrons are effectively bound up with atoms or molecular groups, and these are arranged in some structure, usually crystalline in the case of solids, which precludes the formation of mobile charged groups and the liberation of electrons.

In an electrolyte, on the other hand, such charged groups are formed, and they are sufficiently mobile to follow the E.M.F. That free electrons are not produced is capable of a simple explanation. Two copper atoms have equal attractions for an electron, but atoms of, say, hydrogen and chlorine have not. Hydrogen loses one of its electrons more easily than chlorine, and when the two atoms of a molecule of hydrochloric acid separate, the chlorine takes one of the normal hydrogen electrons away with it. The *hydrogen atom* thus remains positively charged, and the chlorine atom negatively. The two ions so produced act as condensation nuclei, like any other small charged particles. The study of electric condensation nuclei will, I believe, shed a flood of light on electrolytic problems. The fundamental researches of C. T. R. Wilson have proved *that in vapour*, at all events, ions act as condensation nuclei, and that negative ions are slightly more effective than positive ions. *Of this phenomenon* J. J. Thomson has furnished a simple explanation.

When a charged drop evaporates, its electric charge remains, and its potential increases as its diameter diminishes. More energy is, therefore, required to evaporate a charged drop than an uncharged drop. Condensation on the drop involves an expenditure of available electric energy, and thus condensation is facilitated. This fact has an important bearing on the theory of electrolysis. It explains the low mobility of the ions, the drop of potential at the electrodes, and the liberation of uncharged products at the latter. The different mobilities of the ions can, I think, only be attributed to their different degrees of normal hydration. That hydroxyl should have a mobility over four times that of lithium, points to the lithium atom as a particularly efficient condensation nucleus when deprived of one electron. It moves so slowly through the water under the influence of the potential gradient because it has to drag a number of water molecules (probably not more than half-a-dozen) along with it. The number must be the same for each ion at a given temperature, but cannot be very large, to judge from the actual mobility (347×10^{-6}) compared with that of the electron in copper (about 5×10^4).

When these hydrated ions reach the electrodes the E.M.F. tends to drive them into the metal of the electrodes. But the atoms of the latter are so closely packed, as a general rule, that no other atoms can force themselves between them. There arises a deadlock, which is only released when electrons are able to pass from the solution into the metal, or *vice versa*. The mobility of electrons, though comparatively great inside a metal, is very small at its surface, where the close packing of the metallic atoms loses its effect. *But* when the E.M.F. exceeds a certain minimum an electron may pass, say, into a hydrogen ion, and neutralise its positive charge. The immediate consequence will be that the hydrogen loses its condensing power. The link between it and the water molecules is broken, and the hydrogen is liberated as an uncharged gas. The converse process goes on at the anode. The chlorine atom passes its superfluous electrode into the anode, thereby becoming neutral and free from its aqueous encumbrance.

In the further theoretical investigation of electrolytic action on the basis of the electron theory the study of mobilities will have to play a prominent part. Bredig's laws of mobility are of special interest in this connection. We require a quantitative determination of the hydration of the ions. This determination should not be very difficult, since a number of data, such as heats of solution, melting and boiling points, are ready to hand. It should be possible to determine the diameter and bulk of the ions, and their shape from stereo-chemical considerations. The fact, noted by Bredig, that the strongly electro-positive and electro-negative metals have a high mobility points to a superior facility of reaction.

A high mobility implies a low degree of hydration of the ion. This low degree of hydration enables such ions, when of opposite signs, to combine more freely and rapidly than is the case in ions having a larger bulk. The heats of reaction, the heats of ionisation, and the electro affinities or electrode potentials of the majority of elements are fairly well known, and afford valuable data for determining the sizes of the ions. We already know that isomeric and metameric ions have the same mobility; that the mobility of an ion of a given sign is the smaller the greater the number of atoms it contains; and that the effect of any change in the constitution of an ion is the greater the smaller the number of atoms contained in the ion.

These facts leave the road clear for a determination of the actual constitution of a single ion on kinetic principles. When an ion contains 50 or 60 atoms it appears to have a minimum mobility which is not perceptibly diminished by a further addition of atoms. Such an ion must have a diameter of about a micromillimeter, and, therefore, comes within the range of Szigmondy's ultramicroscope. There is, therefore, a possibility that the motion of such heavy ions may be studied by actual observation, and that they may be watched as they cover a distance of 1 c.m. in an hour and a half under the influence of a potential gradient of one volt per centimetre. It then becomes a comparatively simple calculation to find the diameter of such an approximately spherical ion, moving through a viscous liquid, or, in the last resort, threading its way among molecules of perhaps half its diameter. Such calculations have been made in connection with metallic conduction, and have led to the conclusion that the carriers of the current in a wire are almost solely the free electrons.

A difficulty is presented by the circumstance that ions of the higher valencies exhibit mobilities which are neither 'independent' nor constant for different concentrations. The extraordinarily high mobility of lead is not easily harmonised with our notions of the physical constitution of the ions. But it is interesting to note that the influence of hydration increases with the valency and the concentration, which is what we should expect.

The future development of electrolytic theory will lie, I think, in the direction of statistical analysis on kinetic principles. Such analyses have yielded most suggestive results in gas discharges, more especially the electric arc, in the vacuum tube, the Zeeman phenomenon, and, quite recently, in metallic conduction. Thomson's famous 'counting experiment' must be followed up. He produced ions in a moist gas, and watched them as they settled down under the influence of gravity. We must follow their motions along the potential gradient in a liquid, and follow the fate of the electrons they convey through the liquid into one electrode, and back into the liquid through the other. The complete determination of the energy absorbed or emitted at the various stages of this transmission means the complete mastery of the problems of electrolysis."—E. E. FOURNIER-D'ALBE.—*Electrical Engineer*, Jan. 25, 1907, p. 129. (H. A. W.)

A RAPID METHOD OF DETERMINING MOLYBDENUM.—"This method, which gives excellent results, both with ores and ferro-molybdenum, is an adaptation of the molybdate method of estimating lead. It possesses, among others, the following advantages:—The results are much better than those obtained by any of the gravimetric methods usually employed. The time required is very much less than by any other method, it being possible to complete the assay in from 30 minutes to one hour. No special chemicals are required, and only the usual apparatus, found in every laboratory, is necessary.

The estimation is conducted as follows:—From 0·5 to 1 gm. of the ore, or ferro-molybdenum (which should be fine enough to pass a 100 mesh screen) is fused, until liquid, with 4 gm. of sodium peroxide in a nickel crucible. After the assay has melted the fusion is continued for 3 to 5 minutes, the contents being gently swirled around in the crucible during this period. The temperature should not exceed dull red. The rotary motion is kept up until the assay has solidified. This treatment oxidises the iron to ferric oxide, converts silica to sodium silicate, sulphur to sodium sulphate, and the molybdenum to sodium molybdate, soluble in water. Lead, if present, is oxidised.

When the assay has set, the crucible should be placed in water in order to hasten cooling; when cold it is transferred to a beaker and the fused mass extracted with boiling water. The crucible is then lifted out and thoroughly washed, the solution boiled down to about 150 c.c., filtered to get rid of the iron, lead and nickel (from crucible) oxides, etc., the filter washed with hot water and the solution acidified with acetic acid. This acid solution, which should be colourless, is titrated boiling with a standard solution of lead acetate. The indicator is the same (tannic acid on spot plate) as that employed in the molybdate estimation of lead, and titration is conducted in exactly the same manner, except that the end point is indicated when the brown colour can no longer be obtained.

The molybdic acid formed during fusion is precipitated in the boiling solution in accordance with the equation:—

$$Pb(C_2H_3O_2)_2 + Na_2MoO_4 = Na_2C_2H_2O_2)_2 + PbMoO_4.$$

Volume of lead acetate solution required for titration × standard of same = weight of molybdenum in ore taken for assay. Therefore, the calculation is:—Standard × number of c.c. lead acetate solution required ÷ weight of ore taken × 100 = per cent. of molybdenum in ore.

Should the ore be high in silica and iron it will frequently be found that the solution comes through of a green colour, probably due to finely divided ferrous sulphide which has escaped oxidation owing to an insufficiency of sodium peroxide. On prolonged boiling this comes down as ferric hydrate To overcome this difficulty it is necessary first, to fuse the ore with caustic soda (10 gm. NaOH per gram of ore). The caustic soda is fused to a pasty mass, and the ore, mixed with 3 gm. of sodium peroxide, is carefully added in small quantities at a time. When the assay has completely melted another 3 gm. of sodium peroxide are added cautiously and the fusion is then conducted as before.

The following solutions are required:—

Standard Lead Acetate Solution.—This is prepared by dissolving 25 gm. of lead acetate in water, a small quantity of acetic acid is added, and the solution is then made up a litre. 1 c.c. of this solution = (approximately) 0·01365 gm. lead or 0·00633 gm. molybdenum.

Standard Ammonium Molybdate Solution.—This is used to standardise the solution of lead acetate, and is prepared by dissolving 10 gm. of finely powdered ammonium molybdate (not white on outside) in water. If required, a little ammonia is added to clear the solution, and it is then diluted to a litre. 1 c.c. of this solution = (approximately) 0·01056 gm. lead.

Tannic Acid Solution.—This is used as indicator and should be freshly prepared by dissolving 0·1 gm. of tannic acid in 30 c.c. of water.

Standard Solution of Lead Sulphate for Standardising.—0·2 gm. of pure lead is dissolved in nitric acid, taken to near dryness, 20 c.c. sulphuric acid added and evaporated on the hot plate until fumes of sulphuric acid are given off. The solution is then cooled, diluted, the lead sulphate allowed to settle, decanted through a filter, and washed twice by decantation. The lead sulphate is dissolved in boiling ammonium acetate, which is poured through the filter into the beaker, to dissolve out any adherent lead sulphate. This solution is titrated boiling with the standard solution of ammonium molybdate, using tannic acid solution on a spot plate as indicator. The end point is reached when a drop of the solution, added to the tannic acid on the spot plate, produces a light brown colouration.

The standard solution of lead acetate is now standardised by titrating it against the ammonium molybdate solution. 50 c.c. ammonium molybdate solution is measured into a flask, acidified with acetic acid, the bulk made up to about 150 c.c., boiled, and titrated boiling with the lead acetate solution. The same indicator is used, and the titration is conducted in the same way as in standardising the molybdate solution with the exception that the end point is reached when the brown colour is discharged.

Assuming that both the lead acetate and the ammonium molybdate are pure, about 40 c.c. of lead acetate solution will be required for titration; 1 c.c. lead acetate solution = 0·01365 gm. lead.

The molybdenum value of the lead acetate solution is found by proportion, since, 207 gm. of lead = 96 gm. of molybdenum and 0·01365 gm. of lead = 0·00633 gm. of molybdenum, *i.e.*, 1 c.c. of the standard solution of lead acetate is equal to 0·00633 gm. of molybdenum."—JAMES DARROCH and C. A. MEIKLEJOHN.—*Engineering and Mining Journal*, Nov. 3, 1906, p. 818. (J. W.)

METALLURGY.

STANDARDISATION OF SCREENS.*—"The principal novelty in the report of the South African committee on the standardisation of screens, consists in taking a series of arbitrary size apertures and an irregular number per inch, so that wires of varying diameter and varying number of apertures per inch will (in the 12 examples given under each standard aperture), give with each size wire the particular aperture called for.

Secondly, 'aperture' is everywhere used for the obnoxious and ambiguous 'mesh,' this being in accordance with my article in *The Engineering and Mining Journal*, Nov. 7, 1903.

Lastly, no mention is made of other workers in this field.† You yourself have been an early writer on the subject. The Institution of Mining and Metallurgy has done some good work along these lines, although I started in to correct the evil 23 years ago. When I found in Cornwall as many standard gauges as there were battery screens, I took the most rational gauge, which happened to be that of J. & F. Poole, of Hayle: measured it, and published the results in the Proceedings of the Mining Institute of Cornwall, 1883, p. 344. This Poole standard Cornish gauge for perforated plate was numbered from 1 to 40. No. 1 aperture was 0·25 in. diameter; No. 10, 0·70; No. 20, 0·105; No. 30, 0·055, and No. 40, 0·01 in., the last being the finest perforation then attainable. The wire gauge used in the published tables of the South African committee is the Imperial Standard, and for illustration one cannot do better than re-produce the complete table for 0·030 aperture:—

APERTURE = 0·030 IN. = 0·762 MM.

Wire.		Apertures per Inch.		Percentage Discharge Area.
Imperial gauge.	Diameter in decimals of an inch.	Linear.	Square.	
21	0:032	16·13	260·11	23·41
22	0·028	17·24	297·22	26·75
23	0·024	18·52	342·92	30·86
24	0·022	19·23	269·83	33·285
25	0·020	20·00	400·00	36·00
26	0·018	20·83	434·02	39·06
27	0·0164	21·55	464·49	41·80
28	0·0148	22·32	498 23	44·84
29	0·0136	22·94	526·06	47·34
30	0·0124	23·59	556 25	50·06
31	0.0116	24·04	577·83	52·01
32	0·0108	24·51	600·74	54·07

No.	Inch.	No.	Inch.	No.	Inch.
1 ...	0·250	15 ...	0·128	28 ...	0 060
2 ...	0·230	16 ...	0·123	29 ...	0·058
3 ...	0·225	17 ...	0·117	30 ...	0·055
4 ...	0·220	18 ...	0·114	31 ...	0·050
5 ...	0·210	19 ...	0·110	32 ...	0·040
6 ...	0 200	20 ...	0·105	33 ...	0·035
7 ...	0·185	21 ...	0·100	34 ...	0·032
8 ...	0·180	22 ...	0·095	35 ...	0·030
9 ...	0·175	23 ...	0·090	36 ...	0·028
10 ...	0·170	24 ..	0·085	37 ...	0·025
11 ...	0·160	25 ...	0·075	38 ...	0·020
12 ...	0·150	26 ...	0·070	39 ...	0·015
13 ...	0·140	27 ...	0·065	40 ...	0·010
14 ...	0·135				

* See this *Journal* Supplement, June, 1903.
† See this *Journal*, p. 168, Nov., 1905.

From which it will be seen that 12 wires of different gauge varying from 0·032 in. diam. to 0·0108 in., will each when spaced give from 16·13 to 24·51 apertures per linear inch (depending on the gauge used), and leave apertures of 0·03 in. It will be further noticed that in the whole table for the 0·03 in. aperture there is but one even division of the inch, namely, No. 25 wire, with 20 apertures per linear inch. The arbitrary division of the inch into an irregular number of apertures, nearly all carrying two places of decimals, does not look practical nor is it necessary. A slight variation in the exact size of aperture is of no particular moment except in testing screens.

The Washburn & Moen gauge, the American standard, with *an even number of apertures to the linear inch*, for example, gives the following, all of which are sufficiently close for any practical purpose.

Number of Wire.	Apertures per Inch.	Size of Aperture.
21	16	0·0308 in.
23	18	0·0298 ,,
25	20	0·0296 ,,
29	22	0·0304 ,,
33	24	0·0299 ,,

Great exactness in battery-screen apertures is an unnecessary refinement, inasmuch as screens are subject to continuous wear, thus a standard 0·02 in aperture screen may become 0·03 in. after a few day's run, and the average aperture for the period may approximate 0·025 in. For what are called *laboratory screens*, however, the greatest possible exactness attainable should be insisted upon, and all weekly or monthly battery samples should be treated wet in these standard screens and so reported; by this means the exact work of the batteries can be closely approximated and the reduction of the ore determined with scientific precision, not alone for the maximum aperture, but also for the intermediate sizes; thus, a battery crushing approximately through 0·02 in. aperture might be reported:

+ 0·02 per cent.	+ 0·0025 per cent.
+ 0·01 ,,	+ 0·002 ,,
+ 0·005 ,,	− 0·002 ,,

I have called attention to the use of these standard testing screens, which I invariably use as standards, in my paper on 'Dry Crushing,' read before the Institution of Mining and Metallurgy, London."—PHILIP ARGALL.—*Mining and Scientific Press*, Dec. 1, 1906, p. 654. (W. A. C.)

THE METALLURGY OF LEAD IN 1906.—"The chief feature in the metallurgy of lead in the United States in 1906 was the further introduction of the lime roasting process, which has been modified, however, by the metallurgists connected with the American Smelting and Refining Company, so that as used by them it is rather a process of "pot" roasting than "lime" roasting, the distinction hanging upon the point as to whether lime does or does not play a chemical part in the process, *i.e.*, any part other than merely serving as the diluent of the charge, which function may be fulfilled by ferric oxide or other material. A third alternative is that lime or other material may possibly act as catalyzers. The nature of the reactions which occur in these processes of desulphurising galena is still a disputed point. Pot roasting, as practised by the American Smelting and Refining Company is performed on charges low in lead, and free or nearly free from limestone. However this modification does not appear to be an unqualified success, the time required for the working of a charge being rather long and the proportion of fines produced, which must be re-treated, being rather large. Certainly the results reported are much inferior to those obtained with the Huntington-Heberlein process on high grade galenas in Australia, Europe, and elsewhere.

In the construction of dust chambers, there appears to be a general reversal of fashion, the flues of reinforced concrete construction, which were so much in vogue a few years ago, being now out of favor. It has been found impossible to prevent them from cracking, which, of course, is highly undesirable. In new constructions, the flues are built of brick in the form of an inverted catenary.

Another new feature has been the restoration to fashion of the bag-house which has been before the attention of silver-lead smelters since 1880 and found its leading exponent in Dr. Iles. However, it never came into general use. An installation was made at the East Helena works, but a few years ago was abandoned. In 1906, however, the bag-house at East Helena was put into commission again, and the United States Smelting Company at Salt Lake began the installation of a similar fume-saving device.

A prominent feature of 1906 was the extension of interest in the Betts process of electrolytic lead refining. The installation of the Consolidated Mining and Smelting Company at Trail, B. C. was materially increased in size, and a new refinery was erected and put in operation by Locke, Blackitt & Co., at Newcastle-on-Tyne, England. Most important of all was the erection of a plant of 2,500 tons per month capacity, near Chicago, by the United States Metals Refining Company. This plant went into operation early in December, and at the end of the month was in smooth running order. There seems to be no question as to the success of this process of lead refining in so far as the electrolytic work is concerned, but the problem of handling the anode slime does not seem yet to have been satisfactorily solved. Mr. Betts has patented a new process for this purpose, but both at Trail and Chicago the slimes are being worked up by independent processes. Anyway, the treatment of this material is only an ordinary metallurgical problem from which an economical method will doubtless be developed by a little experimentation."—W. R. INGALLS.—*Engineering and Mining Journal*, Jan. 5, 1907, p. 20. (K. L. G.)

USE OF WOOD IN COPPER SMELTING.—"It may interest the readers of the *Journal* to know of the progress in smelting copper-sulphide ores direct with the use of wood, charcoal, and coke, at the Mitchell Mining Company's mines in Guerrero, Mexico.

At the present time, pending construction of our railroad, we are operating a 200-ton smelting plant, and on account of the high cost of coke we have endeavoured to dispense almost entirely with the use of coke, which we have very nearly accomplished. In various experiments with one-third oak blocks, one-third charcoal, and one-third coke we have not been very successful. Using two-thirds wood and one-third coke, we found with this large amount of wood on the charge that we did not get the desired degree of concentration. For instance, in smelting the ore with a full coke charge we make a matte of about 40 per cent.; with two-thirds wood and one-third coke we make a matte of about 28 to 30 per cent. from the same class of ore. We found that wooden blocks, which we have cut in dimensions of 3 in., ignite very readily, using up all the oxygen, and burn out before getting to the fusion zone, making a hot top on the furnace. This robbed us of the oxygen necessary for desulphurisation that we would otherwise get by the use of a large amount of fixed carbon in fuel used in the charge. However, we eliminated considerable of this difficulty by dipping the wooden blocks in a thin paste of silica and clay.

The proportions of this paste, or wash, are such that there is enough clay as a binder to adhere to the block so that it will not crack and fall off readily. The mixture should be just thick enough so that the blocks can be readily dipped in it, leaving a thin coating of the paste on the block. This same thing can be done with a mixture of lime, clay and silica. I should advise in case of charges where the ore is silicious that as little silica as possible be employed for the treatment of the blocks, using more lime and clay and *vice versa* with a basic charge.

It was found that blocks treated in this way did not catch fire on the top of the charge as soon as the untreated blocks, and passed down nearly to the fusion zone, thus giving us carbon enough for smelting purposes in the fusion zone. The results have been excellent, and we are smelting with wood entirely as fuel. We have obtained a much higher concentration, making a matte of 38 per cent. as against a matte of about 20 to 25 per cent. with blocks used without dipping in this clay. This ability to use wooden blocks for smelting, and no coke, is a great saving for us. The wooden blocks are far superior to the use of charcoal for sulphide smelting, so far as our experiment has gone, and we are continuing to smelt with wooden blocks, pending completion of our railroad. By this method we are able to keep our smelting and converting plant running and at a very low cost of production.

We do not get the full smelting capacity from the furnace that we would with the full coke charge, and, of course, it goes without saying that the full coke charge is the best, but under our present conditions it can readily be seen what can be done with a mine that is near a big forest and has plenty of timber, when cost of coke is so high."—GEORGE MITCHELL.—*Engineering and Mining Journal*, Oct. 13, 1906, p. 699. (J. W.)

VISIT TO LANGLAAGTE DEEP, LTD.—"The chief item of interest at the surface works was the Blaisdell sands handling plant, and this was fully explained by Mr. A. F. Crank, of Messrs Fraser and Chalmers, and the members had a thorough practical demonstration of the working of this system, which had been the subject of a recent paper by Mr. Crank.*

This plant comprises one class 'A' Blaisdell excavator, discharging sands from tanks 45 ft. diam. by 9 ft. 6 in. deep on to No. 1 Robins conveyor belt, 20 in. wide by 704 ft. long.

No. 1 belt discharges on to No. 2 conveyor belt, which is 20 in. wide by 152 ft. long.

No. 2 belt discharges on to No. 3 conveyor belt, which is 20 in. wide by 685 ft. long.

No. 3 belt discharges on to a cross conveyor belt, which is carried by the class ZX Blaisdell distributor, and this in turn discharges on to a distributor disc over the centre of treatment tank. The speed of distribution discs can be raised to suit the distance necessary for the sand to be thrown to ensure even filling.

Horse-power required for different items :—

Excavator	13	h.p.
No. 1 and No. 2 conveyor belts, driven by some motor	13	,,
No. 3 conveyor	13	,,
Distributor and distributor belt... ...	9·5	,,
Total for plant ...	48·5	,,

* See Journal of Mechanical Engineers, Jan., 1907, p. 142.

The Blaisdell excavator plant ran 223 hours in December, which equals 7·2 hours per day. It excavated and conveyed 12,589 tons, equal to 632 tons daily, or 88 tons per hour. The tanks were draining, average time, 18 hours before excavating. The average of plus 60 contained in sands excavated being 8 per cent.

White and coloured labour cost ...	·72d.
Horse-power and lubricants cost ...	·63d.
Total	1·35d.

Average sands residues with tube milling before using excavator for period of four months, ·45 dwt.

Average sands residues with tube milling with excavator and distributor for period of four months, ·3 dwt.

Difference, ·15 dwt. in favour of excavator.

Three tube mills ran 28 days each during December, 183 stamps crushed 27,505 tons. Percentage of plus 60 leaving battery, 48 per cent. Percentage left in sands, 8 per cent."—Transactions of the Transvaal Institute of Mechanical Engineers, Feb., 1907, p. 191. (J. Y.)

Tube Milling at the Waihi Mine, New Zealand.—"This paper is presented in the belief that metallurgists and chemists will be interested in the practice of grinding in tube mills in connection with stamps, especially since the records of working here given extend over a lengthy period of time (since May, 1905).

The ore from the Waihi mine—more especially that produced in the upper levels—contains a large proportion of hard, chalcedonic quartz, and the gold exists in an exceedingly fine state, conditions which necessitate very fine crushing in order to obtain a high extraction of the precious metal.

Before the introduction of tube mills at the 90 stamp Waihi mill, it was found necessary to stamp through 40 mesh (1,600 holes per square inch) woven wire screens, having a fairly high discharge. The pulp then graded :—

	Per cent.
On 50 mesh	0·1
On 60 mesh	8·74
On 80 mesh	16·06
On 100 mesh	3·66
On 120 mesh	8·77
On 150 mesh	7·48
Passed 150 mesh	55·19

The stamp duty was 2·89 short tons per stamp per day, or a total of 260 tons daily.

Although the extraction on this pulp was: gold, from 88 to 90 per cent., and silver, from 74 to 78 per cent., it was recognised that finer grinding of the sands would prove beneficial, provided a machine could be found to do this work economically. Various grinding mills and pans were tried, but without satisfactory results, the particles of sand being so hard that the capacity of any of the machines was too small to be economical.

The results of grinding in tube mills in other countries were so satisfactory that three tube mills were erected at the Waihi mill, the installation being completed in May, 1905, since which time an average duty of about 2·7 mills has been maintained. The mills are of the Davidsen, 22 ft. type, and are run at a speed of 27·5 rev. per min. Each mill is loaded with 5·5 tons of flints and requires 50 h.p. to operate it. The mills are stopped for inspection and addition of flints once a week. The quantity of flints consumed is 18 cwt. per mill per week. In order to reduce the time required to charge the flints into the tube mill, a new door is being fitted which will admit of two or three charges a week instead of only one, as formerly. In this way the weight of the flints in the mill can be kept at all times much nearer the weight of the original charge, 5·5 tons.

Various liners have been used, including 'Silex' and 'Delarne' quartzite blocks, and also cast iron liners, 1·25 in. thick. The iron liners last about as long as the quartzite blocks—viz., 2·5 months—but the grinding result is not so good. A new lining, invented and patented by Mr. H. P. Barry, called the 'Honeycomb lining,' is now being tried with very promising results. This liner consists of a light cast iron frame, 22 by 14 by 3 in. deep, shaped to the curve of the mill. Thin walls divide this lining into four or six compartments. A temporary sheet iron back is fastened to the frame, and each compartment is then firmly packed with rough lumps of hard quartz or quartzite, varying in size up to 4 in. square, bedded in with a mixture of Portland cement, coarse sand and fine sand. The liners so formed are allowed to set, preferably under exhaust steam, for several weeks—the longer the better—before being placed in the mill. This method of lining calls for a much shorter stoppage than with the quartzite blocks. The frames fit neatly with each other and with the shell of the mill, and only a small quantity of cementing material is required.

If made with hard material these liners stand very well, and cost, including labour, about $175, as compared with $400 for lining with quartzite blocks. The grinding efficiency of a mill with this new liner appears to be quite equal to that of the quartzite blocks.

The stamps weigh 1,000 lb., and crush through 20 mesh screens. The proportion of water to ore is 10 to 1, and the output is 354 tons per day, which is equivalent to about 4 short tons per stamp.

The pulp is lifted by wheel elevators to 4 sizing boxes, each 4 ft. square and 4 ft. deep; no upward flow is used. The slime and fine sand overflow and pass to the treatment plant. The coarse sand, having 2 parts of water to 1 of sand, is divided into three portions and flows directly to the mills. It is intended to put in a dewatering-box at the head of each mill, with a view to improve the grinding.

The grade of the pulp, before and after the mill treatment, is :—

Size.	Before Grinding (90 Stamps, on 20 Mesh).		After Grinding in Three Tube Mills.	
	Per cent.	Tons.	Per cent.	Tons.
On 30 mesh	5·32	18·85	0·03	0·11
On 40 mesh	9·77	34·56	0·12	0·40
On 60 mesh	15·94	56·42	1·13	4·01
On 100 mesh ...	13·96	49·42	7·43	26·28
On 150 mesh ...	12·29	43·50	18·42	65·22
Through 150 mesh ...	42·72	151·25	72·87	257·98

The daily tonnage of sands passing through the tube mills is about 230 tons, or about 77 tons per mill.

It will be seen from the above grading that the mills are doing very good work, practically all the material of 30, 40 and 60 mesh size having disappeared.

An additional tube mill is being installed, and when completed either the coarser portion—up to 100 mesh—will be sent to this mill, or coarser screens, say, 15 mesh, will be used on the stamps. It is a matter of experiment to determine which will give the better commercial result—finer grinding for increased extraction, or larger milling tonnage. In addition to the benefit of increased tonnage by the substitution of 20 mesh screen in place of 40 mesh, the tube mills have favourably influenced the extraction, for the reason that before their use the combined sand and slime residues assayed 31 gr. of gold per ton, representing an extraction of 89·8 per cent., but after installation the combined residues assayed 24 gr. of gold per ton, representing an extraction of over 92 per cent.

A most important result of grinding in tube mills has been the effect on the slimes. A large proportion of sand is ground so fine that it passes the spitzlutte with the slime, the result being that the slime is more easily treated either by the filter-presses or the vacuum process. The result is shown by the time required for filling and washing the presses, which can now deal with 30 per cent. more slime than in treating slimes from stamps on 40 mesh size.

The cost of running the tube mills, per ton of sand passed through the mills, is :—

	Cents.
Power	12·5
Flints and liners	14·0
Labour, repairs and stores ...	1·5
Total	28·0

or, on the total mill tonnage, 18·2 cents per ton of ore crushed.

The chief benefits derived from tube mills at Waihi are :—

1. Increased extraction, amounting to about 36 cents per ton on the whole of the ore crushed.
2. Increased tonnage of fully 36 per cent.
3. A saving of 75 per cent. on the cost of screens. The 20 mesh now used costs less and lasts considerably longer than the 40 mesh previously used.
4. Amalgamation improved by from 5 to 7 per cent.
5. The slime, owing to the contained fine sand, is more easily treated.

The reduction in milling cost due to the tube mills is fully 12 cents per ton on the total tonnage. This, altogether with the 36 cents improved extraction, represents a total increased saving of 48 cents per ton, or $169 per day on the 90 stamps.

When it is considered that, in addition to this result, the bullion production is augmented by the product from the extra 94 tons per day, it must be conceded that tube mills have proved highly successful at Waihi.

Owing to these results at the 'Waihi' mill, arrangements are now in hand to equip the 'Victoria' mill of 200 stamps with a plant of at least 9 tube mills.

By the improved methods now coming to the front for handling slimes, and the economical grinding which is obtained with tube mills, it is my opinion that the time is not far distant when such ores as those at the Waihi mine will be treated mostly in the form of slime."—E. G. BANKS.—*Transactions of the American Institute of Mining Engineers*, vol. 13, January, 1907, p. 63. (J. Y.)

MINING.

THE SIMPLON TUNNEL.—"The chief feature of this route is its small altitude (2,313 ft.) above sea-level, which compares favourably with other Alpine tunnels. In the tunnel the gradients were decided primarily by assuming that the progress of excavation would be the same from both ends, and, secondly, by the least fall capable of giving efficient drainage; thus a minimum of 1 in 500 was adopted for the north side, and 1 in 143 for the south side, the two gradients being joined by a vertical curve in the centre.

The work provides for two parallel single line-of-way tunnels, 55·8 ft. apart, connected by oblique cross passages; the reasons for this arrangement were:—(1) Ventilation during construction; (2) greatly reduced pressure on the tunnel-lining; (3) increased facilities of transport and drainage during construction; (4) increased facility in subsequent maintenance during traffic; (5) safety in working traffic.

One tunnel only has been completed to the full section, the second gallery being left at present as a heading.

The completed tunnel measures 16 ft. 5 in. in width and 18 ft. ½ in. in height above rail-level. It is lined throughout with masonry. Refuges and chambers are built into the cross passages for use by the maintenance gangs.

In December, 1890, Messrs. Sulzer, of Winterthur, and Messrs. Brandt, Brandau & Co., of Hamburg, presented the plans, and in 1895 the Swiss and Italian Governments ratified a convention for the construction of the tunnel. The cost was estimated at £3,040,400, towards which the two Governments contributed; the period of construction was to be 5¾ years. The actual cost is about £3,200,000, and the period taken 6¾ years.

In August, 1898, the excavation was commenced with the pick, pending the installation of hydraulic power; at Brigue the Brandt hydraulic drills began work on November 22, 1898; but at Iselle, owing to the necessity of transporting all plant over 12 miles of steep roadway, drilling was not started till February 18 of the following year. The two ends were worked on the same general plan, each independently; about 2,000 h.p. was developed both from the Rhone and from the Diveria, driving high pressure hydraulic pumps.

A full description of the Brandt hydraulic rotary drill and its capabilities is alluded to in the paper, with methods of blasting. Ventilation was effected by fans; the air, forced into the mouth of one of the galleries, travelled back by the parallel gallery, the latter being used as means of exit and entry for the trains of material, etc.

The whole works were kept remarkably fresh. To supply the men working in the faces, air was taken from near the last cross-cut, cooled by means of a fine jet of water and driven through light iron pipes to any desired point. Later, on meeting the hot springs, the air was cooled at various points in the finished heading by means of jets of cold water spray. Though in the St. Gothard a temperature of 93 deg. F. proved in many cases insupportable, yet in the Simplon, owing to the excellent ventilation, a temperature of 133 deg. F. was not unbearable. Diagrams are given in the paper showing the relation of the temperature in the tunnel to the height of mountain above it.

On leaving the tunnel the workmen entered a large warmed building fitted with dressing-rooms, and with hot and cold douche baths. Here they changed into warm dry clothing, and their mining garments were dried or washed ready for the next day.

The work of excavation progressed rapidly at both ends, an advance of 18 ft. per day being frequently recorded. On the Swiss side the rock encountered was chiefly gneiss and micaceous schist. On the

Italian side, after traversing about $2\frac{3}{4}$ miles of hard Antigora gneiss, the thermometers in the rock showed a diminishing temperature, and suddenly a cold underground river of 12,000 gallons per minute burst in. Owing to the treacherous nature of the rock at this point, only heavy joists buried in quick-setting concrete were able to hold open a heading of sufficient area to give access by small hand waggons to the drills beyond. This short length entailed a delay of six months.

After traversing another $2\frac{1}{4}$ miles, hot springs with a maximum flow of 4,330 gallons per minute and a temperature of 45·4 deg. C. were encountered, but by taking the water of the cold spring and throwing it into the crevices of the hot, the heading was made bearable.

During these delays to the south end, the north had been advancing with increasing rapidity, and had reached the central summit of the tunnel; to avoid delay, however, the heading, hitherto on the level of the floor of the tunnel, was made to rise on a gradient of 1 per 1,000.

When the advance heading reached the soffit of the future tunnel, working downhill was attempted, but finally work on the Swiss side was abandoned, the drills were withdrawn and the heavy iron doors which had been erected, were closed (March 20, 1904). Completion was thus left to the south advance, whose drills could just be heard through the intervening 1,094 yards of rock.

On February 24, 1905, at 6 a.m., the final charges on the Italian side were exploded in the roof of the gallery, blowing a hole about 8 ft. by 2 ft. into the floor of the Swiss heading above. The first train passed through on January 25, 1906, the final opening to the public taking place with great festivities on May 30, 1906." —FRANCIS FOX, M.I.C.E.—Abstract of paper read before the Institute of Civil Engineers, London, appearing in the *London Mining Journal*, Jan. 12, 1907, p. 43. (J. Y.)

CALCULATIONS FOR MINE VENTILATING FANS.—"In figuring the size of a ventilating fan, it is necessary to consider the amount of air to be furnished and the pressure required to discharge the same. At a given speed a fan can maintain this pressure over a certain area only, which is called the equivalent or capacity area. This term has been introduced by Murgue, who made thorough investigations of mine ventilators, to facilitate comparisons of different fans.

The equivalent area of a fan may be described as the opening in a thin wall between two vessels holding air of different pressure, through which flows the specified volume.

The quantity V in cubic feet delivered by a fan varies directly as the velocity of flow v through the equivalent area a; therefore $V=av$. Due to resistance in flowing through the opening, and due to contraction, this value has to be multiplied by a coefficient f, thus $V=fav$. Murgue gives $f=0·65$.

The velocity v in feet per second depends upon the difference of pressures on the two sides of the opening a and equals $\sqrt{2gH}$.

g=acceleration of gravity.

H=height of column of air in feet equal to difference of pressure.

Usually h is given in inches of water, thus

$$v=\sqrt{\frac{2gh}{12}\frac{do}{d}}$$

do=weight of cubic feet of water.

d=weight of cubic feet of air.

Substituting this expression for v in formula $V=fav$, we have,

$$\text{No. 1.} \quad V=fa\sqrt{\frac{2gh}{12}\frac{do}{d}}$$

The pressure of air in inches of water is proportional to the square of the peripheral velocity u (in feet per second) of the impeller.

$$h\ (\text{theoretical})=\frac{12u^2}{g}\frac{d}{do}$$

Due to leakage, eddies, etc., this theoretical value has to be multiplied by a coefficient c, which has to be determined from actual fans.

$$\text{No. 2.} \quad h=\frac{12cu^2}{g}\frac{d}{do}$$

This expression may be written thus,

$$h=\frac{12c\pi^2D^2d}{60^2gdo}n^2.$$

D=diameter of impeller in feet.

n=number of revolutions per minute.

As can be seen from the formula, the pressure h varies with the square of the number of revolutions and $\frac{h}{n^2}$=constant for a given fan.

From formula No. 1 the equivalent areas may be found.

$$a=\frac{V}{\sqrt{h}\left(f\sqrt{\frac{2g}{12}\frac{do}{d}}\right)}$$

Let

$$\frac{1}{f\sqrt{\frac{2g}{12}\frac{do}{d}}}=L$$

then $a=\frac{Lv}{\sqrt{h}}$ and for a given fan and opening a, the expression $\frac{V}{\sqrt{h}}$=constant. From this follows $\frac{V_1^2}{V_2^2}=\frac{h}{h_2}$ that is, the squares of the volumes discharged are proportional to the pressures.

From formula No. 2 it also follows that $\frac{n_1^2}{n_2^2}=\frac{h}{h^2}$; or $\frac{h_1}{n_1^2}=\frac{h_2}{n_2^2}$ = constant; that is, for a given fan the pressure divided by the square of the number of revolutions is a constant quantity.

As found above, $\frac{V_1^2}{V_2^2}=\frac{h_1}{h_2}$, then $\frac{V_1^2}{V_2^2}$ is also equal to $\frac{n_1^2}{n_2^2}$ or $\frac{V_1}{V_2}=\frac{n_1}{n_2}$; that is, the volumes are proportional to the number of revolutions, or $\frac{V_1}{n_1}=\frac{V_2}{n_2}$=constant.

The two coefficients c and f being determined, it is easy to calculate other sizes of fans of the same type provided the velocities of air through the fans and the shapes of blades, etc., are made proportional to those of the original fan.

A fan moves V cub. ft. of air against a pressure of h in. of water. The work it is doing is therefore $V \times h \times$ weight of cub. in. of water $\times$ 144, or 5·2 Vh ft. lb.

As V varies directly as n, and h as the square of n, the foot pounds of work vary as the cube of n."—J. F. MAX PATITZ.—*The Engineering and Mining Journal*, Jan. 19, 1907, p. 146. (K. L. G.)

DETONATING CAPS FOR BLASTING.—"The general principles of the detonation of powder and the important function that blasting caps play in the successful breaking of ground are much overlooked in practical blasting and in mining literature; and miners, in spite of their experience in placing and drilling of holes, and in the handling of powder, are troubled with premature blasts, smoky shots, unbottomed holes and misfires, and are perplexed as to the cause.

This paper will undertake to present some notes upon the values of different caps or detonators in developing the energy of explosives, so that a better knowledge of their relation will aid in a judicious selection of caps, which, together with a proper regard for apparently insignificant details, will materially assist in removing or at least lessening the recurrence of those undesirable conditions above mentioned.

MAXIMUM STRENGTH OF POWDER—HOW PRODUCED.

Detonators or blasting caps are made in several different grades of strength, because some powders require not only a greater but a different initial detonation than others to convey their maximum energy through a whole charge, and the detonating qualities of each powder vary by changes in its physical condition—whether it be warm or cold, rigid, plastic, homogeneous or otherwise.

The full significance of 'detonation,' as applied to high explosives, will become apparent in the course of this paper, but briefly it may be stated that *detonation is a very much higher degree of explosion* than that produced by fire alone or by a blow. While either of these will explode powder under certain conditions, neither of them will cause it to produce its greatest effect. An explosion is merely the rapid transformation of powder from its solid or liquid state into gases which struggle to occupy a space hundreds of times greater than that occupied by the original substance; but in order that these gases may produce their greatest rupturing force on the surrounding material, they, too, must be expanded suddenly to their greatest possible volume. This requires a practically instantaneous decomposition and oxidation at maximum temperature into their simplest elements, the result being the highest degree of explosion, which is called 'detonation,' and which can only be produced by a peculiar combination of intense heat and concussion, such as is supplied through the agency of detonators, or blasting caps, as they are commonly called. Hence, a thorough detonation of powder is controlled by the cap, the natue and strength of which is as essential to successful results as is the powder itself.

The susceptibility of powder to detonation depends more upon the nature of its ingredients and on the physical conditions previously mentioned than on the amount of nitroglycerine or high explosive which it may contain. For instance, ordinary dynamite, with 40 per cent. nitroglycerine, is easier to detonate thoroughly than a gelatine dynamite containing even as much as 80 per cent. nitroglycerine, because in the first the liquid nitroglycerine is merely absorbed mechanically in a dope, whereas in the latter it is chemically transformed with guncotton into a gelatinised mass, which is harder to detonate and harder to make transmit its detonation through a whole charge of it than ordinary dynamite; that is, a comparatively weak cap will detonate a longer charge of straight dynamite than of gelatine dynamite, yet gelatine dynamite, when detonated with a suitable cap, is somewhat stronger than ordinary dynamite containing the same amount of nitroglycerine and possesses greater shattering effect.

A spark will detonate fulminate of mercury; 2 gr. of fulminate will detonate nitroglycerine; but it requires at least 10 gr. of fulminate to detonate guncotton. That there is something more, however, than the actual force and quickness of these 10 gr. of fulminate is shown by the fact that, although the mechanical force of nitroglycerine is more than that of fulminate of mercury, ten times more nitroglycerine or 100 gr., will not detonate guncotton; it will only scatter it, yet a small quantity of dry guncotton, which is slower than nitroglycerine, will easily detonate nitroglycerine and even wet guncotton, which are the two extremes, nitroglycerine being one of the most sensitive and wet guncotton one of the most inert forms of high explosives. Therefore the equilibrium of the different chemical molecules of these powders is susceptible to explosion not merely by the force of the shock, but by different kinds of impulses or vibrations. Another example of the disruptive effect of a particular wave motion without special mechanical force are the glass globes frequently exhibited in physical laboratories, which withstand a strong blow, but are shattered by the mere vibration of a particular musical note, whereas a note of different tone will not affect them.

The different degrees of faci ity with which some explosives will detonate others, and their susceptibility to one kind of detonation more than to another, must now be apparent. Let us next consider the action of the same explosive under different influences. It appears to many that when a charge of powder explodes at all it explodes with maximum force throughout, but such is not the case. For instance, a large number of sticks suspended in the air close enough to explode one another (12 to 36 in. apart, according to the kind of powder and size of cartridges used) will explode down the line for a certain distance if a detonator be used to start the first stick, but a point will eventually be reached where one will not set off the stick next to it, showing conclusively that each successive stick of powder has lost some of its detonating force.

That its explosive force also becomes weakened as it proceeds down the line may be illustrated by placing under each stick a thin plate of soft steel over the end of a piece of 4 or 6 in. iron pipe. The force of each explosion striking these plates of steel will cup them into the hollow of the pipe and the size of the cups will diminish as the explosion gets farther away from the initial detonation. It has also been demonstrated that when the first stick is fired with a weak cap the sympathetic detonation will not extend far down the line; per contra a very strong cap, or one of some other composition to which the powder is more susceptible, will carry the detonation much farther.

DIFFERENCE BETWEEN COMBUSTION, EXPLOSION AND DETONATION.

The effect of merely lighting a piece of unconfined dynamite with a squib or piece of fuse without any cap attached is that the dynamite will burn quickly without exploding, and make a dense smoke which has a disagreeable smell and produces violent headaches. This is simple combustion. Confine another piece of dynamite, and light it in the same way and it will explode, but it will belch forth similar fumes. A very weak cap, like the old single-force cap, fired in dynamite will explode it with considerable energy, but there will still be some of the objectionable smoke. Repeat the experiment with a triple-force cap and the dynamite will be detonated with great violence even when unconfined, developing great explosive force and very little smoke. This illustrates the difference between combustion, explosion and detonation, showing that the same powder may be made to transmit its energy by different means and with different degrees of intensity from a rapid burning to a violent detonation.

The relative strengths of three well-known explosive compounds have been compared when exploded by fire simply and then by detonation. Considering the explosion from simple inflammation of gunpowder as unity, guncotton when exploded simply by fire is three times stronger than gunpowder, and when detonated by a cap, it is six and one-half times stronger. Nitroglycerine is five times stronger than gunpowder when exploded by fire and ten times stronger when detonated. Hence these figures explain the enormous force which is given by detonation as compared with that by simple explosion.

CONDITIONS INFLUENCING DIFFERENT POWDERS.

Gelatine powders do not transmit their explosive energy through themselves as readily or as far as regular dynamites, hence they require a stronger detonator, larger cartridges and more confinement completely to detonate a whole charge. A 3X cap gets nearly all the energy out No. 1 and No. 2 dynamite, but gelatine dynamites, nitrogelatine and other inert powders require at least a 5X cap to develop their energy, and a 6X or stronger cap will do it still better, especially if the charge be a long one. This relation between the length of charge, the diameter of the stick and the strength of caps is another noteworthy fact, more marked with the inert powders than with ordinary dynamite. Thin sticks require a stronger cap than sticks of larger diameter and a long charge, especially of slender sticks, requires a stronger cap to convey sufficient impulse through the whole charge; otherwise all the powder in the hole will not be detonated.

The so-called 'fumeless powders,' meaning that their gases are not visible or noxious, are only fumeless in that sense of the word when well detonated. If the fuse burns them, or the cap is too weak, they, too, make 'stinkers' and produce headaches. A poor detonation of gelatine and other inert powders, which does not go all through the charge, will disintegrate some of the other sticks without exploding them, leaving the hole unbottomed and scattering the unexploded powder about the mine, which is dangerous. This sometimes happens when the cap has been buried under several sticks of powder and there is no tamping on top of the charge.

The matter of tamping high explosives is much debated amongst miners, many asserting that it is unnecessary. As a matter of fact, tamping is not so essential with high explosives as with black blasting powder, because in the one case the expansion of gases is so sudden that just a small proportion get a chance to escape, while in the case of slower powders the expansion is gradual; but in any explosive the better the confinement of the gases the greater will the effect be. The fact is, however, that most blasters use an excess of powder so as to make doubly sure of breaking the ground, and this excess also makes up for the loss of power by the escape of untamped gases.

Close confinement, by ramming the powder well into a hole so as to fill up any spaces around the charge, is also important, as much of its effectiveness may otherwise be lost. For example, ¼ oz. of No. 2 dynamite will throw a ball of certain weight from a mortar 300 ft. Leave ½ in. air space between the ball and the powder and the same quantity of dynamite will throw the same ball only 210 ft., lessening the distance 90 ft. in 300, which is a loss of 30 per cent. of its efficiency.

Several years ago a mining superintendent in Arizona noticed irregularities in the progress of different shifts. Some of the miners complained of unbottomed holes and bad air. He was supplying them with 40 per cent. gelatine dynamite, ⅞ in. sticks and 5X caps, shift and shift alike, but with no more powder than his foreman considered was sufficient to do the work. Upon investigation it was found that one shift always rammed the charges with a wooden bar and put tamping on top, but the other shift was not tamping. All hands have been using tamping ever since, and work has proceeded satisfactory with the same powder and caps.

Another consideration in handling any powder is the diameter of the sticks used. Seven-eighths inch sticks require more confinement and greater initial impulse than 1¼ in. sticks to carry the detonation through the charge, because the more powder there is in the immediate vicinity of the cap, the greater will be the initial explosive energy established, and this is particularly essential with gelatine dynamites and other inert powders.

When powder becomes chilled, it is difficult to detonate it properly with the usual detonator, hence the advisability of using a very strong cap in cold weather. Many of the holes are frequently loaded for some time before firing, and even if the powder is soft and normal while charging, it afterwards becomes somewhat chilled in the cold ground. As said before, a 3X cap, or even a double-force cap, will detonate ordinary dynamite if it be soft and plastic. But, on the other hand, if it be hard, or if it should present a mottled appearance, even a 5X cap may fail to detonate it completely.

SELECTION OF DETONATORS.

It is the nature of the initial detonation to the powder around the cap which governs the greater or less effect of the explosion of the whole charge. The cap communicates to the first particles of powder a disruptive impulse, which according to the nature and strength of the cap more or less completely overthrows their equilibrium and decomposes the powder with great energy, setting up sympathetic vibrations which explode the next particles of powder and so on by the violent disturbances or friction between them in a regular succession of impulses and decompositions, which, if started with sufficient energy, are of such intense heat and velocity that the rupturing force of the explosive is developed practically instantaneously. This detonation has already been shown to be not only the result of mechanical force, but a combination of extremely sudden chemical and dynamical or impulsive reactions which set up vibrations to which different powders are more or less susceptible, and these explosive reactions will be propagated through the mass of the powder according to the intensity of the vibrations and the resistance with which their motion is opposed by the nature and consistency of the powder, whether it be difficult or easy to oxidise, soft and plastic like dynamite, or hard. If the initial detonation of the powder surrounding the cap is of the highest degree, the vibrations will be most intense and will be propagated farther through the mass than by a poorer detonation. Hence the different degrees of detonation. Unless the first particles of powder are so thoroughly decomposed by a detonation of high order, of first degree, as to convey the necessary heat and energy to detonate the whole charge, the greatest force of the powder will not be developed. There will frequently be unbottomed holes or pieces of unexploded powder scattered about, or both, and the air in the mine will be contaminated with some obnoxious gases which have not been completely oxidised."—ROLAND L. OLIVER.—*Engineering and Mining Journal*, Oct. 13, 1906, p. 682. (J. W.)

MISCELLANEOUS.

EFFECT OF MOISTURE ON WOOD. — "Little is definitely known about the influence of moisture on the strength of wood, even by those experienced in handling the material. Since the whole subject is one of great importance, the Forest Service has been making a thorough study of it during the past three years and is about to publish the results of its investigation in an exhaustive technical bulletin. Some of the chief points presented by the study are:—

1. Relation of moisture to strength follows a definite law which can be graphically expressed. Proper drying greatly increases the strength of all kinds of wood, the amount of increase in strength depending upon the species and the dryness. The increased strength given to green wood by thoroughly drying it, is so great that it will surprise many. For example, the strength of a piece of unseasoned red spruce may be increased over 400 per cent. by a thorough drying at the temperature of boiling water. Strength decreases again, however, as the wood absorbs moisture. Air-dried wood, protected from the weather, and containing 12 per cent. of moisture, is from 1·7 to 2·4 times stronger than when green, varying with the species. Stiffness is also increased by drying. These conclusions, however, are drawn from small-sized pieces not exceeding 4 by 4 in. in cross-section such as are used in vehicle work, tools, etc. Large timbers require years of drying before the moisture is reduced to the point where strength begins to increase. It must also be taken into consideration that more or less checking always occurs when large timbers dry; and if this checking is excessive it may cause weakness to counterbalance, partially or entirely, the strength gained in drying. Consequently it is not safe to assume that the average strength of large, so-called seasoned timber is much greater than that of green or wet ones.

2. The fibre saturation point of a number of species has been determined. This point, which varies with conditions and species of wood, designates the percentage of water which will saturate the fibres of the wood. It has been found that, under normal conditions, wood fibre will absorb a definite amount of moisture; beyond this the water simply fills the pores of the wood like honey in honey-comb. Only that water which permeates the wood fibre has an influence upon the strength. For the following species, the saturation point occurs at the given percentage of moisture based on the dry weight of the wood: Longleaf pine, 25 per cent. moisture; red spruce, 31 per cent. moisture; chestnut, 25 per cent. moisture; loblolly pine sapwood, 24 per cent. moisture; red gum, 25 per cent. moisture; red fir, 23 per cent. moisture; white ash, 20·5 per cent. moisture; Norway pine, 30 per cent. moisture; western tamarack, 30 per cent. moisture.

3. Prolonged soaking in cold water does not reduce the strength of green wood below that of its fibre saturation point provided it remains in perfect condition. When wood has been dried and is resoaked, it becomes slightly weaker than when green.

4. Wood soaked in heated water absorbs more moisture because the amount of water which the fibre will contain is increased. This causes a reduction in strength and stiffness, as in wood that is heated or steamed for bending."—*The Engineer*, Chicago, Dec. 1, 1906, p. 796. (J. Y.)

INFLUENCE OF MINERAL CONSTITUENTS OF THE MIXING WATER UPON THE STRENGTH OF PORTLAND CEMENT CONCRETE.—"As it is a very important matter to get all possible light on factors which may affect the durability of concrete, the following may be of interest to engineers.

In connection with dock construction at Ashtabula, Ohio, the contractors found that a water-supply available at some distance from the lake would be convenient for a part of their work. The water came from an old slag fill and was of the following remarkable composition, the presence of thiosulphates (hyposulphites) in such large percentage, being outside our previous experience. The thiosulphates were of course derived from the sulphide of lime which is always present in blast-furnace slag.

ASHTABULA WATER.

	Parts per 100,000.
Silica	1·80
Carbonate of lime	36·22
Carbonate of magnesia	·67
Sulphate of lime	31·28
Thiosulphate of lime	38·00
Thiosulphate of soda	64·75
Chloride of soda	6·04
Nitrate of soda	trace

As the action of such a water when used for mixing concrete could not be foreseen, practical tests were made. Batches of neat cement and of the usual 1 : 3 cement and sand mixtures were made up.

For one set, Pittsburgh hydrant water (Allegheny river water) was used. For the second set Ashtabula water was used. Pittsburgh water contains very little mineral water.

PITTSBURGH WATER.

	Parts per 100,000.
Silica	·56
Carbonate of lime...	2·68
Carbonate of magnesia	·46
Sulphate of lime	3·40
Sulphate of magnesia	·45
Chloride of soda	2·47

The results of the cement tests with the two waters were as follows:—

NEAT TESTS.

	Pittsburgh water.	Ashtabula water
1 day	553 lb.	......
7 days	781 lb.	815 lb.
28 days	805 lb.	828 lb.

SAND TESTS. (1 Cement : 3 Sand.)

	Pittsburgh water.	Ashtabula water.
7 days	233 lb.	250 lb.
28 days	362 lb.	374 lb.

The above figures are each the average of three briquettes. The cement, selected at random, was 'Old Dominion' Portland.

It is evident from these tests that a water containing considerable amounts of sulphates and thiosulphates does not injure the strength of concrete, but seems to improve it. As natural waters vary greatly in composition, and as certain alkali salts would affect concrete injuriously, chemical and physical tests made in advance would seem a proper safeguard."—J. O. HANDY.—*Engineering News*, Dec. 27, 1906, p. 691. (W. A. C.)

CHARACTERISTICS OF STEAM COAL. — "The apparatus employed in the researches to be considered consisted of two Babcock & Wilcox boilers, one being 14 tubes high and 18 wide, of approximately 5,000 sq. ft. of heating surface, fitted with a chain-grate stoker 75 sq. ft. in area, which discharged the gases of the fire from under an ignition arch 5 ft. long, immediately among the tubes of the boiler; this boiler was also fitted with a Babcock & Wilcox superheater having an approximate area of 1,000 sq. ft. The other apparatus employed in one of the series of tests differed only in sizes; its boiler was 12 tubes high and 16 wide, contained 4,000 sq. ft. of heating surface, was provided with a superheater, and served with a chain-grate stoker 66 sq. ft. in area.

'The experiments were for the purpose of studying the following features and their influence with the particular apparatus used, and are presented in the following order:—

Effect on capacity and efficiency due to coal of different sizes. Influence of ash in coal on capacity and efficiency. Effect of variation in size of coal screenings. Results of different thicknesses of fire.

The experiments consisted in the use of coal separated into various sizes by means of screens having the following square openings, 0·25, 0·50, 0·75, 1·0, and 1·25 in. The coal was all from one lot, so that the different portions resulting from the screening process were necessarily the 'same kind of coal,' except that some portions were uniformly larger and others smaller, and that the smallest, on account of its size, was higher in ash.'

These tests made with the fuels of these five different sizes were conducted with much care to insure that all conditions, excepting the size, were constant. Plotting the results in the form of diagrams, it appears that the maximum efficiency was obtained with the coal which passed the ·075 in. screen, this attaining about 70 per cent., the curve at this point being nearly flat, and indicating the efficiency to be nearly constant for sizes from $\frac{7}{8}$ to $\frac{5}{8}$ in. The maximum capacity was found with coal of about the same size, this curve being much sharper, however, dropping off rapidly on each side of a point indicating about $\frac{3}{4}$ in. size.

The percentage of ash in the several sizes showed a marked increase in the proportion of ash in the smaller coal, this being undoubtedly due to the fact that the fine-sized foreign matter separated from the larger coal, or from the roof or floor of the mine, naturally finds its way into the smaller coal. Tests to determine the influence of ash in coal on the efficiency and capacity of a boiler gave some very interesting results. If the ash acted merely as a diluent it should affect only the capacity and not the efficiency of the boiler. If, however, its presence offers any obstruction to the combustion process, it is doubly harmful.

The results of the presence of varying quantities of ash are given in diagrams showing the results of tests up to 40 per cent., and both capacity and efficiency are shown to be affected.

'It appears that the useful effect from the fuel drops to zero with 40 per cent of ash, notwithstanding the fact that the other 60 per cent. of the composition was pure coal. The fact should be emphasised that although over half of the composition fed to the fire was fuel, it burned without producing any useful effect, for which there are two reasons, one, that on account of obstructed air supply through the fuel bed, incomplete combustion and escaping hydrocarbons carried away a portion of the heat, because the gases passed immediately among the tubes of the boiler. The other is, that owing to the presence of an excess of ash, the percentage of fuel on the rear portion of the grate is greatly reduced. On this account a larger proportion of the air passing through the fuel bed does not combine with the fuel, but enters the furnace as free air. As the prime function for a furnace is to heat the gases passing through it, any increase in the amount of air entering the furnace without corresponding increase in the amount of fuel burned must result in a lowering of the furnace temperature.

'This lowering of temperature, besides making a long smoky flame which reaches up among the boiler tubes, and is there chilled to below the burning point, also reacts on the fuel bed, reducing the rate of combustion and still further increasing the adulteration of the furnaces gases with free air. When the temperature of the furnace has been thus reduced to about 600 deg. F. the boiler is unable to absorb any more heat than is necessary to make up for radiation losses.'

'The curves for both efficiency and capacity drop midway between the tests with both small and large coal. This is a peculiarity which may be explained as follows:—Performance becomes better as the size of coal increases, until a point is reached when the quantity of large pieces becomes so great that there is not enough fine material to properly close the interstices between, with the result that performance drops off, due to excess of air, until a condition is reached when all the pieces of fuel approach uniformity, when, owing to greater agreement in size, they fit together better, and in a measure produce a homogeneous mass similar to that secured by the fine dust filling the spaces in the fuel bed in the first case.

'The presence of fine dust in excess is a great and important source of trouble. Thus coal through a 0·25 in. square screen produced only 108 h.p., yet a size of fuel which will pass through a 0·25 in. round hole (a smaller aperture than the square opening) will produce as high as 600 h.p. under the same boiler. It is true that the lower ash-content of the washed coal has a considerable influence, but this is offset by a larger size of the square screen as against the round one.

The results are influenced by the thickness of the fire. An excess of air accompanies a thin fire, and because of it, efficiency produced through the boiler is affected. On the other hand, a thick fire reduces the excess of air, but increases the volume of hydrocarbon gases which leaves the surface, or, in other words, makes more smoke. If a furnace is located between the boiler and stoker, these gases will be burned, otherwise they will largely escape among the tubes of the boiler as they did in this case. Therefore, under these conditions, a thin fire increases the loss due to excess of air, but decreases that due to smoke and incomplete combustion. On the other hand, a thick fire reduces the excess of air but increases the smoke and escaping combustible gas, and so the best thickness of fire may be a matter of importance.

The value of coal screenings is affected by four variables, which are: heating power, moisture, ash, and size of the pieces of coal. Heating power of the pure coal—in other words, free from ash and moisture, the real coal—ranges from 13,800 as the minimum to a maximum of 14,500 British thermal units per lb., and moisture from about 9 to 14 per cent. These two characteristics, however, are of minimum importance, as either can affect the result by only a comparatively small amount. With the other two features, amount of ash and size of the pieces, each may exert an influence of such moment as to cause the fuel to be valueless." — W. L. ABBOTT. — *Engineering Magazine*, Dec., 1906, p. 434. (H. A. W.)

Reviews.

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

NEW ZEALAND MINING HANDBOOK. Published by John Mackay, Wellington, New Zealand, 1906.

This handsome work is issued under the authority of the Minister of Mines, and is edited by the Secretary of the Mining Bureau. It is nicely printed and well illustrated, and its production has been inspired by the approaching exhibition, the largest of its kind in the history of New Zealand. The handbook is largely a compilation of views expressed by Government officials and men intimately associated with the mining industry of the islands, and it deals with the mineral wealth of the latter very comprehensively. Dredging and hydraulicing come in for a large amount of attention. A very valuable addition to New Zealand mining literature. (J. Y.)

MODERN TUNNELLING PRACTICE. By DAVID MCNEILY STAUFFER. 21s. (London: A. Constable & Co., Ltd.)

"In this work on 'Modern Tunnelling Practice' the various matters are dealt with in a practical manner, and the work should prove a valuable help, especially to students. The chapters dealing with ventilation, surveying, and explosives are scarcely up to the general standard; those, however, dealing with structural work generally are admirably written, and invaluable comparisons of cost are given, and the working drawings are as excellently executed as they are designed. The literature on tunnelling is enriched by this the latest contribution on the subject, and the work may be looked upon as a standard book of reference."—*The Mining Journal* (London), Feb. 2, 1907, p. 163. (W. A. C.)

WEST AUSTRALIAN METALLURGICAL PRACTICE. Published by the Chamber of Mines of Western Australia (Incorporated).

"Between July, 1905, and September, 1906, the Chamber of Mines of Western Australia contracted with Mr. Robert Allen, M.A., B.Sc., for twelve articles descriptive of the principal reduction plants in the State. The articles, which were printed in the monthly journal of the Chamber, described the processes at the following gold mines:—Ivanhoe, Oroya, Brown Hill, Associated Northern, Sons of Gwalia, Kalgurli, Perserverance, Proprietary, South Kalgurli, Associated, Lake View Consols, Golden Horseshoe and Great Fingall Consolidated. Most of these companies operate at Kalgoorlie, and as treatment costs are important features in connection with the mines, thus necessitating constant alteration of the plants to get a maximum of extraction at a minimum of cost, there have been many modifications in the plants since the articles were written. The Chamber has, however, attempted to keep pace with the progress in this direction, and a majority of the original articles has been supplemented by information in the form of addenda. The book contains over 180 pages, and the principal features of the various plants described are illustrated with reproduced photographs and diagrams. It should serve as a splendid record of the metallurgical practice in Western Australia up to September, 1906."—*Australian Mining Standard*, Feb. 20, 1907, p. 171. (W. A. C.)

LEAD SMELTING AND REFINING. Compiled and edited by W. R. INGALLS. Published by the *Engineering and Mining Journal*, New York City. Octavo. Cloth. Pp. 311. Illustrated. Price $3.

"A work concentrating a vast amount of information relative to the recent progress of the lead smelting and refining industry, a compilation of the important articles on the subject published in the *Engineering and Mining Journal* in the last three years. Among the most valuable features are detailed descriptions of the new process of lime roasting, including the Huntington-Heberlein, the Carmichael-Bradford and the Savelsberg experiments. The volume is up to date in every detail and conveys comprehensively the progress and advancement made in other branches of lead smelting that has been developed in the recent past. It embodies valuable information which will materially assist the lead smelter when perplexing problems confront him, and altogether the treatise will prove of the greatest practical utility to all smelters and metallurgists.

The table of contents is as follows:—Chapter I.—Notes on Lead Mining; II.—Roast—Reaction Smelting in Scotch Hearths and Reverberatory Furnaces; III.—Sintering and Briquetting; IV.—Smelting in the Blast Furnace; V.—Lime Roasting of Galena; VI.—Other methods of Smelting; VII.—Dust and Fume Recovery, including Flues, Chambers and Bag Houses; VIII.—Blowers and Blowing Engines; IX.—Lead Refining."—*Mines and Minerals*, Feb., 1907, p. 308. (W. A. C.)

ROCK MINERALS, THEIR CHEMICAL AND PHYSICAL CHARACTERS AND THEIR DETERMINATION IN THIN SECTIONS. By JOSEPH P. IDDINGS Published by John Wiley & Sons, New York. Cloth. Pp. 541. Illustrated. Price $5.

"A work easily the best and most complete published on the subject up to date.

Divided into two parts, the first composed of three chapters deals with the general principles and methods of research, the second point being devoted to the detailed description of the rock forming minerals.

Chapter I. is a complete discussion of the chemical principles involved in the subject, including methods of analyses, preparation of rock material and calculation of formulas from results. The second chapter deals with the involved physical principles, including crystallography, etching of figures, and determination of specific gravity. The third chapter descriptive of the optical properties of minerals gives one of the finest discussions of this rather difficult subject yet published in English, there being 100 pp. of text finely illustrated by copious drawings and diagrams devoted to this section.

The second and larger part of the work describes in its 300 pp. the various rock minerals in detail, many valuable tables being included and the various crystal forms being copiously illustrated

In conclusion, the optical characteristics of rock minerals are tabulated in a series of tables arranged according to their increasing refringence. An appended table of birefringences illustrated by a large coloured diagram, adds much of value to the work. Altogether Prof. Iddings is to be heartily congratulated on this work which will prove a recognised standard for years to come."—*Mines and Minerals*, Feb., 1907, p. 308. (W. A. C.)

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.) 85/07. R. L. Cousens. Improvements in apparatus for the treatment of diamondiferous ground and metalliferous ores. 7.3.07.

(P.) 88/07. E. Mantel. New motive power with its method of application. 9 3.07.

(P.) 89/07. K. P. O. Koch. Coil safety time fuse. 11.3.07.

(P.) 91/07. A. H. Hobbs. Combination wagon and scotch cart. 12.3.07.

(C.) 92/07. L. Stange. Improvements in the manufacture of matches and igniting surfaces therefor. 12.3.07.

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(P.) 100/07. K. P. O. Koch. Automatic street indicator for electric rail and tramways. 15.3.07.

(C.) 101/07. G. D. Ross. An improved wheel for motor vehicles. 15.3.07.

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(P.) 104/07. F. Swanton (1), B. Price (2). Improved detachable bit holding crown and self locking cutting bits for percussion rock drills. 18.3.07.

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(C.) 109/07. F. F. Moore. Improvements in jockeys or rope grips for mechanical haulage arrangements and the like. 20.3.07.

(C.) 111/07. R. K. Donald. Improvements in cradle crushers. 21.3.07.

(P.) 112/07. A. E Duguid. Improvements in or appertaining to trolley wheels or collectors for electric traction. 21.3.07.

(P.) 113/07. P. A. Chiappero. Improvements in or appertaining to rock drilling machines. 21.3.07.

(C.) 114/07. W. Dunz. Improvements in laying jointless stone-wood flooring. 22.3.07.

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