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Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

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Proceedings
AT
Ordinary General Meeting, February 18, 1911.

The Ordinary General Meeting of the Society was held in the Lecture Theatre of the South African School of Mines, on Saturday evening, February 18th, Dr. James Moir (President) in the chair. There were also present :—

51 Members : Messrs. C. B. Saner, W. R. Dowling, Tom Johnson, E. J. Laschinger, H. A. White, W. A. Caldecott, E. H. Johnson, R. G. Bevington, A. McA. Johnston (Members of Council), E. L. Adams, S. Beaton, G. H. Beatty, W. Beaver, A. J. Bowness, J. Brown, J. Chilton, M. H. Coombe, W. M. Coulter W. J. Creasey, M. Dodd, M. J. Doyle, A. L. Edwards, R. Gascoyne, W. L. Hamilton, J. H. Harris, A. B. Inglis, A. J. Johnson, W. W. Lawrie, G. A. Lawson, H. S. Macgregor, L. Marks, H. Meyer, Prof. J. Orr, E. Pam, C. S. Parry, J. F. Pyles, E. Roberts, K. K. H. Sartorius, A. Schwarz, G. H. Smith, Ralph Stokes, J. A. Taylor, W. A. C. Tayler, A. Thomas, C. F. Thomas, F. W. Watson, J. Watson, E. M. Weston, and A. Wilkinson.

17 Associates and Students : Messrs. H. Abao, J. Gibson, T. W. Gilbert, J. S. Grace, A. King, H. G. Kirkland, L. T. Leyson, H. J. v. d. Merwe. H. A. Pattle, F. J. Pooler, R. Sawyer, H. Stadler, A. H. Thomas, J. Thorlund, I. Tom, E. J. Wiseman and A. L. Wright.

30 Visitors, including Sir Wm. Preece, K.C.B., F.R.S., and Fred. Rowland, Secretary.

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

NEW MEMBERS.

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

DICKSON, GORDON FRASER, London and Rhodesian Mining and Land Company, Limited, Lonrho Buildings, Salisbury, Rhodesia. Mining Engineer.

HAWLEY, THOMAS, Commercial Hotel, Salisbury, Rhodesia. Miner and Prospector.

IZOD, EDWIN GILBERT, Messrs. H. Eckstein & Co., P. O. Box 149, Johannesburg. Mechanical Engineer.

LAURIE, ROBERT ANTHONY, Crown Mines, Limited, P. O. Box 158, Fordsburg. Shift Boss.

LILLY, ALEXANDER, Princess Estate and Gold Mining Company, Limited, P. O. Box 114 Roodepoort. Mill Manager.

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

As Associates.—

INNES, CHARLES WILLIAM ROSE, Knights Deep, Limited, P. O. Box 143, Germiston. Cyanider.

JAMESON, JOHN JULIUS IRVINE, P. O. Rooiberg, *via* Warmbaths. Mine Manager.

TAMPLIN, ERIC HORNBY, Ferreira Deep, Limited, P. O. Box 5977, Johannesburg. Reduction Works Learner.

TAYLOR, MICHAEL, Princess Estate and Gold Mining Company, Limited, P. O. Box 114, Roodepoort. Cyanider. *(Transfer from Student Roll.)*

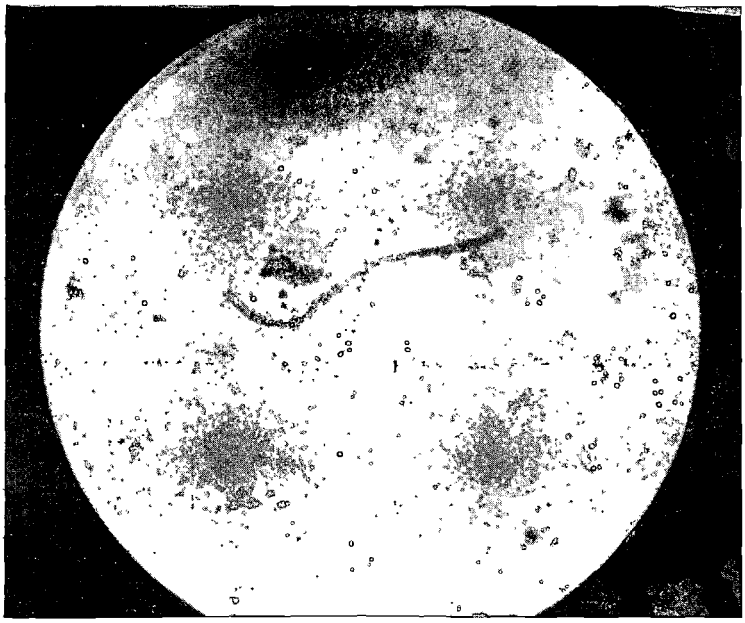
VAWTER, J. E., Knights Deep, Limited, P. O. Box 143, Germiston. Mining Engineer.

WELSFORD, HUBERT MEREDITH, Knights Deep, Limited, P. O. Box 143, Germiston. Cyanider.

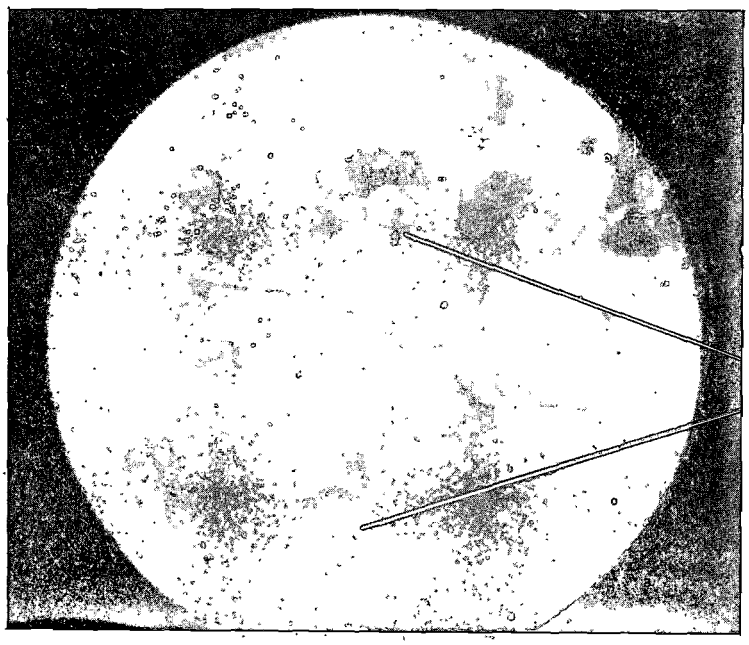
WILSON, GEORGE CALDWELL, Mysore Gold Mining Company, Limited, Marikuppam, Mysore State, S. India. Chemist.

GENERAL BUSINESS.

The President : I have some more slides to show you in connexion with the mine-air question. They were done in order to see if the fog of upcast shafts (which is due to rarefaction) contained any silica particles. Mr. Hildick Smith got me the samples by exposing glucose slides for 15 minutes underground near the upcast shaft of the Ferreira G. M.—a mine which contains much timbering. The top one shows no silica but a fungus filament and many oval spores and a few cocci, also a large flat cell which may be derived from skin or epithelium. The lower one shows a large piece of decayed timber about $\frac{1}{6}$ mm. long, also a number of flat cells and two pieces of quartz.



Organic Dust from Ferreira G.M. × 800.



From Air of Ferreira G.M. × 500.

The President introduced Sir William H. Preece, K.C.B., F.R.S., who, he pointed out, should be very well known to them all as one of the pioneers of electricity, particularly in wireless telegraphy, and who had an announcement to make as to a scheme for the advancement of mining and metallurgy, namely, the Bessemer Laboratory at South Kensington.

Sir William Preece, who met with a hearty reception, said: Gentlemen, it gives me great pleasure to renew my acquaintance with Johannesburg. I was here six years ago with the British Association, but I had not then acquainted myself sufficiently with the peculiarities of the atmosphere in the Transvaal. I was rather more interested in the new scenery, so much so that I was from 5 o'clock one cold morning until late in the day examining the beauty of the scenery from the platform of the train with the result that I caught a severe chill, but I managed to struggle one day into one of the sections and read a paper on "Wireless Telegraphy." I was subsequently taken all round about and I saw distinctly the nucleus of something that was going to be very big and very satisfactory. I come here now six years afterwards and I find that in every respect my anticipations have been realised. The place has grown immensely; the population is greater. Institutions for the promotion of the practical application of science are growing fast, and the result is, I find myself now in what I firmly believe to be the greatest centre of electrical enterprise and electrical energy in the British Empire. We have nothing so astounding to show the Britisher at Home as what you have to show him here. It passes all human understanding to see the rate at which things have grown. I am, however, bound to say that during the past six years we have not been quite idle at Home. One of the movements in which I have taken a very active part has been the work of the Standardisation Committee. I have been a member of the Electrical Standards Committee since its formation, about thirty years ago, and we have done well. Our electrical units are in universal use. We have established standards that are being followed everywhere, but we are not satisfied with the first and great point we started with. It was not so much to establish a system of measurements, but to start with firm decisive definitions which shall clearly express to everyone the properties of materials, the nature of operations, and the result of actions. In the same way, strangers like myself who come here would wish very much that we had a dictionary of the terms which have grown, flourished and stayed here, but are not very well known in distant places like poor old London. I would suggest that you should be asked to give us clear and well thought-out definitions of such things as slime, sand, concentrate, tailing, etc., things common to everyone of you, but things we know precious little about until we get here. Now that leads me to this, that I also notice the great strides that have been made in the advance of education, and it is in technical education, more than any other that we want to see progress made. We are doing very well in London. To-night the principal object of my remarks is to lead you up to the fact that we are establishing in London what I think will prove to be the most perfect laboratory for mining and metallurgy that is to be found anywhere. It arose in this way. A good many years ago it was decided to erect a memorial to Henry Bessemer, and a committee was formed to organise the collection of funds for the erection of this memorial. We did very well. Our late King Edward VII. laid the foundation stone of the building. We have every reason to hope that the laboratory will be opened by King George V., not very long after the Coronation. The building itself is complete. It is, as far as we are aware, the largest laboratory of the kind in any part of the world. It will be equipped with every possible form of apparatus that will contribute to the complete education of the mining and metallurgical engineer. We are promised help in all directions. We want the help and assistance of the British manufacturers. They are rather difficult gentlemen to move. In America if they want anything for a laboratory the American engineers vie with each other in supplying apparatus and never think of making a charge. In England, the first thing if there is some money in hand, and it is known that certain apparatus is required, is to be waited upon by some agent who wants to get a good order. That is not what we want. We want them to come forward and simply say "I will let you have this," and then we shall get our apparatus right up-to-date and ready for use without having to pay agents' commissions and manufacturers' profits.

Now there is an idea that we are rather behind in England in technical education. I do not think that is just. I do not know that there is any technical institute in this world that has been so successful in sending accomplished students out into the world as our School of Mines. Again, if you take Naval Architecture I do not believe there is any country that can show students of Naval Architecture who have acquired such positions and such great eminence. I do not think I should be very far wrong in saying that we are not very much behind in electrical engineering. I ought not perhaps to do that for I can only do it by making a boast, as I was

the first to establish a school of electrical engineering. That was in Southampton in the early sixties. I turned out two or three good students. One of the earliest was Prof. Ayrton, who lectured to you when the British Association was here. Another one, who was by far the most able man I ever had with me, and who (very foolishly I think) dropped engineering, was Sir James Sivewright. I only want to mention these facts to point out to you how interested I am in the advancement of education. I cannot suggest anything to improve the conditions of education in this country, especially when we are here in a building erected for the very purpose. We have nearly completed in London the Imperial College of Science and Technology, of which we shall be proud. I am not going to ask for anything, but I say this, that if I am spared I shall come here again one or two years hence, and I am sure I shall find in this very live place a constant steady improvement. I have visited America four times, and spent three months there on each occasion, and I have come back from America with the feeling that there is something in the electrical contact between Briton and American to the great advantage of the Briton, for he acquires by this contact a species of electrical energy. He is a better fellow to work with, and knows his work better. I believe the reason to be—not that there is any racial difference between American and Briton—that the former lives in an atmosphere totally different to that of London. There is an atmosphere—a champagne-like atmosphere in the States which makes one lively immediately one gets there. You never tire there. You work all day there. I come to Johannesburg and find that you are all imbued with the same kind of champagne effect. In your low atmospheric pressures, in your climate, in your surroundings, and in the busy world in which you live, there is not much difference between the life of the Johannesburger and the very active New Yorker. There were several young Britons who came out with me on the steamer. It is good for them to come to such a place as this, for we are kept down at Home by our atmosphere and climate. We have not the gorgeous sun you have here, we have not the air you breathe, and we are utterly deficient in that energy such as managers here possess, supported by the enormous capital you have at your command. When we in England want capital for any purpose we cannot get it. There is something in the company promoter which deters the public from subscribing. As an active exponent of new things electrical I have almost cried over the way our proposals are met by the financial members of the City of London. I will give you one case. I had a little apparatus that might be useful for anyone, for household purposes, for office purposes, and for many other purposes, even Government purposes. I only wanted £10,000 to start this thing, and I went to one of the leading men on the Stock Exchange, a personal friend. He was a very wealthy man and one who was connected with a great many successful undertakings. He said, "Well, what do you want?" I said "Only £10,000." "Pooh!" he said, "If you want £200,000 or £300,000 I could do something for you; but £10,000, we do not look at that on the Stock Exchange!" The result was I did not get my money from him; I had to get it myself! Gentlemen, I have had the great pleasure of coming here to-night and, whatever I have said has been with the firm desire that you will go on as you are going, and that in the immediate future I may come here again and find as great an advance in Johannesburg as in the last six years.

Mr. E. J. Laschinger (*Member of Council*): We very much appreciate Sir William Preece's remarks to us. He has taken the trouble to come here to see the Society at work, and to give us encouragement. I think it a great honour when a man of Sir William's standing comes here to say what he has said. He has told us about the marvellous developments which have been made in Johannesburg since he was here last, and expressed the hope that we will continue to expand and progress. Further, with regard to the mining and metallurgical laboratory which is being opened in London, we, as a Society, ought to take a lively interest in it as much as possible, and keep in touch with what is going on in the great financial centre of the world. It is to some extent perhaps a fallacious idea that the people in England are behind the times. It might have been true some time ago, but they have taken the challenge up, and we all know that a great deal of the best work in the mining and metallurgical world emanates from London to-day. This is because they have obtained the co-operation and assistance of various technical societies and workers all over the world. They have recognised the principle that science is universal, and that the best results are achieved by all working together, concentrating their ideas, and putting the best forward as a standard for those who come after to start from. I think I am voicing the opinion of members when I say that we owe Sir William a hearty vote of thanks for attending our meeting this evening.

Sir William Preece: I need hardly say I am very thankful to you all for the kind reception you have given my remarks. I wish they had been a little more carefully considered, but at the same time I think I have spoken rather more

from the heart than the head. I have taken every possible opportunity to find out what you are doing here, and during the time I remain, I shall probably worry a few more of you to give me a little further information.

The President (*Contributed*): I have just received from Mr. A. C. Claudet an account of the Imperial College of Science and Technology, from which the following extract will be interesting:

The Mining Department.—"The main entrance to the mining section will be in Prince Consort Road, and the buildings in their entirety occupy a space of about 1½ acres, with a frontage to Prince Consort Road and to Exhibition Road. The buildings will accommodate the mining, metallurgical, geological and engineering departments—the three first named being to the west of the building and the engineering department to the east. The mining department includes on the ground floor, a large court, lighted from the roof, about 246 ft. long × 125 ft. wide.

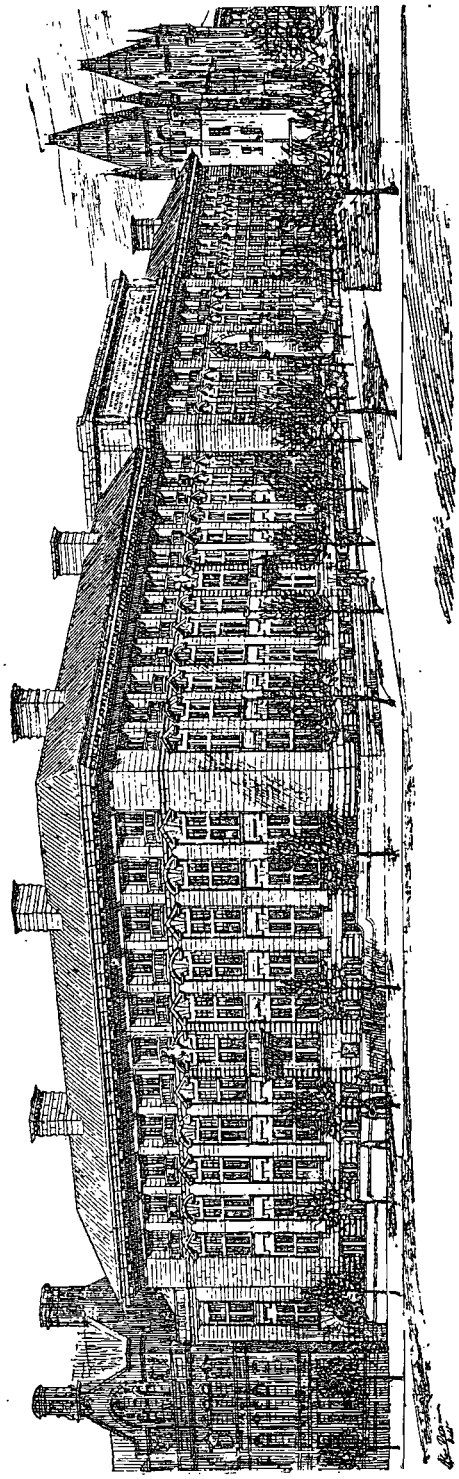
Another court adjoining will contain the roasting and smelting furnaces, in connection with which are the laboratories for wet and dry assay, with balance-room, lecture-room, laboratories for micrography, pyrometry, electro-metallurgy, the advanced course of metallurgical operations, and the equable temperature room. In connection with the mining department are two large lecture-rooms, museum and drawing office, machinery, assay, laboratory, and departmental library,

The geological department on the second floor contains laboratories for palæontology, petrology, mineralogy, economics and rock cutting, a museum 86 ft. × 40 ft., elementary laboratories, large drawing office, and research rooms.

All the buildings will be of the latest construction, fire resisting, amply lighted in both rooms and corridors, and laid out on simple and direct lines, with easy staircases and lifts at frequent points and good cartway approaches at the rear to all departments. There will also be large store rooms and separate cloak and lavatory accommodation for staff and servants. The building will be lighted throughout with electricity and heated by hot water and by steam, both electric current and steam being probably supplied from the central station.

There is a plot which lies to the north of Prince Consort Road, and here the building to be erected will contain on the ground floor a lounge hall, large dining-room and kitchens, smoking-room, ladies', guests' and committee rooms. On the upper floor will be provided a large concert and debating room, to be used also as gymnasium library and reading-room, and rooms for staff, with a separate entrance.

The Bessemer Laboratory.—The Bessemer Laboratory is now being equipped with machinery.



Sketch of Proposed New Buildings at the corner of Exhibition Road and Prince Consort Road, South Kensington.

It is, as already stated, a top-lighted building about 240 ft. × 125 ft., with large upper ore sampling floor, an upper concentration floor, and a main concreted lower floor. All the usual type of wet and dry crushing machines will be installed with amalgamation, concentration, cyaniding and other processes, arranged for practical working scale tests of ores. In the metallurgical department there will be various types of furnaces to illustrate the teaching courses; the chief object of the whole arrangement being for the purpose of illustrating in a practical manner the teaching work of the professors.

The installation, though far from complete, already comprises a five-stamp battery, two-stamp battery, two crushers, a Huntington mill, two ball mills and elevators, all of full size such as would be found in operation at an ordinary mine. In fact the laboratory is on a scale commensurate with the working of a good-sized mine. It is quite correct to say that no such laboratory exists in any other part of the world.

No doubt seems to be felt that the mining building will be completed by the end of the year, from which time the training of the future mining engineer and metallurgist will be on an infinitely broader and more satisfactory basis than it has ever previously been.

How the Movement Originated.—The movement was started by the Institution of Mining and Metallurgy in 1901, and has been well described by Mr. McDermid, its secretary, as "for the co-ordination and re-organisation of higher technological education at South Kensington." The Government of the day has been most sympathetic, as no one can doubt who reads the speech of Mr. Haldane at the annual dinner of the Institution some eighteen months ago.

What the College will do for the Student.—Having thus described the Imperial College of Science and Technology in its relationship to the industries of mining and metallurgy, it is well to be precise in stating what it is calculated to do for the student in both these branches of his profession.

Mr. Claudet says: Let anyone go to South Kensington and examine what is being done there, and, if previously unacquainted with the subject, he will be astonished at what he sees. Practical metallurgical work is there to be conducted on a large scale in the new Bessemer laboratory. Much of the equipment which is of an elaborate kind is being provided out of the Bessemer Memorial Fund, and a large amount has already been spent.

The contention running through a recent article in the *Mining World*, entitled "How to Train Miners," was that the instruction given in the School of Mines (temporarily located in the old premises at South Kensington) is theoretical rather than practical, but this is not so, as I shall have little difficulty in proving. Students can go through a four-year course and obtain the advantage of a fifth year as Post-Graduates at mines in this country and abroad, under conditions I will presently explain. Hitherto, the Royal School of Mines has not been so advantageously placed for giving practical underground instruction as the schools in Cornwall, but it is obligatory under the present curriculum that a certain amount of practical work underground shall be done by the student during the long vacations. After the ordinary theoretical course, *plus* the underground experience gained during vacation time, any student who has obtained his associateship of the Royal School of Mines is eligible for selection for a Post-graduate course in Mines or Works, at home or abroad, inaugurated by the Institution of Mining and Metallurgy some eight years ago. Twenty or more graduates of the Royal School of Mines and other recognised colleges are selected annually by the Council of the Institution for these Post-Graduate courses, and those selected are subjected to thorough medical examination before their selection is confirmed. During the course (which is for one year, except in India, where it is for two years) the graduates are rotated through all the departments of the mines or works to which they are sent, and they receive from the mine owners remuneration which is more than sufficient to cover the cost of living. In addition to this, the Institution awards annually five scholarships of £50 each, and makes grants in certain cases from a special fund in its possession. The Council in their annual reports have frequently expressed their gratification at the results of these courses, which are far-reaching in their effect. It may be useful in this connection to quote what Sir Julius Wernher said about the Post-Graduate courses so recently as December last: 'I know of a good many Post-Graduate students who have been sent to South Africa and can say I have never heard a complaint about them. I believe they have always done their duty and will be a credit to your Institution in the future."

PROFIT PER FATHOM.

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

These are a few notes in favour of a partial adoption of Mr. H. F. Marriott's fathomage system,* bringing forward certain favourable points, which I do not consider he made the most of.

* *S.A. Mining Journal*, March 12, 1910, p. 29; and March 26, 1910, p. 105.

With widely varying conditions, such as stope widths, nature of hanging, etc., it is impossible to say exactly what is the total cost (mining and reduction) of rock broken in any particular stope. The best we can do is to obtain a working approximation. The actual cost of stores and labour for any one stope is known accurately, but this charge amounts to less than one-fourth ($\frac{1}{4}$) of the total cost, in the case of large machine stopes.

The other charges shown in Table I. cannot be directly apportioned to each stope, but are distributed over hand, machine, small machine stopes, and the average for each class determined. All charges are distributed on a fathomage basis, with the exception of tramming, hoisting, reduction and residue. These latter are on the tonnage basis.

Sorting.—The value of sorted rock is often taken as one pennyweight. In a series of prolonged experiments I obtained a waste value of 0·4 dwt., when sorting from 10% to 20%, with very small variations in individual assays. It would seem, therefore, at first sight that a deduction should be made from the value per fathom to allow for the amount sorted. In the stope valuation, however, all waste rock is taken as being of no value, and all assays less than 1

TABLE I.

				SW″		SW″		SW″
Fathoms (measured) ...		2,568	1,190	55	1,140	122	238	40
Fathoms adjusted ...		2,758	1,310	—	1,200	—	248	—
Tons		59,476	18,000	—	39,000	—	2,476	—
Allotted.	Method Distribution.	Total Amount £	Hammer £	Shillings per Fathom.	Big Machines £	Shillings per Fathom.	Small Machines £	Shillings per Fathom.
Compressor Charges ...	F	1034·7	—	—	852·0	14·2	182·7	14·7
Rock Drill Maintenance	F	727·5	—	—	595·0	9·9	132·5	10·7
Machine Drill M & Sharp	F	593·6	—	—	485·0	8·1	108·6	8·7
Air Pipe Maintenance	F	95·4	—	—	77·5	1·3	17·0	1·4
Rigging	F	559·0	—	—	559·0	9·3	—	—
Hand Drill M Sharp ...	F	740·5	740·5	11·3	—	—	—	—
Central Pump ...	F	521·2	247·0	3·8	227·0	3·8	46·8	3·8
Tramming	T	3049·6	924·6	14·1	2000·0	33·4	125·0	10·0
Hoisting	T	1393·4	422·0	6·4	915·0	15·2	56·4	4·6
Timbering	F	664·6	316·0	4·8	289·0	4·8	59·6	4·8
Mine Administration...	F	783·1	372·0	5·7	340·0	5·7	71·1	5·7
General Charges ...	F	461·0	219·0	3·3	201·0	3·3	41·0	3·3
Sub Accounts	F	187·2	89·0	1·4	81·5	1·4	16·7	1·4
Underground Extras		10809·9	3330·1	50·3	6622·0	110·4	857·4	69·1
Stores and Labour ...	F	—	—	110·4	—	65·6	—	72·7
Total Underground ...	T	—	—	161·2	—	176·0	—	141·8
Reduction	T	9300·0	2820·0	49·1	6100·0	101·5	380·0	30·6
General Charges ...	F	1540·0	731·0	11·0	670·0	11·2	139·0	11·2
Residue	T	4360·0	1320·0	20·0	2860·0	47·6	180·0	14·5
		—	—	74·1	—	160·3	—	56·3
Total Deduction ...		—	—	235·3	—	336·3	—	198·1
Less Stores and Labour		—	—	110·0	—	65·6	—	72·7
Additions for Tables 2, 3 and 4.		—	—	125·3	—	270·7	—	125·4
Total excluding Residue		—	—	215·5	—	288·7	—	183·6
Cost per Ton ...		—	—	15·6	—	9·5	—	18·4
					Total cost per fathom mined			244·0
					Total cost per ton mined			11·7

dwt. are returned as a trace and calculated as of no value. No doubt some of the 0·4 dwt. of waste rock assay is due to mud derived from richer rock. On the other hand some waste rock, such as portions of "black bar" and poor looking bastard, assays considerably more than 1 dwt. It is, therefore, best to take the value of the waste as it is reckoned in the valuation, *i.e.*, of no value. So the value per fathom of any stope is unaltered by sorting. Sorting cannot raise the number of dwt. in a fathom, and its only effect is to reduce the total reduction charge. This charge, in a perfect method, should be distributed over each stope, according to the proportion which it is estimated could be sorted from the stope. In practice this is impossible, as anyone who has tried it will admit. The sorting charge has, therefore, to be put in with the other general charges. When, however, a stope is on the border line of unpayability, it should be examined to see if the average percentage sorted applies to it or not. If it is capable of a very large amount of sorting, special allowance must be made, which will increase its payability.

Fathomage.—A practical difficulty, that will arise on most mines, is that the tonnage as reckoned from the fathomage by the surveyors will be considerably short of that returned by the reduction department. In my experience, even this latter return is often materially short of the truth. Every effort should be made to secure agreement in the tonnage; stope widths must be checked, and allowance made for stripping of foot and hanging wall. The tramming returns

TABLE II.—HAMMER STOPES.

+125·3.

	Inch.	Dwt.	Fathoms.	Stores and Labour. £	Shillings. Stores and Labour cost per fathom.	Shillings. Value per fathom.	Shillings Profit per fathom.	Shillings. Loss.
10 W 1 E	45	7·7	59·7	351·7	117·5	364	121	
10 W 1 W	57·3	4·4	36·6	328·5	145·0	349	79	
10 W 2 E	65·4	10·4	8·4					
10 W 3 E	52·7	2 3	6·5					
10 W 3A E	55·5	6·0	10 5	176·3	175	284	16	
10 W 3 W	47·7	7·9	2·9					
10 W 4 E	79·8	4·9	22·5	293·8	180	388	83	
10 W 4 W	51·1	2·5	10·0					
10 W 5 E	38·1	10·1	86·1	396 0	92	405	188	
10 W 5 W	36·9	8·3	65·7	375·8	114	322	83	
11 W 1 E	44·0	5·0	44·3	205·0	93	231	13	
11 W 1 W	50·4	10·5	41·0	296·6	142	556	289	
11 W 2 E	47·3	2·3	14·2	171·3	98	376	153	
11 W 2 W	47·3	11·4	20·6					
12 W 1 E	40·4	7·0	32·5	348·0	95	416	196	
12 W 1 W	59·0	8·7	40·6					
12 W 2 E	41·2	5·1	45·5	298·9	131	221		35
12 W 2 W	51·1	6·9	51·7	313·5	121	371	125	
12 W 3 E	48·9	11·0	65·0	340·2	105	566	336	
12 W 3 W	50·1	6·9	39·2	360·9	90	412	197	
12 W 4 E	57·7	7·8	40·9					
12 W 4 W	39·1	17·7	28·9	136·5	94	726	507	
13 W 1 E	40·4	4·0	48·6	177·1	70	168		27
13 W 1 W	74·2	7·3	66·5	329·3	99	569	345	
13 W 2 E	65·8	8·1	59·4	318·9	107	560	328	
13 W 5 W	43·6	3·2	31·4					
14 W 1 E	43·2	10·4	11·4	389·4	111	289	53	
14 W 2 W	57·3	1·8	21·2					
14 W 2 E	56·5	3·6	5·8					

Average cost, stores and labour per fathom = 110·4 shillings.

Average stope width ... ... = 55 inches.

TABLE III.—MACHINE STOPES (LARGE MACHINES).

+270·7.

	Inch.	Dwt.	Fathoms.	Stores and Labour. £	Shillings. Stores and Labour cost per fathom.	Shillings Value per fathom.	Shillings. Profit per fathom.	Shillings. Loss.
1 W 2 E	143	2·4	31·2	102·7	65·6	360	24	
1 W 3 E	130	4·8	26·5	91·6	71·8	655	313	
1 W 3 W	133	4·4	20·7	96·2	92·8	612	249	
2 W 2 E	107	2·3	38·1	85·0	44·5	259		56
2 W 1 E	120	2·4	36·9	102·5	55·6	303		23
2 W 3 W	133	3·5	35·1	108·7	61·8	490	158	
2 W 3 E	162	1·8	26·2	98·5	75·1	306		40
4 W 2 E	55	3·3	36·5	109·5	60·1	189		141
5 W 3 E	116	4·2	25·2	91·4	72·5	512	169	
6 W 1 E	137	3·3	22·7	96·0	42·3	475	162	
6 W 1 W	132	3·6	20·6	49·5	48·0	499	181	
7 W 1 E	118	2·9	64 7	264·2	81·6	359	7	
7 W 1 W	120	3·9	26·7	74·5	55·7	492	166	
8 W 1 E	105	4·8	30·6	96·5	63 0	530	197	
8 W 1 W	88	2 4	37·0	106·6	57·5	222		106
8 W 2 E	85	2·4	55 0	138·1	50·1	214		107
8 W 2 W	112	2·6	31·5	109·5	69·6	306		34
8 W 3 E	100	2·6	35·4	90·5	51·2	273		49
9 W 1 E	120	2·6	36·5	128·8	70·4	328		13
9 W 1 W	143	2·6	19 1	88·3	92·4	390	27	
9 W 2 E	130	2·3	27·0	104·8	77·6	314		34

Average cost, stores and labour per fathom = 65·6 shillings.

Average stope width ... ... = 122 inches.

TABLE IV.—MACHINE STOPES (SMALL MACHINES).

+125·4.

	Inch.	Dwt.	Fathoms.	Stores and Labour. £	Shillings Stores and Labour cost per fathom.	Shillings. Value per fathom.	Shillings. Profit per fathom.	Shillings. Loss.
1 E 1 E	43·7	11·0	26·0	145·5	112·0	505	268	
1 E 1 W	44·0	8·0	36·3	139·0	76·6	370	168	
1 E 2 E	52·4	5·4	19·9	79·2	79·6	297	92	
1 E 2 W	40·6	18·0	21·0	87·4	83 0	768	560	
1 E 3 E	39·3	8·0	25·6	83·6	65·2	330	140	
1 E 3 W	32·1	20·6	27·4	97·8	71·2	661	465	
1 E 4 E	26·2	12·7	27·5	75·1	54 8	333	153	
1 E 4 W	40·4	3·5	17·3	23·5	27·2	148		4

Average cost, stores and labour per fathom = 72·7 shillings.

Average stope width ... ... = 40 inches.

are only useful to determine the proportion of rock trammed from the three classes of stopes The total tonnage from stopes, after making all known deductions, is then distributed over hand, machine and small machine stopes in the proportion of the trammer's tally. The distributed tonnage is then converted into fathoms by using the known average stope widths for the various classes of stopes (hand, machine, small machine). The new fathomage is known as "adjusted fathoms," and is used for purposes of distribution. Having thus outlined the method, I advance the following claims for it :—

1. That the essential factor, gold contents per fathom, is independent of sorting. This factor in shillings is given by the formula : Reef width (in.) × assay value (dwt.) × 1·05. It will be noticed that stope width does not enter into this factor.

2. That the final figure, "profit per fathom," conveys more to the mine manager than any other figure. He has a very good idea of what fathomage to expect from any stope in a month ; he thus knows which stopes to push when the profit falls.

3. That it will help the manager to escape that terrible bogey "grade." The cry for grade is as pernicious as the shout for tonnage, it is only the happy combination of the two that spells profit ; and this is what the manager wants, or should want.

From the tables it will be seen that while it pays to work certain stopes at 2·6 dwt., other stopes are run at a loss although assaying 5 dwt. This shows how misleading the sampler's value may be, if considered by itself.

Sampling.—It is not always advisable to stop a stope that shows a small loss per fathom, as the calculations depend so largely on the sampling. In any doubtful case the last three month's assays should be taken into account and the assay plans consulted to see if there is no chance of better ore ahead.

The sampling of a large machine stope is a very difficult matter, and I consider that a section should be made of each stope face, showing drives, cross-cuts, box-holes, above and below stope and giving values. (See Fig. I.)

These sections are of great value in showing what reef should be stoped or left. They also ensure the sampler taking an intelligent interest in his work, as a stope carelessly sampled will never plot well on a section.

Pay Reef.—On some mines the percentage of pay reef mined is determined for each stope. I have drawn up Fig. II. so that a sampler on being told the total underground cost per fathom for any class of stope (in this case 161·2 for hand, 176·0 machine, 141·8 small machine) can at once see what is the pay limit for any stope width. To this must be added the value of the residue unrecovered.

Reduction of Tonnage.—In the hypothetical mine considered, let us say 60,000 tons per month are being crushed with 200 stamps. Suppose that all stopes which give a loss or a doubtful profit are stopped. This will knock off about 13,000 tons per month, and it will be possible to close down 50 stamps. The saving as shown by the sheets would be about £1,150. But it will be obvious that although we are reducing our tonnage by one-fourth, the costs will not be decreased in the same proportion. For example, one quarter of the reduction costs will be about £2,710 ; practically the saving will not amount to more than £1,460. This difference must be borne by the remaining tonnage and cancels all that was saved by stopping these stopes. It appears, therefore, that no great advantage would accrue by shutting down all stopes that

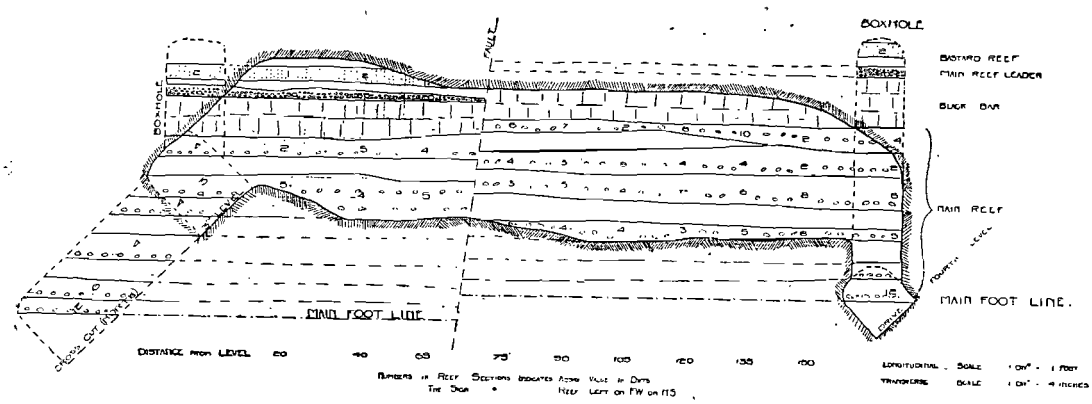
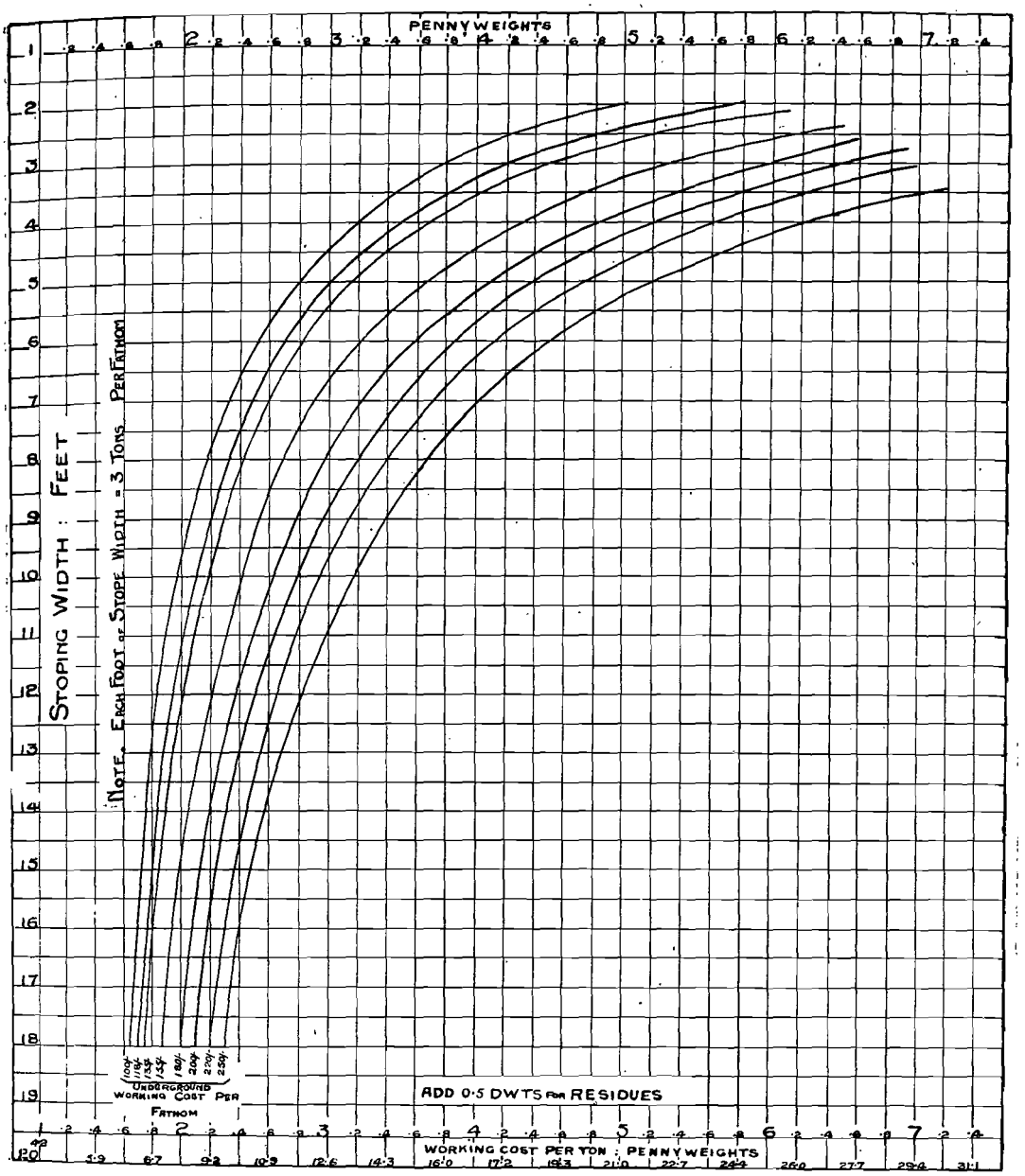


FIG. I.—4W3E Stope : Numbers in Reef Sections indicate Assay Value in Dwt. The Sign + indicates Reef left on F.W. or H.S.



Curves showing Limit of Payability for Varying Stope Width and Cost per Fathom.
Reduction Cost per ton taken at 4s. 6d. per ton mined.
General Charges ,, ,, 6d. ,,
Sorting 10 per cent.
(Development Redemption excluded.)

FIG. II.—Working Cost per Ton (Pennyweights).

show a loss, the correct course being to stop only those stopes which show a heavy loss, and put the machines or hand labour into better stopes.

On a large mine, that is divided into sections under the control of mine captains or shift bosses, it is advisable to call for a certain tonnage of a certain grade from each section, and the grade called for by the stope assays should be worked out daily for the whole mine. This should agree very closely with the screen assays. I would go further and say that while still working out the daily grade for the whole mine as a useful check, the daily profit from each section should be called for, and let the grade and tonnage take care of themselves.

A sheet would be prepared showing name of stope, stope width (in.) and a constant. These will not be varied during the month if psssible. The constant for any one stope is :

$$\frac{\text{Capacity of truck (tons)} \times 4 \times \text{profit per fathom}}{\text{Stope width (in.)}}.$$

The daily entries will be number of trucks trammed, and the number of boys or machines working at that point. The daily profit for each stope would be calculated as follows :—

Trucks × constant = profit for the day.

The profit for each section can then be obtained by addition. The calculation is simpler and takes less time than that of the average grade.

A careful study of the results in the tables will repay those interested. A noticeable point is the efficiency of the small machines.

The figures given are compiled merely as examples.

For the sake of argument a proportion of the large machine stopes have been shown as of low value, so as to come out unpayable.

NOTE.—All the formulæ quoted above are worked out on a basis of 12 cub. ft. of rock, in the solid, = 1 ton (2,000 lb.)

A square fathom = 36 sq. ft.

$$\text{Hence } \frac{\text{Fathom} \times \text{SW (in.)}}{4} = \text{tons}$$

Also 1 dwt. has been taken = 4·2 shillings.

NOTE.—In Tables II. and III. the figures, over the column headed "Stores and labour, cost per fathom," represent the total addition to be made to this heading to give the total deductions.

The President: I have much pleasure in moving a hearty vote of thanks to Mr. Sawyer for his paper, and hope someone else, in whose province it is, will discuss it.

Mr. Chas. B. Saner (*Vice-President*): With pleasure I will second the vote of thanks. The paper contains a lot of controversial matter, but as I have only just seen it, I will not criticise it now.

PRACTICAL NOTES ON COAL.

By MICHAEL DODD (Member).

In contemplating the uses of coal and the history of coal mining, I am driven very forcibly to the conclusion that this invaluable, and exhaustible, commodity has probably been handled in a fashion more extravagant and wasteful than has any other article of the world's great natural wealth. Coal has often been mined by methods which have given little heed to the future; the economy and the profit of the moment were the only considerations. Secondary seams have been sacrificed by the adopted mode of working the best one, so that in almost every coalfield there are left behind millions of tons of valuable fuel which it will never be possible to reach again

In consumption, too, there has often been a measure of ignorance and indifference such that an infinitely greater tonnage of fuel was constantly being used than was justified by the amount of work got out of it. Probably this was evinced more at the coal mines themselves than anywhere else. In my young days it was estimated that a colliery might be expected to consume in its own boilers about 10% of its total product. But in less than a generation an enormous change has come about: Scientific education, the wider study of all economic problems, the improved mental equipment of engineers and of business-men, the advance of discovery, the crying demand for the cheapening of the cost of power, have all contributed to bring about this change. The engineer of to day is never worth his place unless he knows a great deal more about the character, the source, and the cost of his power supplies than the colleges were in the habit of teaching five and twenty years ago.

That which prompted me to bring forward these few notes was one of the questions put to candidates in a recent Examination for Mine Manager's Certificates. The question was the eminently practical one: "If you were called upon to make a contract for supplies of coal, how would you set about it?" And this question shall be borne in mind in subsequent remarks. Leaving out such questions as the origin of coal, the distribution of it, and the mining of it, I propose to discuss—(1) its composition, (2) the different classifications, (3) the uses of the different sorts, (4) the question of selection

(1) *Composition.*—Without going into the question of ultimate analysis, as being outside the scope of a purely practical paper, the composition of coal may be put down as consisting of volatile hydrocarbons, fixed carbon, sulphur, ash, water.

The first three of these represent the combustible portion, sulphur being invariably present as pyrite. In small proportion, up to .1%, the presence of sulphur may be of little consequence, but, if this limit be exceeded, the sulphur is a source both of trouble and danger; trouble, because, given the presence of some impurities in the ash, sulphur induces clinker in the process of burning, and danger, because of the tendency to spontaneous combustion. Fires, both in the hold and in the bunkers, have all too frequently occurred in sea-going vessels.

Water.—All coals contain a small proportion of water both free and in chemical combination. As a rule, deeper seams contain less water than shallower ones; and generally, also, the older the geological formation from which the coal is produced the smaller the percentage. To both these rules, however, exceptions are common.

The effect of moisture in the coal is simply to cut down, by whatever proportion may be present, the total percentage of combustible—indeed, the effect is slightly more than this, because a little of the combustible is used up in evaporating the moisture.

The ash represents the total of the solid incombustible constituents of the coal. No coal is entirely free of ash, though some come very near to perfection in this respect, for analyses of British coals with so little as 2%, are by no means uncommon. Yet the most wonderful sample which has come to my notice was of South African production: it was a bit of freak coal from the Karoo, which contained only ·2% of ash.

With not more than 1% S in the coal it may safely be carried oversea; 2% is a distinctly dangerous figure; 1½% would give pause to a buyer.

Classification.—All classifications of coal are based on the same principle, *i.e.*, on the relative proportions of volatile gases and fixed carbon. No two authorities agree in their classification, but a simple method is to write the sorts down as:—

Highly bituminous,	40% and upwards	of volatiles
Bituminous,	18 to 40%	,,
Sub-bituminous,	12 to 18%	,,
Anthracite,	less than 12%	,,

The coal known as cannel, and some gas coals, are of the first named. Household coal, according to *taste*, may be chosen from any of the four. Coking coals may be either the first or second, whilst steam coal of the most useful quality belongs to the second and third classes.

The uses of Coal.—(1) For Gas-making.—The introduction of electricity as an illuminant has made a vast difference to the consumption of coal gas; still in Europe, and especially in Britain, there is an enormous production of gas, both for lighting and heating. The most suitable coal for the manufacture of gas is one which is high in volatile hydrocarbons, and in which the relative contents of the various gases are such that the gas produced will be high in illuminating power. A high-class cannel coal, with volatile contents of probably 45%, will yield 13,500 cubic feet of gas per long ton, of illuminating power of 36 candles; a good Durham gas coal, volatiles 35%, about 12,500 cubic feet, and illuminating power of 16 candles. Selected Witbank District coal, with 33% of volatiles, gives over 11,000 feet per ton, and an illuminating power of slightly over 14. The long ton is here meant, as it is the British standard.

For Coking.—In the selection of coal for the purpose of coke-making, it would appear reasonable to assume that with the scientific knowledge of to-day, an expert ought to be able to put his hand on analyses of coal and declare off-hand which were or were not suitable for coke-making; but this does not seem possible. Some of the best British cokes are made from coal whose volatile contents exceed 30%, while some of the best American are from coal whose volatiles fall short of 24%. There are unexplained mechanical or structural differences in coals of similar chemical composition such that, while one of these coals will produce an admirable coke, another will not do so, failing, it may be, to give either cohesion, hardness, or porosity, each of which qualities is an essential of good coke. In addition, a good coking coal must be low in ash and sulphur contents.

Steam Coal.—It is, in this country, to a very small extent only, that we are interested in the manufacture of gas or coke. Coal to us is important only as fuel used in the generation of power. This phase of the subject calls, therefore, for more detailed consideration. For use in steam boilers we seek, of course, to get full advantage of all the combustible contents of our coal, whether in the form of volatile hydrocarbons or fixed carbon. In the process of burning, the fixed carbon remains on the fire grate until it is consumed, so that, roughly speaking, all the value is extracted therefrom. The volatile gases on the other hand, are set free by the heat of the fire, and immediately start off for the smoke stack, and in every case a proportion escapes. The gases are elusive, and some power thus escapes. At first it would appear from this that the greater the proportion of fixed carbon in your combustible the more economical the coal. Given a forced draught and an excessive grate area this, in certain circumstances, holds good But under ordinary conditions of firing, non-

volatile or anthracitic coal burns so slowly as to render it impossible to get out of the boiler the amount of work which ought to be expected. A coal, therefore, for steam purposes should be one which contains a sufficient proportion of hydro carbons to give flame enough to burn the whole with such rapidity as to get the best work out of the boiler, and yet a proportion sufficiently low to prevent undue loss of combustible by the chimney. The vital question in determining this is: "What is the percentage of volatiles in the best and most economical steam coal?" The question is not an easy one to answer, because the figure must, naturally, vary with varying conditions. The stronger the flue draught the less assistance does the furnace need in the shape of gases. The higher the percentage of ash in the coal the greater the need for flame to hasten combustion The so-called smokeless coals of South Wales contain 10% or 11% of volatile, but these in consumption call for a special draught. Welsh coals are best for steam purposes, under ordinary conditions of firing, when they contain from 13% to 17% of volatile, but such coals will contain probably from 2% to 6% only of ash. Natal coals contain from 9% to 12% of ash, and probably the best steam producers amongst them are those which contain from 18% to 21% of volatile. Amongst Transvaal coals we find that the best Witbank coals contain from 13% to 16% of ash. These in consequence may be expected to give the best result when the volatile contents are from 22% to 24%. If we recognize these figures as being approximately reliable, a very natural enquiry is, how much we should write down the value of a coal for steam purposes because it contains a higher percentage of volatiles than the figure which is considered to be the most economical? This is hard to answer, since the reply depends so much on other questions, as for instance: Are the boilers hand fired? What is the space between the bars and the boiler shell? But with the average boiler plants in use on the Rand in mind, I should be disposed to hazard the opinion, that as good results may be expected from a Witbank District coal whose percentage of volatile is 24%, and whose calorific value is 12·6%, as from one whose volatile contents are 29%, while giving a calorific of 13%.

Anthracite.—The world's supply of anthracite is comparatively limited in comparison with the abundance of bituminous sorts, yet the occurrences are far from being unimportant. This class of coal is extensively used in the large towns of Europe and America because of its smokelessness. It is used for steam frequently enough when its cheapness, as compared with other coals, is such as to justify the provision of forced draught to aid combustion, whilst it is of great service to the suction gas engines which have come to the fore so rapidly during the past decade. At the present moment the makers of suction gas engines ask for a coal containing not more than 10% of volatile matter, though there is little doubt that in time they will succeed in adapting their generating plants to the use of bituminous coal. As yet it would appear that the tar generated in the fusion of this latter class of coal calls for too frequent stoppages for cleaning, and an excess of hydrocarbon gases in the explosive mixture increases the danger of pre-ignition

Calorific value—I must now refer to a point in reference especially to steam coal which, perhaps, should have received notice at an earlier stage in my notes, *i.e.*, the estimation of the relative heating power of coals. This is usually spoken of as "calorific value," and calorific value means the number of units of water a similar unit of coal will convert from boiling point into steam. Thus, when the calorific value of a coal is said to be 12, we understand that one pound of such coal will, in the laboratory under ideal conditions, convert 12lb. of water into steam, after it has first been heated to boiling point. The instrument by means of which such a test is made is termed a calorimeter. Of these there are several in use, of which the best is the "Mahler Bomb," the standard instrument in use on the Rand. Another form of expressing the calorific value of a coal is in terms of the "British thermal unit." The value of a coal in British thermal units is the number of units of water which one unit of coal will heat from 60° to 61° Fahr. The number of British thermal units is arrived at by multiplying the calorific value by 966—the figure which represents the latent heat of steam. The calorific value of a coal is, of course, its heating power under ideal conditions, *i.e.*, its theoretical power. That which is obtained from it in actual boiler practice is a different matter. This latter—the percentage of efficiency—depends on the character of the boiler plant, and on the amount of care displayed in the management of it. There are mine plants on the Rand to-day which do not probably give more than 45% efficiency, while others do as much as 60%. In South African railway practice, a figure of 55% of three or four years ago has improved, in the newer locomotives, to over 60%. In the more modern and best equipped stationary boilers 70% has certainly been left behind; and with the most approved methods of mechanical stoking it is claimed for some plants, that the high figure of 80% is now being attained

This brings us to the consideration of the very interesting question referred to earlier in this

article, *i.e.*, the question which was set in the chemistry paper at a recent examination for mine managers' certificates: "If you were called upon to make a contract for coal, how would you set about it?" The following suggests itself as a practical sort of reply, viz.,

1. Call for tenders, to be accompanied by certificates of analysis and calorific value.
2. Rule out such tenders as are manifestly unsuitable, either from excessive price or known unsuitability of the coal offered.
3. Having reduced the choice to two or three, have these carefully sampled, and the samples analysed and tested for calorific value.
4. Decide on purchasing the coal which gives its heat unit at the lowest cost, provided:
   a. It does not clinker;
   b. It is neither too high nor too low in volatile contents;
   c. It is uniformly well separated and cleaned.

Naturally, the contract subsequently entered into must provide securities for the due delivery of coal of sample quality.

The United States Government buys a large tonnage of fuel. Some time ago the Minister responsible appointed a special committee of experts for the purpose of laying down on a scientific basis the conditions of purchase. A bulletin has been published explaining the conditions which have been adopted, and this contains some very interesting information. Both anthracitic and bituminous coals are purchased. In the case of anthracite, purchases are made on the basis of the percentage of ash contained in the dry coal, which means that all moisture is driven off before the test is made. A tender having been accepted, sampling is systematically carried out by a responsible official The samples taken are in quantities of not less than 100lbs, and these are carefully quartered down for analysis. Payments for the coal are made on the results of these analyses, credit being given the supplier if his coal shows a lower percentage of ash than that specified in his contract, while he is debited in the case of any excess. Credits and debits are calculated on a definitely fixed scale. When bituminous coal is purchased, the coal is rated on the ash factor, plus calorific value, and in such cases it is specified that the percentage of volatile contents shall not exceed a certain fixed figure. Such conditions appear sound, and are certainly effective, but they strike one as very elaborate, involving a labour and expense which would only be justified in the case of very large purchases. It is an easy and *inexpensive* matter to ascertain calorific value, while an analysis is a much more cumbersome piece of work.

Too much stress cannot be laid on the importance of correct sampling of coal if reliable results are sought for. I have known coal sampled by one man to be tested to a calorific of under 11, while a sample of the same bulk, taken by other hands has shown 12·5. The rough and ready way of sampling is to pick up a chunk of coal, good or indifferent, according to the result desired, and send that to the laboratory. A test of a sample so taken is valueless. Sampling must be done by taking from the various parts of a heap a large number of small portions, and the aggregate of these should be carefully mixed, crushed, and quartered down if sound results are sought for.

As a dissertation on coal, the foregoing is very incomplete and scrappy. The object has been to give prominence only to some of the main practical factors which are worthy of note in the consumption of coal, and especially in consumption for the generation of steam.

The President: I am sure this is a most excellent type of paper, and one which, in agreement with the title, is intensely practical. I think also we ought to congratulate Mr. Dodd on his excellent delivery, for I fancy we very seldom get such a good speaker.

Mr. A. McArthur Johnston (*Past-President*): In seconding the proposal to move a hearty vote of thanks to the author, I feel that we ought to congratulate ourselves on having such an authority to speak on this subject. Mr. Dodd, as we all know, has been long connected with the collieries of South Africa, and more especially of the Transvaal, and is therefore most competent to help us in estimating the value thereof.

With your permission I would take this opportunity of criticising the author's paper, because he is not always with us and I am anxious to let him see that though we may criticise severely in this Society sometimes, we do so, as one of our Past-Presidents used to say, *suaviter in modo, fortiter in re*.

Generally speaking, I am disappointed in the paper. From our knowledge of the author's attainments and of the store of figures which he must have by him pertaining to Transvaal coals, we were entitled to have expected from him information bearing on the local supplies. Such would have been beneficial not only to the gold industry, but to the coal mines and the country generally as advertising the class of coals which can be obtained here. His remarks are, too, very indefinite in many places, and seem to point to the intention of not giving too much away.

For example, he talks about the moisture in the coal as cutting down simply the total per centage of combustible—or slightly more than

this, since the moisture has to be evaporated. Now, I am in agreement with this remark when referring to Middelburg coals, which as a rule give a moisture content of under 2%, but I decidedly object to coals containing 8% or even 10% of moisture,* such as are on the market here, being placed under this category. This quantity of moisture will have a material effect on the value of the coal.

Again, I am disappointed at the author not giving us some information on the coking capabilities of the Middelburg coals. I had hopes that he would have placed before us some data showing how by picking or by mining one particular seam, with subsequent washing, a high class coking coal could have been obtained, on which future smelting works in the Transvaal might rely. We know that in the past a little good coke has been produced in the Transvaal, but we are anxious to hear from an expert what can be done, and what possibly will be done, now that the huge coal industry is under such powerful and concentrated control

I note that the author gives us a definition of the British Thermal Unit. As a practical definition I have no quibble to find therewith, but as a scientific definition I am anxious to have the point made clear. Consulting most of the text-books at hand I find quite a diversity of opinion. Carpenter[1], Cremer and Bicknell[2] and Jamieson[3] define the B.T.U. as the heat required to raise 1 lb. of water 1° F. at or near the temperature of maximum density 39·1°; Lunge[4], Schwackhofer and Browne[5] and Phillips[6] give as the temperature 32° F. to 33° F.; Roberts Austen[7], Lewes[8] and Poole[9] state 1° F. without mentioning the particular range; Sexton[10] affirms 60° F. to 61°, whilst Deschanel[11] states "there is not at present any very precise convention as to the temperature at which the cold water is to be taken. If we say that it is to be within a few degrees of the freezing point, the specification is sufficiently accurate for any thermal measurements yet made." Since such a diversity exists, it seems we had better refer this to the Standardization Committee. The point is interesting.

Another point worth noting is the pressure used in the Mahler bomb during combustion of the coal. In the report issued by the United States Geological Survey on the coal testing plant at St. Louis, 1904, it is stated in Part I., page 180, that a pressure of 18 atmospheres of oxygen was used in the bomb, except in some duplicate determinations, in which 25 atmospheres were used. As these gave practically identical results, the lower pressure was deemed sufficient. In December last Mr. E. A. Allcut* contributed an article on the effect of varying pressures on the calorific power obtained. Calculating at 25 atmospheric pressure of oxygen as giving the maximum heat value, he tabulates descending pressure results as follows:—

Oxygen pressure (atmospheres)								
25	20	15	13	11·3	9	7	5	3·2
Heat value (per cent. of maximum value.)								
100	99·7	98·6	97·7	97	95	90	71·75	59·6

Personally speaking, my experience favours, when burning the coal in powder form, that of the U.S. Geological Survey, but when doing test or check work it is our invariable practice to ignite with a pressure of 25 atmospheres.

Mr. Dodd bases much of his paper on the question "If you were called upon to make a contract for coal, how would you set about it?" To my mind this is a question set by examiners to find out how deeply the answerer has thought of, or even read of, such a subject, and I view the author's answer as being insufficient. He evidently thinks so himself, as he proceeds to tell us about the buying of coal by the United States Government, and the conditions laid down by them. I personally feel that he would have been quite justified by including such remarks in his answer to the question, and it would have been an excellent ending to his paper, had he drafted for our perusal a specification, under the terms of which he would have been pleased to sell coal.

If I may, I would like to mention two points, not very clearly brought out by the author. He quotes that credit is given the supplier if his coal shows a lower percentage of ash than that specified in the contract, while he is debited in the case of any excess. This fails to recognise that steadiness in the quality supplied is very material to good firing, and I should certainly advocate that coal falling below a certain definite value, be returned to the mine at the supplier's risk and cost. Again, I am in complete agreement with the author in emphasizing the care required in sampling, and would only point out the absolute necessity of sampling immediately after weighing and putting the sample obtained in an airtight box or jar, since loss of moisture very quickly occurs in the boiler shed, with, of course, consequent loss to the buyer.

I trust that these remarks will be taken by the author as fair criticism, and that they will stimu-

* *cf.* A. F. Crosse, this *Journal*, Vol. X., p. 311.

[1] Experimental Engineering, p. 311.
[2] Metallurgical Handbook, p 150.
[3] Steam and Steam-Engine, p. 32.
[4] Chemists' Handbook, p. 60.
[5] Fuel and Water, p. 12.
[6] Fuels, p. 25.
[7] Study of Metallurgy, p. 172.
[8] Liquid and Gaseous Fuels, p. 59.
[9] Calorific Power of Fuels, p. 3.
[10] Fuel, p. 35.
[11] Natural Philosophy, p. 311.

*Engineering, December 2nd, 1910.

late him to help us in threshing out this important subject.

Mr. E. M. Weston (*Member*): Mr. Dodd, in suggesting his answer to the question regarding selecting coals has, I think, overlooked one practical point which cannot be neglected, especially here on the Rand where some of the coals sold contain such a high percentage of ash. Should not one always hold a practical test of any coal with regard to the type of furnace and draught employed, and the boiler it must be burnt under? If one burns one of these high ash coals in an ordinary grate with natural draught under a water tube or tubular boiler, even if one burns nut-size coal only, one finds any laboratory tests of calorific power are useless and misleading. These tests may show a value of 6,000 or over in B.T.U.'s; but if one expects to get an evaporation of water anything like one might expect in accordance with that, one would be disappointed. Owing to the large percentage of ash an examination of the ash dump would probably show that only 60% to 70% of the carbonaceous matter had really been consumed, the unburnt carbon having gone to enrich and enlarge the ash dump. If, however, such a coal could be burnt in specially designed furnaces or mixed in proper proportion with a richer coal, better results might be obtained.

Mr. E. J. Laschinger (*Member of Council*): This subject of coal presents a very large field for investigation and discussion. There is one thing with regard to specifications in general. For whatever purpose material is required, I am a great believer in the fact that the only way to buy materials is to buy them on the specfication of their physical properties alone. The main disputes on contracts, especially coal, arise in this way. Coal is bought under certain guarantees of performance, and as soon as the guarantee is not fulfilled, the coal supplier is notified accordingly. He replies that the coal is not used properly, and so the dispute goes on, and there is nothing definite by which either party can come to a real settlement. The question as to what is a suitable specification of the physical and chemical properties of coal has been exercising the minds of most engineers who are responsible for the large power plants for the last 10 or 15 years, and more especially the last 5 years. A great deal has been published on the subject, and the only way to deal with it in regard to this discussion, is to get some of our members who know more or less about coal, to give us the salient points that should be included in the specification on coal.

Another point of scientific interest may arise from a discussion of the paper. The question is: does the Mahler bomb give a true idea of the heat value of coal? It is said that a great deal of heat which gas is supposed to give out in combustion is absolutely unaccounted for—15% to 20% of the power does not appear. We know that experiments have been made by well-known scientists recently, and it has been found out that, during the explosions of gas, there was energy transformed which escaped altogether without doing useful work of any kind, not even appearing in the form of heat.

Mr. M. Dodd (*Member*): I do not know whether it is desirable that there should be a reply to such points as have been raised immediately, or whether it is desirable they should form part of a subsequent discussion?

The President: As a rule a reply is given four months hence, but if there is anything urgent, you may as well give it to-night.

Mr. M. Dodd: There is nothing urgent, but there are points which I think properly belong to discussion later on.

Mr. F. J. Pooler (*Associate*): As a teacher, I should be glad if we could get this question of the British Thermal Unit fixed. In the metric system the unit is fixed as that quantity of heat that will raise 1gm. of water from 0°C. to 1°C., but in searching for a definition of the B.T.U., one finds different text books giving different temperatures and we have given up the attempt to fix this unit definitely, as a bad job, *e.g.*, Clerk Maxwell avoids the difficulty by defining the unit as "that quantity of heat which, if applied to unit of mass (one pound) of water at some standard temperature (that of greatest density, 39°F. or 4°C., or occasionally some temperature more convenient for laboratory work, such as 62°F. or 15°C.) will raise the water 1° (F. or C.) in temperature." This being rather indefinite, I sought elsewhere and found the temperatures stated as

1 "at or near 39·1°F.,"
2 "from 39·1° to 40·1°F.,"
3 "from 39° to 40° F.,"
4 & *5* "from 32° to 33° F."

Definitions *1* & *4* were by the same author, and *4* & *5* the only two in agreement, differ from Clerk Maxwell.

It is, of course, not a matter of much practical importance, for Callendar & Barnes (B.A. report, 1899), state that the specific heat of water varies between 1·0054 at Fr. Pt. and 1·0074 at Bl. Pt., with a mean value of 1·0000 at 68°F. and a minimum value of ·9982 at 106°F., showing a maximum variation of less than 1% for the whole range, so that a calorific value returned as 10 might be either 9·91 or 10·09, not a very serious error either way, yet one that might make a fairly big difference in using large quantities.

In regard to the question of coal washing before coking is undertaken, a considerable amount of

work has been done at Sweetwaters in Natal by the Maritzburg Iron Company, Ltd., and coke is now being turned out from there yielding 10% of ash and 1% of sulphur. The results were not so satisfactory till recently, but the ash per cent. has been lowered lately by washing the small coal, twice on a jigger-washer with a sieve provided with a felspar layer. Further analyses of coke from this process may yield interesting results, as our South African coals are generally thought to be poor for coking purposes. One would also like to know whether there is any more of that Karroo coal with 0·2% ash, for much that I have seen contained nearer 20% of ash.

Mr. W. Laurie Hamilton (*Member*): I would like to suggest that some of our engineers might give us a paper on the proper use of coal, and the better management of the boiler. That is the more important point I believe on the Rand to-day. I will give you two instances. There are two mines of 200 stamps each. One used better class coal than the other. Yet the cost per ton crushed in one case of the inferior coal was 10d. and in the other 3s. 6d. The general manager investigated and he found this. That in one case 50% of coal went on the ash dump and in the other 11%. In a case where there was only 18%, the ash was riddled and part re-used. The main cause was this. The one with the high consumption had better boilers than the other, but they were neglected. They had not a spare boiler and were driving those in use all the time so that they could never get the boilers cleaned out or repaired. In the other case they had a man who made a pet of his boilers, and I say that this has more to do with the consumption of coal than any other point on the Rand. Keep your boilers clean, use the coal suitable to them, and it will reduce your costs not only to 10d. but even lower.

Mr. Tom Johnson (*Member of Council*): I would like to bear testimony to the truth of Mr. Hamilton's remarks, though I believe at the same time the cost has gone up at the mine with the low costs through changing their coal in the same boilers.

Mr. M. Dodd (*Member*): The only point on which I think, at the present moment, it is necessary to remark on is the question of the British Thermal Unit. Of course 39·1° F. is the temperature of the greatest density of water, but to my mind there should be no difference between taking it at 39·1° F. and taking it at 60° for the reason that you do not need to take the density into account at all. You only take into account the weight of the water.

The President: Of course there is also the possibility that the specific heat of water changes when it is heated. I am pretty sure it does.

FAULTING PHENOMENA IN RAND MINES.

By G. H. Beatty (Member).

The subject matter of these notes is very well known, but in virtue of its important bearing on efficient development, I venture to bring it before the Society. I propose to open the discussion by an exposition of and some comment upon certain examples of complicated faulting which have come under my notice.

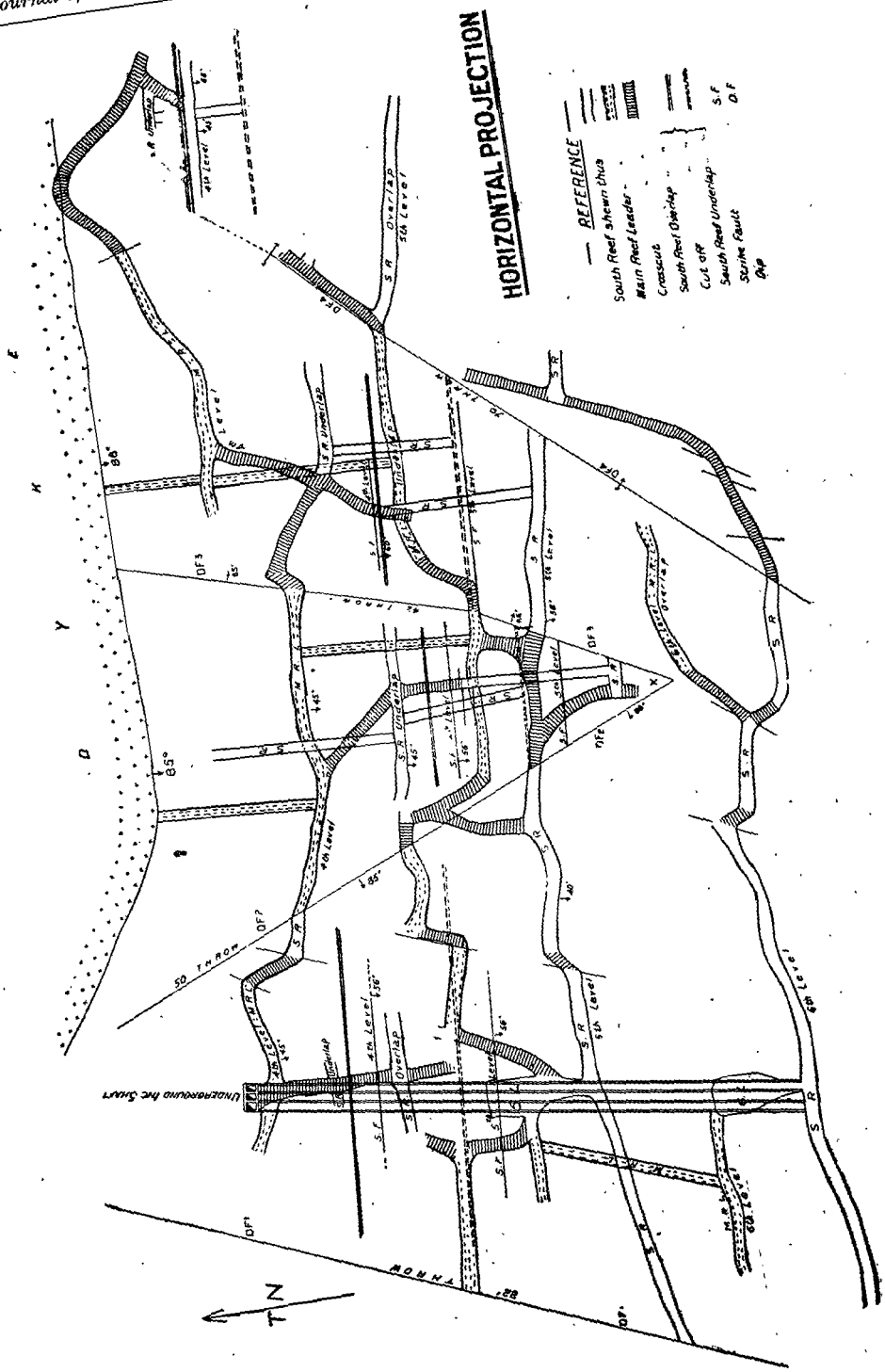
There is a lamentable looseness in the use by miners of expressions applied to faulting. For example, such general terms as "upthrow," "downthrow," "normal fault" and "reverse fault" are frequently used with little respect to their true application. To illustrate this, suppose in a level being driven east on a reef dipping south, that a dip fault is encountered dipping west; the average miner would speak of this as an upthrow of the reef, because, in driving through the fault he found the reef thrown south and upwards into the hanging wall. The fault is, however, a normal fault, *i.e.*, movement has taken place on the hanging wall (or western) side of the fault in a downward direction, and in effect, the reef on the western side of the fault along which a level has been advanced eastward, is properly regarded as the dislocated or downthrown portion, and the portion of the eastward side, which he calls upthrown, is really the reef in its normal position. A normal fault is a downthrow, and is accompanied by a loss of reef-bearing ground. The converse is true for a reverse fault, which is an upthrow and shows an overlap in horizontal projection. For all purposes it can be assumed that normal faults owe their existence to gravity, and reverse faults to pressure. Some evidence supports the belief that normal faults are not always due to subsidence, but the exception is rare and of no practical interest. In Rand formations, as a general rule, reverse faults are older than the normal ones. When the reverse fault so happens to be a strike fault, I have come across no important exception. It seems quite likely in many cases that the normal faults occurred when the lateral or tangential pressure which caused the reverse faults was relaxed. It follows that normal faults being younger displace the reverse faults. The appearance of a fault is frequently misleading as to the extent of its displacement. I know of one instance where the minimum movement along the fault plane was at least 1,000 ft., and yet the fault itself could not be distinguished. One meets with other faults which, though strongly defined, have little or no throw, but, of course, the actual movement may

have been considerable. One meets the same difficulty in attempting to find any relation between the amount of throw and the relative dips of the fault and the reef, as these seem to bear no discoverable relation to the extent of the displacement of the reef by the fault. When it is necessary to locate a reef thrown by a single unknown fault, such indications as known strata, fault-rock, slickensides, folding of the strata on either or both sides, should be looked for and carefully examined. Failing any information from such sources, the dip and strike of the fault must be carefully taken, and the fault treated as one having a normal throw, the prospecting cross-cut being carefully examined after every blast for indications. When two or more faults have competed to dislocate the reef, the case becomes more interesting and calls for closer study. A valuable aid to the solution of problems arising from the disturbances due to faults and dikes, is the constant cultivation of geometrical perception. The full significance, however, of plans and sections is more clearly revealed with the aid of a model. Either one of two faults may cut out or throw the other, the former condition being rare. Almost every fault will be found to have an increasing or diminishing throw, ultimately dying out entirely in both directions. Two faults of the same system (reverse or normal) dipping in opposite directions may, upon approaching each other, coalesce, and terminating as individual faults, continue as one with a diminished throw. Again, if both dip in the same direction and coalesce, they will continue as one fault with an increased throw. Faults rarely unite, it need hardly be said, unless they have a similar trend, and probably belong to the same period. The direction of movement on a fault plane should, whenever possible, be determined. When one plane has cut and displaced two other planes of dissimilar dip, the direction of movement on the one can be determined graphically. When the average dip, strike, nature, and direction of movement of a fault have been determined, its effect upon faults, dykes, and reefs, with various dips in other parts of the mine can be ascertained with reasonable accuracy. Speaking generally, faults in Rand mines show a marked consistency in strike and dip. There are, of course, many interesting exceptions to this rule. Very often a big fault is accompanied by smaller sympathetic faults of similar trend and dip, causing troublesome stoping in the vicinity. An important fault is often possessed of peculiar characteristics, and its individuality admits of its easy recognition in various parts of the mine.

The principal feature of the section shown on the plan (Fig. I.) is a true strike fault having a reverse throw, causing an overlap or duplication of reef of 100 ft. on the west, and diminishing to the east, where it dies out in a monoclinal fold, some 500ft. east of the workings shown. This fault is readily distinguished on the western section where it carries an inch of fault-rock, but east of the shaft shown, its presence is only minutely revealed by a close examination: in fact, it is only noticeable where it comes in contact with a reef, and for development purposes its position was calculated. Considerable development was done in this neighbourhood in the nineties, at which time the faults shown were little understood, the existence of the strike-fault passing unrecognised. Recent development was, therefore laid out with a view to taking the best advantage of the old work. The plan further shows a series of dip faults numbered DF1, 2, 3 and 4, all of which have down throws, and were caused by movements subsequent to the lateral pressure which caused the strike-fault. Therefore, the strike-fault is displaced by all the dip faults. Upon examination, fault No. DF2 was found to have a down throw (vertical displacement) of 50 ft., and the direction of movement on it was clearly shown by joining, in cross-section, the apices formed by the reefs and strike fault. This direction proved to be nearly horizontal. In my experience this is the exception rather than the rule, for generally the direction of movement approaches the vertical.

The nature of fault No. DF2 being determined it was reasonable to assume that the characteristics of the other dip faults, which probably belonged to the same system, were similar. An examination of faults Nos. DF3 and 4 on the plan will show that this was nearly the case. As the movement on the dip faults was roughly horizontal the relative positions of strike fault and reefs remain unaltered on either side of the dip faults, on the same horizontal plane. Had the motion been vertical the strike fault would of course have, on the dropped section, approached the overlap and receded from the underlap portions of the reefs on the same level. Faults Nos. DF2 and 3 are especially interesting, they have downthrows of 50 ft. and 42 ft. respectively, and dipping in contrary directions, unite at the point x, appearing in the lower level as one fault with a throw of 8 ft., this actually being the difference of their throws as individual faults.

The sketch will now, I think, explain itself. At the point 0 it will be noticed that the overlap portion of the south reef does not reach the 4th level. The available data showed that it could not be far away, and the strike fault not being visible at this point, a rise was put up from the 5th level, the last round in which blew through into the cross-cut. The cross-cut is old work,



probably driven to pick up the south reef—the underlap portion of the same reef having been mistaken for the main reef leader. The strike fault has, of course, exactly the same overlapping effect upon the main reef and main reef leader at a lower level. These reefs have been omitted from the plan, wherever possible, for the sake of simplicity. The dyke, which forms the north boundary of the section, is not displaced by the dip faults. Its dip is roughly vertical, and remembering that the direction of movement on the faults was horizontal, it follows that the dyke was subsequent to them. Had the movement been vertical, similar to the dip of the dyke, the dyke might have been faulted without showing any horizontal displacement. This horizontal movement further eliminates the possibility that the faults were subsequent to, and terminate on the dyke. The section of ground shown in Fig. I. is itself an overlap, probably caused by the dyke rather than by any later movement on it; firstly, because the dyke face shows no evidence of movement, and secondly, because such movement could only have been caused by a return of pressure after the dip faults had been developed. The thickness of the dyke is about 100 ft., and its underlap reef is also the overlap of another dyke to the north. In consequence of this the cross-cut from the vertical shaft to the incline shaft shown, exposes the reef three times. The two dykes mentioned are separate, and not one dyke faulted, as might be inferred. They have a similar but somewhat irregular strike. They meet in both directions, encircling an oval shaped piece of ground, 250 ft. wide at the widest point. This section of ground is, curiously enough, entirely free from faults of any description. In addition to the overlaps formed, there has been a westerly movement of several hundred feet on the same dykes, proved by their displacement of an old vertical dip dyke to the west of the sketch. It would be expected to find on the underlap portion corresponding to the section in Fig. I. dip faults similar to those of the overlap As mentioned above, however, the underlap portion is free from faults.

Fig. II. will serve to show in cross section the positions of the apices formed by the strike fault and reef at the cessation of movement on faults DF2, 3, and 4 (Fig. I.).

The above example and remarks may prove of interest and use to those who have broken country to deal with. Each faulted section of a mine, however, has to be developed from data gathered on the spot, and no amount of general remarks and rules will prevent mistakes.

The next step—after it is considered that the country is well understood—is to lay out a scheme of development which is at once econo-

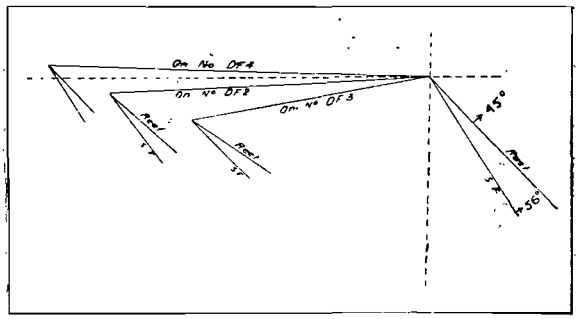


Fig. II.

mical and complete. By this I mean that the value of gold recovered from the section must show the maximum profit over the combined development and working costs. This may seem to be an obvious remark, but I have often noticed a penny saved on development cost, increased the mining cost by two pence. The converse is true —it is, in fact, more general to overdevelop than underdevelop.

The cause of much inefficient development is due on a milling property to a natural desire to keep the mill running. The development in consequence does not receive its share of attention. Straight drives in the footwall with boxholes to the reef or reefs, could very often be driven to great advantage in country where the general strike and faults are known. There is a great desire to be always on reef which admits of better sampling, but more often the reason is that the powers that be are rarely averse to a few hundred tons of doubtful development rock for the mill. The result is that future tramming and mining costs do not receive their due consideration. The reef actually broken by driving on reef is not lost if the drive be in the footwall, but can be far more neatly stoped and profitably milled at a future date. Straight driving from point to point has a decided tendency to reduce the total necessary footage. Moreover, every 500 ft. of straight, well-equipped, laid and kept track represents one penny per ton trammed saved over the usual prevailing conditions, namely tortuous drives. Another point which tends to inefficient development is the short and uncertain tenure of office held by the average mine official. An official reaps the immediate benefit of good stoping, but good development work often militates in a small way against present success. An official who would kick at a wasted sleeper has been known to wink at 100 ft. of useless driving—the sleeper is against costs, but the 100 ft. is footage.

It is bad policy to intersect a reef from the hanging side, causing in the future expensive

mining and the leaving of valuable pillars. It is generally better, when feasible, where a fault of known displacement has thrown the reef into the footwall, to go back in the drive, and from a point determined in it, to interesct the reef and fault contact on the further side of the fault. The surveyor has in the course of his work the best opportunity of studying the reefs, faults, and dykes in a mine, and should with care and observation make few mistakes. The observation of some underground phenomena has led me to think that there is still a tendency to movement along some fault planes. Allowing that radical dynamic agencies will never again disturb the strata, they may still contain unreleased strains, which, together with the pressure due to great depth, will be released by stoping operations. The pressure at, say, 5,000 ft. will probably cause a virtue to be made of a necessity, by causing driving to be done in the footwall.

In conclusion, let me say that these notes are in no way intended to be exhaustive; I have, in fact, only touched upon a subject on which a volume might be written. I am hoping that many criticisms and additions will be forthcoming before the last word is said.

Mr. E. Pam (*Member*): This is a very valuable paper, and I have much pleasure in proposing a vote of thanks to Mr. Beatty. It is impossible to grasp all the points after one reading, and I feel diffident about making any remarks without further thought. The improvement in locating the throws of faults does exist, but I would point out that part of the credit for this is due to the large amount of development done on the Rand, and the improved way in which our records are kept, so that every fault of any importance can be referred to at once, and the reef can usually be located without difficulty. Compilation plans of the districts are also very helpful as by means of them the experience of one mine is of material assistance to its neighbour.

Where working in virgin country such as our deep deeps a model is very useful, and a proposal was made some months ago to build a complete model of all the mines on the Rand, to be kept in a central position for reference. It would be costly I know, but the clear idea which can be got from a model would save much expense in laying out and development work.

Mr. J. Cellier (*Member*): As regards the models of some of these mines, in many cases the damage is done before the model is made. There are some mines at present that would come out at a loss if they had to make models.

Mr. M. H. Coombe (*Member*): This is a very interesting paper, a paper which has evidently called forth a great deal of observation on the part of the author. I think we have all need to be thankful that such papers are brought before this Society. We are far more advanced to-day in our knowledge of faults, dykes, second throws etc., than we were some years ago, and I dare say that on the Rand in our practice to day, the general underground man is more conversant with throws and faults than miners in any other part of the world. The reading of this paper puts me in mind of the old days—25 years ago, when we first started the outcrops along these reefs, and when we had no data whereby we could decide whether there was an upthrow or a downthrow. If we were driving east and encountered a fault dipping west, we knew almost to a certainty that we had to go in the hanging wall. I claim that the old miner did very good work in that respect, and the data known to-day for the deeper mines have been compiled from the practical work done by the old miners. They may have thrown away a good deal of money in cross-cuts, etc., but they found it. There is a lot of money needlessly thrown away to-day in these big mines cross-cutting, etc., in impossible directions for the reef! I know of one special case in one of the leading mines of the Rand where they went 200 ft. into the hanging wall looking for a reef that was 5 ft. in the footwall.

Mr. Chas. B. Saner (*Vice-President*): As the hour is late I propose further discussion of papers be postponed.

This was agreed to, and the meeting closed.

Proceedings
AT
Extra General Meeting, March 4, 1911.

An extra general meeting of the Society was held in the Lecture Hall of the S.A. School of Mines, on Saturday, March 4th, the President (Dr. Moir) in the chair. There were also present:

36 Members: Messrs. W. R. Dowling, R. Allen, Tom Johnson, E. J. Laschinger, A. Richardson, G. O. Smart, H. A. White, A. Whitby, James Littlejohn, A. F. Crosse, W. A. Caldecott, E. H. Johnson, R. G. Bevington, A. McA. Johnston (Members of Council), W. Beaver, B. V. Blundun, A. J. Bowness, J. Chilton, A. A. Coaton, J. M. Dixon, R. Gascoyne, J. Gray, A. J. Johnson, J. Lea, G. Melvill, P. T. Morrisby, E. Roberts, W. H. Roe, S. Shlom, G. Hildick Smith, W. H. Smith, W. A. C. Tayler, A. Thomas, E. M. Weston and A. Wilkinson.

12 Associates and Students: Dr. J. L. Aymard, Messrs. F. C. Carbis, W. M. Chester, J. Cronin,

H. J. Filmer, J. Gibson, B. W. Holman, A. King, F. J. Pooler, H. Stadler, P. A. Tucker and A. M. Wilcox.

12 Visitors, and Fred. Rowland, Secretary.

GENERAL BUSINESS.

The President: I have first to ask you to accord a very hearty vote of thanks to Mr. Pearce and the other gentlemen who organised that excellent visit to the Crown Mines last week, one which we all so much appreciated. I have also to announce that Mr. M. Torrente has been kind enough to arrange a visit to the Roodepoort United Main Reef Mine for us on March 25th. We have also very great pleasure in welcoming to this meeting Principal Thompson, the new head of the S.A School of Mines. I think it is very kind of him indeed to come to our meeting only two or three days after his arrival here, when he must be worn out with seeing people and trying to remember who they are.

NOTES ON BATTERY PRACTICE.

(*Read at September Meeting, 1910.*)

By A. R. STACPOOLE (Member).

REPLY TO DISCUSSION.

Mr. A. R. Stacpoole (*Member*): I am sorry my paper missed one of the principal objects that prompted me to write it, which was, to draw the mill men of the Rand into a general discussion.

Mr. E. H. Johnson points out that the reason for removing battery plates from the front of mortar boxes to the foot of tube mills, is to prevent scouring by coarse grit when coarse screens are used. This is a very sound reason, and one which we all admit; but has the point ever been decided that the gain by this change is greater than the loss in not being able to catch the free gold until it has passed into the launders, pumps and tube mills? Certainly the results from the new plants, which were recently started on the Rand where amalgamation takes place only after the pulp has passed the tubes, leave room for doubt on this point. With more care and time given to the plates which are in front of the mortar boxes, better results might be obtained and less amalgam and mercury would be found in the launders and tube mills.

Mr. Crosse states: "I am afraid that some of our members will consider the loss of amalgam mentioned is much over-estimated." If he is of this opinion, I would ask him to obtain figures as to the quantity of mercury drawn from the mine store for use in the mill for a period of, say, six months, and I think he will agree with me that at least, in many cases, the quantity of mercury lost per ton of ore milled, or per ounce of gold recovered, is excessive. There can be little doubt that where mercury is lost, gold goes with it.

I said: "The mill manager and amalgamator are rapidly having their power and responsibility usurped by the reduction officer and cyanide manager," but Prof. Stanley put my meaning in a nutshell, when he said: "I think if the mill men would make themselves heard a little more they would get on a little more. It is generally the cyanide manager who rises to be reduction officer. Judging from Dr. Caldecott's remarks it was he who originated the post of reduction works manager. I am not prepared to say whether these officials have been a success or otherwise, but what I do know is, the inauguration of this new post has been the means of making all the ambitious mill men invade the cyanide works, and the cyanide men are to be found in all the mills, each gaining knowledge of the others' work with the object in view of qualifying for the much coveted post. This has brought about a better understanding between the two departments.

Mr Alexander states: "I cannot agree that this paper is really representative of common battery practice on the Rand." I also agree with Mr. Alexander on this point! but I am sorry he did not see fit to take the hint thrown to him by Dr Caldecott, and give us a description of his up-to-date methods of handling amalgam and black sand, etc.

Mr. J. Hayward Johnson is under the impression that my paper was more directed to mill practices in outside districts than to mill practices on the Rand, but this is not so. My experience is that the outside districts pay more attention to the plate and mill recovery than is the case on the Rand. In speaking of sampling the pulp as it leaves the lip of the mortar box, he said: "Owing to the plate being close to the boxes it is very difficult to take an accurate sample." In this I do not agree with him. A reliable sample may be taken from the screen, if each screen has a strip of thin sheet iron inserted in the frame at the bottom, 3 in. wide, and running the full length of the screen; this will form a sill for the pulp to run off and the sampling vessel can be passed under it the full length of the screen thus enabling a representative sample of the pulp to be caught.

Mr. F. W. Cindel gives the percentage of gold recovered in his mill, but it would have pleased me more if he had given the quantity of amalgam taken from the launders and tube mills, which he naively omitted to do. I hope his general manager will take his hint, and not whisper down

the back of his neck, "send a few more ounces of gold in the residue to the dump, but increase the tonnage." Mr. Cindel might find a trolley useful to bring back the "few more ounces of gold" (which he speaks so lightly of) from the dump; he could even employ the much talked of horse to draw the trolley, if he was successful in his search. My critic asks, "what will become of the free gold which concentrates in launders?". A part of it will ultimately find its way to the tube mill plates, and the balance would be absorbed in crevices in the launders, loss in handling when cleaning up the launders, and also when renewing tailing pumps, and tube mill liners; as well as offering a temptation to thieve.

Mr. A. King remarks: "If, however, the tube mill circuit is properly arranged and is provided with the requisite number of cone classifiers with diaphragms, there is no chance of any amalgam overflowing with the cyanide pulp." It is evident from this remark that Mr. King wants to convert the tube mill into an amalgam trap. A large proportion of the amalgam and mercury entering tube mills is ground to flouered amalgam, which will float over the plates, and which can be found at water mark adhering to the sides of launders both in the sand and slime plants; it is even questionable if a portion does not float away on the water from the slime plants. My critic is nothing if not emphatic; he settles one point after another in a decided and definite manner, even the knotty problem of tube mills, which is occupying the attention of the leading Rand engineers at present, as to whether tube mills are not more expensive to work than stage crushing by stamp mills. His method of collecting black sands, I will refer to later. I agree with his method of treating black sand residue in a Brown air lift vat by cyanide.

Mr. D. J. Pepler states: "The author must be an absolute stranger on the Rand, for he seems not to have the remotest idea of the methods in vogue in mills here." I may say that it is sixteen years ago since I first worked in a mill on the Rand, and have worked in one of the large mills there as recently as six months ago. Since I first knew the Rand I never lost touch with it, and paid regular visits to it every year or eighteen months, always making a point to see any new machine or method adopted in connection with the reduction works. During my last visit I went to a mill in the Germiston section, one in the central section, and one on the West Rand to see what was new in milling, and it struck me then that the care and time given to the plates and in dressing them was not as great as was bestowed on them some years ago. I have seen, morning after morning, eighteen plates scraped and dressed within forty-five minutes. Does Mr. Pepler think this is sufficient time to scrape, collect black sand and dress eighteen plates in? I know a change for the better has recently taken place in this mill, and that it is to-day one of the most carefully run mills on the Rand. The mere fact that the mine manager requires a large tonnage, or that coarse crushing is carried on, or that the cyanide works are more perfect and capable of better work now than in years gone by, is to my mind no reason why the plates should not have care and time given to them. The objection he brings against cyanide managers becoming reduction works managers is: that they cannot supervise the maintenance of the mill. There are a number of mill managers who hopelessly fail on this point, and a visit to some of the mills will convince one that their maintenance is not a particularly strong point with the mill manager. I cannot agree with his method of collecting black sand; he hangs up the stamps, eight seconds later the water is shut off, and then he states, "by that time most of the tailings will have disappeared, while the black sand will remain on the plate." I would like to know what retains the black sand on the plate? If the plate is examined with a magnifying glass, it will be found that a quantity of black sand is held on the plate by large bits of sand, and if the plate is hard and dry, particles of free gold may also be seen which have not amalgamated; the moment the large particles of sand are disturbed, the gold and black sand can be seen moving down the plate, and are washed away with the tailing. I want to ask Mr. Pepler what would happen if the flow of water is too strong, or if the valve is stiff and cannot be shut off for half a minute, or a minute, instead of being shut after eight seconds? Will the black sand be still on the plate, or will the plate be washed bright and free of the greater part of the black sand? He gave the following figures:—"Tube mill plates, black sand gave 59%, scrapes and other sources 41%; in the battery, black sand 42%, scrapes and other sources 58%, which should be considered satisfactory." Why should these figures be considered satisfactory? Is it because 5, 10, 15%, or even more of the black sand and free gold which had rested on the plates are washed down into the tailings launder? Mr. A. King advocates Mr. Pepler's system of collecting black sand, but I consider it risky and haphazard, and when dealing with a concentrated product which yields 50% of the total mill gold, no chance should be taken.

Mr. G. A. Robertson remarks; "Instead of the author then showing us some method whereby a saving might be made in the free gold, mercury and amalgam when they find their way into the cyanide works, he proceeds to tell us how to

collect sand from plates, &c." My paper was not written with this object, but with the object of preventing free gold, black sand, mercury, and amalgam from entering the cyanide works, which can be best done by paying great care to the dressing of plates, giving sufficient time to each plate, careful collecting of all the black sands, and by not using mercury to excess. An ounce of mercury should be to the amalgamator what a pound of cyanide is to the cyanider. The cyanider is never tired of trying to curtail the quantity of cyanide, and not only every cyanider on a mine, but every mill-man can tell you the quantity of cyanide used per ton of ore treated; yet how many amalgamators can tell exactly the quantity of mercury used per ton of ore milled, or per oz. of gold recovered?

If the practices of each mine manager were more generally known and criticised, each would be able to discard his own weak or bad points and adopt the better ones of his neighbours, which would be a distinct advantage to the industry. Mr. Robertson quotes from authorities on the loss of mercury: "15% of the entire mercury fed is lost; and it is well known that the amount of gold carried away and totally lost by this means is enormous." These quotations go more to strengthen my remarks on this point than to weaken them. These losses are admitted by the mill men on the Rand and accepted as inevitable, as not one of the mill men have come forward to tell us what is being done to prevent this loss of amalgam.

I am sorry Mr. Robertson did not give us figures as to the percentage of mercury lost, instead of the percentage of mercury recovered by riffles; it appears that what is recovered is history, but what is lost is mystery, and judging by the strain of the criticism on my paper, the mill man is determined that it will remain a mystery.

The President: This seems to have produced a very profitable discussion, and I hope our friends the mill men will give us something more this year to keep the interest up.

THE CLASSIFICATION OF TAILING PULP PRIOR TO CYANIDING.

(Read at October Meeting, 1910.)

By Edward H. Johnson, M.I.M.M. (Past-President).

DISCUSSION.

Mr. J. Vine Jory (*Member*): In commenting on this paper I do not propose to deal with the theoretical considerations of the classification of tailing pulp, but with a few mechanical points of obtaining classification in this type of plant, which have developed during the experience gained during the last nine months in the continuous operation of the apparatus.

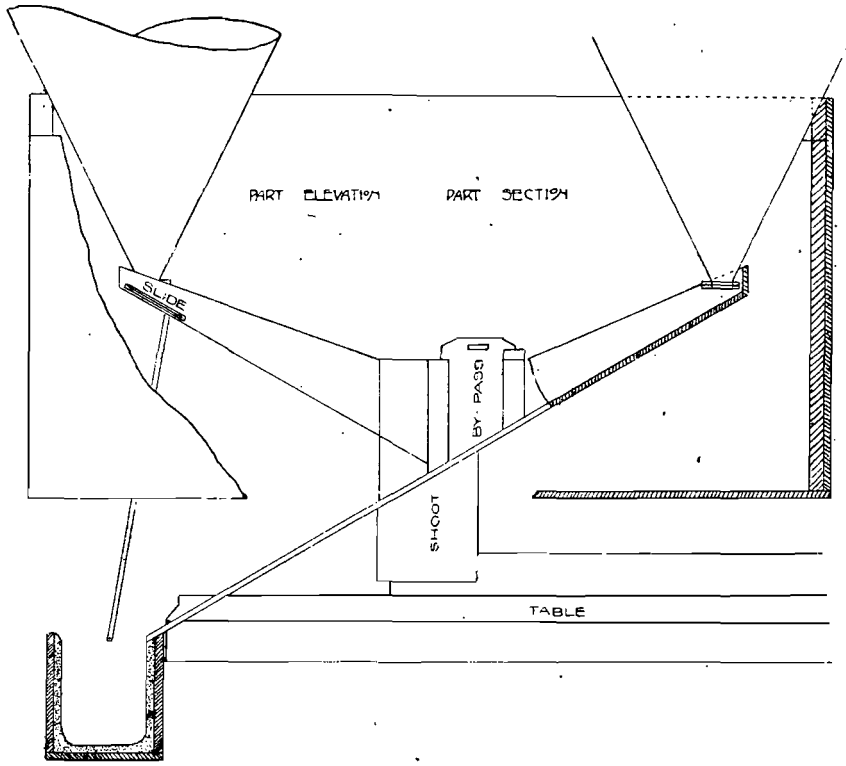
Primary Cones.—As in any settling apparatus, or differential settlement as in the case of classification, the amount of agitation caused by the feed of fluid pulp must be controllable. There should, therefore, be as little fall as possible between the outlet of the feed launder and the surface of the cone. Also provision should be made to eliminate the occluded air in the pulp at the centre of the cone, otherwise coarser material than is desirable will overflow. This point was probably emphasized in our case by the pulp elevation being by air-lift. A wide sleeve surrounding the sub-level inlet and carried slightly lower and above water level will correct the agitation effect of the entangled air. Similar provision was also made in the return sand cones with a reduction of +200 product in the slime from 4% to under 1%.

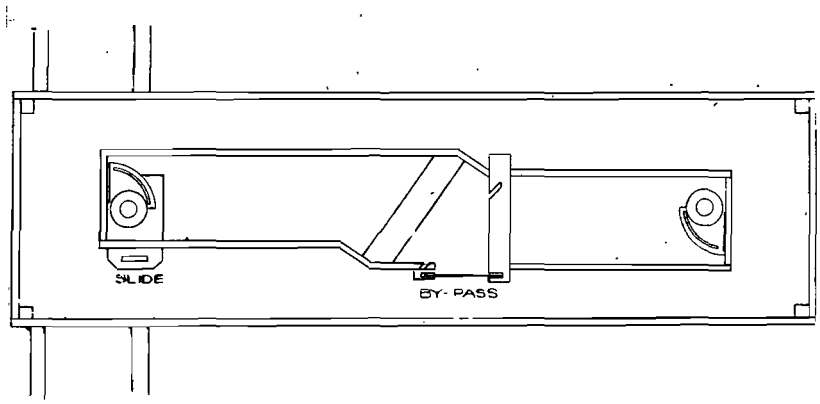
Secondary Cones and Vacuum Tables.—The vacuum tables have given little trouble, but we have found it advantageous to substitute loose jute cloths for the finer calico originally used. Although the time taken for dressing a table is very small, the shutting off of the underflow of the cones during this operation interferes with that continuity of action of the cones which makes for good work. For this reason the by-pass shown in the accompanying sketch was introduced and has proved itself extremely useful. The introduction of the underflow of the secondary cones direct into the stream of solution for the short period necessary during dressing tables has not caused any accumulation of solution to take place. This underflow of secondary cones carries between 26% and 28% of moisture, the average of the table moisture being 12%.

Sampling.—The continuous sand plant lends itself to very accurate sampling of both sand and slime products, as neither is complicated by the return-sand spitzkasten as is usual in pulp sampling.

The extraction results obtained during the past six months may be of interest to members:—

Tons sand treated 152,930 = 47·97% of tons milled
Average grading + ·01 in. 12·1% + ·006 in. 32·3% − ·006 in. 55·6%.
Average original value 5·118 dwt.
Average residue value 0·595 dwt. = 88·37% extraction.
Average final draining 0·06 dwt.
Tons slime treated 165,298 = 52·03% of tons milled
Average grading + ·003 in. 1% − ·003 in. 99%
Average original value 3·076 dwt.
Average residue value 0·214 dwt. = 93·04%
Average washed residue value 0·08 dwt.





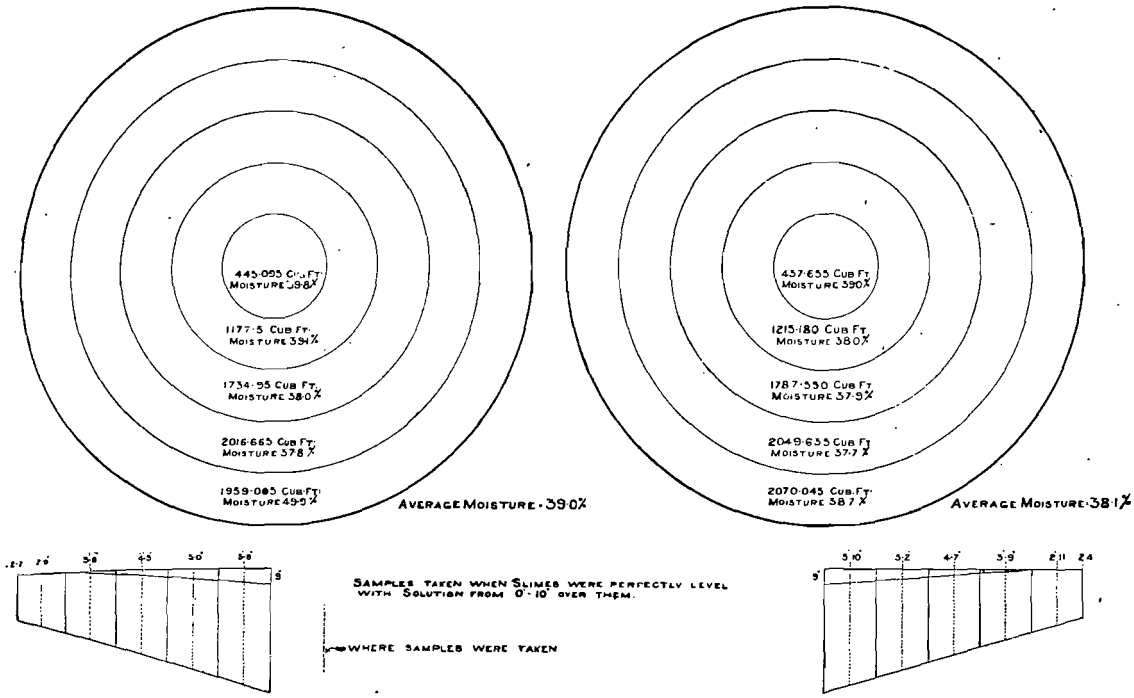
The cost of operating the continuous sand plant, including all white and native labour, power, maintenance and re-elevation of all the sand and solution 48 ft. has worked out over the tonnage dealt with at 1·159d. per ton.

I am indebted to Mr. Penlerick, general manager East Rand Proprietary Mines, for permission to publish these details of extraction.

REPLY TO DISCUSSION.

Mr. E. H. Johnson (*Past-President*): The discussion elicited on this paper has been almost entirely of a confirmatory nature, and I have to thank Messrs. A. McA. Johnston and G. O. Smart for the very valuable data they have adduced, and for the leniency of their slight criticism. It is somewhat surprising that, although at the present time, some quarter of a million tons per month are locally being classified by the means described, or approximately $13\frac{2}{3}$% of the total Rand tonnage, only two members have contributed to the discussion on the classification aspect.

Mr. McArthur Johnston confirms so very closely the data given in my paper that there is little to reply to. I think, however, he perhaps overemphasizes the increased length of time of treat-



ment due to the East Rand single treatment, as compared with the double treatment, and overlooks the relative initial values of the material dealt with, viz., 6·00 dwt. at the East Rand as against 2·88 dwt. at the Simmer Deep. It is fair to assume that a little longer treatment would be necessary for the higher value. The slightly longer treatment is, however, I think more than compensated by avoiding the cost of the double handling needed for the double treatment, as with the perfectly clean sand obtained the same ultimate residue is attainable. His later reference to the experiments he made of dropping the transferred sand into solution is confirmatory of this, as they very closely imitate the conditions of single treatment.

Mr. Smart's data on the results obtained from single cone classification are extremely valuable as showing what can be done where the plant does not lend itself to the elevation required for the installation of the secondary cones, but where treatment of the sand as collected is practised, the installation of secondary cones is preferable. I I must thank Mr. Smart also for his grading of battery feed, which more or less confirms that I quoted. The proportion of fine in battery feed will necessarily be a fairly variable quantity according to the nature of reef and mining condition, not to mention, as perhaps treading on dangerous ground, the economy or otherwise (principally otherwise) in the use of explosives.

I was particularly pleased that Mr. Smart, through the instrumentality of Mr. McLean had been able to practically confirm my experience of the changed conditions that the better classification has produced on the density of settled sand and slime. Mr. McLean's work in this direction is a model of careful determination and could very well have formed the text for a paper dealing with the subject of tonnage measurement of moist settled solids. The difference of 4% higher moisture content of the Simmer and Jack settled slime as compared with East Rand Proprietary Mines is quite comprehensible when the difference of 42% and 52% respectively of the mill product collected as slime is considered, the latter naturally containing a higher proportion of the finest sand.

Replying to the queries asked: —

(1) The long 1 in. pipe was at right angles to the cone of the vat, and when falling ran along the guides at that angle.

(2) The terms 1st, 2nd and 3rd sections are, perhaps, East Rand Proprietary Mines localisms, for collecting, 1st wash and 2nd wash sections of slime plants.

(3) The impact of the falling cylinder was found to displace a little of the fluid surface slime, which contained approximately 60% moisture. The correction, however, did not affect the total determination.

Regarding the difference Mr. McLean shows between the moisture content of the peripheral and central samples of a settled slime charge I am indebted to Mr. P. R. Nethersole for the accompanying diagram showing that these differences do not occur to the same extent on the East Rand Proprietary Mines as on the Simmer and Jack. The reason is due to the concave cross section of the settled charge and the relative lengths of decanter arms. The East Rand Proprietary Mine decanters are 12 ft. long therefore do not reach the concave centre (a defect I confess), consequently the supernatant solution in the centre corrects the greater density of the settled solid.

Mr. Tonnesen's contribution is particularly valuable, as giving us, what many of us have sought, a convenient and accurate core sampler for settled slime. His apparatus has been in daily use on the East Rand Proprietary Mines for some time now, and has proved itself a great improvement on the cumbersome device used in the original determinations. I should like, not only to congratulate Mr. Tonnesen on his successful solution of what has hitherto baffled most of us, but also to thank him for providing us with such a neat and convenient tool.

Mr. Jory's somewhat belated contribution contains several notes that I hope will prove of service to those operating this type of plant. I should like to take this opportunity of thanking Mr. Jory and Mr. Lloyd, who are in charge of the respective East Rand Proprietary Mines continuous sand plants, for the enthusiasm they have shown in their working, which has contributed so largely to the success this type of plant has achieved on the East Rand Proprietary Mines.

The President: As I have said already, it is most gratifying to find our Past-Presidents taking such an interest in the Society, and I am sure we all thank Mr. Johnson very much for his interesting reply. As an example of the activity of our Past-Presidents I may point out that at this extra meeting we have no less than five of them present, practically all who are still resident in Johannesburg.

NOTES ON THE OCCURRENCE AND CONCENTRATION OF TIN ORES.

(Read at October Meeting, 1910.)

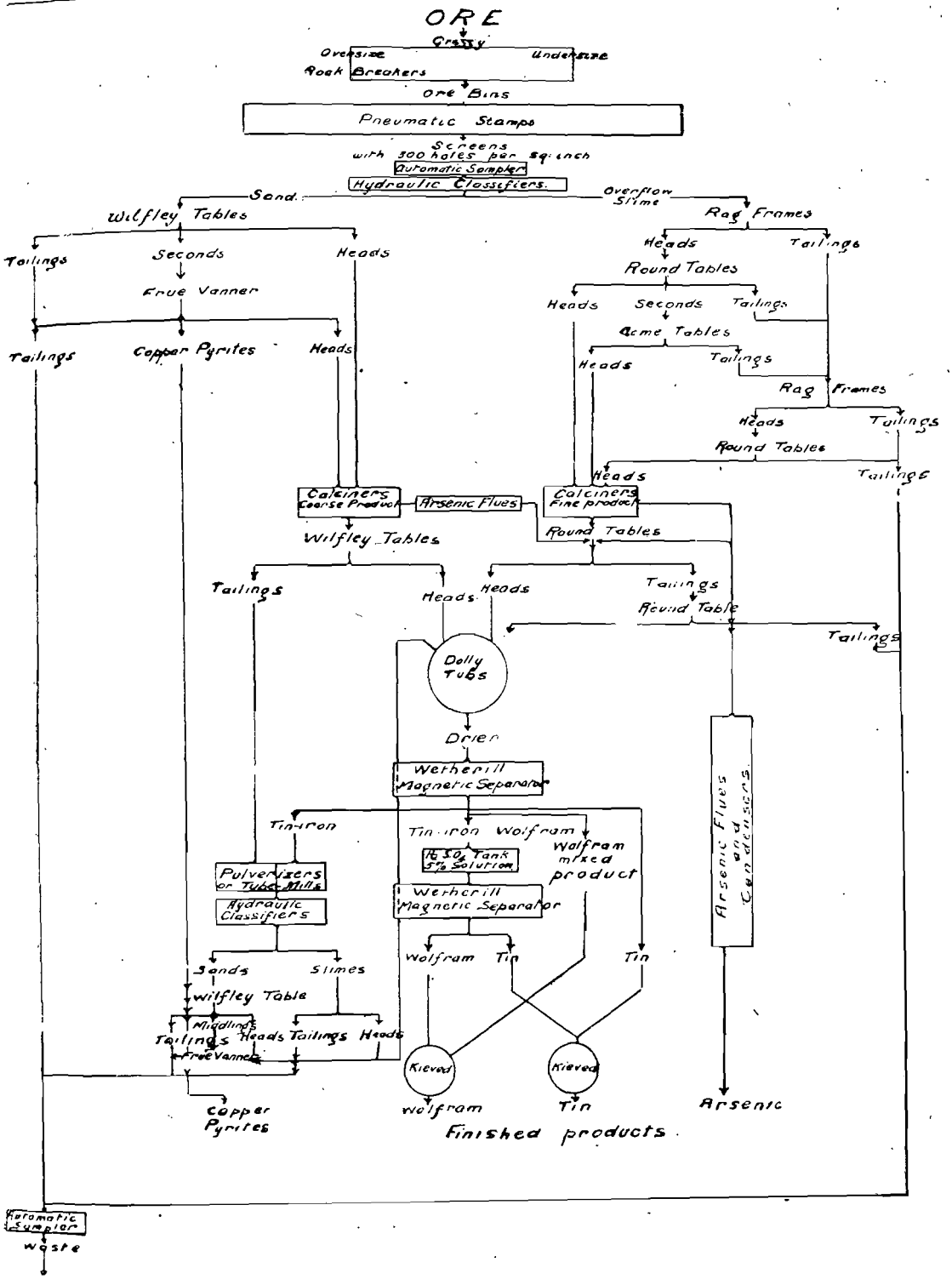
By C. Fred. Thomas (Member).

DISCUSSION.

Mr. A. Treloar (*Member*): If Mr. Weston could not congratulate Mr. Thomas on his paper on "The Occurrence and Concentration of Tin Ores," I am afraid I cannot congratulate Mr. Weston on his contribution to the discussion. It is always an easy matter for anyone to write sarcastically on any subject, provided he has sufficient sarcasm in his nature, but sarcasm and criticism have an altogether different value.

With the concentration of tin ores, as well as with most scientific treatments, it is wise to observe with an unbiassed mind and to take a broad view. Perhaps the author did try to cover too much ground in his paper, and it may seem as if some of his statements are rather vague; at the same time there is much truth in what he says, and seeing that he is the first contributor of a paper on tin concentration read before this Society, I think he is to be congratulated on the result, in spite of the fact that he happens to be a Cornishman. Mr. Weston evidently speaks under some provocation when he says "that the Cornish tin expert is prone to strut around the world posing as the one and only authority on the ore and its concentration, and inflicting out-of date Cornish dressing devices on young and unsophisticated tin industries in other countries." Might I ask, where this has been done? And does he not know that in South Africa, and in many other parts of the world, the tailing from some of the mills (erected *not* by Cornishmen) is richer than the ore of the average Cornish mine, and that if the same percentage of loss were escaping in Cornwall the tin streamers on the Red River would sell, not 30 tons of tin monthly, but nearer 100 tons, and that if the Red River were red through ruby tin escaping it would then contain enough tin to cause it to stand still.

In order to discuss percentages of recovery in tin concentration it is necessary to see the samples taken and also to know the assay value of the pulp from the stamps. A Wilfley concentrator if properly erected and adjusted loses practically the same amount of tin in the tailing from an ore containing 1% as it does from an ore containing 3%, and, naturally, the percentage of recovery in the first instance would be much less than in the latter—a fact often overlooked. To provide for the irregularity of the percentage of an ore it is necessary when laying down a plant to add an extra concentrator for the specific purpose of using it when the value of the product goes up. Supposing the average loss from a concentrator of the Wilfley or Buss type when doing good work on sand to be 0·2% metallic tin, then if the sand pulp contained 5% and 0·2% was lost, the result would be a recovery of 96%; if however the sample assayed 1% and 0·2% was lost, it would mean a recovery of 80%; thus in the case of two mines equal work might be performed and yet the results widely differ. The above



Flow Sheet for Complex Tin Ores.

is an illustration of sand concentration; and of course a further loss would occur with the concentration of the slime, still further reducing the percentage of extraction from the original pulp sample. It is customary to think that with high values you get high losses, but that is not true when comparing values with losses. A machine works irrespectively of values, and however well it is erected and adjusted there must and ever will be a loss, but if the load is regulated according to the value the loss is fairly constant.

It is scarcely necessary for anyone with even a small knowledge of mining conditions in Cornwall, to hesitate to reply to Mr. Weston's remarks as to why the mines do not put down a succession of rag frames. I will, however, answer by informing him that, unfortunately, nearly the whole of the mining area is owned by one owner, and he, for personal reasons, lets only a portion of land to the mine, generally not nearly sufficient for the plant required, and then lets the adjoining portion to a tin streamer, giving him the right to come close to the mine discharge, the streamer paying a toll in the form of one-eighth of the gross return. The price of land to the mines, if purchased, works out at £100 per acre, or over £200 per morgen, not 5s. per acre as in South Africa, or a comparatively small price as in Australia. Mr. Edward Walker (whom I have the pleasure of knowing) ought not to ask why more rag frames are not put down after spending so much time as he did in Cornwall, and anyone conversant with Cornish mining should not have to ask for information seeing that the question of "Lords's dues" has for the past five years created such a stir in Cornwall, and especially during the past three months. I may say, to give credit to two of the owners, that in the case of the Carn Brea and Tincroft mines, during the three months mentioned, they have given up their dues and added an installation of plant to assist the mine, but this was only done under pressure and when the capital of the mine was practically exhausted. Might I also inform Mr. Weston that in every case I know of the slime is treated twice, and often three times if space permits, and that the average percentage of slime caught on a rag frame is not 5% of the product fed on, but nearer 65%, as he will discover if he makes a proper test.

For the last century the tin mining world has been waiting for a slime concentrator, and it still waits in spite of the Lührig and other machines; and if Mr. Weston has had the privilege of testing many of these slime concentrators he could only have come away with a sad heart. Personally, I have found that with a wooden bed set at a good angle and the surface kept roughened, a revolving table is the most effective machine, and with three or four times treating I have got a higher percentage than from any other type. The Lührig, Wilfley slimer and Frue vanner, are only effective on certain material, but for a very fine product, such, for instance, which will pass through 20,000 holes per square inch, the results they give are not satisfactory. I might also say with reference to Cornishmen refusing to adopt up-to-date methods, that these (so-called) up-to-date methods have done Cornwall irreparable injury during the past five years, and that out of a nominal capital of £750,000 spent there is nothing to be seen to-day but machinery standing idle. The good work done by the Germans at Clitters resulted in the payment of a dividend and the stoppage of the mine after a nominal capital of £160,000 had been spent. A new company was formed in 1908 with a capital of £15,000, and this company is now in liquidation, and, as far as I know, never paid a dividend. I could mention many others where the results have been similar, and one, an American company having the North Crofty mine, spent an enormous sum installing a plant of their own design, with disastrous results as far as outputs and dividends were concerned. If by these things Mr. Weston considers Cornwall owes a lot to either Germans or Americans I must beg to differ. I grant that Germans are, as a nation, extremely clever in scientific research, and that they introduced magnetic separation into Cornwall, which has helped several mines considerably. It is generally known, however, that these revolutionists have returned home with much less money and a great deal more experience. It is a well known fact that experience is necessary when dealing with any particular ore, and the treatment which does well in Australia is not workable in South Africa, and the same applies to Cornwall, and it behoves any mining engineer to first consider and experiment before making a definite statement.

I agree with the author that the average extraction does not exceed 80%, considering that in many mines where the ore is poor, it does not reach that. There are to-day, when tin is fetching nearly £200 per ton, many idle mines in Cornwall with ore of an average value of 1%; although mining, with crooked shafts and over 2,000,000 gallons of water, from some mines, to pump daily, with "Lords' dues" and a complex ore, is done for an average cost of 23s. per ton. It should then not be difficult, if such marvellous results can be obtained in Australia and elsewhere, to make these mines pay. If the cost of tin mining in South Africa could be obtained, the information would be most valuable to a new industry, and would brush away some of the misceptions prevalent.

I append a flow sheet of a plant treating a complex ore, where the slime is treated three times and where the extraction is equal to 82% only. By referring to the sheet it will be noticed that four products are sold, viz., copper pyrite, wolfram, tin and arsenic. The pulp sample assayed 0·01% for copper, 0·015% for wolfram, 1% for tin, and 1·35% for arsenic. As the flow sheet clearly shows the treatment it is unnecessary to furnish any explanation, except as regards that pertaining to the copper pyrite, which being simple might be useful to someone running a small plant, possibly at their own expense where copper pyrite is present. It was found that the waste oil from the bearings of six Frue vanners, treating middling from twelve Wilfley tables, got into the boxes with the water used to wash the concentrate off, and this water with the very light skim of oil carried with it a large percentage of copper pyrite. To collect this the water was allowed to overflow into another box and from that into a launder 30 ft. long and 1 ft. wide. A piece of perforated copper grate was fixed across the launder at the end, with a piece of cloth placed across it to act as a filter. So well did this answer that practically all the copper pyrite was collected in the launder and the water which passed through the filter was quite clear. About 30 tons of copper pyrite were collected yearly by this means, assaying on an average 17% copper, which were sold to a smelter. The wolfram, as the sheet shows, was extracted by magnetic separation and assayed when finished 69% tungstic acid. After the concentrate was roasted and the wolfram extracted, the tin was treated in the usual way by dollying, etc., and assayed 65% metallic tin. The arsenic was collected in chambers and assayed when sold from 90% to 94%. I might add that the water used for treating the roasted concentrate was allowed to flow over a series of settling tanks into which was thrown scrap iron, and a little copper was collected by precipitation, but owing to the largest percentage being saved in the launder referred to, previous to the concentrate being roasted, the percentage of copper from these tanks was very small.

I very much question if with a complex ore it is possible to obtain a much higher percentage of extraction than 82%, although with an ore free from impurities of the kind mentioned above a little higher percentage might be recovered, but that would depend on the constitution of the ore, and whether fine crushing was used to eliminate the tin from the waste.

Mr. E. M. Weston (*Member*): As Mr. Treloar's contribution to this paper is mainly a criticism of my criticism, the President has allowed me to supplement my remarks. Regarding my attitude Mr. Treloar does not understand the tradition of this Society. The more pungent and sarcastic criticism is, as long as it is fair and impersonal, the more members, and in most cases the person criticised, enjoys it. I think the atmosphere is a healthy one, and Mr. Treloar will have to try and get acclimatised. If Mr. Treloar had understood this he would not have been so simple as to vehemently deny the fancy derivation I invented for the origin of the name Red river.

Regarding rag frames, Mr. Treloar has quite missed the point of my criticism, which was not why more frames were put down, but why the Cornishman used so unsuitable an appliance.

If Mr. Edward Walker did not know it was impolite to ask awkward questions after visiting Cornwall, I am not prepared to apologise for him. I would draw Mr. Treloar's attention to the remarks of the Cornish correspondent of the *London Mining Journal* of a recent date, who wants to know why one tributor easily draws 10 tons a month from the Red river with primitive appliances. And in connection with losses I would draw his attention to the prospectus of a company to treat the Carn Brae dump of 500,000 tons, containing 17 lb. of tin ore per ton giving a recoverable value of 5s. to 10s. per ton. If, as Mr. Treloar says, a rag frame extracts 65% of the slime the three treatments he mentions would recover 95% of slime values, so I am afraid there is a mistake somewhere; for the tin is in the Red river, and it comes from the mines. I note in the Rooiberg plant he has installed callow screens thus justifing my criticism on the paper.

Mr. Treloar favours slime tables of the Acme type and has installed them at Rooiberg. Tables of this class were installed 25 years ago at Mount Bischoff and do splendid work in series. I believe I am correct in saying that the metallurgists there are replacing them by machines of a more modern type which they have found better. Clitters I believe failed not because the ore dressing was bad; but because the Clitters mine was worked out, and there was more water than ore in the lower levels of "Kingston, and this has been largely the reason that these revolutionists returned home with much less money and a good deal more experience." They put up expensive plants to treat ore that investigation proved existed only in the imagination of the gentleman who tempted them. We all know in every country the fairy tales about the rich ore "the old men". left and the marvellous lode at the bottom of the flooded winze, and if the foreigners failed, not to get the tin from the ore, but to get the ore from the mine, apparently Cornishmen, at least, did not suffer.

And now having said most evil things I could think of about Cornishmen and their methods, I should like to add that I could say most of it about the men who have managed mining in every field in the world I know of, including the Rand and Australia. Mistakes have been made and money squandered in vast sums everywhere, and if some of us got the chance we would, no doubt, make some large and healthy mistakes ourselves. So honour to "the old men" Cornish or otherwise, for they were strong, brave men, and did their work in the world with their might which is more than can be said of some of us though we have better knowledge and better tools.

REPLY TO DISCUSSION.

Mr. C. F. Thomas (*Member*): I may say that the concentration of cassiterite is a widely discussed problem, and plants must vary according to the particular ores to be treated. If the ore should be chloritic and contain sulphides, float slimes are to be expected.

Mr. Walter McDermott's paper on "The elements of slime concentration" read before the Institution of Mining and Metallurgy in April, 1910, together with the discussion and contributed remarks thereon, contains valuable information. Mr. W. S. Welton gave some interesting figures on float tailing with a concentration to only four times the value of mill feed, proving great losses on silver, copper and lead ores. Mr. Weston is amazed to learn that wet concentration for the extraction of the sulphides of copper is unsatisfactory. It is a surprising confession to make, and a careful study of the matter might prove there is much to learn on the subject. It is necessary to carefully note to what exteut concentration has to be effected. To bring a copper ore to four times its value as a mill feed is not to be compared with a concentration of a cassiterite ore from 1% to over 80% cassiterite. There is a peculiar affinity between certain sulphides and oil. The Elmore Vacuum Process has done good work in preventing such heavy losses as have been often proved in the wet concentration of sulphides. Broken Hill, in Australia has had great difficulties in wet concentration. Broken Hill, in N. W. Rhodesia, has proved that with a complex ore the use of wet concentration is a failure.

It is unwise to make rash statements in a criticism unless one has definite proofs, and I regret having to show that Mr. Weston was extremely rash in many of of his remarks. "The extraction of mispickel is low by wet concentration and selection previous to milling is advisable." Mr. Weston evidently does not understand the meaning of this statement by me and then endeavours to prove it incorrect. Having considered he had proved the statement wrong, he says "the author really should try and realize Cornwall is not the universe or even the hub of it." Mr. Weston has mentioned Clitters and I believe he visited these mines about 1907. This plant erected bv Germans, which "gave the Cornishmen ocular demonstration in the art of ore dressing under modern conditions," is now idle. They selected mispickel previous to milling, roasted it, and then sent the residues to the mill, to increase the extraction. The Luhrig vanners were not successful on this particular ore. The loss of mispickel through float tailing was high. The Chairman of the Company was an Englishman, the Consulting Engineer was an A.R.S.M. and received his first practical experience in Cornwall. The manager was a Cornishman. The jigs were rarely at work; the Buss Tables made by the Luhrig Co. gave most excellent results, and great credit is due to the Company for introducing the Wetherill magnetic separator into Cornwall.

Stannite is a comparatively rare mineral found near the contact of slate with granite. Mr. Weston misquotes and says "it is not always found in slate near granite." I agree with him on this point.

Production. — "Australasia, Cornwall and Africa produce 12% to 13% of the worlds production." In regard to my quoted statement Mr. Weston says "the author appears ignorant of the fact that very extensive deposits of alluvial tin have lately been discovered in the Niger Protectorate" which bid fair to compensate for the stationary or declining output of the Straits Settlements and Australia. The Niger Protectorate is in Africa and I did not consider the output of sufficient importance, to mention under the heading of production. Bolivia was mentioned and its output has rapidly increased. One Bolivian mine is producing more tin than all the mines in Africa. The Province of Yunnan in Western China is producing approximately 4,000 tons of tin per annum. The Niger Protectorate may rapidly increase its output, but recent discoveries of cassiterite have not been considered of such importance to effect the market, and the price of tin metal has risen substantially in the last two to three years.

The Editorial Committee is next blamed for my using the expression "fluidity of the tin product." This seems unreasonable. It was stated that this particular concentrate was almost free from impurities which might have a hardening tendency on the metal. The so-called English tin is several pounds less in value than that from the Straits Settlements. Before the Bolivian concentrates came on the home market, English tin

was higher in price than that from the Straits Settlements. If one were to ask a smelter the reason, he might have something to say on fluidity.

"Sand from a modern plant with good classification should not be worth further treatment (or the tailing from the tables in front of the mill can be made too low in grade for further consideration). The object of wet concentration is to eliminate the maximum amount of crushed ore as waste in the first concentration.". This quotation from my paper should be plain enough to be understood by one who has even a small idea of wet concentration. Of course Mount Bischoff takes a middle head from the tables for regrinding, and also sends a sand tailing to waste.

Ilmenite is often associated with cassiterite, and Mr. Weston makes a bold statement when he says it calls for magnetic separation methods. If the concentrate is fine, I venture to say, leave magnetic separation alone until a better method for separation is found. The magnetic separation of slime has not been a success up to the present. Again, ilmenite is often present and is not liberated from the cassiterite, even after fine crushing. A test made after roasting a concentrate from a 30 mesh screen gave the following results:—The concentrate from the furnace assayed 51% Sn. Re-concentration on a No. 5 Wilfley table gave at the head 54% Sn, and at the tail 46% Sn. I would like to ask my critic whether there is any reasonable excuse for calling ilmenite, cassiterite.

It has been proved that with depth in granite, sulphides and wolfram decrease and the cassiterite becomes finer grained. "Sizing for fine grained cassiterite is unsatisfactory." In stating this I, according to Mr. Weston, show my ignorance of modern practice. The notes define fine grained cassiterite as yielding a concentrate of which over 90% will pass a 150 mesh screening.

The Callow screen is doing excellent work on the discharge from a 30 mesh screening, but what a suggestion to size for almost a slime!

In my paper I mentioned that "Elevators for pulp should be avoided if possible." Mr. Weston says it is not at all necessary to avoid pulp elevation. Who would not avoid elevating pulp containing 5% to 7% cassiterite, if possible?

Great attention has been paid to the slime question in wet concentration throughout the mining world, and particularly in Cornwall because the ore slimes to a great extent. Some mines are filtering the overflow water from the final concentration of slime through coke, etc. Such firms as Messrs. Fraser & Chalmers, Luhrig, Humboldt, etc,, are keenly interested in the matter. Mr. Walter McDermott says:—"In considering the progress of concentration methods for the last 30 years, it appears possible to draw certain conclusions which may be considered as elements governing the probable developments in the future. To those who have been in touch with this branch of ore treatment, it is very evident that there has been nothing revolutionary in the best practice for the period mentioned."

Mr. Weston must have solved the concentration of the slime, as he states "to me the explanation seems quite simple." I grant the Red River is returning 10% to 12% of the value that the mines are selling. It is probable this river is sending into the ocean 7½% to 10% of the output of the various mines. The river and its banks are a mass of slime concentrating plants for over 8 miles in length. All those who may be interested in the wet concentration of slime, will be anxious to have this explanation.

I purposely refrain from replying to certain remarks of Mr. Weston, and regret that prejudice is distinctly shown in the remarks I refer to.

Replying to the remarks of Mr. Amos Treloar, I may say that my paper purposely covered a wide area, and I hope it will lead to some papers on the concentration of tin ores. Recent experiments on slime containing 0·5% cassiterite prove a fair recovery of tin metal by means of electric smelting, but from an economical standpoint they have proved a failure. The percentage of recovery in tin concentration may not have received the attention it deserves, but it is difficult to obtain reliable information. Chemical analyses on low grade tailings are not always satisfactory. Not only the tin mining world is interested in water concentration, but the mining world has long been waiting for an efficient slime concentrator. It is probable that the cost per ton mined on the tin mines in Africa will prove exceptionally high.

Replying to Mr. Weston's further remarks, I may say that the recoverable value of Carn Brae dumps may average 6 lb. of cassiterite per ton. My sampling of these dumps gave an average of nearer 10 lb. per ton, but some waste burnt leavings exceeded 17 lb. of cassiterite per ton.

The Transvaal Consolidated Lands quarterly report to December 31, 1910, under the heading of "Groenfontein," states:—"It has been decided to re-treat the sand residues, which are estimated at 11,000 tons, assaying 1·29% metallic tin."

Other "waste" tailing dumps in the Transvaal will pay to re-treat, although a considerable loss has occurred through slime. I still venture the opinion that the average extraction obtained from mined cassiterite does not exceed 80%.

THE MINE DUST PROBLEM.

(Read at January Meeting, 1911.)

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

DISCUSSION.

Mr. G. O. Smart (*Member of Council*) read the following contribution to this discussion :—

Mr. A. W. Stockett (*Associate*): The model exhibited shows an improved method of manufacturing Dr. Aymard's collaring iron. In the original design this is made from a piece of steel plate, cut as the development of a frustrum of a cone, and then lap-rivetted, entailing considerable work. The present model is made from a piece of solid drawn boiler tube, which is cut to the required length with a saw, and drawn cold to the conical shape on a mandril by a single blow under the steam hammer. The cost of the material is about 6d., and the cost of manufacture is reduced to a minimum.

Mr. Tom Johnson (*Member of Council*): Dr. Aymard in his paper seems to have used a terminology of his own, which makes it rather difficult to criticise his paper.

From what I can gather the author seems to think there must be some difference in principle between the ventilating of a gold mine and a coal mine. There should not be—at least, not in the sense that the author means. Of course there is a difference, for, as a rule, coal mines are well ventilated artificially, and gold mines mostly ventilate themselves, which is certainly no credit to anyone. Nothwithstanding the fact of these terrible disasters we hear of, coal miners understand ventilation, and for the author to say that they must stop these disasters before they can teach us ventilatlon, is like a medical student telling the doctors he is studying under that he can learn nothing from them, until they can guarantee the life of every patient they accept, which would be rather absurd.

The author understands very little of mine ventilation, and is not in a position to judge of other people's knowledge of the subject. For instance, in the exhibited model of a portion of a mine; the upcast headgear was bratticed or closed in ; this he said contained a small fan, but it was not an exhaust fan. Now I should like to know what kind of a fan it was. Then he speaks of the practice of leading the foul air through the whole workings. I should like to know where this happens, as it would be rather a curious thing to see on the Rand in any of our self-ventilated mines. After all his condemnation of sending the foul air all through the mine, however, he calmly commends the Village Deep installation, which is simply passing the foul air of the Village Deep through the whole workings of the Village Main. There is some qualification needed somewhere, else he is straining at the gnat and swallowing the camel. I think he has missed his vocation in trying to teach us ventilation.

Again, he asks us who is to be told off to regulate the regulating doors at all times of the day and night. I think I will be a Scotchman for once and answer his question by asking him another. If he had a patient with a wound in which he, the doctor, had inserted a drainage tube, would he plant a nurse there to watch the drainage tube the whole time, when he knows from his experience that the tube would be all right for a number of hours without attention? The author should have read some elementary work on ventilation before writing his paper, and he would have found that there are thousands of regulating doors in use with no one sitting beside them.

In another place he speaks of "short circuiting the air." What does he mean by the term? He does not use it with the same meaning as it is generally used: I think he means *splitting*. Most of the trouble of poor ventilation in our mines is caused by short circuiting of the air. Then again he says, "without seriously interfering with the system of natural ventilation existing on many mines, I think the more extensive use of return foul air pipes along the roof of the drives would be beneficial." What does the author mean by this? Does he not know that the system of ventilation, natural or artificial, makes no difference ; the means of coursing or guiding the air are the same, *i.e.*, how the air is produced has nothing to do with how it is used.

Natural ventilation is one of the systems of production and belongs to the *science* of ventilation. Air pipes, doors, etc., used in coursing or guiding the air belong to the *art* of ventilation.

Who told the author that the ladderways were the most used path for travelling? In most mines they are not, so one can only judge whether a mistake has been made by making the ladderway the return, after knowing the conditions.

The author disagrees with the M.R. Commission for wishing old stopes to be closed off, then calmly recommends the same thing, and I think for the same reason, viz., to prevent them being made into latrines.

Although I cannot admit that the author understands ventilation, I do admire his perserverance in trying to help us with the dust question. I heartily agree with him that this question has not advanced much the last ten years. At the Geldenhuis Deep in 1901 we tried sprays, atomisers, jets, etc., and found that washing down the place before blasting was the

most effective method for allaying the dust raised by blasting, and that a small jet playing on the rock under the hole whilst drilling dry holes was good.

I have kept dust down very well with the ordinary milk tin, that is, keeping the face wet, but I did not use a 2½ in. or 3 in. bit to start with. I used a 2 in. bit which made much less dust. This is one of the points that needs looking after—the less dust there is made the less trouble to prevent it getting into someone's lungs.

Under the problem politic the author uses his new terminology again. The machines that are used three on a bar are percussion machines and the others must be air hammer machines. The author speaks of the difficulty of getting men to carry out the laws, but the difficulty is more apparent than real. If an Inspector of Mines took it into his head to visit, say, the development work on any mine, he should, on visiting the various places, be able to judge if the rules and regulations were being carried out, and if not, who was to blame. I think one great reason that things are not better is that *we* officials are much too easy, and are as much in fault as the men. If we only did our own duty, and made the men keep their places damp, or summons them for not doing so, we should make a great stride forward towards knocking out the dust question. It would cost fewer pounds in fines than we have lost lives through it.

The President: Dr. Aymard has a new device to show us: it has nothing to do with dust, though it comes under increased efficiency.

Dr J. L. Aymard (*Associate*) here exhibited a patent leg protector for the use of natives in the mines, saying:—"The hospital statistics show that injuries to boys' legs are very frequent and quite apart from the number of boys who go into hospital there must be a large number of boys who receive injuries to their legs, and who are working partially incapacitated. Boots and leggings have been tried but had to be given up, as the boys would not use them. A boy cannot walk up a slippery stope with boots on, so I have devised this modification of a boot. The idea is for the boy to wear out his own sole, and as ordinary leather would be perfectly useless in a short time I have substituted raw hide and turned the hairy part inside. I have made it perfectly flat, and turned it in so as to protect the toes. The boy simply slips his foot into it. It will probably last for a very long time as raw hide can be used in water for a long time before it becomes soft. I have had them placed on a boy's legs and thrown rocks at him without his feeling any hurt. The only question is that they are rather expensive, because raw hide is different from ordinary leather, and you can only make about eight pairs of these out of one hide.

Mr. G. Hildick Smith (*Member*): The following are a few points which have occurred to me in reading the author's interesting paper on "The Mine Dust Problem." With regard to his remarks on mine ventilation in which he says that it is the idea of promoting further discussion on the subject, which has prompted him to include it—ventilation—in his paper, I think a full discussion on the problem of ventilation could with ease be carried on *ad infinitum*, and at the finish there would still be a doubt as to whether the correct solutions had been arrived at What is really wanted, in order that the question of ventilation may eventually be thoroughly worked out, is actual practical experiments carried out by competent men in a thoroughly scientific manner from the results of which reliable formulæ can be deduced and standard methods adopted. All through the underground work in mines there is too much guessing, and this is a point which cannot be too strongly emphasised. It is due to several causes:—

(1) The great cost which would be incurred in making underground experiments. To commence with a State mine is required, either an old mine, which has been practically worked out, or a mine abandoned for various reasons would have to be acquired to start with and run as a combined training and experimental mine by the Government in conjunction with the Chamber of Mines. The whole might be controlled by a Central Committee consisting of representatives of the various mining houses and the Government, the mine itself being under the management of a thoroughly trained engineer. Or an alternative method to this would be the appointment of an underground experimental committee, who would appoint suitable men to experiment on various subjects underground on any of the mines of this field, permission having first been granted by the management of the mines for the experiments to be carried on, expenses being defrayed by a general experimental fund. We on the Rand like, at any rate, to pride ourselves that we are working on the most efficiently new and up-to-date mines in the world, therefore let us show that we are.

(2) Underground work is not an ideal occupation, it is too dirty, unhealthy and altogether too much against the grain to suit many men. Yet it is where the real spade work is done, and therefore where constant attention is most needed. There is much too much of the "look at the plan" game and tell them what to do about it

still. Experiments in chemical, mechanical and metallurgical laboratories are a very nice form of interesting amusement when one can sit on a stool in the fresh air and smoke and watch a beaker full of water boil, etc., but when it becomes necessary to spend every day of a week underground, for example, in order that a given experiment might be carried out, it becomes a different matter.

Ventilation can be taken as the first item on the programme, which has reached a stage where experiment is now needed and not discussion.

As to the "medical aspect" put forward by the author. We are here again guessing at present. The writer would like to suggest that experiments should be conducted on mine rats. It would be necessary first to determine whether the lungs of the rats living in the mines are affected with silicosis, if so, then healthy rats or other animals should be obtained, kept underground, some continually, others during the various shifts only. Some in cages or what not, so that they cannot inhale dust, and others along side them so that they can inhale dust, and after various periods post mortem examinations should be carried out on their lungs, etc. The smaller animals theoretically should be affected in a shorter time than human beings, due to their quicker breathing. Much could possibly be learnt in this way.

Coming now to the question of the respirators and their uses. I must first thank the author for saying that his work in this direction is entirely due to the suggestion made by me at one of our previous meetings. Not having been at the January meeting, on reading through the author's paper I was suddenly confronted with this announcement, and received at first a slight shock, but on second thoughts a further stimulus to work in this direction, in which I am firmly convinced that we have a sure preventative for phthisis for those who really are anxious to have one. The baffle principle can hardly be termed new, when in reality it is the principle, although on a much smaller scale, that prevents dust from passing through a damp sponge or two pieces of damp sponge superimposed through which all air inhaled has to pass in a zig-zag course before entering the mouth, depositing on the way any dust particles. I have here the type of sponge that I find handiest after having for several months experimented with all kinds. A rough practical test as to whether any dust particles pass a respirator can be carried out by means of some substance, such as snuff or pepper, which may be dusted around the outside of the respirator when in position, and deep and quick breathing resorted to, care being taken to protect the eyes. I have not tried this test with the author's respirator yet; but I think from an inspection of his respirators that the baffles are not close enough together to prevent air carrying dust from passing obliquely through the passages without striking any part of the baffles. Another point to be raised against respirators large enough to cover the nose and mouth is the difficulty of obtaining a good fit against the face and also the difficulty of being able to see over them when looking downwards. With a respirator such as I have here it is necessary to use small pieces of cotton wool in the nostrils, but a good fit against the face is assured and also there is no difficulty in being able to see just as well as without it in any direction. In my work as a shift boss I find no difficulty whatever in breathing through my respirator even after having run up 100 ft. of vertical ladders in order to test it.

There are just a few remarks I should like to make with regard to shift bossing. The author is correct in stating that it is the most arduous work on a mine, but he is wrong in stating that shift bosses to-day are called upon to do more work than formerly, the opposite being the case in all the well organised mines, especially in the older mines which require the most careful supervision to ensure safety. Here again we have an instance where it would be possible to adopt a proper standard in underground work. In very many cases the shift bosses finish their shift, finished physically, and when the dose has been repeated for many months, even when strict training has been resorted to, in order that a constant fitness for work may be kept up, yet eventually the result is, that the majority of shift bosses become so continually tired that they drift into nothing more or less than walking machines, not having the time or inclination to think. The remedy for such conditions is more shift bosses with better supervision and fewer accidents. The standard round of a shift boss should be set by the possible comfortable walking distance for underground, so that undue physical strain can be avoided. The standard distance allowed would vary somewhat as to whether a mine was a new developing mine or an old mine; in the former case the time taken up in walking, will be a greater percentage of the total time spent underground than in the latter case where more time has to be spent in more careful supervision. I would suggest as a standard day's walking underground a distance of about three miles with supervision of about 25 white men and 250 boys as a good day's work for a shift boss.

Mr. E. M. Weston (*Member*): I have marked a few passages that seem to call for comment.

Personally, I have always had the idea that in trying to shut off disused stopes and other places, the current would lose its velocity and become short circuited. Now, dealing with this matter of miners' phthisis, I should like to give you my recollection of some interesting conversations with a medical man in this town, which seemed to me to throw a good deal of light on the subject. It has already been noted that the amount of silica in the lung does not bear that proportion you would expect to the tissue of the lung when the lung is examined after death. I really forget what proportion of quartz was found in some of the lungs incinerated, but it was something very small indeed, and the slides which Dr. Moir showed us recently, raise that question again. It is probable the size of any of these pieces of quartz shown in them would be something smaller than 1/100th millimetre, and you would have noticed that the area taken up by the quartz was really very small indeed. To come back to my conversation with a medical man, I said to him: "Is it not true that the *small* proportion of solid matter existing in the air, which each one of us—without reference to miners—each one of us living on the surface must breathe into our lungs would suffice to choke them up entirely in the course of time if there were not some provision for removing matter reaching the lungs, as well as for preventing it from entering them?" The doctor replied: "That it was very well known, that Nature had several methods of removing ordinary foreign matter from the lungs." He said "the white corpuscles of the blood had the power of carrying away foreign matter from the lungs; that there were two glands where this foreign matter was deposited; that if we examined these glands (in the case of a person living in smoky cities) we would find them full up with smuts!" He said "that in the case of people who are breathing quartz dust, nature is continually at work removing these grains of quartz, perhaps as fast as they enter the lung;" but he said that "in the case of miners, the sharp character of the dust wounds the tissues of the lung, and that the first stage of miner's phthisis was generally the irritation caused by the presence of these wounds, caused by the particles of quartz. These particles of quartz may be removed after they have wounded the lung, but a certain scar remains as the effect of the wound." He went on to say: "that the second stage of progress of the disease was caused by fibrosis, due to these wounds. The formation of these scars or fibroid growths is a gradual process, reducing the area of lung available for oxidizing the blood, and if the scarring is extensive enough, may cause death, without any complications due to the presence of germs," That seemed to me a clearer explanation of the disease than I had ever heard from anyone else. No doubt learned members of this Society knew all about it before, but I think Dr. Moir will tell you that what we do not know is just the different effects on the lung of different sizes of quartz particles. Dr. Aymard says that many of the drives on the mines have a very peculiar stalactitic appearance, and that they ought to be nicely trimmed down. Well, unfortunately, mining is not an exact science, and we can scarcely guarantee that our drives shall always be as nicely and cleanly excavated as Dr. Aymard would wish. I do question the advisability of his recommendation, when he says that the whole of the drives in the mines should be systematically washed down once a week with some suitable disinfectant. Considering that in the Village Main Reef there are 20 miles of drives, it seems to me, one would have to increase the labour efficiency to a very large extent. I think Dr. Aymard is to be congratulated on the work he has done in attempting to stop the dust at the mouth of the hole. I think this question of miners' phthisis is largely a question of education. If we could drill into the managers the loss they suffer from the destruction of their most skilled and efficient labour; if we could only drill into the workers what they are exposed to, and how to avoid these dangers, good would come. The process may seem sometimes heartbreaking, but I agree with Mr. Johnson, that it is a process which, in the long run, will bear fruit. I think, also, that Dr. Aymard's suggestion that hose pipes should be armoured with wire, covered by tin, is a very good one.

Mr. R. Gascoyne (*Member*): I think it would have been better if Mr. Weston had followed his own advice to Dr. Aymard and confined himself to things he understands, and that his lecture on the medical aspect might have been left alone. The author, in referring to Mr. Penlerick's paper on East Rand ventilation, criticises that paper, but has evidently forgotten that the paper was devoted exclusively to the East Rand Proprietary Mines system of ventilation and was not intended to apply to any other mines. I wish to say that it is a very good system, and whatever fault there may be in carrying out such a system, it will be more in connection with the details than the general system. The author also criticises coal mine ventilation systems, but I agree with Mr. Tom Johnson when he said that it would have been much better for the author to have studied some elementary work on ventilation before tackling the subject. The author

is not aware that this dust question in coal mining is one of the most serious questions we have to deal with, far more serious even than in the case of metalliferous mining. Explosions do not happen through lack of ventilation in coal mines as generally supposed, but through the presence of coal dust, and great attention is therefore given to the removal of this dust. Coal dust is formed in a much different way to the dust in gold mines. The coal is, of course, much more fragile than local rock, and forms dust at every operation it undergoes, even during its transport along the drives of a coal mine. On that account it constitutes one of the greatest risks in colliery operations so that great and constant care has to be exercised so as to keep it within safe limits. The author says that the air enters along the hanging wall and returns along the floor. As a matter of fact in a deep mine with no system observed it will be quite the reverse. With regard to letting the foul air through the whole workings, I think that is never done when the mine is of any extent. Mr. Johnson has pointed out an instance where the ventilation after passing through one mine and becoming polluted is taken through the workings of an adjoining mine. Well, that is not a good system of ventilation, for every mine where possible should be self-contained and have its own upcast shaft. You will agree with me, I think, that whilst miners do not complain about the foul air generated in their own mines that it is scarcely courteous and polite to ask them to put up with other people's stinks. Of course the author thinks that managers ought to sandpaper their drives and make them smooth so as to reduce the friction of the circulating air. It is not the height or cleanliness of a drive that makes it better for ventilation, but it is the area of a drive rather than the height and the velocity at which the air travels that decides the friction. As Mr. Johnson points out, no one is wanted to watch regulators. In fact in a well arranged mine the ventilation should be self-acting. No one will depend entirely on doors or regulators, and they should only be used when there is no other alternative. There are such things as overcasts, and their use would go far to get rid of the artificial element in mine ventilation. As a rule the fewer doors you have in a mine, the more reliable the ventilation should be, and by adopting these overcasts the number of doors is reduced to a minimum. The author says that the recommendation of the Mining Regulations Commission to split the air cannot be carried out. As a matter of fact good ventilation in a large mine depends upon splitting the current; and cannot be obtained without judicious splitting. Mr. Weston also refers to the question of having the disused stopes and drives closed up. The author says they ought to be left open, as they afford a reservoir of cool air. As a matter of fact in a deep mine, these abandoned stopes, drives and other places will rather form reservoirs of hot foul air, and they ought to be closed up so as to obviate this accumulation of foul air and so prevent a sluggish current of air in the mine. Now I come to the question of the medical aspect. One would think it is rather a damaging confession for the author to say that the medical aspect of this question remains about the same as it did ten years ago. We mining engineers are inclined to ask why has he not given more attention to the medical aspect and less to ventilation, if that is the case, because in the medical aspect he ought to be better versed than in the ventilation of mines, no matter how well intentioned and praiseworthy his efforts in this dust question may be.

I think we are indebted to the author for the way in which he has taken up this matter, and can only regret that his paper does not go more fully into his promised methods of dealing with it for the benefit of those who have not seen it We are quite aware he has done it solely for the relief of suffering humanity, and we ought to encourage him all we possibly can. It is the duty of every mining engineer and mine manager to assist him in every possible way. There is one thing we are not surprised at, and that is the conclusion he has arrived at that miners are sadly indifferent in regard to this question. It is very unfortunate, but easily understood why it is so with such a slow and insidious disease. He has used some very strong language with regard to this indifference, so it may have the desired effect. No doubt if the mining regulations, as a whole, were carried out in a thorough manner, this indifference would cease to exist. Let us hope that the new efforts now being made in carrying them out thoroughly will have the desired effect, and that the miners' indifference will cease to exist.

Mr. F. J. Pooler (*Associate*): I will not presume to criticise, I merely wish to ask one or two questions with regard to the medical aspect of the question. Some time ago I saw an article discussing the relationship between moisture in the air and the working efficiency of those people who are working in that air. There was a statement about the loss of efficiency of the lungs in purifying the blood as regards addition of oxygen and removal of carbon dioxide, and I would like to know:—

1. Is it a fact that increased moisture lessens the power of the lungs to absorb oxygen? If so, are any tables available showing this effect?

2. What connection is there between human working efficiency and percentage of moisture in air?

3. Are miners more liable to lung troubles in damper mines than in drier ones?

Perhaps the author can give me some information on these points.

Dr. J. L. Aymard (*Associate*): I may say that Dr. Porter himself gave me some information which is not exactly such as to be favourably received by the mining community. It was that Prof. Haldane holds that there will be no difficulty in mining at very deep levels owing to the humidity of the air, but you will have to reduce the working hours. I think it is well established that human efficiency is largely decreased by humidity in the air. The great effort we should make is to keep the air as dry as possible.

Mr. E. J. Laschinger (*Member of Council*): It seems to me that a certain degree of humidity is necessary for efficiency. The point to be ascertained is what is the exact amount necessary. In certain diseases of the lungs a fixed humidity point is prescribed for the cure of patients. I have recently read that in America in private houses, schools, etc., humidity of the air is regulated and maintained at its efficient point. Everyone who has given any great attention to the matter knows that if the air is saturated it has a bad influence on the muscular system. This fact was brought very plainly to my notice years ago when taking underground temperatures. The moisture thrown off by the skin does not dry away, and you are bathed in your own sweat and heat. Schemes have been brought forward lately for regulating humidity, and I think from an engineering point of view, if the medical authorities can say what ought to be the proper humidity of the air, it is not without the bounds of possibility to do this on a practical scale. It is a problem which will have to be taken in hand before long, especially in very deep mines. If we can get the air cool as well as regulate its humidity, it will be all the better. This is an engineering matter which, of course, will require money, but it is not without the bounds of possibility to artificially maintain an atmosphere that will conduce to the maximum output of labour

The President: I may point out that the consensus of medical opinion is that 70% is about the best humidity for human life. In the Rand mines we have a humidity always over 90% generally near 100%, and therefore the mines have no chance of reaching the best conditions. Our only hope is to bring it down from 100 to 90.

Mr. E. J. Laschinger: My contention is that it is not at all impossible, but that it is within the bounds of practical engineering to regulate the humidity and temperature of air in mines without excessive cost.

The President: All the better: I am glad to hear it.

Mr. E. M. Weston (*Member*): Is not our trouble this: that as the mines grow deeper and hotter, and no doubt drier, we must use water largely in our stopes and drives to allay dust, and under these conditions the evaporation of this water must tend to increase the humidity to a dangerous degree, even if we dry and cool the air as Mr. Laschinger suggests before it enters the mine.

The President: Yes, but the question of watering dust underground only refers to development work, whereas the air of the whole of the other workings of the mine is saturated to begin with.

Dr. J. L. Aymard (*Associate*): Another interesting point is this. The engineers at work in the engine room of the Atlantic boats work under great heat, and engineers have told me that men can work long hours without trouble providing they perspire very very freely. When a new engineer goes down he is watched very carefully to see the amount of water he drinks and the amount he perspires. If he does not perspire freely he is sent up and his hours of work are reduced. Another point overlooked is the question of altitude. There was an interesting paper read recently and very little attention has been paid to it. A man coming to work here may feel a change for a short time, but I am sure compensation takes place. Our blood is supposed to become very thick, and to have a very deleterious effect upon the heart. I think it is purely a question of getting acclimatised. I believe you can live here more healthily than in any other part of the world if you only get acclimatised. Of course living at one altitude and working at another is different, and this is what the deep level miners do.

Mr. Gascoyne (*Member*): My experience is, that working in a temperature of 90° and over, is very detrimental to the efficiency of the workmen. I have found that working in that temperature, men are not able to do a full day's work. In deep underground working, when drives have been exposed for any length of time, they gradually cool down, and air can be delivered to the working face at practically the same temperature as it leaves the bottom of the downcast shaft. It is only a question of frequent splits, having special drives, and delivering the air to the advanced workings without coming in contact with other workings *en route*, that will keep the workings as cool as possible and

increase the efficiency of the men. In very deep mines, in the newly-opened working faces, the ground is perceptibly warm, and the return air, after having gone through the working places, is distinctly hot and moist, and carries a good deal of heat and moisture out of the mine, so that ventilation must do a great deal towards helping to keep up the efficiency of labour in the deep mines.

Mr. E. M. Weston (*Member*): In the silver-lead mines of Przibram, Bohemia, they are mining below 3,000 feet, and the Government who own the mines are making provision to supply the miners with, not 60 cubic feet per minute, but with 200 cubic feet of air per man per minute, so as to keep the efficiency of their workmen up to the mark. It is only a question of time when the fact must be recognised that the mines working below 4,000 or 5,000 feet must be prepared to supply air in somewhat the same proportion, and this air may have to be dried and cooled to keep down the heat and humidity of the workings to a level that will render human labour possible, let alone properly efficient.

Mr. Tom Johnson (*Member of Council*): We must use water in our working places, and if we increase our quantity of air we can carry much more water than we do when using a small quantity of air.

Mr. R. Gascoyne (*Member*): When Dr. Haldane said that men were not able to work more than six hours, he was probably referring to coal mining at say 3,000ft. and over, but I consider that similar conditions cannot be expected on the Rand until we attain a depth of 10,000ft.

Mr. T. G. Martyn (*Visitor*): There is one point which has not been mentioned this evening, *viz.*, that as the fresh-air circulation is increased in a mine, the evaporation of moisture is greatly increased, and with every unit of moisture taken up by the air, you will have a *corresponding reduction of temperature*; the spontaneous evaporation of water being almost the most effective way of cooling anything. If we increase the current of unsaturated air, the cooling effect will be enormously increased at the same time that the percentage of moisture in the air supply at the working face is reduced to a lower and healthier figure.

Mr. G. A. Robertson (*Member*) (contributed): Water spraying underground is only in a measure effective so long as the faces damped retain moisture. In connection with the present crusade against coal dust in collieries I noticed in an English paper recently that extensive experiments were conducted in a coal mine with a view to finding a suitable fluid for spraying purposes. It was found that water spraying had to be repeated more often than was practicable, and the spraying of soapy water seems to have been the best solution tried due to the fact that after evaporation has played its part a pasty substance is left to which the dust adheres. Where practicable in our mines here the idea is certainly worth a trial.

The meeting then closed.

Visit to the Crown Mines, Limited.

About 150 members of the Society availed themselves of an invitation from the Directors and Management of the Crown Mines, Ltd., to visit and inspect a portion of the surface works of their great property on Saturday afternoon, the 25th February.

The visitors were received at the mine by Mr. R. C. Warriner, the General Manager, Mr. H. T. Brett and Mr. Pitchford (Joint Managers), Mr. Fraser Alexander (Reduction Officer), Mr. S. H. Pearce (Consulting Metallurgist), and other members of the staff. Under this able direction they were shown the new crusher stations, the arrangements under construction for the more economical handling of ore from the shafts to the mills, the Butters' filter plant (which Mr. C. G. Patterson demonstrated and explained), the new staff quarters, the inhabitants of which were envied by many visitors not so advantageously situated, and the quarters for the men who are being recruited in South Africa for the purpose of being trained as miners.

At the conclusion of the tour of inspection, which lasted over two hours, the visitors adjourned to the Manager's beautiful grounds, were they were received by Mr. and Mrs. Warriner, Mrs. Brett and Miss Pitchford, and hospitably entertained. Dr. Moir (the President) in expressing on behalf of the members their thanks to Mr. Warriner, Mr. Brett and Mr. Pitchford and the staff for the instructive and pleasant afternoon, paid a well merited tribute to the management for their efforts to improve the conditions under which the men lived.

He also desired to thank especially Mrs. Warriner and the ladies for their courtesy and kindness in looking after them so well that afternoon. Mr. Warriner briefly responded, and the gathering dispersed.

The following description of the property was circulated to the members for their information:

The property embraces, from the east, the Robinson Central Deep, Crown Deep, Crown Reef and South Rand, — Langlaagte Deep, Langlaagte Royal and Paarl Central on the west,

and in addition 1,278 claims of deep level ground. In extent it is about three miles from east to west on the strike of the reef.

There are on the property, nine main shafts and seven crusher stations when including those at the Paarl Central and Langlaagte Royal, and the property is being so laid out, both on the surface and underground, that in the future there will be only two large crusher stations; one at No. 5 and one at No. 7 shaft. By a system of underground chutes and haulage, the rock from the Langlaagte Royal, Paarl Central, Langlaagte Deep and western areas will be concentrated at No. 7 shaft and hoisted there, while all the rock from the eastern section will gradually be concentrated at No. 5 shaft. These two shafts will have to handle between 9,000 and 10,000 tons daily or the full requirements from the mine. The two shafts will be connected on the 13th level at a vertical depth of approximately 2,200 ft. This level will be a main haulage level, the main drive being 14½ ft. wide and practically straight from one end of the property to the other. This drive will be served by electric haulage so arranged that ore may be delivered to either shaft.

No. 7 Shaft.—This shaft is at present vertical to incline with three hoisting ways and pump way. Alterations are well in progress to convert the hoisting at this shaft into double stage with four hoisting ways in the vertical, hoisting four ton skips, and four hoisting ways in the incline, hoisting five ton skips, all hoisting being done electrically.

No. 7 Shaft Crusher Station.—This is the western station of the Crown Mines, and is being equipped to handle 3,500 to 4,000 tons per day on day shift only. Special features are three 30 in. conveyor belts delivering into nine 30 in. × 12 in. Hadfield & Jack crushers. The return side of these belts are utilised for waste which is delivered to a transverse belt delivering to the waste bin and thence to dump. The rock from the crushers is caught in bins of 1,000 tons capacity, thence it is discharged through pneumatically operated doors into 40 ton hopper trucks. These trucks are hauled in train by 50 ton electric locomotives, and may be delivered to anyone of the mills of the Crown Mines. The trucks are constructed so that their discharge may be pneumatically controlled from the locomotive, thus reducing the labour required to a minimum.

No. 5 Shaft.—Total vertical depth to be 3,400 ft. Three main haulage levels will be established in this shaft at distances of 600 ft. apart, vertical. These main haulage levels will be the 13th, 16th and 19th, and they will control all the ore down to the South Rand dyke. On each of the levels electric haulage will be installed. At each of these levels the ore bins will have a capacity of 2,000 tons, and winding will be done by three 8-ton electrical winders—as large, if not larger, than any electrical winders in the world.

No. 5 Crusher Station.—This station will be identical with that at the No. 7 shaft, excepting that its capacity will be larger, being about 5,000 to 6,000 tons per day of 10 hours.

Metallurgical.—The present equipment is 675 stamps with 20 tube mills, and sand and slime plants made up as follows:—

A. Crown Deep	300	stamps and	10	tube mills
B. Langlaagte Deep	200	,,	6	,,
C. Crown Reef	120	,,	3	,,
D. Bonanza	55	,,	1	,,

With the present plant we have a capacity of 165,000 tons per month.

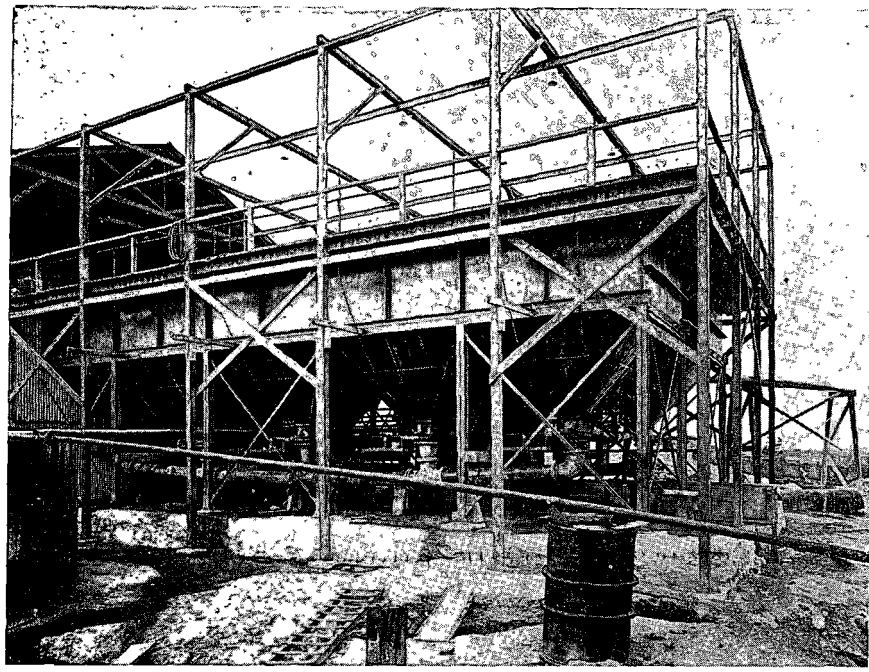
A fifth mill is being erected of more modern type, which, when completed, will increase the total crushing capacity to well over 200,000 tons per month. Special features are the tandem classifications and the tube milling at A plant.

The installation of a 300 leaf Butters' vacuum filter slime plant at C plant, which is unique not only on account of its being the first vacuum filter plant erected on these fields, but that it should occupy the site of the first slime plant designed and erected on the Rand by Mr. J. R. Williams in 1894.

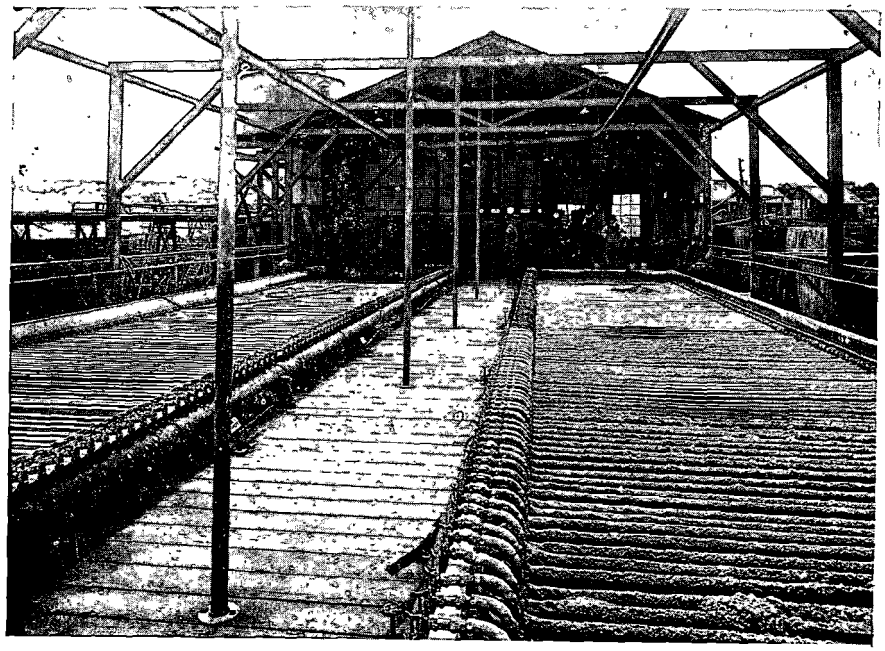
Butters' Vacuum Filter Plant:—We have also to thank Mr. C. G. Patterson for the following description of the Butters' vacuum filter plant as installed and worked on the Crown Reef section of the Crown Mines:—

The plant consists of two stock vats equipped (temporarily) with air agitation to keep the slime in suspension. After the values have been dissolved in Brown agitators, the pulp at a dilution of 2 to 1 is transferred to the stock pulp vats, from where it is fed to the filters as required.

One wash solution vat. All precipitated solution is delivered to this vat to be used subsequently for a wash in the filters. Two Butters' filter boxes each fitted with 150 Butters' patent vacuum filter leaves and one 14 × 14 Gould's vacuum pump. Each filter box is an independent filtering unit. One 10 in. Robeson-Davidson slime pump handles pulp and solution to and from the filter boxes and the stock vats, serving the boxes alternately. The piping is arranged round the pump in a loop, having four valves interposed so as to reverse the direction of flow through the pipes. The pump is set in either the emptying or filling position instantly, by means of one pilot valve introducing hydraulic pressure into the cylinders of the four valves simultaneously. The motor for the 10 in. pump and also valves in the pump systems are operated from the



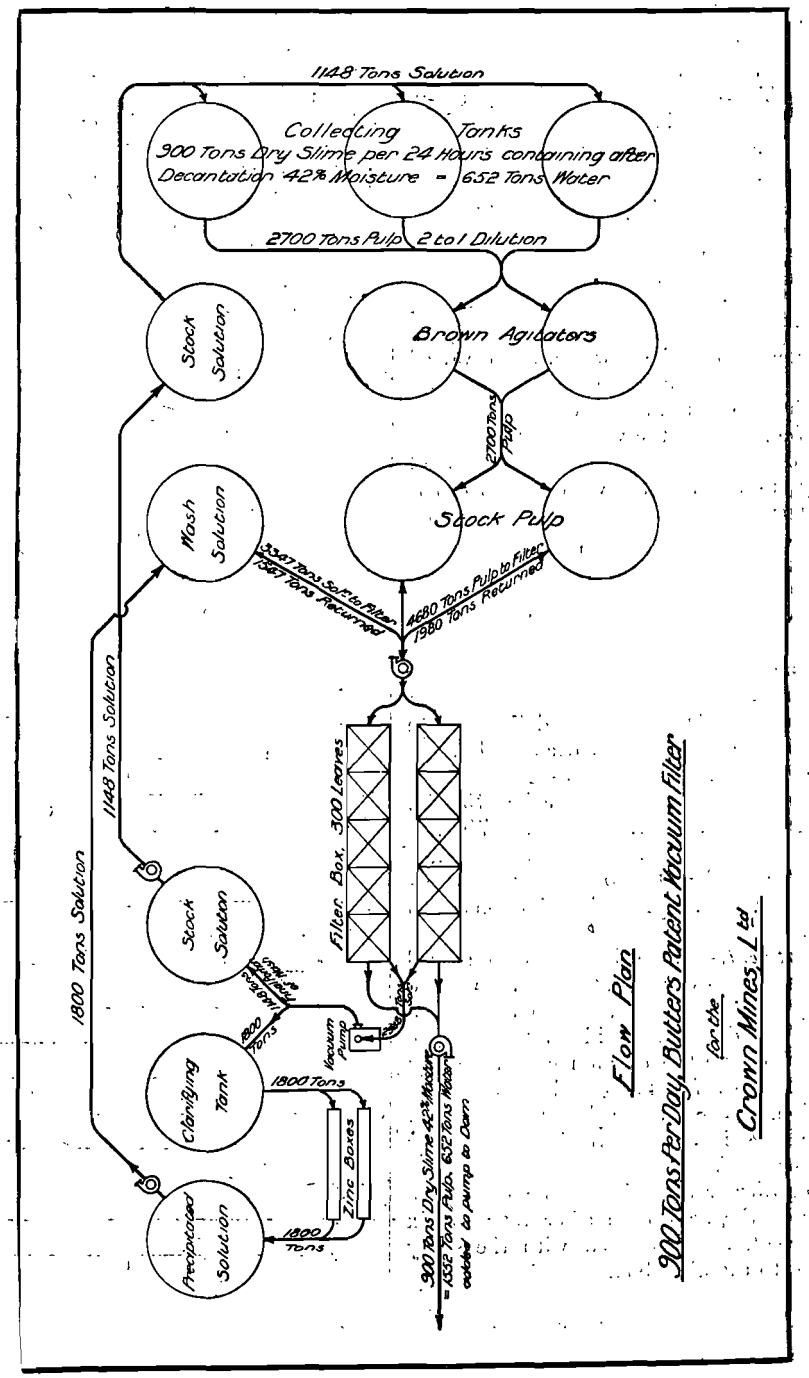
View of Butters' Vacuum Filter Plant, from beneath.



View of Butters' Vacuum Filter Plant, on Operating Platform

switch board. The style of plant is called the "pumping system," and the process of filtration is performed as follows:—

Forming the Cake.—The filter box is filled with pulp to a point over the top of the filter leaves, and a valve opened connecting the vacuum pump directly with the filters. Clear cyanide solution is drawn from within the filter leaves and delivered to the clarifying vat for precipitation, the slime remaining as a cake on the outside of the filters. The filters are kept submerged by refilling the box at intervals, and jets



of air are introduced at the points of each hopper to keep the slime in suspension. When a cake 1 in. to 1½ in. thick has been formed, the surplus pulp is pumped back to the stock pulp vat, and the box is then filled with solution to wash the cake. During the time of forming and washing the cake, the vacuum is maintained at the highest possible point, but when the cake is exposed to air during the transfer of pulp and wash solution, the vacuum is reduced to 5 in. to prevent the cake cracking.

Washing.—The cake being formed by atmospheric pressure, the resistance and permeability is equal over the whole surface of the leaf, thus producing an ideal condition for the recovery of the valuable moisture contained therein, which equals 30% to 35%. Sufficient wash solution (about 2 tons per ton of slime) is drawn through the cake by the vacuum pump to effect a complete displacement of the original moisture. A portion of this solution goes to the clarifying vats for precipitation; the flow is then diverted to a stock vat to be used in making up new charges in the Brown treatment vats.

Discharging.—When the wash is complete, the vacuum is disconnected and a reverse flow of solution (by gravity from the vat on the roof) is introduced to the interior of the filters, causing the cakes to drop. The surplus solution is then pumped from the filter box through decanters and returned to the wash solution vat. The mass of thick sludge remaining in the box is diluted with water and agitated with air for a few minutes to make a homogeneous pulp of 1 to 1, which is then pumped to the residue dam by a second, 10 in. R. & D. pump, the delivery pipe of which is fitted with an automatic sampler.

Cycle of Operations.—

Filling box with pulp and forming cake	45	min.
Transferring and washing	70	,,
Discharging	20	,,

Total time of cycle 2 hours 15 minutes.

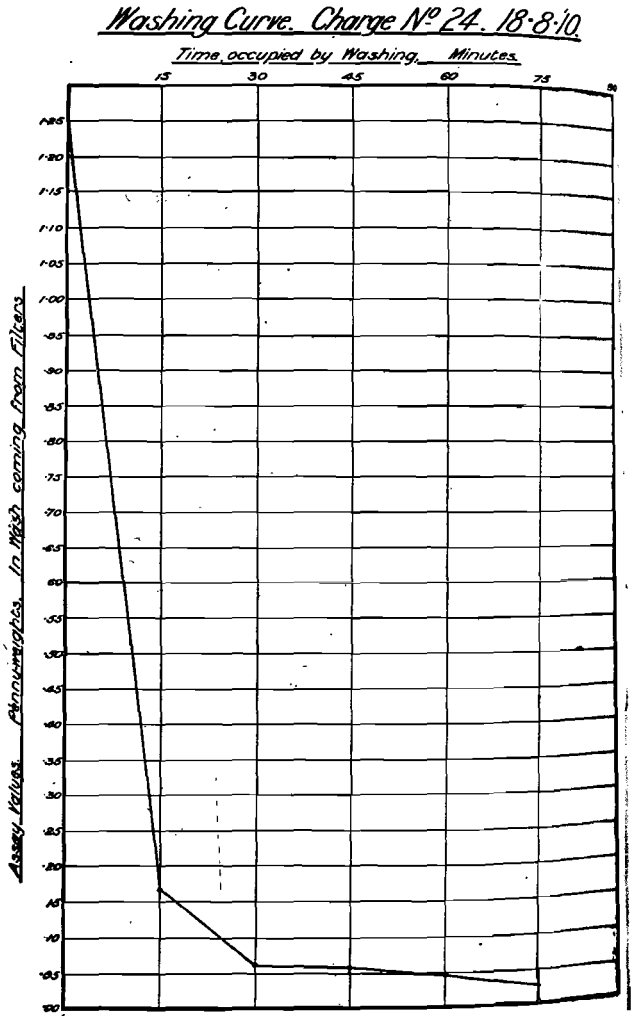
Tons treated per cycle, 1¼ in. cake = 50 tons each box.

Acid Treatment.—Five leaves are removed from each filter box every day, thoroughly washed with a spray of water and air, and then immersed in a vat of 2% hydrochloric acid solution, for the purpose of dissolving the calcium carbonate and keeping the leaves soft, pliable and in good working condition. The HCl solution is passed through the leaves in reverse directions alternately by means of an automatic arrangement that requires no power or attention. The leaves are removed from the acid bath after four to six hours' treatment, again washed with the spray and returned to the filter box.

Space will not permit of a complete analysis of the six month's test work, as conditions were not normal, owing to insufficient slimes to work the plant to full capacity, and to the treatment of deleterious accumulated slime in combination with the current slime the major portion of the time.

In January a special test was made on current slime only, treated first by the Adair-Usher process, the residues from which were delivered to the filter for the purpose of determining what further recovery of dissolved values was possible by filtration. In this test, as also in the former operations with accumulated slime, the efficiency of the filter was fully demonstrated, assays of the residues showing consistently during the whole period over 99% recovery of dissolved values.

There is some dissolving of gold, incidentally effected, during the process of filtration; however the Butters' filter is essentially a slime washing machine, purely mechanical in its functions, and might be termed a process of forced decantation.



The plant was designed to treat 500 tons per day. Subsequent operations proved, that, owing to the exceptional adaptability of Rand slime to filtration, it has a capacity of 900 tons per day.

The plant was put in commission on August 12th, 1910, and after a most exacting test over a period of six months, has been formally taken over by the Crown Mines, Ltd., as a part of their permanent plant.

Obituary.

The deaths of the following members are recorded with much regret:—

Dr. MAX MARCUS KLEIN, M.D., Ph.D., who died suddenly on the 16th January. Dr. Klein was well known for the great interest he took in the health and dietary of the natives on the Witwatersrand, and in April, 1905, contributed a paper on "Food, and the Practical Aspect of the same in Compound Work" to the S.A. Association of Engineers. Dr. Klein, who practised at Brakpan and was also medical officer for the Rand Collieries, was elected a member of the Society in March, 1908.

Mr. DOUGLAS WILLIAM GREIG, who died on the 10th March from the result of burns received a week earlier whiledestroying damaged nitro-cotton was one of the technical chemists of the Dynamite Factory at Modderfontein. A lance-corporal in the Imperial Light Horse, he was buried with military honours at the Factory Cemetery on the 11th March. Mr. Greig, who was admitted an associate of the Society in April, 1909, read an interesting contribution to the discussion on Prof. Stanley's paper on the "Smelting of Titaniferous Iron Ores" in January, 1910, and in collaboration with Mr. Wm. Cullen submitted a paper to the Society in September, 1909, on the "Analyses of Gases from Burning Nitro-Glycerine Explosives. His untimely death came as a great shock to his many friends.

Mr. DAVID MURDOCH, cyanider at the Simmer and Jack Proprietary Mines, Ltd. Mr. Murdoch was elected a member in April, 1909.

Mr. W. D. MORTON, who was elected a member in July, 1906, was at one time a partner of Mr. Howard Pim, the well-known accountant and auditor of many Rand Mines and De Beers Consolidated Mines. Mr. Morton had been in indifferent health for some years past.

Mr. C. C. MARSHALL, M.I.M.E., one of the oldest associates of the Society, having been admitted in May, 1898. Mr. Marshall, who practised as a mining engineer and surveyor had a varied experience on the Rand, having been employed at various times with the General Mining and Finance Corporation, Ltd., the Van Ryn Estate, West Rand Mines, Geduld Proprietary Mines. On leaving the Rand he spent some years in Rhodesia, where he died.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

CHEMISTRY OF COAL-DUST EXPLOSIONS.—"The chemical aspect of coal-dust explosions has been carefully studied at the Experimental Station at Liévin, France, and the discussion of the results obtained in this direction forms one of the most important parts of a report on the production of dust explosions recently issued by the Director of the Station. The experiments were conducted in the main test gallery, then 65 mm. long (1 metre being equivalent to ·914 yd.), and in order to collect the gaseous products of combustion a glass flask, exhausted of air, and connected by means of a sealed glass tube to the interior of the gallery, was caused to fill itself immediately the explosion reached that point. This was done by the flame firing a detonator attached to the tube, which was shattered, thus allowing the gases to rush into the flask. To ascertain the composition of the gases entering in this way, the analysis had to be corrected for the amount of air previously existing in the flask owing to incomplete exhaustion. In the accompanying Table I., the actual analyses are set forth in columns 3, 4, and 5, while the corrected figures are given in columns 6, 7, and 8. The figures in the first column refer to the number of the experiment, samples of the gases not being taken in every one of the tests, but only now and again.

An examination of column 7 shows how little free oxygen remained after the passage of the flame; the combustion must, therefore, have been almost complete. In the test No. 43 the residual oxygen attained 8·4%, but it is seen that this experiment was conducted with the lowest dust charge; namely, 112 gm. per cubic metre, a gram being equivalent to ·0353 ounce. Theoretically, this amount of dust is sufficient to absorb the whole of the free oxygen of the air; therefore, the analysis shows that, as 40% of the air remained unchanged, a portion only of the 112 gm. of dust took part in the explosion.

In column 9 is expressed the relation between the volume of carbon monoxide and the total volume of the two oxides of carbon formed in the combustion—that is $\frac{CO}{CO_2 + CO}$. Leaving the results of Nos. 150 and 151 out of account for the present, it is seen that this ratio, though very variable, is low, and that it appears rather larger for the heavier dust charges than for the lighter ones. The fact revealed here could hardly have been anticipated; it is that although an excess of dust may be present at a high temperature, the amount of carbon dioxide formed in the flame greatly predominates over the amount of carbon monoxide. It must, however, be noted that the gases were taken from immediately behind the breast of the flame, and before the red-hot carbon

TABLE I.

Number.	Dust charge in grams per cubic metre of gallery.	Analyses of the gases collected in the flask.			Corrected composition of the gaseous products of combustion.			$\frac{CO}{CO_2+CO}$ (volumetric proportion.)	Relation between the weight of hydrogen burnt and the weight of carbon burnt.
(1)	(2)	CO_2 (3)	O (4)	CO (5)	CO_2 (6)	O (7)	CO (8)	(9)	(10)
		per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	
43	112	7·50	11·00	·50	9·00	8·40	·60	6·0	·1043
53	225	10·25	5·00	3·00	12·10	1·20	3·60	23·0	·1196
79	337	10·25	5·75	1·50	10·50	4·60	1·50	13·0	·1391
56	337	9·75	5·75	2·00	11·40	2·10	2·30	17·0	·1463
39	450	9·75	4·25	4·50	11·60	·30	5·40	32·0	·1210
139	450	12·50	3·25	1·50	13·05	1·45	1·60	10·7	·1242
36	450	11·00	3·00	4·00	9·95	1·90	4·10	28·5	·1610
58	450	10·25	5·00	2·25	12·00	1·20	2·60	18·0	·1410
77	450	12·00	2·50	1·50	12·00	1·25	1·50	11·1	·1677
57	450	9·25	5·75	2·00	11·10	1·50	2·40	17·7	·1715
62	450	7·75	7·00	3·25	11·00		4·60	29·5	·1565
63	450	7·50	7·00	3·25	9·90	1·65	4·30	30·2	·1700
108	450	10·00	2·75	3·75	10·60	·48	4·00	27·2	·1772
35	450	8·00	6·50	1·50	9·20	2·90	1·70	15·7	·2394
150	450	5·50	2·00	6·50	5·30	·95	6·30	54·1	·3275
151	450	4·25	2·50	6·50	4·20	1·00	6·40	60·4	·3972
75	610	10·50	5·00	1·25	10·60	3·80	1·30	10·6	·1623
74	610	10·25	2·75	4·50	10·50	1·50	4·60	30·5	·1454
59	900	7·00	6·75	4·25	8·40	3·00	5·10	37·7	·1682

had a chance to re-act on the carbon dioxide and reduce it to the monoxide. That the latter reduction actually takes place, and that the reaction takes a short but appreciable time to complete, was demonstrated by tests Nos. 150 and 151, wherein the gaseous products were obtained from distances, respectively, 10 and 5 meters behind the breast of the flame. A glance at the analyses of the gases taken in these two tests will show that there was an excess of the monoxide over the dioxide of carbon at these distances behind the flame. It is, therefore, apparent that chemical activity continued behind the flame, resulting in the rapid increase in the percentage of carbon monoxide.

How very dangerous is the afterdamp of a dust explosion may be gathered from these last analyses. Not only had the oxygen almost entirely disappeared, but carbon monoxide was produced in such high proportions that if the products had been diluted with a large quantity of fresh air they would still have been dangerous to breathe even for a short time.

In the last column of Table I. is stated the ratio by weight, w, of the hydrogen to the carbon consumed in the combustion. The figures in this column are noteworthy in that they indicate the importance of the part played in the ignition by the volatile constituents of the dust. Before the bearing of these relations can be discussed, it is necessary to explain the manner in which they were calculated.

The quantity of carbon burnt is deducible straightway from the amounts of carbon dioxide and monoxide produced. The hydrogen, however, cannot be computed quite so easily, since it forms watery vapour in burning, which condenses, and hence does not make an appearance in the results of the analyses. The weight of hydrogen has, therefore to be obtained indirectly by calculating the amount of oxygen which has disappeared as water. Now the analyses render account of all the oxygen, free and combined, except that forming water; while the nitrogen formerly existing mixed with oxygen as the air of the gallery, is obtainable by difference. Thus, by using the well-known relation between the volumes of nitrogen and oxygen in normal air, we are able to compute the total original amount of the latter gas, and then, by difference, the amount which, after the combustion, exists in combination with hydrogen as water.

The following gives further particulars of the calculation: Let 100 volumes of the gas in the flask contain a volumes of CO_2, b volumes of oxygen, c volumes of CO, and d volumes of hydrogen and hydrocarbons, the remainder being nitrogen. Among these various gases will be mixed r volumes of air, being the quantity initially present in the flask by reason of imperfect exhaustion. The latter quantity, r, is easily found from the initial pressure in the flask. Making the necessary correction for r, the total volume of oxygen entering the flask, both in the free and combined states, is:

$$O = a + b + \frac{c}{2} - \cdot 21r;$$

and in the same way the quantity of nitrogen entering is

$$N = 100 - (a + b + c + d) - \cdot 79r;$$

Of the nitrogen so calculated a small quantity, n, will have been derived from the coal dust; the remainder $(N - n)$ existed originally in the air of the gallery, and accompanying it there must have been $\frac{21}{79}(N - n)$ volumes of oxygen. If k volumes of oxygen were also derived from the coal dust, then, by difference,

$$\tfrac{21}{79}(N - n) + k - O$$

measures the amount of oxygen now in union with hydrogen in the form of water. Therefore, by volume,

$$\frac{\text{Water vapour}}{CO_2+CO}=2\left(\frac{\frac{21}{75}(N-n)+k-O}{a+c}\right)$$

and by weight,

$$\frac{\text{Hydrogen consumed}}{\text{Carbon consumed}}=w=\tfrac{2}{12}\cdot 2\left(\frac{\frac{21}{75}(N-n)+k-O}{a+c}\right)$$

Substituting for N and O their values as obtained above, we may write:

$$w=\frac{8\cdot 75-\cdot 421(a+b)-\cdot 255c}{a+c}-\frac{d}{12(a+c)}+\frac{4k-n}{a+c}$$

This expression includes a principal term—the first one, and two corrections—the last two terms, of which the latter are of little importance. It has been found that d has a value never exceeding unity, and that the smallest value of $(a+c)$ is 12; therefore the term $\frac{d}{12(a+c)}$ is at the most equal to $\frac{1}{144}$; *i.e.*, only 5% of the mean value of w. To evaluate the term $\frac{4k-n}{a+c}$, it is necessary to consider the weight of dust producing the quantities k and n. Let us suppose that 450 gm. per cubic metre of air had been put into effective suspension. This amount will be equivalent to 45 gm. per 100 liters of air, and will very nearly be equivalent to 45 gm. per 100 litres of the gas in the flask. Now 45 gm. of the dust used in these experiments contained 8·5% by weight of oxygen and nitrogen, that is to say, 3·8 gm. of these gases; and these when liberated would occupy 3 litres. Since the residual particles after an explosion still contain a large part of the volatile constituents of the dust, only a portion of the 3 litres of gas will actually be set free. Inasmuch as those quantities of oxygen and nitrogen existing in the proportion in which those gases are found in normal air will be eliminated in the difference $(4k-n)$, the latter term can only represent a fraction of a litre. It is therefore apparent that the last term of the above expression is of even less importance than the middle one. Hence, in calculating the figures in column 10 of Table I. these last two terms were neglected.

The general high value of w is striking and important. In the dust used for the experiments there were only 4 parts by weight of hydrogen to 75 of carbon. If the carbon had completely burned, w would have been about ·05, while as a matter of fact, it always attained at least double that figure.

If the volatile matter were taken to consist entirely of hydrogen—certainly an incorrect assumption—the above results would show that the weight of the volatiles taking part in the combustion would be derived from at least twice the weight of the dust wholly burned; the proportion will, as a fact, exceed this, for besides hydrogen, the volatiles contain carbon in the form of hydrocarbons, and that element goes to swell the denominator of the ratio w.

The mean value of w appears to be increased when heavier dust charges were used, and this might be explained from the fact that the more numerous the particles of dust in a cloud, the greater the total surface from which volatiles may be distilled.

Now, it has already been stated that the gases entering the flask in all the other experiments contained only an insignificant amount of unburnt volatiles; however, on estimating as marsh gas the unburnt volatiles obtained in tests Nos. 150 and 151, they were found to be present in the proportion of 3·8% and 5·2% by volume, respectively. It, therfore, follows that for these tests the last two terms of the formula for w derived above are no longer negligible, and must be taken into account. After the necessary corrections had been applied, it was found that the values of w for the two experiments in question were, respectively, ·301 and ·352. Although these figures are less than those given in column 10, they are nevertheless considerably larger than their equivalents in the other tests where the gases were taken from close behind the flame. The presence of unconsumed volatile matter, and the high value of w obtaining when the gases were taken some distance behind the front of the flame, show that the distillation of the dust continued in that region after the flame had passed. Since there is no more, or nearly no more, free oxygen available to unite with the volatiles so produced, there must remain a surplus of the latter. The increment in w shows, however, that some of the hydrogen of the volatiles liberated after the passage of the flame had united with oxygen, while the proportion of carbon monoxide has also increased; it is, therefore, probable that, in the region behind the flame, reactions such as the following take place:

$$H_2+CO_2=H_2O+CO.$$

Other observations were made on the phenomena of combustion. The first of these was in reference to the amount of smoke produced by an explosion. By raising a shutter, a connection was made after every experiment between the gallery and a fan drift, and the smoke then blown out of the open end of the gallery by the fan, when its colour and other characteristics could be noted. When the dust charge was at least 450 grams per cubic metre of air, the smoke was always thick and black. With lesser charges it was a clear grey, and sometimes almost white.

Dense black smoke consists of an excess of fine dust particles, together with watery vapour which has cooled and condensed, and soot resulting from the combustion of hydrocarbons in an atmosphere almost depleted of oxygen. Grey or white smoke indicates a combustion of the dust which is complete or nearly so, only ash remaining, together with watery vapour in process of condensation. In the last case there existed a sufficiency of oxygen to burn the hydrocarbons without the formation of soot.

In a number of experiments the solid residues in the gallery were systematically collected. They were obtained from the floor and from a dozen transverse shelves each 20 centimetres wide, placed every 2 metres between points in the gallery, respectively, 18 and 40 metres from the origin of the explosion, it being in this portion of the gallery that the bulk of the solid products were deposited. As a rule, little of the residues was found near the source of the explosion, and often none at all in the last few metres of the gallery. This latter fact might be explained through the re-entry of air occurring immediately after an explosion, which would sweep back into the interior any solid matter lying near the mouth of the gallery.

Table II. gives the weight and composition of the residues collected, the weights being stated per cubic metre of the zone from which the products were taken. From what has just been said, it will be apparent that had the products been collected from the full length, and compared with the full volume of the gallery, the results would have been lower than those given below. On the other hand, they would have been higher had the matter from the walls also been included, and also if it had been possible to have added those solid particles ejected from the gallery by the force of the explosion and not drawn in again by the back suction of air.

As would be expected, the weight of residual solid matter increases with the dust charged into the

TABLE II.

Number of Experiment.	Weight of dust per cubic metre of gallery	Weight of solid residues per cubic metre of gallery.	Analyses of solid residues.			Percentage of volatile matter (moisture deducted) in the solid products after the ash has been eliminated.	
			Volatiles including moisture.	Moisture.	Ash.		
	Grams	Grams	per cent	per cent	per cent	In detail.	Mean.
43	112	40	21·15	1·69	22·52	25·0	25·00
53	225	123	21·57	2·42	14·52	22·4	22·40
56	337	210	25·08	1·99	12·45	26·3	26·25
79	337	220	25·09	2·19	12·94	26·2	26·25
36	450	240	25 70	2·20	13·95	27·2	25·30
39	450	227	22·86	2·20	14·54	24·1	25·30
58	450	335	23·37	2·21	13·12	24·6	25·30
75	610	530	26·49	2·19	12·70	27·8	27·80
54	900	670	27·09	1·87	10 52	28·2	27·50
59	900	680	25·98	2·02	10·39	26·8	27·50
Composition of the coal dust used in the experiments			28·00	1·00	9·00	29·6	29·6

TABLE III.

	Volatile Matter Per Cent.	Ash Per Cent.
Coke in grains, or agglomerated	15·3	14·04
	14·4	14·23
	13·4	11·08
	12·3	19·20
	11·4	27·20
Coke in thin flakes from the surface of dust	24·6	11·71
	24·0	11·35
Soot mixed with dust	13·8	19·20
Residual coal-dust	28·1	10·75
	26·3	14·05
	26 2	10·11
	22·4	13·10
	18·9	14·70

gallery; it is almost proportional to the excess of the charge over about 100 grams per cubic metre, which corresponds to the complete combustion of the carbon of the coal-dust by the oxygen of the air.

The analyses show that the products were poorer in volatiles and richer in ash than the original dust from which they were derived. A reference to the last column of the table also shows that, even after the ash constituent has been eliminated from the products and the original dust, the former is still the poorer in volatiles, thus proving that the reduction in volatiles revealed by the analysis does not result merely from the increase in ash, but that there must have been a partial distillation of hydrogen and hydrocarbons from that part of the dust which was not completely burned. This result is in concordance with the conclusions which have already been drawn from the gas analyses. The solid products were appreciably more humid than the original dust, owing to the condensation of some of the large quantity of watery vapour produced in the explosion. Water was also found condensed on cold portions of the walls of the gallery.

A further examination of Table II. shows that there was generally a more pronounced reduction in the percentage of volatile matter when the dust charge was small. In other words, although the amount of volatile matter per cubic metre is greater with the heavier charges, it does not increase proportionately with the charge, but at a lesser rate. This can be explained partly from the laws of variation of temperature during combustion, and partly from the fact that, with the heavier charges, the dust is not perfectly lifted; thus there must be a portion of the dust in contact with the floor, which, although included as 'solid residue,' has not been thoroughly subjected to the effects of a high temperature Hence, in reality, Table II. registers the analysis of a mixture of the actual solid products of combustion of the dust lifted, with dust lying immediately against the floor, the composition of which would hardly be altered.

Examination showed that the solid residues usually consisted of three parts; namely, dust whose physical aspect remained unchanged, coke either in a finely divided condition or as grains and soot. These three elements, which were difficult to separate properly, were distributed in unequal proportions along the length of the gallery. Circumstances in that part of the gallery not allowing of the agglomeration of large pieces, the coke forming in grains the size of a pea or of a pin's head, within a few metres of the origin of the explosion, was carried by the rush of air either towards the middle of the gallery or sometimes—especially for the heavier dust charges—nearer the open end. The soot, very fine and greasy to the touch, was deposited on top of the coal-dust and coke. It required some time to settle, and was not seen at all when the fan was started straightway after the explosion.

In certain parts of the gallery a firm thin skin of caked matter was occasionally noticed on the surface of the unconsumed dust, but the conditions under which the skin was produced were not clearly determined.

Table III. gives the analyses of the various solid products of combustion, separated fairly well one from another."—*Mines and Minerals.*—Dec., 1910, p. 264. (A. R.)

METALLURGY.

THE EXAMINATION OF WATER BY ELECTRICAL METHODS.—"The well known physical fact that the electrical conductivity of distilled water is greatly increased by the addition of even minute traces of impurities is the basis of a simple device for testing water for boiler-feed purposes which recently made its appearance in England. One of the inventors, W. Pollard Digby, has described its construction and uses in a communication to the Institution of Electrical Engineers, which is abstracted in *The Electrician* of July 29. Mr. Digby does not suggest that the measurement of conductivity alone will supersede chemical analysis in water testing; that the electrical method has important supplementary uses, however, is amply evident from an examination of the results quoted in his paper. We are unable to reproduce these results in our review, but we give Mr. Digby's description of the apparatus used in the conductivity test and a few details of its applications.

'That water in its varying degrees of impurity is anything but a medium of constant value comes within the experience of all engineers, and hence frequent resort is made by the engineer to the analytical chemist for advice and assistance. However, this is not always done as often as might be desired, and a variation in the nature of a supply may take place with no visible change in the appearance of the water, but yet with such changes in the

constituents as would render the water quite unsuitable for boiler-feed purposes. The author's object is to point out the value of simple tests made *in situ* as safeguarding the owners of boilers from such happenings, and as determining when the analytical chemist should be employed. These tests, however, are not intended in any degree to supersede the analyst, but may serve to determine when detailed analyses are necessary by indicating changes in the impurities in the water. The method resolves itself into a determination of the conductivity of the liquid at any predetermined temperature and a comparison of such determinations with the known values of analysed samples. Any marked variation from the normal should be followed by a further analytical examination.

'An apparatus for conductivity measurements has been devised by Mr. C. W. V. Biggs and the author. The original type consists of a straight glass tube so constructed as to hold the equivalent of a body of liquid 10 cm. in length and 1 square cm. in sectional area, the liquid being contained between platinum electrodes attached to plugs of ebonite fixed in cups which form enlargements of the ends of the tube. The electrodes are suitably connected to terminals in the ebonite ends, and are capable of being adjusted. The liquid to be tested is introduced into the main tube through a small tubulure, rising at an angle from the middle of the upper part; and when tested is run off through a small tube furnished with a tap attached to the middle of the lower part. At each end of the upper surface of the body tube a vent tube is attached, inclining to the middle of the main tube, and the two unite at a height of about 2½ cm. above it, with a short vertical outlet.

'Manifestly such a piece of apparatus is hardly suitable for use outside the laboratory. The form for practical work consists of a glass U tube, to which is attached to the lowest point of the bend the tube brought from the filling funnel, whilst the outlet, controlled by a glass tap, is joined to the inlet at its lowest point. Near the extremities of the limbs of the main tube overflow ways are sealed on, and terminate in india-rubber tubes grouped with lower outlet. The form and arrangement of the electrodes are especially designed to minimise the disturbing effects of polarisation and other difficulties inseparable from the original type of tube. The electrodes are open cylinders of platinum, about 9 mm. in diameter and 3 mm. in height, connected by three equidistant platinum wires to stout brass glass-covered rods passing through the brass covers which are connected to the terminals. The dimensions of tube and electrodes are such that the equivalent of a body of liquid having a length of 10 cm. and a sectional area of 1 sq. cm. is obtained. The apparatus is mounted on a strong wooden support carrying a thermometer, and the whole is contained in a lock-up portable case.

'The most convenient instrument for measuring the conductance is the 'conductance meter' made for use with the tube. It resembles the familiar 'megger,' but is furnished with a scale graduated in reciprocal megohms and ohms, and with a tube of sectional area one-tenth the length it gives readings of one-tenth of the specific conductivity—equivalent to the reciprocal of ten times the specific resistance. Correction for variation of temperature for water containing less than 1% of dissolved salts may be made with sufficient accuracy by taking the coefficient as 2·19% per 1° C., as referred to 20° C.; but above 38° C. such correction is not reliable owing to complications arising from disengagement of small quantities of dissolved gases and also from physico-chemical action.

'At the outset the author experienced considerable difficulty in determining standards for comparison. Of samples passing through the author's hands, good distilled water has varied in its specific conductivity from 4·0 to 1·362 reciprocal megohms for laboratory distilled water, and for distilled water from surface condensers the best has been 3·3 reciprocal megohms. As a general standard of comparison, good distilled water might possibly be deemed as possessing a specific conductivity of 3·3 reciprocal megohms, or a specific resistance of 300,000 ohms at about 20° C., this value representing an approximate average value of the output of the Liebig condensers in the laboratory of one of the author's friends, and also representing the best practice from central-station surface condensers that has come under the author's notice.'

The effect of minute traces of impurities in greatly increasing the conductivity of distilled water is a well known physical phenomenon. Mr. Digby gives a number of typical results of his investigations of the effect of minute traces of sodium chloride, sodium carbonate and calcium suphate. The difficulty with the electrical test, of course, lies in the fact that it cannot distinguish between the different impurities. Nevertheless, conductivity tests are of value in detecting variations in the quality of feed water, and in checking the operation of marine evaporators and of evaporators for the supply of distilled water for hydraulic gun mountings. One of their most practical applications is in checking the operation of surface condensers. Given a boiler free from priming, a single conductivity measurement of water passing from the condenser to the hot well will indicate the tightness of the condenser tubes. If the approximate rate of flow is known at any moment, together with the value of the circulating water, a reference to standard curves, examples of which are given by Mr. Digby, will give the percentage of leakage at that moment. Conductivity determinations, while indicating that overhauling is necessary, may save unnecessary examinations. Conductivity tests may also be used to indicate boiler priming. If the conductivity of the hot-well water rises as the load on the engine increases, the only possible deduction is that the boiler is priming. Mr. Digby gives the results of a number of tests of boiler plants, which serve to demonstrate the procedure and the utility of electrical tests for this purpose.

'So far as checking the operation of steam plants by conductivity methods is concerned, their application does not cease with checking the nature of the feed water or with ascertaining condenser tightness, or even with defining boiler priming. A film of oil is more to be dreaded than scale-forming impurities in the management of boilers. An oil eliminator in one form or another is a necessary adjunct in all electricity-supply stations containing reciprocating sets, but their careless operation in a manner other than that designed by the makers may involve the substitution of a less evil for a greater one. The author has good reason to believe that in certain cases an excess of chemicals is added beyond that required for the elimination of the oil. This in cumulative small doses can only result in the increasing impurity of the boiler water through its enrichment with a substance which by common consent is regarded as a source of priming.

'A last point may be mentioned. Where hard waters containing an excessive quantity of calcium and magnesium carbonates are softened by

the Clark process; the conductivity tube and conductance metre can be used as a substitute for the standard soap test in defining how far the process of softening has been carried.' "—W. POLHARD DIGBY, *Journal of Institution of Electrical Engineers.—Engineering Magazine*, Sept. 1910, p. 911. [Abstracted from *The Electrician*. July 29, 1910.] (R.-A.)

AIR-LIFT FOR RAISING SAND.—"Most mining men are familiar with the principle of the 'Pohle' air-lift, but there is a common impression that, compared with other methods of raising liquids, it is not economical in respect of power costs. The air-lift under notice was installed under conditions well suited to accurate measurement of the air used and the work done; and it is thought that the following particulars may be useful.

In this case it was necessary to carry the sand residue from the ordinary cyanide leaching vats across a public road, requiring a lift of 23 ft. 3 ins. The submergence was fixed at 63% of the total length of water pipe. To get that with a single lift would have required a pit 39 ft. 6 in. deep, but by adopting a double or two-stage lift, the depth of the pit was reduced to 15 ft. 6 in., saving 24 ft. of sinking, and still maintaining the 63% submergence.

The supply of air is regulated by floats in the receiving head of each lift, so that a nearly constant level is maintained in each head-box and no air is blown through to waste.

The air used was drawn from a large receiver. In testing the air-lift, this receiver was filled to a gauge pressure of 70 lb. per sq. in., and was then shut off from the compressor, and the fall in pressure in a given time noted. During this time no air was drawn from the receiver for any other purpose. Mine water was used for sluicing, and the amount available was only little more than sufficient to carry away (along a V-shaped launder having a fall of $\frac{7}{8}$-in. per foot) as much sand as one man could shovel into the discharge door of the vat. The sand is heavy, and rapid motion is necessary throughout to prevent it settling; the proportion of water to sand is about $2\frac{1}{2}$ to 1.

Before the air-lift was put in, it was the practice to shovel the sand through the bottom discharge-doors into trucks; with the air-lift one man empties the vat in considerably less time than two did with the trucks, no time having to be lost in changing and waiting for trucks. The vats hold 30 long tons and, with one man shovelling, they are emptied in three and a-half hours, using 45 cub. to 47 cub. ft. of free air per minute.

Each discharge door has a 4-in. socket screwed into it, and the door is never removed. From the bottom of the socket a pipe leads down vertically, with an elbow just above the launder; inside the vat a pipe is screwed into the top of the socket long enough to reach above the top edge of the vat. To discharge the vat the pipe projecting through the sand is unscrewed and pulled out, leaving a convenient hole through which to start sluicing. To avoid the risk of having more sand sluiced into the launder than the water is able to carry along, from 25% to 30% of the total added water is supplied to the highest end of the launder running under the discharge doors.

Both sections of the lift are of the same dimensions, except in height, and consist of a 6-in. cast-iron pipe (which constitutes the well) with a 3-in. wrought-iron pipe inside, extending from within four inches of the closed bottom end of the 6-in. pipe, up to the required height of lift.

The air pipes are $\frac{3}{4}$-in., though $\frac{1}{2}$-in. would be ample; they are carried down the pit outside the 6-in. pipes, and are turned up at the bottom through the centre of the dead-end at the bottom of the 6-in. pipes. They extend upwards for 10-in. in the 6-in. and for 6-in in the 3-in. pipes. The nozzle ends of the air-pipes are closed and twelve hack-saw slits are cut across each of the ends, the cuts extending round about one quarter of the circumference of the $\frac{3}{4}$-in. pipe and cut at an angle of 45 deg., thus giving the air an upward direction.

The lift has worked well from the start and (except on occasions when the supply of water has suddenly failed) it has caused no trouble or delay. When the water supply fails a $\frac{1}{2}$-in. water pipe (which is kept connected by flexible hose to a supply having a pressure of about 50 lb. per sq. in.) is passed down the 6-in pipe which is cleared almost as fast as the $\frac{1}{2}$-in. pipe can be lowered. Two or three minutes is sufficient to clear it at any time.

The only wearing parts are the 3-in. pipes, and these, having no bends, are likely to last a long time. The consumption of air may be taken as about 50% more than the best pump would use when in perfect condition. Unlike sand pumps the air-lift remains in perfect condition.

The added water is heated to a temperature 95° F. by passing a part of it over exhaust steam pipes on its way to the lift. This heat, no doubt, adds to the efficiency of the lift.

Dimensions.

	No. 1 LIFT.	No. 2 LIFT.
Well pipe	6 in. C.I.	6 in. C.I.
Well pipe length	13 ft. 6 in.	22 ft. 6 in.
Water column	3 in. W.I.	3 in. W.I.
Water column length ...	22 ft. 2 in.	38 ft. 0 in.
Air pipe	$\frac{3}{4}$-in.	$\frac{3}{4}$-in.
Depth of water	15 ft. 6 in.	24 ft. 6 in.
Lift	9 ft. 0 in.	14 ft. 3 in.

Work Done by the Two Lifts Combined.

Cub. ft. free air per min.	Lb. sand per min.	Lb. water added per min.	Lb. sand per cub. foot free air.	Total lb. sand and water per cub. feet free air.	Cub. feet free air per gallon (10 lb.)	Cub. feet free air per ft. gallon.
47	320	800	6·8	23·83	0·4	0·0182

—A. R. MILL.—*Monthly Journal of Chamber of Mines of W. Australia*,—Nov., 1910, p. 367. (H. A.W.)

RESINITA.—"This new substance, which appears to offer some analogies to Celluloid and to present a wide field for industrial application, is obtained from phenol and formaldehyde by adding catalytic reagents. The result, a yellow liquid, which the inventor has named 'Resol,' can be used for the impregnation of woods, paper, or other porous material, which it renders impermeable. From the distillation of the resol is produced 'Resit,' whose properties depend on the rapidity and temperature of the distillation; normally it is hard, but acquires plasticity on elevating the temperature; if it is submitted for a certain time to 80°, and the temperature

is afterwards raised to 200°, the Resit proper is obtained. This is solid, infusible, insoluble, and resists both acids and alkalis. Its colour is red, ruby, or purple, unless ammoniacal salts have been used, when the colour is yellow. It is transparent or translucent, very brilliant, with a conchoidal fracture. By sacrificing transparency its elasticity can be augmented by the addition of talc, fecula, &c. In its diverse states Resinita has characteristics of value, on account of the similarity to glass, celluloid, ebonite, and vegetable ivory. This substance is analogous in preparation, properties and applications to Bakelite, an American invention, and a staple product of the United States. The empirical formula is $C_{43}H_{38}O_7$."—(Reprinted from "Revista Minera."—*The Mining Journal*,—Jan. 14, 1911, p. 41. (R. A.)

PROPERTIES OF TUNGSTEN AND MOLYBDENUM.—"Tungsten is known as a grey brilliant metal, hard and brittle. It is used chiefly in the manufacture of special steels, and for the filaments of lamps on account of its high point of fusion. Commercial tungsten is a grey powder obtained from the reduction of yellow oxide, and is usually impure; when employed for the fabrication of filaments it is refined. The pure metal is still brittle and lacks ductility, though in the laboratory of the General Electric Company ductile tungsen has been recently produced. with attributes which differ from those of ordinary tungsten. Ductile tungsten is brilliant and possesses the colour of steel, and can be drawn into very fine wires—can be even attenuated to 1·50th of a millimetre. The power of resistance augments with the stretching; thus a wire of 0·125 mm. in diameter opposes a force of 322 to 343 kilogrammes per square mm., whilst one of 0·03 gives 406 to 427. Ductile molybdenum wires, in the first case, resist with a power of 150 to 182 kilogrammes per square mm., and with a diameter of 0·038 gives a resistance of 189 to 217. The density of both metals increases with the slenderness of the thread Before drawing, the density of tungsten is 18·81, but after, it grows to 19·20, and even to 20·19, according to the diameter. Molybdenum originally 10·02, acquires, after drawing, a density of 10·04 to 10·32. The hardness of tungsten and molybdenum varies with the mechanical treatment to which either has been subjected; in its hardest form either scratches glass, whilst the softer kinds can be easily cut."—(Reprinted from "Revista Minera").—*The Mining Journal*,—Jan. 14, 1911, p. 42. (R A.)

MINING.

THE FINAL REPORT OF THE SOUTH AFRICA MINING REGULATION COMMISSION.—"Good ventilation is not merely a legally recognized necessity for the preservation of health, but has an important economic aspect in its effect on the industrial efficiency of the workman and the cost of mineral production.

The necessity for ventilation in metalliferous mines arises mainly from the injury to health caused by the presence in the mine air of fine dust, of the poisonous gases produced in blasting, and of human emanations, respiratory and other.

The ventilation of mines may be (*a*) natural, and (*b*) artificial or mechanical; natural ventilation depends upon (1) the difference in temperature and humidity, and consequently in weight, between the air in and out of the mine; (2) the absolute humidity of the outside air; and (3) the difference of level between the mouths of the connected shafts; natural ventilation has the advantage of being inexpensive, but is subject to the following drawbacks, viz., (1) the amount of air supplied depends upon conditions beyond control, and independent of the varying mine requirements and hygienic necessities; (2) as the temperature and humidity of the outside air approximate to that of the mine air, the ventilating current diminishes and may completely disappear; (3) the direction of the air-current is variable.

Natural ventilation is supplemented on the Witwatersrand by the exhaust air from machine drills; this supply is of great local importance, as it is derived at the working place, but the amount only constitutes a fraction of what is required for the proper ventilation of a mine, and its beneficial effects do not extend for more than 100 ft. from the face; some miners are prejudiced against compressor air, though there is no evidence that it is injurious to health; it stirs up from the sides and floor of the working place the dust which is the principal cause of miners' phthisis, and occasionally contains some of the poisonous gas CO derived from the accidental combustion of the oil used for lubrication.

Judged by the relative frequency of gassing accidents, natural ventilation is, on the whole, not so effective on the Witwatersrand as on some other fields, this inefficiency being probably due to (1) the very slow rise of the rock temperature as depth increases; (2) the high temperature and humidity of the outside air at certain seasons; (3) the great extent of the underground workings and large number of men at work; and (4) the large consumption of explosives in blasting, and consequent production of great quantities of poisonous gases.

Artificial or mechanical ventilation is effected by means of either (*a*) the extractive force of a furnace at the bottom of the upcast shaft; or (*b*) fans—usually exhaust fans—at the top of the upcast shaft; at the East Rand Proprietary and Cinderella Deep Mines the total running cost of an extremely effective installation is under 1d. per ton milled.

The degree of ventilation in a mine may be measured either by (*a*) a quantity standard, that is, the quantity of pure air entering the mine per minute; or by (*b*) a quality standard, this being a determination of the amount of impurity present; the existing Transvaal law provides for a quantity standard of 70 cubic ft. per man per minute, and also for the splitting of the current and distribution of the air over the working faces; the application of this standard is open to very serious practical difficulties; the provision as to distribution is not enforced, probably because attempts to direct natural air-currents usually merely retard them, and the quality standard is better adapted as a general indication to mine inspectors than as a basis for legislation.

The object of a quality standard is to fix the permissible amount of air vitiation, and for this purpose the quantity of carbon dioxide present is accepted as bearing a roughly constant proportion to the amount of impurity present.

Our knowledge of the exact nature of such impurity is incomplete; there is no reliable evidence to support the former belief that during respiration the lungs exhale a volatile organic poison; the immediate ill-effects, headache, general discomfort, etc., of bad ventilation are probably the results of the oppressive smell which arises from the breath, bodies, and clothes of those present, and is caused by very minute quantities of volatile substances present in the air.

According to Pettenkoffer (1858), Dr. J. S. Haldane, F.R.S., and other modern observers, this

smell becomes distinctly perceptible when the carbon dioxide CO_2 in the air exceeds 10 volumes per 10,000; but in 1875, De Chaumont recognized it in barrack-rooms when the CO_2 reached 6 volumes per 10,000.

Continued subjection to bad ventilation means increased liability to disease, and especially to infection produced by organisms present in the mouth and air passages, and conveyed directly through the air from person to person.

Dr. Haldane, F.R.S., who has closely investigated the subject and is the foremost British authority thereon, considers that the worst consequences of a defective air supply are 'the evil effects produced by inhaling poisonous or infective dust'; he doubts that 'constant exposure to volatile respiratory impurities has by itself a very great influence on health,' and agrees that carbon dioxide is 'the best objective criterion of the sufficiency of ventilation.'

In mines, the highly poisonous gases, carbon monoxide CO and nitric oxide NO_2 are also present, the result of the detonation or of the burning of explosives; in dead ends, and immediately after blasting, the ratio of CO_2 to CO in the gases produced by explosives in local use averages 1 to 12, and therefore CO_2 serves in some degree as an index of this danger (presence of CO).

Carbon dioxide, unaccompanied by any injurious substances, is in itself innocuous in quantities under 1 per cent. Of this nature are the normal atmospheric CO_2, amounting to 4 volumes in 10,000 of air, the CO_2 produced by open lights and by the action of acids on carbonates.

The difficulty in fixing a quality standard lies in the impossibility of distinguishing between the noxious and innocuous CO_2 when both are present together.

On the Witwatersrand the only innocuous CO_2 known to exist in appreciable quantities is the normal atmospheric CO_2, and that produced by open lights.

Exhaustive inquiries made by the Mines Department show that a considerable body of carbonates which could give rise to CO_2 by the action of acid water, is present in the workings of one mine only, the remainder having either no carbonates at all, or only inappreciable quantities in the shape of flakes in fault planes, or as an occasional stringer adjoining a dike; in view of the minute percentage of acid in mine water, there would generally be in these places a sufficient excess of water to hold in solution the CO_2 generated, and as mine air is nearly saturated with moisture, it is improbable that any dissolved CO_2 would subsequently be released by evaporation.

In the Lydenburg and other districts, and in base metal mines, masses of carbonates occasionally exist in proximity to very pyritic reefs, and a considerable amount of innocuous CO_2 may be locally produced.

It was suggested to us that additional quantities of CO_2 might be produced from the following sources, viz, (1) 'ground' gas contained in rock cavities, or occluded in quartz; (2) from the oxidation of food and timber, evaporation of stagnant water, and decomposition of animal waste.

We find that cavities containing CO_2 are practically unknown in the Witwatersrand metalliferous mines; that the occluded gases would not be liberated under the conditions of underground work, and are in any case noxious, containing a large percentage of the poisonous CO; that the oxidation of timber and food would produce quantities of CO_2 too small to affect any standard of vitiation, and that the gases from stagnant water and animal waste are inappreciable and offensive or noxious in character.

Careful experiment was made at the Langlaagte Deep mine, under the supervision of the Mines Department, to ascertain whether any production of "ground" CO_2 could be inferred from the difference between the estimated amounts of CO_2 entering and leaving the mine; the possibilities of error in the assumptions upon which the estimates were based appear so considerable, and the results calculated on different assumptions so widely discordant, that we regard the various Langlaagte Deep results as inconclusive, and in this view we are supported by the Government Mining Engineer.

In the absence of any theoretical source of any appreciable quantity of 'ground' CO_2 in the Witwatersrand metalliferous mines, we consider that practically the whole of the noxious CO_2 is due to respiration and explosives, including fuse, etc., and that the innocuous CO_2 is derived from the atmosphere and open lights only.

The limits for noxious CO_2 previously recommended or embodied in legislation are as follows:

(*a*) Five volumes per 10,000, by the Roscoe Committee (1896) on the Ventilation of Humidified Factories. This was legalized under the Cotton Cloth Factory Act, and also in the Factory and Workshops Act, 1901.

(*b*) Eight volumes per 10,000, by Haldane's Committee (1902) on Ventilation of Factories and Workshops. This standard now regulates all factories, including humidified, in the United Kingdom.

(*c*) Eight volumes per 10,000, by West Australian Mines Regulations Act.

(*d*) Six volumes per 10,000, by New South Wales Mines Act.

(*e*) Eight volumes per 10,000, by Victoria Mines Act, 1907. Because we cannot definitely state that there is no material quantity of 'ground' CO_2 in the mines of the Rand, though we believe that the actual amount, if any, is small, we propose that a working allowance of 5 parts in 10,000 be made for it, and for CO_2 from other uncertain possible sources, with the sole object of fixing a standard which is practicable from the administrative point of view, and which will enlist the voluntary co-operation of the mines in its enforcement; and, in view of our recommendations (see below) as to a CO limit, and as to sectional and local ventilation, the prevention of dust and fumes, the total limit of 20 parts of CO_2 per 10,000 is well within the limits of safety, is reasonable and easily obtainable, and should be enforced.

We, therefore, recommend as follows (see Draft Regulations 56--63):

GENERAL VENTILATION.

(*a*) That the legal maximum for noxious CO_2 permissible in mines in the Transvaal be fixed at 8 parts by volume in 10,000 of air.

(*b*) That an amount of 4 parts of CO_2 by volume in 10,000 of air shall be allowed in addition to the aforesaid maximum as representing innocuous CO_2 normally present in the atmosphere.

(*c*) That where candles or similar illuminants are used, a further addition of 3 parts of CO_2 by volume in 10,000 of air shall be allowed as representing innocuous CO_2 resulting from the combustion of such illuminants.

(*d*) That in order to meet, from the point of view of practical administration, difficulties in regard to possible innocuous CO_2 from 'country rock' and other uncertain sources in the mines of the Rand, a

further allowance of 5 parts per 10,000 be made, making a total limit of 20 parts of CO_2 per 10,000 of air.

(*e*) That in the Lydenburg and other districts where there is geologically strong presumptive evidence of a production of ground CO_2, early investigation be undertaken by the Government, and that a proper and reasonable allowance be made therefor, the total amount in the mine air not to exceed 1% by volume.

(*f*) That all samples for testing purposes under these provisions be taken not less than one hour after blasting.

(*g*) That each mine be informed of the results of any official analysis of the air therefrom, and notified that the ventilation is defective when the above proportions have been exceeded, and at the same time supplied, so far as practicable, with information as to the nature of any defect noticed; and that legal proceedings be not taken against a mine unless, after a reasonable interval following such notice, the stated proportion is found on examination of one or more samples to be again exceeded, and the mine is unable to show that steps have been taken reasonably calculated, in the opinion of the Government Mining Engineer, to secure the requisite ventilation.

(*h*) That any analysis on which a prosecution immediately depends shall be made by a specially qualified person.

(*i*) That arrangements be made for inspectors of mines to have the use, when desired, of a properly tested portable apparatus for estimating on the spot the proportion of CO_2 in the air.

With regard to the very interesting question as to the necessity for correcting the proposed CO_2 limit for the altitude of the Rand, the evidence is somewhat conflicting, and many samples will be taken at considerable depths and, therefore, we do not recommend any addition on this account to the proposed standard.

In view of the extremely poisonous effects of CO and NO_2 on the human system, and the frequency of gassing fatalities on the Rand, we also recommend that the maximum permissible amount of CO in any part of a mine shall not exceed ·01%, and no practically determinable amount of NO_2 shall be permitted in any part of a mine."—*Mines and Minerals*, Jan., 1911, p. 337. (A. R.)

EXPLOSIONS IN COAL MINES.—The recent disaster in the Lancashire coalfield has called forth numerous comments from correspondents, and attention may be directed to some remarks which seem most nearly to indicate the probable cause of the explosion, and to suggest a definite line of action for their prevention. Mr. Jacob Atherton objects to the present method of working a coal mine by a single down-cast and a single up-cast shaft, and he shows that this leads to accumulations of gas in the old workings, and that a spark from a pick striking flint, damage to a lamp, or the firing of a shot may ignite this gas in such circumstances that the men at the working face and about the levels are hopelessly trapped. As a remedy, he urges that mine-owners should work upon the principle of driving levels—down and up brows—from the pit's mouth to the boundaries of their properties, thus bringing the face of the coal towards the pit shaft, instead of the present system of driving the face away from the shaft. Levels, down-brows and up-brows, all with airways, should "be driven through the solid coal, and thus assure free exit from the working face of the mine from all directions along these solid main roads." In support of his contention he cites the case of a Lancashire colliery worked on this principle, "with the result that miners worked with naked lights, such as candles and torches. No explosions took place, the ventilation was perfect, the lighting was good, and the miners were perfectly happy under such conditions." As compensation for initial cost, he suggests the "saving of timber, day wagemen, and constant repairing of levels and airways." Mr. J. Marriner arrives at the same general conclusion that the number of exits is insufficient. He advocates that the coal-dust trouble should be investigated by the Government, and he expresses wonder that the Government "refused to contribute towards the cost of experiments." He further holds, that it would be quite reasonable to insist that miners should be allowed to work only where two exits are available, and he advises that these exits should enter the workings at opposite ends of the mine; moreover, they should pass through solid ground or be secured so that they will not fall in at the time they are most required.—*Times Engineering Supplement*, Jan. 4, 1911. (J. M.)

CONCRETE FOR SHAFT TRACKS.—"The extended use of reinforced concrete on the Rand is a noteworthy feature at the present time, and especially is this true of new equipments. Concrete now seems to be utilized wherever practicable. Its extensive employment in the metallurgical works of the City Deep plant has already been dealt with, and we are now able to give particulars of the use it is being put to at the Bantjes Consolidated Mines at Florida.

At this property it is being utilized in a new direction; new as far as the Rand is concerned, at any rate, with the exception of some similar work done at the Angelo Deep two or three years ago. But as this Angelo Deep work does not appear to have attracted much attention, the employment of concrete in two shafts of the Bantjes mine is a most interesting matter. The central incline has been stripped and enlarged, and the shaft is now 32 ft. 4 in. wide all over, instead of 17 ft., as formerly. Five compartments are now prepared, and there will be four hauling ways instead of two only in the old shaft. Concrete blocks are now being carried down the shaft, which dips at an angle of 35°. The skip rails run on these, and the gauge has been increased from 3 ft. to 4 ft. 2 in. The central concrete blocks, which carry two rails, are 2 ft. 9 in. in width at the top, whilst the outside blocks, on each of which only one rail rests, are 12 in. wide at the top. Only one divider is being put in between the two pairs of skip roads. Sixty-pound rails are used, and strong steel supports are employed in the shaft, which will contain very little timber; in fact, no timber at all. The shaft is indeed an excellent piece of work, and it should be possible to haul in it at the rate of a mile a minute with a minimum risk.

The advantages claimed for this method of supporting skip rails are: (1) Higher rate of hoisting; (2) greater safety; (3) a cleaner shaft; (4) much more permanent work; (5) less wear and tear on the rope. The cost is estimated at less than that of a wooden road, and the work of laying the concrete proceeds very rapidly. At a little depth in the shaft, where solid rock exists, the concrete is mixed on the floor of the shaft and put in the skip road direct."—*Mining Science*, Sept. 18, 1910. (K. L. G.)

THE CARE OF MINERS' EYES.—"It is really astonishing that the eye pulled this way and that by the muscles every day for years and years, and sub-

jected to all kinds of blows and rude shocks, should keep its beautifully delicate organisation throughout. Any other instrument such as an opera glass or mscroscope if submitted to the thousandth part of the rough usage that the eye has to put up with would be ruined past all repair, and yet the eye remains useful all the time. It is at once an autochrome camera, a cinematograph producing life-sized coloured pictures in motion; a photometer, a stereoscope, a range finder, a microscope, and an opera glass; while the whole apparatus is provided with a compound non-distorting rectilinear lens working at F/4, or in some cases at F/3, and provided with a self-adjusted iris diaphragm. Helmholtz could hardly have borne these facts in mind when he stated that, had an optician made him an instrument as imperfect as the eye, he would have returned it to him. From a large number of experiments made by the writer, he has found that when shooting at a target in dull light, or when the target was painted khaki colour, plain spectacles, made of a light shade of spectrum blue glass, enables him to see the mark much better. This material has the peculiar property of cutting off both the irritating violet rays as well as the red ones On the other hand, if the target be a black and white one, the marksman can see it better through a pale amber in a pale pinkish orange yellow glass. The glass used by Lumiere for taking photographs in colour answers admirably, but the so-called Euphos glass of Schanz does fairly well.

People talk about their sight being strong or weak, and they often boast that they can see to read without spectacles up to the age of 60, or even 70 years. Now, this is a silly thing to boast about. It is well-known to occulists that the normal healthy eye which can see distant objects quite well, always requires spectacles on attaining the 45th year. The lens in the eye is controlled by a little circular muscle which surrounds the eye inside it. The lens is made to alter its shape by means of this little muscle, so that one can see both distant and near objects at will. The nearer the object the more the muscle has to act, so that when the object, such as a newspaper, is held about 14 inches from the eyes, quite a considerable effort is required on the part of the muscle to bring the words into sharp focus. Now, during childhood, the lens is very elastic, and the muscle can adjust its form quite easily, but as the child becomes an adult, the lens becomes much more rigid, so that it gets year by year more difficult to see the newspaper at comfortable reading distance. At length, a pair of spectacles has to be procured. But after a few years the person finds that he must either hold his paper at arm's length or move his glasses to the tip of his nose, by which he makes them of stronger power. This constant strain causes the eyes to water, and in this way acts injuriously. It is wise, therefore, for anyone when he gets to 40 or 45, to be properly fitted with glasses. People who are naturally a little short-sighted can read quite well when they get to adult age without glasses, but those people who are naturally long-sighted need them even for seeing distant objects. Such people should always wear them for reading whatever age they are. By so doing they greatly rest the eyes, and prevent their becoming tired and misty.

The eye is a spherical ball about the size of a plum (*i.e.*, an inch in diameter), having behind a round, thick stalk—the optic nerve—which conveys the impressions of the images seen to the brain. Many people imagine that dust or dirt can work its way to the back of eye and set up terrible inflammation, but this is quite a mistake. The eye is covered with a kind of skin known as the conjunctiva, which is quite transparent where it covers the clear part of the eye; if traced backwards it forms a kind of cul-de-sac all around the eye about half-way back, and is then deflected (*i.e.*, folded back) on itself to line the under surface of each lid. Thus the eye is quite shut in and no dirt can get behind. When dust or particles of grit or steel fly into the eye they are arrested by the conjunctiva, and, if sharp, they may stick into it. The most painful cases are those where they are lodged either on the cornea (*i.e.*, the clear part of the eye in front), or underneath the upper lid. These are the commonest places for dust particles to lodge, and everyone should know how to remove them, as they are exceedingly painful, and often a doctor is not at hand to remove them.

If the particle is lodged on the front of the eye the best way to remove it is to let fall a drop or two of sweet oil right on to the front of the eye with a feather, and then to brush the foreign body off either with the soft end of the feather, or a small camel's hair paint brush. If there is a chemist near, get him to put a drop or two of cocaine solution in—it cannot possibly do any harm—and the sufferer will not feel the brush, and consequently will keep quite still while it is being removed. If you can see nothing, and the eye is very painful, look very carefully to see whether the 'cornea' is scratched by the particle. If it is, a drop of cocaine, followed by a drop of sweet oil—or castor oil—will give the necessary relief. If, however, nothing can be seen, and the eye is very irritable, the probability is that the piece of grit or steel has lodged under the upper lid. First, get the sufferer to catch hold of a few of the lashes of the upper lid, and tell him to pull down the lid, looking down at the same time. Two or three attempts will probably dislodge the particle, and the tears will wash it away. If that is no good, let him sit down on a chair, wash your fingers, and procure a wooden match. Now stand behind him and tell him to look down. Catch hold of a few of the eyelashes with the left hand finger and thumb, and press the match, holding it horizontally, downwards and backwards with the right hand against the outside of the lid, and at the same time pull the lid up. This will turn the lid inside out, and in all probability you will see the piece of grit resting on the red shiny surface of the inside of the lid. Then remove it with a brush or the wood end of the match, which latter you can take away while firmly holding the lid back. A drop of cocaine or oil on the surface will at once put matters right, and the patient will suffer no longer. It is a wise thing for miners to keep a 1% solution of cocaine in a bottle in a handy spot—as a drop in the eye can never do any harm, and it helps one to remove both the grit and the pain in a marvellously short time. It is very important to remove the foreign body as soon as possible, as it invariably provokes inflammation, and every hour makes the poor sufferer worse, and if neglected, may bring about a troublesome disease which may confine him to bed for days.

Miners are very careless about dust. When working in the mine, the dust should always be kept under by water, both by squirting it into the drill holes, and sprinkling the galleries, adits, and other passages. Dust not only affects the eyes and brings about all sorts of troubles there, but it gets into the lungs, and causes a form of consumption known as fibroid phthisis, which sometimes ends

fatally, and always causes severe coughing fits, and even pleurisy in bad cases.

Manager- of mines are often gr atly to blame for giving the miners insufficient illumination. The galleries cannot be too well lighted, as the wretched candles and lamps usually provided tend to tax the eyesight severely. The miner often has to work in a very confined position, lying on his side or back, or crouching down with his head and eyes turned obliquely round. This produces an undue strain on certain muscles and, together with the bad light, causes a tremor of the eyes, known as nystagmus. This tremor, if continued for a long time, becomes at last chronic and automatic, so that the miner habitually moves his eyes rapidly from side to side, even when he leaves the mine. The bad light is chiefly responsible for this, because the eye trembles in its endeavours to see badly lit objects. Were the light better in quality and better distributed, by having plenty of lamps scattered about, this nystagmus would not occur.—GEORGE LINDSAY JOHNSON, M.D., F.R.C.S.—*The Australian Mining Standard*, Jan. 25, p. 84—5, 1911. (W. A. C.)

GEOLOGY OF KOLAR GOLD FIELD.—"Practically the whole of the province of Mysore consists of a plateau about 3,000 ft. above sea level. It is quite undulating on the whole, but with the exception of the granite or gneiss peaks scattered about, the country is not hilly. With the exception of the region mineralized with gold-bearing quartz, the whole country is of a foliated granitoid rock which the geologists insist upon calling gneiss. It is uniformly gray in colour, varying in crystallization from coarse to fine, and from light to dark in tint. The most striking feature of the landscape is the gneiss hills, which are scattered about without any regularity whatever in their arrangement In size these vary from a few boulders in elevated places to single haystack-like cones more than a thousand feet high, some forming miniature mountain ranges 10 miles long and 1,500 ft. above the surrounding country at the highest points. Much of this gneiss disintegrates rather rapidly, leaving a lot of sandy, barren soil. This rock furnishes the building stone of this whole region, being readily obtained in pieces from 4 in. to 1 foot thick and of any length and width that can be handled, making an ideal stone for steps, copings, and the like.

The laterite drift is the most puzzling phenomenon presented in all this region, its very obscurity adding interest to it.

The whole surface of the country, with the exception of the gneiss hills and 'Goldfield Ridge,' is covered with laterite. Indeed, so nearly universal is it that the theory of its covering the entire surface up to certain altitudes at the time it was laid down seems quite correct. How far to the north the laterite extends beyond the sea north of Madras the writer does not know, but between Kolar and Madras it covers many thousand square miles. Near Madras the laterite is used for buildings, railway stations, and bridge piers, but that about Kolar is quite unfit for building purposes. Where found in large masses it is quite amygdaloidal in structure, the cells in it being from the size of beans to that of small marbles. The laterite occurs massive on the top of certain hills, which are uniformly flat, and on one hill 15 miles from Kolar, it is about 20 feet thick; whereas, all over the country—scattered everywhere—is the fragmentary laterite, nearly decomposed, giving the peculiar iron colour, dark red or maroon, to the soil to a depth from 2 ft. to 4 ft., the portions remaining being little shot-like balls, either round or kidney shaped.

The state geologists have not discovered the origin of laterite, nor a place where it is found to great depth; so the theory is that it was spread over the country under water at some very remote period, coming from 'parts unknown.'

The hornblende schist formation extends roughly for 30 miles north and south, and varies in width from 1 to 4 miles. The Kolar gold field is approximately at the south end of the formation. The rock has a greenish colour and its ability to withstand the weather varies everywhere, with the result that ridges of the rock are seen protruding above the surface in some places, while in others it has been completely decomposed into a clayey soil running through all gradations and combinations of colour from light green and light yellow to nearly white—and this to a depth of from 6 ft. to 12 ft. It is common in digging to pass through the iron stain from the laterite at the surface for a depth of 2 ft. or 3 ft., and then come to the unstained clay of the decomposed country rock.

In this schist, running nearly north and south, are many quartz veins of various widths from a few inches to 10 ft. and even more. These quartz veins carry free and almost pure gold; for example, at the Balaghat mines gold is about 97% pure as it comes from the mill. Many of the quartz veins are barren, although the quartz to all appearances is the same in one vein as another. The quartz is either white or gray, both carrying some or no gold as the case may be.

The quartz veins which showed gold at the surface were worked out by the natives a long time ago. There are no records extant of these old workings, but tradition indicates that the work ceased with the invasion of the Mohammedans under Arumgzeeb in the latter part of the seventeenth century. Be that as it may, in several places, both at Kolar and in other fields of South India, the natives did work out all the surface quartz down to depths varying from 60 to 300 feet. The present gold mines are working on the same veins at much greater depths.

The natives seem to have prospected this field thoroughly in the old days, for, although there are many quartz outcrops, none of them carry any gold, from which it is quite clear that whatever gold was at the surface was found and removed. So great is the confidence of the present-day mining engineers in the thoroughnesss of the work of the ancients, that there has been no systematic prospecting of these fields, except at or near old workings. No doubt some day in places where there are barren quartz outcrops with placer gold in the ground all about, there will be serious effort made to find out what exists at depth. There are many such places.

The Goldfield Ridge is one long and nearly straight upheaval bounding this last formation on the west. It is the most interesting feature to the student of geology of anything in this region. The combinations are mostly iron and quartzite, but; for variety in lamination, crumpling, and folding, as well as variety in colours and texture, it would be difficult to duplicate. It seems certain that the 'ridge' is a comparatively recent upheaval. There is no laterite on it, although but half a mile from it is a hill 50 feet higher whose top is covered with laterite, from which it may be concluded that if the ridge had been in existence at the time of the laterite drift it would also have been covered with laterite.

Where the rocks of the ridge are in place the stratification is practically vertical, but there has

been so much twisting and squeezing that all the forms of lamination read about in geologies are exemplified in countless places. In height the ridge is 50 ft. to 300 ft. above the surrounding country.

It should be added that there are masses and streaks of quartz (white) in the ridge, which in some places look suggestive of gold. In some places these bodies of quartz have been prospected but no gold of importance found, and the quartz itself suddenly terminated or gradually pinched out.

The Mines.—There are six producing mines in the Kolar field, all of which have been working with various vicissitudes for nearly 20 years. Another half dozen or so which were worked in the past are now idle. In some cases the idle mines had at one time good ore, which was worked out, while in other cases they used up their capital in prospecting.

All these mines are on the two principal veins, which have various short branches extending here and there from them. The principal veins are not entirely continuous either in quartz or in gold, the latter being mostly in 'ore shoots' of varying vertical depths and lengths, all leading to the north along the veins.

The dip of the veins is about 30 degrees from the vertical, west, so that most of the mines have both incline and vertical shafts.

Only one mine has sufficient water for its own needs. One does no pumping whatever—at all events it is called a perfectly dry mine, although down 300 ft.

The ore is free milling and each mine does itsown crushing, amalgamating, and cyaniding. The process of ore treatment is identical at all the mines—stamping, amalgamating, and treating the tailing with cyanide solution. Details in treatment vary with the ideas of the superintendents rather than because of any essential difference in the ore. Some, for example, practice both battery and table amalgamation, and others only table. The slime is rather abundant and gives considerable trouble.

There is no opportunity to take advantage of gravity in arranging the milling plants, owing to the contours of the ground which furnishes no side hills, consequently the tailing has to be elevated to considerable height, the larger mines having tailing dumps as much as 50 ft. high—often higher, and covering several acres. Mine labour is cheap; men, 9 cents a day; women and boys, 6 or 7 cents, above ground. So the tailing especially is handled by manual labour.

Any description of this field would be incomplete without mention of the great Mysore Mine, which began milling operations in 1884, with total amount of ore crushed of 454 tons, from which 454 ozs. of gold was recovered. Two years later the mine paid $150,000 in dividends. The next year the dividends fell to $75,000, but since that have gone on increasing until the annual dividends have reached as high as $2,000,000.

Addenda.—At the thirtieth annual meeting of the Mysore Gold Mining Co., held in London, England, in March, 1910, the following information was given out. The Mysore government re-leased the property to the company for 30 years at an additional royalty of 2½% of the output; however, the government reduced the price of electrical power from £24 to £10 per horsepower per annum, which probably offsets the increased royalty. The working costs, including royalty and income tax, absorb 33% of the total value of the ore. 'The mine employs 10,000 men; women, and children, 3,000 of them miners, and the medical staff looks after 90,000 souls.' 'Whenever cholera breaks out, the healthiest place in the whole of India is Mysore camp.' The ore reserve exceeds 1,000,000 tons, and the ore treated amounted to 234,500 tons, from which was recovered 228,249 ozs. of gold, or 18½ dwt. of fine gold per ton. During the year, 1,053 ft. of shafts and 754 ft. of winzes were put down. The deepest point in the mine is 4,175 ft. on the dip of the deposit. The mine has distributed since its commencement in 1880, £5,935,094 in dividends to shareholders."—C. S. DURAND.—*Mines and Minerals*, Jan., 1911, p. 350. (A. R.)

HYDRAULIC FILLING IN GERMANY.—"At the International Congress of Mining, Metallurgy, Applied Mechanics, and Practical Geology, which began at Dusseldorf on the 19th ult., and to which invitations were accepted by some 1,762 persons in all parts of the world, a large number of papers were read. Among them was one by Otto Putz, mining engineer, of Tarnowitz, Upper Silesia, on 'The Present Position of the Hydraulic Packing Process in Germany.' Owing to its interest locally the following summary is given of it:—

"The hydraulic system of goaf packing, first employed at the Myslowitz Colliery, Upper Silesia, in the middle of 1901, is now used in 145 sets of plant at about 110 collieries. This relatively small extension of the process is due, not to any inferiority in the process itself, but more especially to the heavy wear on the pipes, the difficulty of clarifying the water (or of pumping the unclarified water), and the lack of a sufficient supply of packing material. The annual wear and tear on the pipes in the hydraulic packing plant in Germany is estimated at about £50,000. This item can be reduced, on the one hand by using sand and loam, or by crushing to small size other forms of packing material, and on the other hand by providing the pipes with efficient lining. The Stephan type of oval pipe, with iron lining, and also the porcelain-lined pipes appear to have the longest working life. In the case of the oval pipes, the maximum wear encountered hitherto amounts to 1 mm. ($\frac{1}{25}$th in.) for every 10,000 cub. metres (13,000 cub. yards) of packing material conveyed, as compared with 1 to 4 mm. in the case of porcelain-lined pipes. However, it is not yet possible to form a final opinion on this point. The flushing water is clarified either in the goaf itself or outside; and in the latter case the water is either in motion or perfectly stagnant. Up to the present considerable difficulty and heavy expense have attended the removal of the deposited sediment from the settling tanks, where this form of clarification has been adopted; but the position is expected to be improved by the pneumatic system of transporting sludge introduced by Schubert, of Beuthen (Upper Silesia). In this process the sediment is transferred, intermittently, from the settling tanks into a receptacle, either by natural differences in pressure or by suction. When this receptacle is full, the contents are ejected by compressed air and forced through a pipe to their desired destination. In this manner 700 ft. to 1,800 cub. feet of sediment can be transported per hour, at a cost of about 3d. per cubic yard (as compared with 3s. for hand labour) for a vertical height of 160 feet, and a longitudinal distance of 1,300 yards. In most cases, in order to secure a permanent supply of packing material in abundance, it is necessary to resort to long-distance carriage; and as the State Railways are out of the question for this purpose, owing to their high rates and congested traffic, it is advisable for collieries to associate for the construction and operation of railway tracks,

a venture that is more profitable in proportion as the volume of traffic is increased, and therefore as the number of participators is larger. An association of this kind has already been formed in Upper Silesia, with offices at Gleiwitz, and has purchased agricultural land outside the actual industrial district and intends to construct a line about 16 miles in length In many cases the construction and operation of ropeways will be cheaper. From the foregoing it will be evident that the difficulties still militating against the further rapid spread of the hydraulic packing process will soon be removed, a circumstance that is highly desirable for reasons of national economy, since it is estimated that, by means of this process, about £7,500,000 worth of mineral treasures that would otherwise be inaccessible, can be recovered from the earth in Germany.'"—*S.A. Mining Journal*, July 23, 1910. (C. B. S.)

RAND MINING IMPROVEMENTS.—"In a speech delivered at the annual meeting of the Glen Deep, Ltd., Mr. R. W. Schumacher, the chairman, gave an interesting summary of the improvements being effected in underground methods upon the Rand. Reference to his remarks will provide us with an opportunity for reviewing the principal tendencies of change that have characterized recent progress. In the first place he dealt with the bolder methods of laying out underground workings and the saving of money and labour resulting from the adoption of longer stope backs, permanent tramming levels and mechanical haulage. We have not yet heard of the mechanical haulage system being installed upon the Rand, but underground workings are certainly being planned with a view to its introduction. Preparations therefore must necessarily include longer backs. 'Our methods of breaking rock can in many cases,' said Mr. Schumacher, 'be improved by paying more attention to the natural lines of weakness.' This remark no doubt has reference to the value of 'fracture planes' discussed by Musson Thomas and others before the Chemical, Metallurgical & Mining Society of S. A. In some mines, or some stopes, miners may admittedly be at fault by failing to take full advantage of the rock's breaking qualities, but, judging by the best opinion current on the Rand, the 'fracture plane' fetish is unlikely to lead to any valuable reforms. The benefits of narrow stoping—that is to say excluding as much of the external waste rock as possible—were emphasized in the speech. These, of course, have always been held in view by Rand managements though commonly lost under the baneful influence of the indiscriminating call for low costs, by careless mining.

Another point raised was the possibility of introducing more extensively labor-saving appliances for the transportation of ore from the stope faces to the main tramming levels. When the flatter 'reefs' in the eastern portion of the Rand become more widely exploited and the scarcity of labour is more acute, the 'advantage' of methods replacing the native shoveller will be little more apparent than the 'necessity.' How this may best be done remains to be determined under different working conditions. A good deal has been written of the air-winch operating in the Jumpers Deep, serving a track down the middle of the stope with side tracks, on to which the trucks are switched. The claims made for it so far seem to be little more than optimistic estimates, and there are other schemes which may yet achieve the desired end more economically.

Mr. Schumacher foresaw a greater concentration of work than at present in vogue. In many mines to-day an excessive number of levels are contributing ore. This certainly leads to waste, especially in supervision and standing charges. At the same time, it appears to us that concentration must almost automatically follow the previously mentioned mechanical haulage and increased backs, dealing with big tonnages. 'Much has been done during the last few years to improve the general condition of the native' and, indeed, much remains to be done. The information we have gathered from Rand engineers, while it does not turn us to the belief that the Kafirs are ill-treated or subjected unwisely to extreme discipline, certainly has convinced us that the popularity of the field with the natives can be appreciably increased by devoting greater attention to their comfort and feeding. The pay is ample for their requirements and the work not too onerous.

Finally, Mr. Schumacher touched upon ventilation, assuring the shareholders that the importance of the subject is fully recognized. Artificial ventilation has been introduced upon two mines of the Rand and it is to be employed in other properties in the immediate future."—*The Mining World*, November 27, 1909. (C. B. S.)

THE USE OF FERRO-CONCRETE IN MINES.—"The rock pressure liberated by mining operations cannot be estimated in advance with sufficient accuracy, and is especially subject to frequent changes, so that the miner has to deal with strains of unknown extent and direction acting on the timbering of the mine. In addition to compression, a bending strain also comes primarily into action, so that the interior of the timbering material is subjected to tension strains as well as those of compression. Now brickwork and ordinary rammed concrete are mainly capable of standing pressure only and fail when powerful tension strains come into operation. Ferro-concrete, on the other hand, is able also to withstand a certain amount of tension without destruction of coherence The advantageous conditions of strength exhibited by ferro-concrete rest upon the systematic combination of two building materials, each supplementing the other in their static properties—namely, concrete, which has a high compression strength, and iron, which has a high tensile strength. Owing to its high power of resisting rock pressure, ferro-concrete seems, therefore, specially adapted to replace brickwork and rammed concrete as a lining for mine galleries. Further advantages of ferro-concrete for this purpose are—resistance to the influence of pit air and moisture, impermeability to water, proof against fire, low frictional resistance to the passage of the ventilating current and excellent adaptability to all requisite shapes, combined with compactness of construction. Its defects are—difficulty of working on the finished lining and difficulty of preparation, this latter being the chief, the nature of mining operations being adverse to the planning and execution of constructions in ferro-concrete. On the one hand, the rock pressure cannot be calculated, and therefore the character and strength of the ferro-concrete structures must be based on estimates alone. Then, owing to the narrowness of the spaces, the imperfect lighting and the great difficulties in the way of supervision, a great deal has to be left to the reliability of the men employed for carrying out the work. Failures in ferro-concrete work in mines are almost always due to defects in execution. The chief reason why ferro-concrete has not been very widely employed in lining pit galleries is probably owing to the high requirements exacted with regard to the expert

knowledge and reliability of the technical superintendent and workmen. In any event, the existing ferro-concrete linings in shafts, cross-cuts, engine chambers and so forth justify the conclusion that, given proper execution of the work, ferro-concrete lining in general entirely fulfils the expectations formed with regard to its capabilities."—B. VIEBIG. —*The Colliery Guardian*, July 8, 1910, p. 67. (C. B. S.)

SOURCES OF RAND GOLD.—"In a discussion of vulcanism and differential pressure in ore deposition, the author says in Economic Geology: 'Regarding the origin of the gold in the Rand banket, I believe that the stream of occluded moisture in the magma which formed the dikes was the solvent which deposited the gold and the iron sulphide in the reefs. After the extrusive stage had ceased and the mobility of the magma due to occluded water vapour was insufficient to permit further movement of the mass of the dike, it solidified from the top downward and acted as a plug which prevented the solutions from going through to the surface. The solutions could then seek an outlet through the porous banket and deposit their dissolved minerals by reduction of heat and pressure. Associated hydrocarbons could then deposit graphite in the reef and also precipitate metallic gold from its solutions. The silica in the solutions would be deposited among the pebbles and cement the whole into one compact and impervious mass. By selective action different parts of the reef would thus serve as the channels at different times, and owing to variations in the gold contents of the solutions the reef would be made of different degrees of richness.

The cementation due to the silica contents of the solutions would block up the passage in different parts and force the passage of the solutions in a new channel. Naturally, the bottom reef would serve as the channel of circulation for the greatest length of time because of the dike solidifying from the surface downward, and that would be the last one to be shut off.

The reason, I believe, why the mineralization is not interrupted by the dikes is that it was contemporaneous and emanated from them, and I think that it will be found that in regions where the reef is not intersected by dikes, there is no gold. The same is true of the Calumet conglomerate, which is known to occur for a distance of 30 miles or more and only contains copper within two or three miles of that distance, where it is associated with eruptives from which the solutions were derived.'"—HIRAM W. HIXON.—*Mining World*, Dec. 31, 1910, p. 1244. (W. A. C.)

MISCELLANEOUS.

RADIUM IN PITCHBLENDE.—"Since radium has been found to be always a transformation product from uranium, it is natural to look for it only in those ores which contain uranium. The proportion of radium to the amount of uranium in one ore is so definite that Rutherford and Boltwood have determined the numerical relation. They found that there is ·0000038 gm. of radium to 1 gm. of uranium. Thus 1 ton (2,000 lb.) wonld contain ·0034 gm. of radium for every percentage of uranium present. Or 1 ton of 60% uranium ore will contain two-tenths of a gram of radium, which is equivalent to ·35 gm. of pure radium bromide. Because of this extremely small portion of radium, it would require an ore with a considerable percentage of uranium to be worth treating for the extraction of the radium. This is why pitchblende has been used in preference to other minerals. Although there are a number of other minerals in which uranium is found, pitchblende has the largest percentage."—L. F. MILLER. —*Mining Science*, July 14, 1910. (K. L. G.)

AIR LIFT PUMPING.—"It is still a popular fancy that air in lifting fluids from depths acts in a great measure on an ejector principle and all sorts of nozzles and cones are designed to take advantage of this supposed action of compressed air, but it is all much simpler than that, and the basis of the lift action of air lies in the fact that the discharge pipe contains a mixture of air and water which weighs less than the continuous water discharge pipe; consequently the heavier surrounding water pushes the enclosed lighter mixture upward causing the phenomena known as 'air lift pumping.'

Most pumping experiments by this method lie within the limits of 125 ft., consequently the commercial tables, curves and data in general have been calculated for such conditions, and these will be helpful in consideration of deep well pumping.

In discussing air lifts certain general terms are used and must be understood. By lift is meant distance from the surface of the liquid being pumped to the point of its discharge. By submergence is meant the depth of the discharge pipe under the surface of the liquid being pumped. By percentage of submergence is meant the ratio of the length of the submerged portion of the pipe to the total length of the discharge pipe. The total length of the discharge pipe will of course be the lift plus the submergence. For example, if the surface of the water be 100 ft. below the point of discharge this would be called a lift of 100 ft.; if the discharge pipe extends below the surface of the water 150 ft. it would be called submergence of 150 ft., the total length of the discharge pipe would then be 250 ft. and the submergence would be called 60%. If there be a given ascertained percentage of submergence the actual submergence may be ascertained by multiplying the lift by the percentage of submergence and dividing this product by 100 minus the percentage of submergence, expressed as follows:

$$\text{Submergence} = \frac{\text{Lift} \times \text{per cent. of submergence}}{100\% - \text{per cent. of submergence}}$$

Thus in the above example,

$$\frac{100 \times 60}{100 - 60} \text{ or } \frac{6{,}000}{40} = 150 \text{ submergence}$$

From the beginning of air lift experience it was assumed that the most economical condition for air lift pumping was when the submergence was 60%, but recent developments have somewhat shaken this idea and it is doubtful whether there has been enough of accumulated data collected on this subject to make any definite statements.

The first formula used for determining the amount of free air required to do pumping, assuming 60% submergence, was as follows:

$$\text{Quantity of free air required} = \frac{\text{Gallons and lift}}{125}$$

This is a rough rule which still holds good for small lifts, up to 100 ft., but it is too generous for deeper pumping. For example, if it be desired to know the amount of free air required to pump 100 gallons per minute 125 ft. high the result would be:

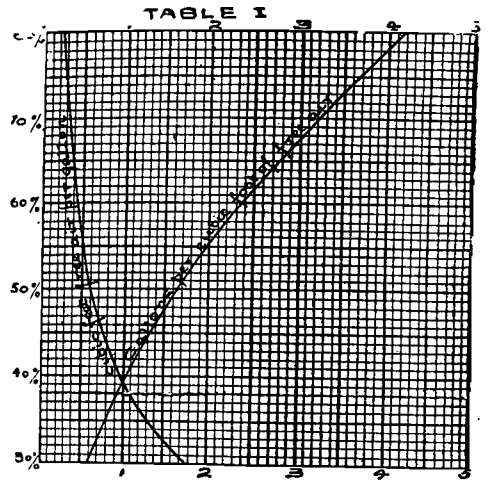
$$\text{Quantity} = \frac{125}{100 \times 125} = 100 \text{ cub. ft.}$$

of free air, and the pressure required would always be measured by the submergence; thus in the above

problem the lift being 125 ft. and the submergence 60%, the submergence would be 1½ times the lift or 187 ft., and the working pressure would be that due to 187 ft. Strictly speaking this would be about 80 lb., but inasmuch as there is pipe friction to be considered it is safe to take this pressure in pounds equal to one-half the submergence, thus one-half of 187 is 93½ lb., which would be a safe working pressure for such conditions.

When compressed air is introduced in the well in a finely divided state so that the bubbles are small and evenly distributed throughout most of the water the best results are produced. It is evident that if the air pipe merely discharges the air into the water with the full opening of the pipe the result will be large bubbles instead of the finely divided condition which is desired. This has led to the construction of many different patterns of what are called 'pump heads,' which is another name for the extremity of the compressed air pipe fashioned in such a manner as to distribute the air to the best advantage to the water being pumped.

The Indiana Air Lift Co. issues an interesting diagram, which I have marked Table No. I.,



and the table of dimensions which I have marked Table No. II. These may be considered fairly accurate at the lifts from 10 ft. to 125 ft

TABLE II.—Capabilities of Air Lift Pumps.

Air Pipe.	Size Pump.	70 per cent.	65 per cent.	60 per cent.	50 per cent.	40 per cent.	33 per cent.	Size of Well.
⅜	1	15	10	10	9	8	6	2½
½	1¼	30	15	15	13	10	8	3
½	1½	40	25	25	22	15	10	3¼
¾	2	75	55	45	40	30	20	4
1	2½	100	80	75	65	50	30	4¾
1	3	200	120	110	95	70	50	5⅝
1	3½	225	150	150	125	90	70	6
1	4	350	200	200	170	125	90	6⅝
1¼	4½	450	275	250	210	170	120	7⅝
1¼	5	550	350	320	260	200	150	8
1½	6	800	500	450	380	300	200	9⅝
1½	7	1200	750	650	550	425	300	10⅝
2	8	1700	1000	800	675	525	400	11⅝
2	9	2000	1250	1050	900	700	500	13
2	10	2500	1600	1300	1100	900	600	14

With these two tables it is easy to determine all the elements of an ordinary air lift installation for pumping water. Having determined the percentage of submergence by dividing the submergence by the submergence and lift—let us say it was 50%, look along the left hand edge of Table No. I. and find 50% and follow along the right until it intersects the second curve and you will have the value 1·65 which means that at that submergence 1 cub. ft. of free air will lift 1·65 gallon of water.

Table No. II. gives the proper sizes of the Indiana pump heads and the proper sizes of water and air pipes for any given condition. Following up the previous problem of 50% submergence, if it be wished to deliver 125 gallons of water per minute the 50% column should be followed down to 125 gallons, then on the second column will be found the size of the Indiana pump head, namely, 3½ in., which is also the size of the discharge pipe. On the first column will be found the size of the air pipe, 1 in., and on the extreme right hand column will be found the smallest size well that will contain the outfit; namely, 6 in.

It will be noted that no mention is made of the lift, because the table being intended for ordinary conditions of 125 ft. or less, it has been assumed that it takes the same number of cubic feet of free air to lift 10 gallons with 60 ft. submergence as 10 gallons lifted 80 ft. with 120 ft. submergence, the working pressure only changing, in the former case being 20 lb. and the latter 40 lb. Now this assumption is not exactly true, but within the practical limits of these lifts it is near enough to be a good convenient rule. When more accuracy is required for greater depths Table No. III., calculated by George H. Reichard, is valuable, as it takes into consideration the expansion of the air bubbles on their way from the lower depths to the surface.

The reason these expansions must be taken into consideration is evident from the very nature of the action of the air lift. Inasmuch as the action of the air lift depends upon an emulsion of air and water, which mixture is lighter than water, it is evident that a perfect condition would be where the bubbles, when introduced at the bottom of the well would maintain the same size in their passage to the discharge. It will readily be seen, however, that inasmuch as the pressure is relieved from the air bubbles as they rise toward the surface, the bubbles get larger and larger, the proportion of air to water

TABLE IV.—Brake Horse Power to Compress 10 cub. ft. Free Air per Minute.

Gauge Pressure.	Brake h.p.	Gauge Pressure.	Brake h.p.	
5	·235	130	2·14	Two Stage.
10	·435	140	2·23	
15	·606	150	2·31	
20	·756	200	2·60	
25	·9	250	2·85	
30	1·02	300	3·07	
40	1·25	350	3·26	
50	1·45	400	3·40	
60	1·60	450	3·54	
70	1·77	500	3·68	
80	1·92	600	4·00	
90	2·05	700	3·85	Three Stage.
100	2·18	800	4·00	
110	1·98	900	4·16	
120	2·07	1,000	4·32	

TABLE III.—Approximate Cubic Feet of Free Air and Working Pressure Required to Raise One Gallon of Water by Air Lift.

$$\text{Formula} = \text{Log.}\frac{H+34}{34} \times 234$$

H = Submergence in feet
L = Lift in feet

Ratio of Submergence to Lift.

Lift in feet.	25% ⅓ to 1		30% ½ to 1		43% ¾ to 1		50% 1 to 1		55% 1¼ to 1		60% 1½ to 1		66% 2 to 1		70% 2½ to 1		75% 3 to 1	
	Free air cub.ft.	Working press.	Free air cubic feet.	Working press.	Free air cubic feet.	Working press.	Free air cubic feet.	Working press.	Free air cubic feet.	Working press.	Free air cubic feet.	Working press.	Free air cubic feet.	Working press.	Free air cubic feet.	Working press.	Free air cub.ft.	Working press.
20							·428	9	·365	11	·310	13½	·252	18	·217	22½	·195	27
30							·470	13½	·400	17	·350	20	·290	27	·255	34	·230	40½
40							·508	18	·435	22½	·387	27	·325	36	·287	45	·263	54
50							·546	22½	·470	28	·422	34	·360	45	·320	56	·285	67½
60							·582	27	·510	34	·457	40½	·392	54	·350	67½	·323	81
80							·653	36	·575	45	·522	54	·455	72	·410	90	·380	108
100					·850	34	·720	45	·640	56	·585	67½	·512	90	·465	112½	·433	135
120					·915	40½	·785	54	·703	67½	·642	81	·567	108	·520	135	·483	162
140					·982	47	·847	63	·763	79	·697	94½	·622	126	·572	157½	·533	189
160					1·047	54	.907	72	·820	90	·755	108	·675	144	·624	180	·583	216
180					1·107	61	·965	81	·875	101	·810	121½	·725	162	·672	202	·630	243
200	1·8	30	1·436	45	1·167	67½	1·022	90	·930	112½	·862	135	·775	180	·720	225	·675	270
250	1·96	38	1·592	56	1·312	84	1·156	112½	1·069	141	·988	168	·895	225	·830	282		
300	2·12	45	1·750	67½	1·507	100	1·292	135	1·206	169	1·110	200	1·010	270	942	338		
350	2·28	53	1·897	79	1·635	118	1·449	157½	1·317	197	1·232	236	1·110	315	1·050	394		
400	2·45	60	2·045	90	1·725	135	1·542	180	1·429	225	1·345	270	1·232	360	1·155	450		
450	2·60	68	2·182	100	1·850	152	1·669	205	1·542	253	1·457	304	1·337	410	1·280	506		
500	2·74	75	2·328	112½	1·952	169	1·790	225	1·657	281	1·570	338	1·442	450	1·356	562		
550	2·88	83	2·455	128	2·105	185½	1·907	247½	1·772	309	1·678	271	1·564	495				
600	3·02	90	2·564	135	2·225	205	2·018	270	1·884	337½	1·784	410	1·642	540				
650	3·16	98	2·730	146	2·345	219	2·175	292½	2·012	365½	1·908	438	1·742	585				
700	3·31	105	2·845	157½	2·460	236	2·258	315	2·100	394	2·000	472	1·842	630				
750	3·45	113	2·970	169	2·576	256	2·353	337½	2·225	424	2·080	512	1·935	675				
800	3 60	120	3·095	180	2·690	270	2·465	360	2·320	450	2·190	540	2·063	720				
850	3·72	128	3·215	191	2·800	287	2·570	382½	2·410	478	2 29	574	2·125	765				
900	3·85	135	3·338	202½	2·915	304	2·675	405	2·50	506	2·325	608	2·220	810				
950	3·98	143	3·455	214	2·0	322	2·780	427½	2·610	535	2·485	644	2·310	854				
1000	4·11	150	3·575	225	3·465	337½	2·885	450	2·710	562½	2 580	675	2·407	900				

increases exactly in proportion to the expansion and this decreases the efficiency of the lift.

The quantity of air given in this table, No. III., is 2½ times the theoretical quantity required to do the work. Two and one-half has been selected as a co-efficient in this matter as a result of experience. Some engineers have advocated the use of 3 and even 3½ as a co-efficient, but I believe that the table as given to be approximately correct. In the first line of the table the percentage of submergence is given; also the ratio of the submergence to the lift. After having determined the amount of free air necessary to do the pumping and the pressure required, then by reference to Table No. IV. the brake horse-power to compress the air may be determined. This table shows the actual horse-power necessary to compress 10 cub. ft. of free air per minute to the pressure mentioned. An allowance is made in this table for friction and other losses of power, and is generous enough to allow an ample amount of power to do the work."—E. A. RIX.—*Mining and Scientific Press*, Oct. 15, 1910, p. 505. (W. R. D.)

CEMENT CONCRETE VATS AND TANKS.—"Impervious, odourless, tasteless, and sanitary vats and tanks can be constructed of reinforced concrete, the reinforcing to be designed by a competent engineer, provided the interior surfaces are treated as follows:

After the forms are removed, grind off with a carborundum stone any projections due to the concrete seeping through the joints between the boards. Keep the surface damp for two weeks from the placing of the concrete. Wash the surface thoroughly and allow to dry. Mix up a solution of one part water-glass (sodium silicate) 40° B., with four to six parts water, total five to seven parts, according to the density of the concrete surface treated. The denser the surface the weaker should be the solution.

Apply the water-glass solution with a brush. After four hours and within 24 hours, wash off the surface with clear water. Again allow the surface to dry. When dry apply another coat of the water-glass solution. After four hours and within 24 hours, again wash off the surface with clear water and allow to dry. Repeat this process for three or four coats, which should be sufficient to close up all the pores.

The water-glass (sodium silicate) which has penetrated the pores has come in contact with the alkalies in the cement and concrete and formed into an insoluble hard material, causing the surface to become very hard to a depth of ⅛ to ½ in., according to the density of the concrete. The excess sodium silicate which has remained on the surface, not having come in contact with the alkalies, is soluble, therefore, easily washed off with water. The reason

for washing off the surface between each coat and allowing the surface to dry, is to obtain a more thorough penetration of the sodium silicate."—A. MOVER.—*Mines and Minerals*, Jan., 1911, p. 364. (W. A. C.)

Reviews and New Books.

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

CHEMISTRY OF COAL. By MYLES BROWN, M.E. (Wigan: *The Science and Art of Mining*.)

"This little hand-book, comprising about 80 pp., contains a lot of useful information for students, colliery managers, and purchasers of coal. The use of coal analysis and fuel tests has come prominently to the front of late, and is a clear indication that purchasers of coal are becoming dissatisfied with the old form of contract note and are adopting specifications which give the contract note a reliable scientific basis. The information which the author of this book presents should be of considerable help to those who are endeavouring to keep pace with the more advanced requirements of purchasers."—*Iron and Coal Trades Review*, Dec. 16, 1910. (A. R.)

PRACTICAL DATA FOR THE CYANIDE PLANT. By HERBERT E. MEGRAW. pp. 93. Illustrated. Soft cover. Price $2 net. (New York, 1910: Megraw-Hill Book Company, 239 West 39th St.)

"To help the 'Man on Shift' this volume was written. Although it is confessedly a compilation, it is not without original matter. The author, Mr. Herbert A. Megraw, while claiming little originality, hopes that the book will accomplish its object in solving the everyday difficulties of the worker in cyanide. We are sure that, in many cases, it will.

The ground surveyed is as follows: Crushing and grinding, the cyanide plant, slimes, precipitation, formulæ in mensuration, tables of general weights and measures, general reference tables. The section 'precipitation' is thus divided: Solutions, stoichiometry, preliminary experiments on ores, trouble, data. Under these heads, the sequence of steps is well presented. Necessary chemical equations are included and explained. Under the heading 'trouble' a lot of very helpful and practical hints are given."—*Canadian Mining Journal*, Dec. 1, 1910. (A. R.)

PRACTICAL SHAFT SINKING. By FRANCIS DONALDSON, Chief Engineer of the Dravo Contracting Co. 8vo, pp. 139. 63 Illustrations. Price $2. (New York City: McGraw-Hill Book Co.)

"This book is written by a practical man engaged in the business of shaft sinking, and covers the ground of modern shaft sinking from A to Z. Chapter I. includes contract agreement for excavation; the extra prices to be paid for excess of water pumped above 100 gallons per minute; and timbering specifications where shafts require to be lined. Chapter II. covers the power plant required for sinking shafts to various depths; the disposal of excavated material; and an itemized cost of an entire sinking plant for a shaft 500 ft. deep. Chapter III. In this chapter the author shows how to sink and support earth from the surface to rock; the various kinds of piling used, including steel; the use and construction of circular and oblong concrete caissons, with the construction of the shoes. Chapter IV. covers the pneumatic process of sinking through soft ground; also the shield method practiced in Illinois. Chapter V. covers rock excavations; the tools for drilling; placing holes for blasting; progress and probable cost per foot. Chapter VI. The processes followed abroad and the Poetsch-Sooysmith freezing process are described. Chapter VII. The Kind-Chaudron process, and the cementation of water-bearing fissures. Chapter VIII. is devoted entirely to lifting water during the progress of shaft sinking. Chapter IX. deals with various kinds of shaft linings used abroad and in this country. Chapter X. gives the cost per linear foot for rectangular, angular, elliptical, and quadrilateral cement-lined shafts."—*Mines and Minerals*, Dec., 1910. (A. R.)

MODERN ASSAYING. By J. REGINALD SMITH. (J. B. Lippincott.)

A text book on "Modern Assaying," which only boasts 150 pages or so, can scarcely be expected to be an exhaustive treatise on so wide a subject. In so far as sampling and crushing go, the matter of the book is excellent, but beyond a description of the various processes employed in assaying gold and silver ores, together with brief notes on lead and copper, and mercury assays—all of which can be obtained in greater detail in any of the ordinary text books on assaying—we see little object in the publication of this book, unless it be as an advertisement for a certain make of ore-crusher. (M. T. M.)

TESTING FOR METALLURGICAL PROCESSES. By JAMES A. BARR. San Francisco: *Mining and Scientific Press*), p.p. 216. $2.

As a text book for advanced students, this publication is one of the most successful that we have seen. Dealing as it does with chlorination tests, with amalgamation and cyanidation of gold ores—with furnace work and calculations of furnace charges, pyrometry, calorimetry, &c.,—it covers the work which a mining or metallurgical student would be required to perform in his final year of study.

Such a book has long been required, and Mr. Barr has certainly made the metallurgical profession indebted to him for putting into a convenient form his laboratory notes. More than that, a large number of the experiments can be performed in ordinary mine assay offices—whether attached to gold, silver, or base-metal mines, so that the book is useful to the practical assayer, as well as to the student. For assayers on the Reef (and cyanide managers, too, for that matter) we can cordially recommend the chapters on "Amalgamating," "Cyanidation," and "Retorting."

Altogether, we have little or no fault to find with the book, which will be of great use in the laboratory. We hope that the author will, at some future date, expand and amplify his book into a comprehensive volume, which will cover all laboratory work for mining and metallurgical students. (M. T. M.)

PRACTICAL STAMP MILLING AND AMALGAMATION. By H. W. MACFARREN. (San Francisco: *Mining and Scientific Press*), p.p. 166. $2.

This little book should be of invaluable assistance to the battery-manager, the amalgamator, and, more especially to the tribute miner and proprietor of the small proposition, who has had little or no experience of metallurgy. Every detail of the routine of stamp-battery practice is dealt with—concisely, clearly, yet fully.

The book is written from the American standpoint, of course, and one notices a few inaccuracies

in the references to work on foreign fields, while here and there the author might have gone into the reasons for certain difficulties which crop up, and for the methods employed in overcoming them, a little more fully. However, the book is ostensibly a *practical* one, and the introduction of theoretical detail might have defeated the end which the author had in view, *viz.*, to give in a concise, brief manner, information by which millmen may be guided, and the methods found to be most satisfactory in treating various types of ores.

Mr. MacFarren is evidently a practical man himself, so that his ideas and suggestions are based on his own experience and observations.

One could only wish that some battery-manager on the Witwatersrand would come forward with a similar treatise on the procedure followed on the Rand. Such a book would be of inestimable value to our millmen, amalgamators and students. (M. T. M.)

ROCK DRILLS—DESIGN, CONSTRUCTION AND USE. By EUSTACE M. WESTON, Reef Lecturer on Mining, Transvaal University College. pp. 367. Profusely Illustrated. Price $4 net. (New York, 1910: McGraw-Hill Book Company, 239 West 39th Street.)

"The gaps in professional handbooks are being gradually and well filled. This latest addition to the list of practical books will be welcomed by many.

Until now, there has been no attempt to cover the whole subject of rock drills. We have needed, particularly, a comparison of English, Australian and American drills. Such a comparison is necessary to aid the engineer in his choice of machine for his special needs.

The successive subjects treated are: standard piston drills; hammer drills; electric drills; operating on surface and underground; piston drills using air exclusively; philosophy of drilling rock; repair and maintenance of rock drills; drill steel and drill bits; explosives and their use; theory of blasting with high explosives; examples of drill practice in Africa, Australia and America; drill tests and contests; dust and its prevention; notes on the use of compressed air. It will be seen that the scope of the book is large and that the sequence is logical.

As probably the evolution of the hammer drill is the most important of modern developments, it is worth while digressing here to notice Mr. Weston's estimate of the comparative merits of the piston and the hammer types. Mr Weston points out that, unless one keeps in mind the fact that the rock drill is a commercial machine, one might be tempted to believe the modern hammer drill to be by far the superior machine. The weight of the hammer of the largest type of hammer drill is 15 lbs. The weight of piston, steel, etc., of a piston drill ranges from 60 lbs. to 125 lbs. Thus, whilst the velocity of the hammer drill should be 16 times that of the piston drill to get equivalent effect, in practice it is only four, times as great. In other words, a very high air pressure must be used to permit the hammer drill to compete at all with the piston drill. Mr. Weston expounds the subject capably and well.

Most instructive are two chapters entitled, 'Examples of Rock Drill Practice,' and one entitled, 'Rock Drill Tests and Contests.' The former takes up 90 pages. They cover practice in South Africa and in America respectively. Many cost items are given. The chapter on 'Rock Drill Tests and Contests' takes up South African tests largely.

Whilst Mr. Weston's book will call for additions and revisions perhaps more rapidly than books on other subjects, yet is is distinctly a book that will help the mining engineer. In its field it is unique.—*Canadian Mining Journal*, Dec. 1, 1910. (A. R.)

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(C.) 21/10. E. J. Way (1), A. J. Arbuckle (2). Improvements in vats or vessels for the treatment of crushed ore products. 22.1.10.

This claim is for a vat, fitted with a number of small cones, and containing both in these cones, and in convenient positions between them, circulating columns in which pulp is made to circulate by the application of air jets, after the manner of the Pohle lift. The claim is for a plurality of such devices contained in one vat.

(C.) 596/10. Otto Stehang Tonnesen. Improved apparatus for sampling slimes and other liquids. 5.12.10.

This application is for a design of apparatus for sampling slime and the like. It consists of a tube with end shaped as a cutting edge, provided with an airtight plunger to retain the sample therein by atmospheric pressure.

(C.) 603/10. Frederick Stubbs. Improvements in safety amalgam receptacles. 8.12.10.

This application is to cover a specified receptacle or vessel for holding the amalgam or black sand that is taken from the amalgamating plates, and the novelty claimed is in connection with a valve at the bottom of the tube or inlet of the vessel, which will prevent any material that has once been put in from being taken out again, excepting by unlocking the lid.

(C.) 628/10. Max Weidtman. Method of separating diamonds and other stones having somewhat the same specific gravity from the matrix. 23.12.10.

This is a device for separating diamonds and other stones, having somewhat the same specific gravity, from the matrix in which they are embedded by treating with a liquid, the specific gravity of which is greater than that of the matter, but less than that of the diamonds.

(C) 638/10. Alfred Arthur Lockwood. Improvements in the treatment of auriferous and argentiferous ores. 29.12.10.

This application refers to the use of an alkaline silicate in treating gold or silver ores with cyanide of potassium, with the object of reducing the consumption of cyanide by such base metal compounds as copper pyrite. It is believed that the base metal compound becomes covered with a thin coating of silicate.

Selected Transvaal Patent Applications.

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