THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

VOL. X. DECEMBER, 1909. No. 6.

Proceedings AT Ordinary General Meeting, December 20, 1909.

The Ordinary General Meeting of the Society was held in the Lecture Theatre of the Transvaal University College, on Saturday evening, December 18th, Dr. James Moir (Vice-President) in the chair. There were also present:—

46 Members: Messrs. W. R. Dowling, C. B. Saner, K. L. Graham, E. J. Laschinger, A. Richardson, G. O. Smart, R. Stokes, H. A. White, Prof. J. A. Wilkinson, R. G. Bevington, W. A. Caldecott, Andrew F. Crosse, H. A. Adams, W. Beaver, F. W. Bentley, W. Broom, E. Browne, W. M. Coulter, M. J. Doyle, G. G. Ferris, A. D. Gilmore, B. J. Hastings, Dr. J. McC. Henderson, A. J. Herald, C. B. Hilliard, J. H. Johnson, T. Johnson, G. A. Lawson, J. Lea, R. Lindsay, W. D'A. Lloyd, R. MacGregor, M. T. Murray, S. Newton, F. D. Phillips, J. F. Pyles, E. T. Rand, D. G. F. Ross, O. D. Ross, A. Salkinson, A. H. Scarf, A. L. Spoor, S. H. Steels, W. A. C. Tayler, and J. F. Walker.

11 Associates and Students: Messrs. E. Brennan, J. Cronin, W. J. R. Hunter, A. King, C. J. McCaffrey, R. Murdoch, J. M. Robinson, J. Sharp, H. Stadler, W. E. Thorpe, and W. Waters.

9 Visitors, and Fred. Rowland, Secretary.

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

NEW MEMBERS.

Messrs. W. A. Caldecott and A. F. Crosse were appointed scrutineers, and after their scrutiny of the ballot papers, the Chairman announced that all the candidates for membership had been unanimously elected, as follows:—

BARRY, RICHARD ALAN, Nourse Mines, Ltd., P. O. 32, Denver. Mining Engineer.
CAMPBELL, JOHN MCPHERSON, Robinson Deep G. M. Co., Ltd., P. O. Box 1488, Johannesburg. Mill Foreman.
CRICHTON, CHARLES, Afrikander G. M. Co., Ltd., P. O. Box 121, Klerksdorp. Analytical Chemist.
DODD, MICHAEL, P. O. Box 1197, Johannesburg. Mining Engineer.
SHARWOOD, WILLIAM JOHN, Ph.D., A.R.S.M., Homestake Mining Co., Lead, S. Dakota, U.S.A. Metallurgical Chemist. *(Transfer from Associate Roll.)*
SHEPHERD, SIMPSON, Village Deep, Ltd., P. O. Box 1145, Johannesburg. Surveyor.

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

As Associates.—

MOFFITT, CHARLES EDWARD, Simmer & Jack Proprietary Mines, Ltd., P. O. Box 192, Germiston. Amalgamator.
SHARP, J. E., Knights Deep, Ltd., P. O. Box 143, Germiston. Mill Foreman.
STRANGE, ERNEST HAROLD, 156, Guilford St., St. John (West), New Brunswick, Canada. Miner.
WHALEY, JOHN, Simmer & Jack Proprietary Mines, Ltd., P. O. Box 192, Germiston. Cyanider.

As Student.—

VOGTS, WILLIAM THOMAS LAING, Simmer Deep, Ltd., P. O. Box 178, Germiston. Mill Learner.

GENERAL BUSINESS.

METALLURGICAL AND MINING TERMS.

The Chairman: I may mention that at the last meeting of the Council, Mr. H. A. White raised the question of what may be called a standard spelling to be used in the *Journal*. He considers that a number of terms now used in mining in the plural ought to be used in the singular, such as "sands," "concentrates," "tailings," etc. It caused an animated discussion in the Council, and a sub-committee was appointed to go into the question. What we should like now is suggestions from members as to what terms should be revised in this sense, and, generally speaking, what the members think of the revision.

Mr. H. A. White (*Member of Council*): This sub-committee has been appointed to consider the possibility of improving the nomenclature of mining and metallurgical terms. For instance, it is considered that it would be better to use such terms as "slime," "sand," and "residue" in the singular where only one such product is referred to. Again, such words as "mullock" and "dirt" which are workmen's terms, might be avoided in scientific literature.

Mr. A. F. Crosse (*Past-President*); I have much pleasure in supporting the suggestion. It is quite right that we should use the singular in using the word "slime" when we are talking about the slime of one mine, but when we are talking about the slimes of the Witwatersrand, for example, we should use the word in the plural.

The Chairman: I hope you will send in your suggestions to the Secretary soon so that the sub-committee may be able to deal with them as speedily as possible.

Mr. A. Richardson (*Member of Council*) read the following on behalf of the author.

ENDLESS ROPE HAULAGE.

By H. G. Kay (Associate).

A very considerable sum of money is expended annually by mining companies in the transport of rock to the reducing plants and waste and tailings to the dumps. The most common form of transport for this purpose is by means of endless rope haulages, and it is proposed in this paper to give a few notes on the system of hauling as practiced on diamond mining properties, where large quantities of ground are handled in open cast workings.

The principle of the system consists of hauling by means of an endless rope to which the trucks can be attached or detached at certain fixed points without the necessity of stopping the rope, thus keeping up a constant supply of trucks to the working places. The power to work the haulage can be transmitted by a stationary engine, electric motor, or by an ordinary clutch and drum arrangement attached to a moving shaft, or a sub-haulage can be driven off a main haulage rope by means of a shaft carrying a double drum with clutch attached.

The speed of the haulage depends largely on the state of the running track; a well laid line with properly constructed onsetting point can be worked quite satisfactorily up to a speed of 5 miles an hour, and at that rate 1,000 to 1,200 trucks per hour can be handled. With a rough track, as is usually laid on stone tips and tailings dumps, the speed should be reduced to about 2 miles per hour, at which rate trucks can be handled with ease and safety.

Where curve wheels are used to work haulages around angles a high rate of speed is not desirable, as even with the best constructed track there is always a great deal of wear and tear on both the truck and the rails in negotiating the small curves which the radius of the curve wheels necessitates. The amount of deflection off the straight for a curve wheel should be between 15° and 30°; if the angle at the intersection is too flat the rope is likely to leave the wheel and, on the other hand, should the angle be too acute the curve, which by necessity has usually about a 3 ft. radius, is too sharp for the truck to work around with any degree of safety: as a support to the wire, a roller fitted to a swinging arm should be placed on the on-coming side of the wheel, and, as a further precaution against the rope leaving the wheel, the latter should be slightly elevated on the off-going side of the rope.

In running inclines a grade of 1 in 8 ($12\frac{1}{2}\%$) is about the limit for a fast travelling haulage, although at a lower speed inclines of 1 in 6 can be worked: the grade to a large extent is limited by the speed of the haulage, as with a fast rope and a steep incline the trucks are likely to up-end as soon as hooked, and also at the starting and stopping of the rope. The usual method of attaching a truck to the rope of an endless haulage is by means of a "jockey," a **V**-shaped iron fork fixed to the top of the truck body, into which the rope is forced until the necessary grip is obtained. The form of "jockey" largely used on the Rand in earlier days was bent out of $\frac{1}{2}$ in. or $\frac{3}{4}$ in. round iron into the form of a **V** with a long arm projecting downwards from one corner to form a means of attachment to the truck. An improvement on the above is the wrought iron fan-tail jockey, made in the shape of a **U** with the opening slightly tapering towards the bottom, the jaws are also broadened at the top so that when the truck receives the pull of the rope and the jockey turns slightly in its bracket the slot holding the rope is partly closed up at the top owing to the overlie of the fan shaped jaws, thus locking in the rope and preventing it, to a large extent, from rising and pulling out of the jockey.

A very successful jockey (Pack's Patent) in use at the Premier Diamond Mine is constructed with renewable jaws. Fitted to the top of the pillar is an oblong cast iron box into which the two jaws are set, these being held in position by means of a wedge driven down between them and through the bottom of the box, this wedge being also held fast by a small wedge and split pin. With this arrangement each jaw can be given a quarter turn, thus allowing four wearing faces before new jaws are required.

In laying a haulage track the rail on the side to which the jockey points must be slightly elevated so that the rope is brought directly over the centre line between the two rails, and to prevent unnecessary wear and tear on the rope, rollers or hard wood rubbing blocks are placed at intervals between the rails to carry the sagging rope.

The most important item in the haulage is a properly constructed onsetting point. The grade feeding the trucks to the onsetter should be such, that when the truck reaches the rope for hooking the speed of the rope and truck are exactly the same: should the speed of the truck be either greater or less than the speed of the rope a sudden jerk will take place on hooking, which is very detrimental to the life of the rope.

At a fast feeding onset, brakes to regulate the run in of the trucks should be used, also a contrivance to turn the jockeys automatically into the right position for hooking, and as a further safeguard against the trucks leaving the rails at the point of hooking, check rails or boxing should be placed for a short distance on each side of the onsetting point. The catenary curve connecting the down grade to the onset with the up grade of the incline requires special attention in laying out, as upon this the rate of hooking largely depends; the rails must follow a line which is parallel to the natural curve taken up by the rope, and to maintain the rope in this position a balance weight or tension is employed. This frame also takes up the amount of expansion or contraction in the rope due to stretch or change of temperature; a well balanced and sensitive rope is absolutely essential to a fast feeding haulage.

At the point of disengaging the trucks an "apex" is formed with a down grade sufficiently steep to cause the truck to overrun the rope, this change from a pull to a push on the rope causes the jockey to come square with the rope and easily free itself. On a long steep incline, or in fact on any haulage which is at all permanent, disengaging frames should be used and "slog-out" boys dispensed with. The frames are made in various patterns, a cheap and effective one is in the form of a double cross frame carrying two long timber runners (see Fig. I.) placed parallel to the track and just sufficiently high to clear the top sides of the truck body; fixed to the top side of these runners and at the off-going end is a bar with a roller carrying the rope; as the truck reaches the frame the body is slightly lifted until it comes into contact with the runners when the rope is pulled out of the jockey and the truck released automatically from the rope.

Another arrangement for a disengaging frame consists of a double frame carrying two lengths of channel iron set parallel to the rope and just sufficiently wide apart to allow it to pass freely between them and up over the roller at the off-

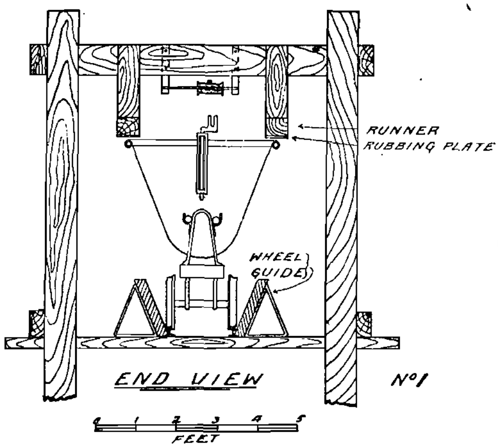


FIG. I.

going end; as the truck reaches the frame the rope passes up through the slot formed by the channel irons, and as the opening is wide enough to admit the rope only the jockey is pulled off the rope and the truck disengaged.

A form of haulage very suitable for tailings dumps consists in having the jockey fitted to the side of the truck carriage instead of on to the body as is the usual practice: with this arrangement the truck can be tipped without being released from the rope, and consequently there is no time or labour lost in disengaging or rehooking. A haulage of this description is very economical as from the time the truck is filled at the bin and hooked to the rope there is no need to handle it again until it is returned to the filling bin, the tipping, righting, and disengaging all being done automatically. With this arrangement trucks will negotiate curves of 12 ft. radius or over by a series of rollers set about 2 ft. 6 in. apart and just on a level with the rope; these curve frames (see Fig. II.) are held in position by ballasting them down with sand bags or stones and can be easily shifted bodily forward as the dump extends.

A serviceable truck tipper (see Fig. III.) consists of a frame carrying a length of rail or pipe set at a height to just catch the top of the truck body, this tipping bar is placed diagonally across the track with the on-coming end about 1 ft. outside the rails and the off-going end over the centre line of the track; as the truck reaches the tipping bar the body runs along it until it is overbalanced and tipped, a check bar is placed over the truck wheels to prevent the carriage capsizing also. The same principle is applied to the "truck righter," a length of rail or pipe is bent into the form of an incline plane and set alongside the track so that the lower end of the incline will just catch under the down turned lip

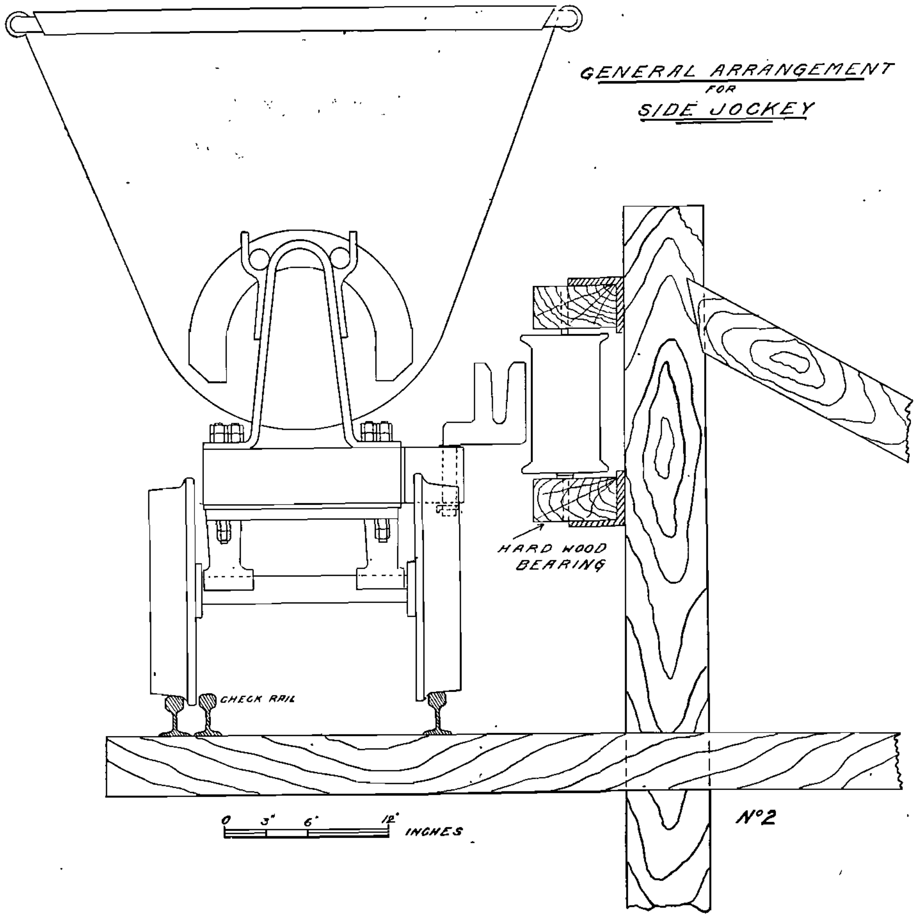


FIG. II.

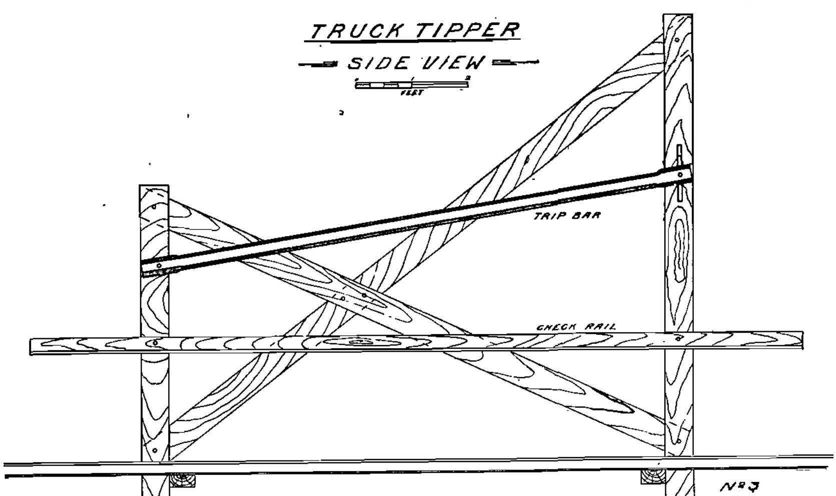


FIG. III.—SIDE VIEW.

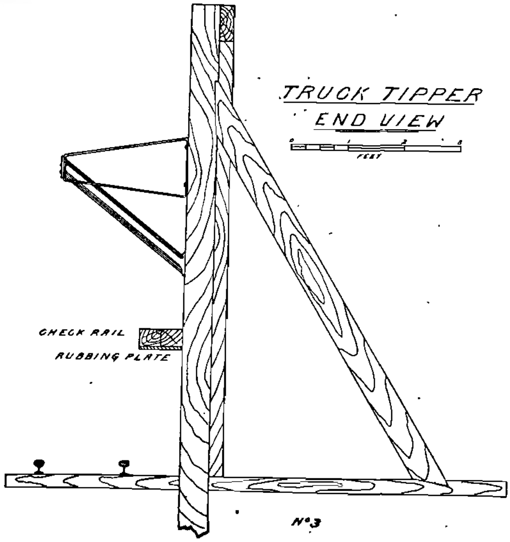


FIG. III.—END VIEW.

of the truck body, and as the truck is drawn along the incline the body is raised until it regains its upright position (Fig. IV.).

At the Premier Diamond Mine endless rope haulages are used throughout the workings; the main haulage to No. III. gear has three changes of grade, the steepest being 1 in 8, or $12\frac{1}{2}\%$, the tracks are laid with 40 lb. rails set on wooden sleepers, width between up and down tracks 6 ft. The rope is of plough steel $1\frac{1}{4}$ in. diameter, travelling about $4\frac{1}{2}$ miles per hour. The rate of hooking on this haulage is from 1,000 to 1,200 loads per hour, although over 26,000 loads have been hauled in a working day of 21 hours, and over 140,000 loads in the week. The length on incline from onset to apex is 3,123 ft., and the vertical lift 239 ft.

The new incline to No. 4 gear on the same mine has two changes of grade 1 in 8·9 (11·2%), and 1 in 8 ($12\frac{1}{2}\%$) respectively, the tracks are also laid with 40 lb. rails, 8 ft. centres between tracks, the rope is $1\frac{1}{4}$ in. diameter plough steel, and travels at about the same rate and has the same capacity as the previous haulage referred to. The length of incline is 2,425 ft., and the vertical lift 270 ft.

The Chairman: I think we owe a very hearty vote of thanks to Mr. Kay for his interesting paper. It is entirely out of my line, so that I do not propose to comment on it. The only thing that strikes me at present is that a paper of this sort seems to go far towards solving the native labour question, by making things more automatic than they are at present.

Mr. R. G. Bevington (*Past-President*): I should like to second the vote of thanks to Mr. Kay. On the occasion of our Society's visit to the Premier Diamond Mine, this was one of the devices that struck me and interested me very much, and it is certainly of advantage to have a description of it on record in our *Journal*. I was interested in watching the way the trucks were hauled along, automatically tipped and automatically righted.

Mr. E. T. Rand (*Member*) read the following paper :—

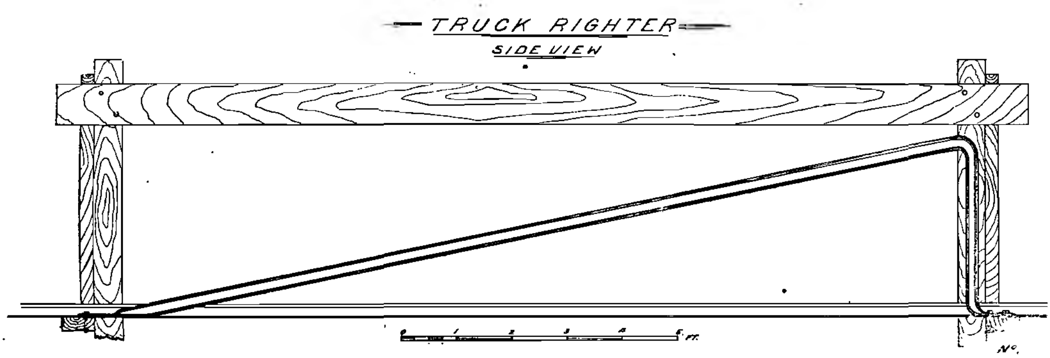


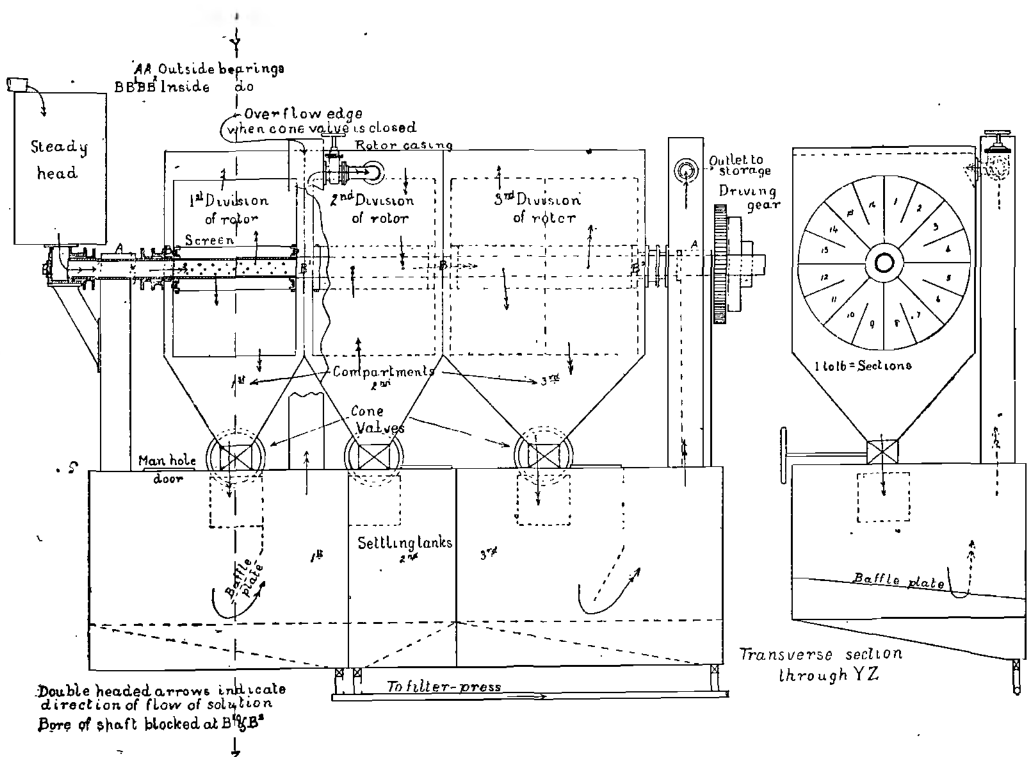
FIG. IV.

A ROTARY EXTRACTOR FOR PRECIOUS METALS FROM SOLUTIONS.

By W. D'Arcy Lloyd and Ernest T. Rand (Members).

From time to time attempts have been made to precipitate gold and silver from their cyanide solutions whilst the precipitating agent was in motion, with more or less success. For example, zinc shavings have frequently been subjected to mechanical motion whilst in contact with the gold and silver cyanide solutions, and in most cases as far as actual precipitation of the precious metals was concerned, some success has been achieved, but mechanical difficulties have developed due to the method of applying motion by attrition, or an insufficient contact of the causing the breaking up prematurely of the zinc solution with the zinc. The main idea underlying all the attempts to perform the operation of precipitation with the precipitating agent in motion, is to avoid the fouling of the zinc, which is so painfully evident in the first compartments of all our extractor boxes after a three days' run from time of dressing. It is well known that after thorough washing and redressing, the zinc will go on precipitating as briskly as ever until fouling starts again. The natural inference from this is that if the zinc could be kept continuously in motion, thus preventing fouling, the highest efficiency would be maintained. Having this in view, we have evolved the machine of which we endeavour to give some idea.

The precipitating agent used was zinc in the form of shavings and clippings, the latter being cut from sheet zinc and approximately $\frac{1}{4}$ in. to $\frac{5}{8}$ in. square The machine is a rotating one, with a water tight casing of comparatively light steel plate, the casing being fitted with plates to divide it into compartments. In the machine with which the experiments were carried out, there were four of these compartments, but we have reason to think that the result required would be attained with three, the third being one-third larger than the first and second (see sketch). In the centre of these division plates are securely fixed bearings, in which a hollow shaft rotates. Two circular discs in each compartment distant from each other almost the full length of the compartment, are securely bolted to flanged collars, which in turn are fixed to the shaft. The shaft with these discs and other attachments form the rotor. The rotor, besides being divided into compartments in length, is subdivided radially, in appearance much as a transverse section of an orange. There are sixteen radial divisions, which number was arrived at experimentally, the pressure of solution during rotation of a smaller number tending to press the zinc against the wall of the divisions leaving a space between the zinc and the next wall. The use of the larger number of radial divisions obviated this tendency. These radial divisions are removable, and are lightly and strongly constructed of perforated ($\frac{3}{16}$ in. holes) steel plate. Between and attached to the discs a suitable framework is fixed to contain the sections. There are many simple methods of retaining the sections when in position. Each section has a door of the same material as that of which the section is constructed, so that each is independent of its neighbour. Around the shaft, and fixed securely



THE ROTARY EXTRACTOR.

to the flanged collars to which the rotor discs are fixed, is a strong screen of $\frac{1}{8}$ in. mesh leaving a space of about 2 in. between itself and the shaft, to prevent any fine material entering the shaft. The shaft, as before stated is hollow, the bore being of ample size to allow of the free flow of the solution. The parts of the shaft enclosed by the flanged collars are perforated by inch holes to allow of the free egress and ingress of solution. At the required position the bore of the shaft is tightly closed to regulate the flow of the solution to wherever it is required. At the inlet for the solution end of the rotor is a small tank to act as a steady head, the top of this tank extending about 18 in. above the top of the rotor casing. At the outlet end of the casing, the pipe for carrying away the effluent is so placed that a constant level of the solution is maintained within the casing, which insures that the rotor will be completely submerged. The bottom of each of the casing compartments is made in the form of a cone, and to this is fixed a valve which connects the cone with a settling tank, whose total capacity is equal to one and a half times that of the casing; this is divided into compartments to correspond with the number of those in the casing. All the solution passes from the casing into the settling tank from both the first and third compartments. The solution passes from the second compartment into the third compartment of the casing along the hollow shaft. The compartments in the settling tanks have a sloping bottom to one point in each, at which point a valve and pipe connection is made communicating with one main pipe which leads to a filter press. To the first compartment of the settling tank a stand pipe of ample capacity is fixed, and stands outside and close to the rotor casing and projects a few inches above it. A pipe from this stand pipe delivers into the second compartment of the rotor casing. A similar stand pipe is supplied to the third compartment of the settling tank, and the outlet pipe from this delivers to the sump, the position of this pipe determining the level of the solution in the rotor casing, as before mentioned. In the case of the first and third compartments of the settling tank a baffle plate is placed between the inlet of the rotor and casing and the exit to the stand pipe. Each compartment is supplied with a manhole door. A screen basket is placed underneath each inlet to the tank to catch any fine zinc that may have passed through the rotor casing. A suitable gearing for rotating the machine is fixed to an extension of the shaft at the exit end of the machine and about 1 h.p. is absorbed in a machine precipitating 250 tons a day.

The operation of the machine is as follows:—The solution enters the steady head, passes into the hollow shaft, and as the bore is blocked at the position corresponding to the end of the first division of the rotor, it passes out through the perforations, coming in contact with the zinc and leaving the rotor peripherally. The solution next passes into the settlement tank, and beneath the baffle plate, rising to the constant level in the stand pipe to the second division. From here it again enters the perforated shaft passing inwards through the zinc, along the shaft, and outwards through the zinc in the third section, again downwards, through the settlement tank (where the speed of the flow is greatly lessened by the size of this receptacle) beneath the baffle plate and up the stand pipe thence to the storage sumps.

By the arrangement of settling tank it will be seen that there is but small chance of slimes being carried over to the other division. The rotor revolves from one to one and a half times per minute, and this is fast enough to allow of a slight motion of the zinc in their sections which is as much as is desired.

All gold slime loosened from the zinc passes to the tank beneath; this can be removed at any time without stopping the machine by closing the valve connecting the rotor casing and the settlement tank, and allowing the solution to overflow the division plate forming the first and second compartments. The contents can then be pumped into a filter press, the solution from this being returned to any rotor desired. By means of the manhole before mentioned the inside of the tank can be washed out, this closed and valve slightly opened until settling tank is full of solution, then the valve opened full.

With reference to zinc consumption, it may be stated that the only zinc taken to acid was that which passed through the rotor in the form of shorts during its operation.

The following is a summary of the results obtained over a period of from November 4, 1908, to May 26, 1909.

Runs were made with strong, weak and slime solutions respectively, the results obtained being as follows:—

	Tons of Solution per cubic foot of zinc per 24 hours.	Value of Solution Entering. dwts.	Value of Solution Leaving. dwts.	Percentage of Extraction. Per cent.
Strong	1·01	2·221	0·053	97·6
Weak	1·84	0·383	0·029	92·3
Slimes	1·53	0·460	0·031	93·2

The above figures represent the mean of assay results over the individual runs.

At the clean-up the solution is shut off, the belt on step cone shifted to faster speed and rotor run on this for a few minutes, then stopped. (We might here mention that the sections on our experimental machine were fixtures, also there was no settlement tank below). The sections on the top side were opened up, the zinc taken out and rinsed though it was found that there was but a small quantity of loose slimes entangled. The zinc was returned and the section filled up with zinc from the second division. We found that finely cut filiform zinc broke up into shorts when using strong solution so that coarsely cut zinc would be preferable.

When coarse zinc or clippings are used, the adhering gold may be removed in an acid bath as it was found in the case of clippings that 94% of the gold was removed in a 5% acid bath in 15 minutes, any deteriorating effect on the clippings being negligible. After the acid bath the zinc is thoroughly washed in clean water, the sections opened and examined, and fresh zinc added where necessary; it is found that the zinc in this form can be used in the rotor for a long time with a minimum consumption of both zinc and acid. To remove the gold from the zinc the sections are placed in a drum which is revolved in the acid bath. We experimented for three weeks in our rotor with clippings and found the precipitation as good as under the conditions of the same space packed with filiform zinc (finely cut), the weight of clippings being 11 lb. to 1 lb. of shavings.

Our experimental machine was somewhat crude, and devoid of perhaps the greatest mechanical essential to its success, *i.e.*, the settling tanks, the solution passing directly from one division to another without separation of precipitated slimes. The advantages of the rotor may be summed up as follows:—(1) Ready access by authorised persons to the gold slimes, without stoppage of precipitation, enabling a daily clean-up to be made if required. (2) With clippings and coarsely cut filiform zinc, absence of breaking down and readiness of removal of adhering gold in an acid bath without consumption of all the zinc, with a consequent saving of zinc and acid. (3) Clean-up quick and cleanly with a consequent advantage of a minimum of loss. (4) Shortness of time rotor is out of action during dressing. (5) No fouling of zinc. (6) While in operation no danger of theft of gold slimes, as all valves would be locked.

Before closing, we must record our thanks to the Management and to the Consulting Metallurgist, Mr. E. H. Johnson, of the East Rand Proprietary Mines, for the interest shown, and encouragement and assistance rendered while conducting our experiments.

The Chairman: I see you appreciate the interest of this paper. There is no doubt there is some scope on the Rand for a process of this sort. On theoretical grounds, any rotary process will expose a larger surface of zinc, but, of course, it remains to be seen whether any particular device is successful commercially. I would like to know whether any gentleman has had any experience of it, and in the meantime I would like to move a hearty vote of thanks to the authors for their interesting paper.

Mr. A. F. Crosse (*Past-President*): I think there is a great deal in this paper. The authors claim several advantages for their method but they have left out one most important advantage, namely, the mechanical driving off of the hydrogen bubbles from the zinc; this removal of hydrogen helps precipitation.

Mr. E. T. Rand (*Member*): In connection with that I may say that the bubbles of hydrogen on the surface of the solution are very evident indeed. There is a very violent action going on continually.

Mr. G. O. Smart (*Member of Council*): I have pleasure in seconding the vote of thanks to Messrs. Lloyd and Rand for their paper. They have certainly shown considerable ingenuity in the invention of their plant. From the reading of their paper, I have not been able to follow the whole process, but it appears to me that the clean-up will be more under the control of the responsible man, and further, the collection of the gold bearing slime ought to be a much cleaner operation, than obtains with our present plants.

NOTES ON CORROSION, WITH SPECIAL REFERENCE TO THE CORROSION OF STEEL WINDING ROPES.

(Read at August Meeting, 1909.)

By M. Thornton Murray, M.Sc.

DISCUSSION.

Prof. J. A. Wilkinson (*Member of Council*): Before the author gives his reply to the criticism on his paper, I should like, with your permission, to make a few remarks. The subject of this paper interests me very much, and I had hoped to have been able to have done some experiments on this subject. Just, however, as the vacation was beginning, and hence my opportunity, a sudden thirst for knowledge on the part of the mine employes has deprived me utterly of the time required, as many of those present will be fully able to realise. The author dealt in his contribution with the effects of corrosion as shown by micro-photographs of some typical specimens. He did not consider the power of resistance to corrosion of new wires, a phase of the subject which, in my opinion, is well worth investigation and can easily be carried out. The methods of attacking this problem is too obvious to require explanation here. Further, the question of the action of lubricants was merely mentioned, and here again I am of the opinion, that there is a wide field for investigation on definite lines. I hope, however, that this is not the last which we shall hear on the subject, and I am sorry to see that the subject has not met with that discussion which its importance to the mining industry warrants.

Mr. Andrew F. Crosse (*Past President*): As Professor Wilkinson has treated this paper in a scientific way may I ask him if the University College staff could not make some experiments on the state of iron or steel wire containing occluded hydrogen. It has probably a very deleterious effect on the tensile strength of the wire. I believe that it has been proved that hydrogen in this state has a specific gravity eight times as high as it should have by calculation. This figure was obtained in using palladium. Perhaps Professor Wilkinson will make some experiments and publish the results.

REPLY TO DISCUSSION.

Mr. M. Thornton Murray (*Member*), in reply, said: I regret that there has been so little discussion on my paper. I had hoped that some of the members would have brought forward the results of their practical experience, for it is only by practical experience of such questions as corrosion that we can really test our theories: laboratory experiments can never quite reproduce working conditions.

With regard to Mr. Crosse's suggestion, I think it is an excellent one. The phenomenon he refers to is not well understood, and I will certainly endeavour to carry out the experiments he mentions, when I have time.

I must thank Prof. Wilkinson for going into further detail. At the same time I have to take exception to one or two of his remarks. I think he has forgotten the title of my paper. Now, I expressly entitled it: "Notes on Corrosion," intending to deal more with the *practical* than the theoretical side of the question. On the other hand, Prof. Wilkinson has justly drawn my attention to the fact that I omitted giving credit to Dr. Whitney. Dr. Whitney has certainly done much good work on the subject, but it was Dr. Cushman who first demonstrated Whitney's theories in so excellent a manner, that his name has eclipsed that of Whitney as pioneer of the electrolytic theory. If Prof. Wilkinson will refer to the *Locomotive Engineer* of (I believe) August, 1908, he will find a summary of a paper which I had the honour of reading before my own University Metallurgical Society, wherein full credit is accorded to Dr. Whitney.

Prof. Wilkinson observes that he would prefer "the CO_2 theory," as a name for the original theory of corrosion. I am surprised that Prof. Wilkinson should make use of such a phrase; it is scarcely academic. "The CO_2 theory" would never be used by chemists; "the carbon dioxide theory" might. Then Prof. Wilkinson has drawn attention to the matter of lubrication, and the effect of the dissociation of oils in promoting corrosion. I think such a phenomenon (if it exists) is scarcely of practical importance, because, after all, we find that lubricants retard corrosion in almost every case, and the case of wire haulage ropes is not so very different from other cases of lubricated surfaces.

I certainly regret that Prof. Wilkinson has not been able, owing to the claims of the "Reef," to carry out the experiments he outlined, so that he might have placed the benefit of his very great chemical knowledge at our disposal.

The Chairman: I think I must congratulate the author on his spirited reply. One point I would like to refer to, is the protective action of alkali on driving wires. I think if Mr. Murray has any spare time he might look into that question a little more fully. Theoretically, I suppose the one which is most alkaline, namely, caustic potash, ought to be the best, but there are obvious difficulties in using it.

Prof. J. A. Wilkinson (*Member of Council*) read the following reply:—

PRECIPITATION FROM CYANIDE SOLUTIONS BY ZINC SHAVINGS AND DUST: A COMPARISON OF RESULTS AND COSTS.

(*Read at January Meeting, 1909.*)

By ALLEN J. CLARK (Associate)

REPLY TO DISCUSSION.

Mr. Allen J. Clark (*Associate*): In replying to the discussion of this paper, I find it necessary to refer also to Mr. Linton's paper in the *Journal* for August, 1909, in which he replies to the discussion of his earlier paper. Indeed, with the exception of this article, there is little to which I can reply, as my paper met many of the points raised by Mr. Pearce.

If I have read Mr. Pearce correctly, and have expressed myself intelligibly, then Mr. Linton has misinterpreted us both in his attempt to compare our results. My statement had reference to but one type of solution, and that (viz., the first and last drainings, or "low solution") of minor value and importance. Mr. Pearce stated that no figures were available for zinc consumption for slime solution—the solution most nearly resembl ing that with which the Homestake experiments were conducted—and gave figures for the whole plant.

I had aimed to confine myself to the discussion of the relative efficiency of zinc shavings and zinc dust upon identical solutions, and sought to avoid any generalisations therefrom, other than as to the Homestake plant, inasmuch as the attempt to compare results achieved at different plants, precipitating, probably by different methods, solutions of widely varying composition, has always seemed to me to be without profit; and while Mr. Linton's later figures only confirm me in this belief, I feel it only fair, in view of his statement, to say, following literally Mr. Pearce's form, that at the Homestake, for the eleven month period ending November 30, 1908, "taking it over the whole plant, it works out, on an average, to ·096 lb. zinc dust per ton treated, irrespective of the grade of the material treated. If expressed in relation to the gold recovered it would be 2·13 lb. zinc dust per ounce recovered," or, if in terms of the gold and silver, it would be 1·55 lb. zinc dust per ounce Au + Ag recovered. This from tailing assaying $1.20 per ton.

With Mr. Linton's review of Mr. Pearce's experiments I am in general accord. To his suggestions as to the factors influencing the results, I would add these: alkalinity of solutions, rate of flow, continuity of flow, and design of press—the latter inasmuch as the Merrill triangular press marks a great forward step in the development of the zinc dust process. I would also suggest that Mr. Pearce might have done better had he reduced the air agitation to a minimum, or even dispensed with it entirely, and given all possible attention to preventing the oxidation of the zinc dust precipitate.

Since reading this article, however, I have made a few brief runs at strengths lower than ·02% KCN, and these have indicated that, though when the average strength is ·02% some few hundred tons of a strength of ·015% or even ·01% may be successfully precipitated, the precipitation of solutions of a lower average strength than ·017% would be difficult, and of an average strength of ·01% well nigh impossible. Our present practice has brought us a long way below Mr. Pearce's minimum strength of ·05%, but it has not brought us all the way necessary to meet his requirements.

The influence upon the zinc consumption of the proportions of gold and silver and of the strength and grade of the solutions to be precipitated, is of course great, whatever form of zinc may be employed. It may be interesting to elaborate Mr. Linton's table, noting that all these results are from zinc dust.

Oz. Au+Ag per ton Solution.	Ratio Au : Ag.	Pounds zinc dust consumed per oz. Au+Ag, Precipitated.	Remarks.
·02	2 : 2	6·60	Homestake 'low solution'
·15	2·2 : 1	·91	,, 'weak solution'
·47	1 : 4	·59	Cerro Prieto.
·49	1 : 4	·57	,,
·70	1 : 4	·42	,,
1·84	1 : 19	·19	Montana, W. J. Sharwood
3·29	1 : 99	·16	An American mill.

As to the cost of refining precipitates the same difficulty of comparison exists; at the Homestake we have never found trouble in acid treating the zinc dust precipitates since we learned the lesson of protecting the precipitate from oxidation. Such plants as have had this difficulty, so far as I am aware, owe it to insufficient attention to this point.

I submit to Mr. Linton that as between the processes the difference in bulk of precipitate can by no means be gauged by comparison of the zinc consumed. Again to elaborate his figures, we have

Plant	Method	Zinc consumption, lbs. per oz Au+Ag, precipitated.
Cerro Prieto	Dust	·4
Liberty Bell	Shavings	·29
Montana	Dust	·18
Homestake	Dust	1·55 (or 2·13 gold only.)
Rand	Shavings	— (1 to 3, gold.)

From these premises, without supplementary data, it would be difficult to arrive at any conclusion; indeed, "that way madness lies."

It may be interesting to note that zinc dust precipitates have carried up to 65% of precious metal, and that the Merrill presses at the Homestake have yielded a product over 42,000 times as rich as the solution from which it was derived.

Mr. Pearce has made clear to us several features of the African practice. I would like to ask him for light upon one more point. He states that the amount of zinc used over "the whole plant" amounts to from 1 to 3 pounds per ounce of gold recovered. Are these the figures for different months at the same plant, or do they represent the extremes found at different plants in the district? And if the former, what causes can lead to such a great variation in the efficiency of the zinc?

The Chairman: We are bound to thank the author for his very interesting paper, and for his still more interesting reply.

CONTRIBUTED.

Mr. S. H. Pearce (*Past-President*): In reply to the above, I have to state that the variation in the zinc consumption here, from 1 to 3 lb. per oz.

recovered, represents extremes on the field, and not month to month results on the same plant. The chief variation in the consumption as expressed in lb. per oz. of gold recovered, is caused by the value of the solution precipitated, *i.e.*, rich solutions will show a low consumption of zinc, and *vice versa*. The consumption of zinc per ton of ore treated will vary according to the amount of solution precipitated, and this again will vary according to the strength of solution employed.

Another factor of some importance is the proportion of zinc removed from the extractor boxes at the clean-up.

As, however, I do not propose to deal with the matter at any length, I might answer Mr. Clark's query briefly as follows :—

1-lb. zinc consumed per oz. of gold recovered represents the best work on rich material, such as 5 dwt. mill pulp and over.

2-lb. consumption represents economic work on 2·5 dwt. mill pulp.

3-lb. consumption will probably cover the average of the least economic work on the same value or lower, and is generally due to a closer clean-up than is necessary to preserve effective precipitation.

It will probably interest Mr. Clark also to hear that we intend to make another attempt to use zinc dust, and that we hope to be able to chronicle more encouraging results than were obtained on the former occasion.

Prof. J. A. Wilkinson (*Member of Council*) read the following reply :—

RESEARCHES UPON THE TELLURIDE GOLD ORES OF CRIPPLE CREEK (COLORADO).

(*Read at May Meeting, 1909.*)

By the Portland Metallurgical Society (edited by Thos. B. Crowe).

REPLY TO DISCUSSION.

Mr. Thos. B. Crowe: In answer to Dr. Moir's criticism upon my article, appearing in your July issue, I am afraid that Dr. Moir has drawn conclusions which are incorrect.

Possibly he is right as to ammonium persulphate not giving off SO_2, however, we are thoroughly acquainted with the fact that our leading authorities differ upon the subject.

As for the liberation of I from KI in an alkaline solution, I ask him to try a simple experiment before making further statements. Make a NaOH solution of one to two-tenths per cent. strength, or about the same strength in alkali as an ordinary working cyanide solution, add a little KI and persulphate and then test for I by any method preferred. (I think that he will find it possible to collect the I with CS_2.) After being satisfied as to the existence of free I, take some of the solution and be satisfied as to its alkaline condition.

We were aware that it was a well-known fact that the halogen salts of cyanide could not resist alkali and it was the following out of this principle (keeping the protective alkalinity at the lowest possible point), that we were able to obtain good results.

As for the replacement of KI by NaCl, the fact that the Na and Cl of NaCl have a stronger affinity for each other than the K and I of KI, makes it impossible to liberate the Cl under the conditions demanded in this solution. Again, if it were possible to liberate Cl from NaCl under these conditions with the same ease as I is liberated from KI, I doubt very much that we would be able to form ClCN, as we have experienced considerable difficulty in making this compound. We have repeatedly tried replacing the KI with KBr as well as with NaCl but with no success.

Prof. J. A. Wilkinson (*Member of Council*) read the following contribution :—

A SKETCH OF THE SMALL CYANIDE PLANT AS ERECTED AND WORKED IN RHODESIA.

(*Read at September Meeting, 1909.*)

By F. J. Thomas (Member).

DISCUSSION.

Mr. R. Murdoch (*Associate*): Having had a few years' experience of Rhodesian cyanide plants, mostly small and of corrugated iron, I venture to supplement Mr. Thomas' paper with a few observations.

For sand plants I have invariably used 24 gauge iron for the sides with 22 gauge iron for the bottoms, on tanks up to 18 ft. diameter and 4 ft. 6 in. sides. Joints must be perfectly true, all other details being as specified by the author. As soon as a tank is in position it is charged and solution pumped on till saturated and full to the brim. After 12 hours' standing leaks are carefully looked for, and if absent, residue sands are allowed to pack round the outside until level with the top. This ensures uniform support, protects the tank and adds to its life. As far as the stability of good corrugated iron tanks go, I might here say that I have run two slimes plants in this country built of that material. Dissolving vats had the usual paddle stirring gear, and were built of 22 gauge iron throughout, the dimensions in one case being 16 ft. diameter by 8 ft. deep.

Small units are obviously the rule on such plants, being readily moved from one place to another, while the shallow depth of sands, and the handling they get tend to an ideal extraction. Even slimy charges from quartz ore (that is, containing 30 to 40% of very fine sand, practically slime), well dug over daily and well drained will give an 85% extraction within four days on a solution ratio of 1 : 1 or 1·5 : 1 put on with a hand pump. I think the average extraction on these plants is high, and I have checked the working of a few run mostly by men whose knowledge of cyaniding was of the poorest. On one occasion I was called upon to locate a constant discrepancy between theoretical and actual extraction, and discovered that the assayer was using grain assay-ton weights for his samples and ½ mgm. riders on a decimal beam for his prills.

Furnaces are certainly primitive, but with a little care can be made quite efficient even in the open air. The method I favour personally is to excavate in a sloping bank, build fire-brick round a suitable dop cask, run a flue out for a few feet and then stick on a good long chimney. When charged with imported coke there is not a better or quicker fire. I once had some petrol smelting furnaces, which were delightfully clean and effective. The cost for petrol was about the same as coke, but we could only renew spares by ordering direct from Los Angelos, and were reluctantly compelled to discontinue their use for that reason. For muffle work in the assay office the same type of furnace cannot be excelled, but it is somewhat noisy.

After the cyanide clean up is over, the small worker very often insists upon doing the regular pot assays in the same furnace for the rest of the month. Charges were weighed, fluxed and put into the pots under the lee of a buck-sail. The furnace was carefully dusted and the fire lighted, then, before the temperature rose, the pots were carefully put in by hand and packed round with coke. Results were repeatedly checked by bank assay and found correct. 30% of the assays were 2·5 A.T., residues going anything up to ·5 dwt., but what was most to the point, on the cyanide assays actual extraction corresponded with theoretical.

Straining zinc slimes on calico frames is still very common, but many ingenious modifications are also to be seen. The favourite is a box with a false bottom, and a suction attached to a hand pump, which removes the liquid percolating through the linen and causes a vacuum. The most effective I ever made was the false bottomed box, as above. The linen was strongly supported on wire screening again supported on a perforated board. Instead of a pump I made a steam ejector out of piping, and on passing steam through, it caused a most effective vacuum, and gave a thin cake of slimes as dry as though it had come from a press. Not only small workers but small mines run by rich companies are often guilty of calcining slimes in the open air. But here again, care counts for a deal. When the tray is filled, sprinkle the slimes with borax and press sheets of filter paper or newspaper well on to the soft mass. As soon as a good heat is obtained a skin is formed and the paper charred. Stirring, of course, is not to be thought of, but if too thick a layer of slimes be not put on the tray the roast is quite effective. Again, in charging pots the stuff is placed straight in on top of the flux with more as a cover. As the author states, I have found that it makes no difference to the product, and is a consideration under the conditions described.

The Rhodesian small worker very seldom has any inducement to put up a slimes plant. It can be safely assumed, that most of these small mines treat free-milling ore. Very often it is rubble and soft surface stuff, which will produce 50% slimes through a 600 screen, yet good amalgamation will leave very small values in either sands or slimes. It may be news to many that 3 dwt. rubble can be made to pay on a 5-stamp proposition, and a glance at the Rhodesian output will show numbers doing well on 4 to 5 dwt. One large mill I know runs its original slimes to waste. The cyanide manager places their value at 2 or 3 gr., but the figures are not guaranteed. I do know of a heap of accumulated tailings assaying from ·6 to ·8 dwt., which has returned a profit of £75 a month consistently. Would any member like to treat the slimes from that ore? When slimes values get to 3 and 4 dwt. or even more they are refractory and need skilled treatment, which the small worker is loth to seek in the proper quarter. When he wants a cyanide plant he calls in the local plumber, and then casts around for a cyanide expert (we are all experts up here!) to run it. To save tanks, he favours collecting in pits and gives you stuff like streaky bacon to leach. On one such plant I tearfully pointed out that with 48% slimes, in the tanks through badly shaped pits and 1 to 3% copper, which might be reduced by blanket strakes my extraction was at least 12% lower than it might be. After much thought on the part of my superior, the final result was my dismissal for losing 12% ! !

Mr. H. A. White (*Member of Council*) read the following contribution :—

A METHOD FOR THE RECOVERY OF ZINC FROM SOLUTIONS OF SULPHATE.

(*Read at September Meeting, 1909.*)

By WM. CULLEN (Past-President) and G. F. AYERS (Associate).

DISCUSSION.

Mr. C. E. Meyer (*Member*): I should like to add my appreciation of the effort made by the authors of the above paper for solving the difficulty, which in my opinion is a question of importance and which before long will require a remedy. As I have been employed on a similar process having the same object in view (namely, the saving of zinc going to waste with present day cyanide practice) I may be able to give the authors some figures and facts to aid them or otherwise in their proposed new venture. I am not wholly of the opinion expressed by Prof. Stanley, that precipitation processes have no scope in this particular branch of the cyanide works, but will prove by figures that the waste proposed to be treated by the authors, is only a small part of the total waste, the greater portion being chemical loss and therefore not recoverable, rather than mechanical loss.

The sources of waste of zinc may be divided into two distinct classes :—A. Chemical loss ; B. Mechanical loss.

A. *Chemical loss.* — This is zinc going in solution to the sumps from precipitation boxes. Also a small portion as double compounds of zinc and cyanide insoluble in a 10% sulphuric acid solution and loss from insufficient washing in the filter press.

B. *Mechanical loss.*—This is caused by a considerable quantity of zinc having to be dissolved in the acid vats to obtain the precious metal before smelting.

For the purpose of dividing these losses I will give you some figures from the October returns from the mines, and I will take four of our largest producing mines for this purpose :

FOR MONTH OF OCTOBER.

	Tons Cyanided.	Stamps No.	Gold from Cyanide.	Duty per Stamp.
Crown Mines	120,466	675	14,983	7·13
E.R.P.M.	157,200	820	23,610	7·07
Randf. South	92,812	400	14,028	8·44
Simmer & Jack	69,000	300	7,096	7 75
Average	109,869	549	14,929	7·58

Average consumption of zinc in lbs. per ton of sands and slimes treated = 0·33 lbs. = 36,256 lbs. of zinc used in one month = 2·428 lbs. of zinc for every oz. of gold precipitated = 66·02 lbs. per stamp per month = £1·03 per stamp per month = 38·848 parts zinc to one of gold obtained.

The total number of stamps running on the Rand during the month of October, 1909, were 9,200. This gives £9,476 sterling as value of zinc used in one month.

Quoting the author's figures of £3,000 recoverable zinc in one month, we get

£3,000 value = Mechanical loss.
£6,476 value = Chemical loss.

The total zinc used = 38·848 to 1 of gold.
which gives us 12·3 approx. = Mechanical loss.
26·242 = Chemical loss.

or less than 1-3rd.

I do not think that this figure of £3,000 was arrived at correctly, as the other base metals such as iron, lead and copper were neglected in this calculation. This would tend further to reduce the recoverable zinc. If this saving of £3,000 were calculated on the basis of tons cyanided, after deductions for treatment, labour, etc., it would be seen that this figure would not be near ¼d. a ton cyanided, and would hardly afford facilities for its treatment with a satisfactory margin of profit. This process would also be subject to its universal adoption by all the crushing mines. With the variations also which occur in individual cyanide works from month to month, which are between 2d. and 3d. per ton cyanided, there seems very little hope of its success, and would hardly warrant the erection of a plant.

The only process which in my opinion is bound to succeed is the one which embodies the recovery of the zinc, decreases the mechanical loss, and if possible recovers the solvent used during the process of cleaning up, and, which is the most important, consequently decreases the loss of gold :—by handling of the rich product, by loss through heavy solutions from filterpress, by calcination. This loss has been quoted at a very high figure in the past, and should therefore be worthy of further investigation. The present-day process for cleaning up not only leaves the zinc in a bad form for recovery, but has so many objections that Messrs. Cullen and Ayers' paper is one to be highly recommended, and it is only by combined efforts and interchanging of views on the subject that a solution is likely to be found.

The Chairman: We thank the author for his contribution, which I am sure will give Messrs. Cullen and Ayers something to think over in their reply.

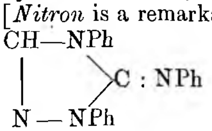
ANALYSES OF GASES FROM BURNING NITRO-GLYCERINE EXPLOSIVES.

(Read at September Meeting, 1909.)

By W. Cullen (Past-President) and D. W. Greig (Associate).

DISCUSSION.

Dr. J. Moir (*Vice-President*): I had intended to discuss this sooner, but find I have no comments to make on their ingenious process of analysis. I just wish to put on record the process I myself used 3½ years ago (this *Journal*, 1906, p. 307), as it has the advantage of greater directness. This method is not mine, being essentially the same as one invented by M. Busch about 6 years ago. The fumes are caught in excess soda and treated (cold) with $KMnO_4$ as long as turned green and acidified. This converts the nitrogen (originally present as a mixture of nitrate and nitrite) entirely into nitrate. The solution (which should be pink) is boiled with a little sodium acetate filtered from MnO_2 if necessary, and precipitated by *nitron* acetate, allowing three hours' cooling. [*Nitron* is a remarkable yellow base:



which gives an insoluble nitrate and is becoming very useful in many technical analyses] and weighing as nitron nitrate $C_{20}H_{17}N_4(NO_3)$. I find there is a discrepancy, however, in our results as regards blasting gelatine, the authors having found about five times as much NO_2 per gram of *gelatine* as I did, although as regards *gelignite* we are in agreement (I found 186 c.c. per gram, they find 202 c.c.). In the former case I consider that if *gelatine* burns vigorously (finely divided) it does not give off so much NO_2 as it does when it burns slowly from a lump, and this point ought to be gone into again: and while they are at it, the authors ought to determine CO_2 and CO in the gases to see if they can confirm my statement, that CO_2 is the chief product from gelatine whereas CO predominates in gelignite fumes.

The Secretary read the following contribution:—

THE BARBERTON GOLDFIELD.

(Read at October Meeting, 1909.)

By A. Richardson, M.I.M.M. (Member of Council).

DISCUSSION.

Mr. E. Browne (*Member*): Alluvial gold was first found on Barrett's in 1881, and considerable quantities were recovered from the various creeks. The Barrett G. M. Co. was formed in 1883, and owns the Barrett's Berlin farm, situated on the plateau between the Kaap and Elands Valley. Crushing started with 6 stamps, and afterwards 30 stamps were erected, but these were discarded in 1894 in favour of the present treatment on account of the excessive amount of slime, which carried most of the values and could not be treated at that time.

The ore, which is a kind of rotten reef, is found in irregular leads and deposits in decomposed diorite over large portions of the farm, and is mined from open workings which vary from a few feet to 100 ft. in depth. The ore is trammed about 4 miles and lowered by self-acting inclines to the mill, which is about 1,000 ft. below the level of the mine, and passed through trommels of ¼ in. mesh, the fines going to the fine ore bin and the coarse to the crusher. The crusher is a Whittaker mill, consisting of a revolving pan with two mullers and a perforated bottom. The grates have holes of ⅛ in. and are replaced when these wear too large. The mill is driven by a Pelton wheel working under a 350 ft. head. From the crusher the ore passes to the fine ore bin and is then trucked to the vats. The vats are 21 in number, and from 30 ft. to 35 ft. in diameter, but only 4 ft. deep, this shallow depth being necessitated by the slimy nature of the ore, amounting to 40% as it comes out of the mine. When a vat is filled, a strong solution of ·15% KCy is run on and the leaching cock opened; percolation is very slow, the solution taking about two days to run through; weak solution and water are run as usual, and finally the vats are sluiced out through bottom discharge doors into the creek. 3,000 tons a month of an average assay value of 2·25 dwt. are treated, the treatment lasting 18 days, and the extraction being 91%. The treatment presents no difficulties although the ore carries a good deal of copper and manganese and sometimes arsenic, cobalt, and nickel; the use of lead acetate has been found to be superfluous and no white precipitate is formed in the boxes. The gold slime is treated with acid and smelted in Salamander crucibles with clay liners, and an analysis of it gives:—

Au	44·44
Ag	0·88
SiO_2	8·88
ZnO	20·30
Cu	11·40
Pb	4·97
Fe_2O_3 (by diff.) ...	9·13
	100·00

The low working costs, about 7s. a ton, which are rendered possible by the simplicity of the mining, and a plentiful supply of water for power and other purposes enable this low grade ore to be worked at a profit. I have to thank Mr. Acutt, the manager, for permission to send these notes.

Mr. W. A. Caldecott (*Past-President*): The reference in the last speaker's remarks to the trommels used at the Barrett G. M. Co. is of interest, inasmuch as these were mentioned in one of our earliest papers.*

The Barrett ore is typical of those suited for dry crushing and direct cyaniding, since it carries very finely divided gold, and is of a porous friable nature, not requiring fine crushing to expose the gold contents. With hard pyritic ore carrying some coarse gold, direct cyaniding is impracticable on account of high operating and maintenance cost when crushing dry to the requisite fineness: such fine product is unleachable under ordinary conditions, and the exposed gold cannot wholly dissolve in a practicable time of treatment.

As illustrating the influence of conditions on working costs, I believe the lowest total mining and milling costs in South Africa, all under 10s. per ton, have been those of the three companies —the Wanderer (Rhodesia), Pigg's Peak (Swaziland), and Barrett (Kaapsche Hoop)—all of which had soft oxidised surface ore, and adopted a similar method of dry crushing and direct cyaniding to that described.

THE ASSAY OF CYANIDE SOLUTIONS AND SLIME RESIDUE CARRYING DISSOLVED GOLD.

(*Read at October Meeting, 1909.*)

By A. Whitby (Member of Council).

DISCUSSION.

Dr. J. Moir (*Vice-President*): I have made some experiments to clear up the theory of Mr. Whitby's process. I made solutions of $KCuCy_2$ and $KAuCy_2$ and mixed them and, of course nothing happened; on acidifying a mixture of CuCN and $CuAuCy_2$ (cuprous aurocyanide) was precipitated and the filtrate from this was entirely free from gold when tested by evaporation with aqua regia and adding $SnCl_2$. On the other hand, when $KAuCy_4$ was used instead of $KAuCy_2$, although the result was the same to the naked eye, I found unprecipitated gold in the filtrate, the reason being presumably that $CuAuCy_4$ (cuprous auricyanide) is not totally insoluble in water. What happens in Mr. Whitby's process is this: when $CuSO_4$ is added to cyanide solution we get potassium cuprous cyanide and free cyanogen — $CuSO_4 + 3KCy = KCuCy_2 + K_2SO_4 + CN$. In presence of acid, we get CuCN precipitated because the acid $HCuCy_2$ (contrary to $HAuCy_2$) is extremely unstable. If we add sulphite, the free cyanogen is removed, and consequently the second reaction can take place unimpeded: $KCuCy_2 + KAuCy_2 + H_2SO_4 = CuAuCy_2 + K_2SO_4 + 2HCN$. But if sulphite is omitted, the cyanogen converts some or all of the gold into $KAuCy_4$ and we get imperfect precipitation, as I have shown above, and as Virgoe found long ago in practice.

* See this *Journal*, Vol. i., August 21, 1894, p. 23.

EXPERIMENTS ON THE ASSAY OF ACID WASHES RESULTING FROM THE CYANIDE "CLEAN UP" BY THE USE OF BISULPHATE.

(*Read at October Meeting, 1909.*)

By L. J. Wilmoth (Member).

DISCUSSION.

Dr. J. Moir (*Vice-President*): I had long suspected that acid washes contain not only suspended Au but also Au present as $HAuCy_2$. I have made the latter and find it surprisingly stable. Its dilute solution can be boiled for some time before it decomposes into AuCN (yellow) and HCN. It was prepared as follows:
(1) $Ba(OH)_2 + H_2S + 2AgCN \rightarrow BaCy_2 + Ag_2S$ etc
(2) $2BaCy_2 + 2Au + O = Ba(AuCy_2)_2 + BaO.$
(3) $Ba(AuCy_2)_2 + H_2SO_4 = BaSO_4 + 2HAuCy_2.$
This fact is very interesting, seeing that both $HAgCy_2$ and $HCuCy_2$ decompose as soon as made.

SOME EXPERIMENTS ON SMELTING TITANIFEROUS IRON ORE.

Part I.—Crucible Experiments.

(*Read at November Meeting, 1909.*)

By Prof. G. H. Stanley (Member of Council).

DISCUSSION.

Mr. A. F. Crosse (*Past-President*): On looking up my old notes on the analyses of titaniferous iron ore we received at Messrs. Johnson, Matthey & Co's., in London many years ago, I find that the ore was more impure than the titaniferous ore we have in this country. The Norwegian ore contained 1·56% of pyrites, which in addition to the titanic acid was certainly a great objection.

The Chairman: *Were these ores successfully worked?*

Mr. A. F. Crosse: I cannot say what was done with it. It merely passed through our hands for sampling and analysis.

Mr. A. Adair (*Member*): Prof. Stanley's paper has interested me very much as a former ironworks' chemist, and again as having myself experimented with titanium ores. As Prof. Stanley is working for a definite practical purpose, it is a pleasure to think one may be able to support him in a task that is not an easy one. The real trouble with titanium ores, is white iron, loss in the slag, and the tendency to form *bears* and *scaffolds*.

In the following remarks and suggestions, one has always to remember, that however careful one may be to provide against contingencies, one can never trust a blast furnace to understand what is required of it, when dealing with new ores. The results are sure to be surprising in some way, and seldom agreeably so. In changing twyers we often get little glimpses of what is going on inside, and many curious samples. I often noticed lumps of ore originally hæmatite or other varieties which accidentally got to the twyers without melting, or even being touched by slag. The porous ores were invariably saturated with carbon, ilmenite would come through apparently unchanged. On testing the former with weak acid, the strong odour of carburetted hydrogen was very marked, with ilmenite scarcely at all. When a scaffold was forming, pieces of it were procurable also from the twyer house—peculiarly sticky lumps (when hot) of slag and semi-fused wrought iron. The *bears* were masses of iron as tough as, and similar to, wrought iron, with abundance of "kish" and some pieces of fire-brick from the lining, also cyano-nitride of titanium, mostly adhering to the metal. Soft hæmatite would (other things being equal) always give a good grey iron with rough fracture and high content of graphite. Compact and dense ore would give an iron with finer fracture and less graphite, whilst ilmenite mixed with the ore would always give white iron and (incidentally) trouble.

From these and other observations, I venture to suggest that the physical character of the ore, viz., its porosity or the lack of it, is the principal factor to take account of in dealing with iron ores. I suggest also that titanium is a hindrance, only so far as it may prevent thorough carbonising of the ore. Further, one may presume that it is the lack of sufficient carbon in this way, which is responsible for the production of wrought iron, instead of the easily fusible carbon compound, and therefore of scaffolds, bears, white iron, and losses in the slag. I judge that with a porous ore, and sufficient time in the reduction zone of the furnace, satisfactory results would be obtainable. Such results might be realisable in practice, by using a slow fusing flux, say a ferruginous clay (for its alumina) and dolomite, to get 50% of lime and magnesia in the slag.

If we take grey iron as the index of success in treating titanium ores, then Prof. Stanley would seem to have achieved success, or near to it, in his experiments 4 to 7, especially in the last case. With 45% of lime or its equivalent, the slag would not be so fusible therefore, a longer time available for carbonisation would be given before melting.

The experiments with the silicious slag are also of great interest as it seems as if the author might be successful in this direction. I would however suggest that a silicious slag would require a special lining, approaching Dinas brick or ganister. The Vereeniging fire-clay with admixture of quartz would perhaps meet the case.

I shall look forward to Prof. Stanley's next contribution, and most heartily wish that his efforts may be rewarded with an unqualified success.

The Chairman in closing the proceedings wished the members a Merry Christmas and a good New Year.

Contributions and Correspondence.

STOPE MEASUREMENTS.

Thanks are due and have been expressed to Mr. Tonnesen for his paper on Stope Measurements, and his detailed description of his Stereometer and its working.

I would add my appreciation, and hope that his instrument may be the means of increasing the efficiency and easing the work of the mine surveyor, as I quite agree with his statement that stope measuring is a cause of "hardship and sometimes of danger" to the mine surveyor, though I am not in accord with the natural inference, that in his work there is an excess of hardship or of danger over that undergone by others whose work lies underground.

I must, however, endorse Mr. Johnson's remark, that, given competent and painstaking men, accurate work can be done, and undoubtedly is done with the present methods. In this connection I would instance a case in which a miner disputed his measurements. Two Government surveyors, both accustomed to mine work, were called on to check the mine surveyor's work, one by the miner, and the other by the mine authorities. They checked the areas mined from the two stopes in dispute, both working by tape triangulation, the mine surveyor having worked with a transit theodolite. The dip of one stope was 30°, with an area about 200 fathoms, of the other the dip was 42°, with area between 600 and 700 fathoms. The agreement between these two checks and the areas totalled from the duplicate cost sheets in the mine office, was between 1% and 2%.

In his objections to theodolite stope measurement the author mentions the difficulty of setting up under the peg in a steep stope. I have found that two 18 in. holes, in suitable positions, drilled and blasted in the footwall, under the peg, gave all the required convenience for setting up and standing room, and, of course, served as long as that peg was in use.

As to the office work, the preliminary reductions of inclined to horizontal distances is obviated by plotting with Bristol's protractor, one of which I had the benefit of using for some time. The stage in the office work described by the author and Mr. Coaton as the chief objections to this method—that of converting "horizontal fathomage to inclined fathomage" depends, of course, on the correctness of the observations for dip and change of dip.

I endorse Mr. Coaton's descriptions of the best method of doing this, and would only add that, in observing the strike line, the candle at the face must be held at approximately the same distance from the same hanging or footwall as is the telescope of the theodolite.

With most of the author's objections to the Tape Triangulation method I am in agreement. The tape sag error can be largely obviated by using more lines, and those approximately dip lines, from which to offset; but the angular error of offsets, which is largely a personal error, and partly due to difficulty in climbing about steep stopes, is a strong objection to the method.

B. Travers Solly.

Germiston,
18th December, 1909.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

The Testing of Galvanized and Other Zinc-Coated Metals.—"Three methods are now commercially used to coat iron with zinc. The oldest and for many years the only commercial method is the '*hot-galvanizing*' process, in which the iron article is simply dipped into a bath of molten zinc. The second is the '*wet*' or '*cold-galvanizing*' process, in which zinc is plated on the iron article by electrolysis from a solution of a suitable zinc salt. The third is the '*sherardizing*' process of Sherard Cowper-Coles, in which the iron article is heated in a closed chamber in the presence of finely divided metallic zinc and zinc oxide. (See our Vol. VI., page 189.)

Preece Test.—Although there is a marked difference in appearance and in structure between these three kinds of zinc-coated iron, only one method of testing them has been used, namely, the 'Preece' or copper-sulphate immersion test.

As standardized by the American Telegraph and Telephone Company this test is essentially as follows: A standard solution of copper sulphate is prepared by agitating a nearly saturated solution of this salt with copper oxide until it is perfectly neutral. It is then diluted to 1·186 sp. gr. at 65° Fahr. When a rod of zinc and one of iron are placed in this solution the metals pass into solution as soluble sulphates, an equivalent weight of copper being at the same time deposited on the metallic rods. The copper deposited on the zinc surface is black, spongy and easily removed, while on the iron it is dense and of a bright color.

When this reaction is used in testing galvanized iron it is assumed that the speed of solution of the zinc is a direct function of the time of immersion, and by the number of one-minute immersions necessary to dissolve the zinc from the iron and to deposit a film of bright copper thereon, the thickness of the zinc can be estimated. It will be seen that this method measures the thickness of the coating only at its thinnest point, and that the assumption is made that no bright copper will be formed until the iron base is reached. To appreciate the limitations of this test, it is but necessary to note the structure of the three classes of zinc-coated iron.

A polished oblique section of ordinary hot-galvanized iron etched with iodine reveals three distinct layers. First, a coating of zinc, which varies in thickness in accordance with the temperature of the zinc and the amount of squeezing or wiping applied to the article before the zinc solidifies; second, a distinct layer of a zinc-iron alloy, termed alloy B, which varies in thickness with the temperature of the zinc bath and the length of time the iron was subjected to it; third, the iron base itself. Between the zinc and alloy B there is generally a second alloy, alloy A, which is a thin, discontinuous layer, richer in zinc than alloy B, and between the iron and alloy B is a third alloy, relatively unimportant, which is very rich in iron, alloy C.

The structure of wet-galvanized iron is comparatively simple, the layer being practically pure zinc.

Sherardized iron, on the other hand, presents a relatively complex structure. The metallic zinc penetrates the iron, forming deep layers of the alloys B and C, and in place of alloy A there occurs a number of compounds, as yet unidentified. Upon the surface there is generally a layer of relatively pure zinc, although frequently the process is carried to the point where only a deep layer of alloys is formed. When examined under the microscope this alloy is seen to be covered with deep cracks or fissures as though the alloy in forming had contracted. It is thus apparent that in testing galvanized iron made by these different processes we are dealing with three very different materials.

Desiderata for a New Test for Determining Durability or Resistance to Corrosion.—It is the purpose of this paper to treat of zinc-coated iron with regard only to its durability or resistance to corrosion, and not to its tensile strength. From this standpoint a test should, if possible, indicate the following:

(1) The uniformity and thickness of the zinc coating; (2) the continuity of the coating with reference to pin holes; (3) the purity of the zinc, and (4) the toughness and ductility of the coating.

The corrosion of pure zinc in water is very slow. If, however, the zinc is in electrical contact with any material upon which the hydrogen can be liberated, the corrosion of the zinc is relatively rapid. The iron-zinc alloy *B*, and iron itself, are both surfaces on which the depolarization action can take place, and hence, so long as neither the iron nor the alloy is exposed, other things being equal, the zinc coating will not corrode. The importance, therefore, of maintaining a uniform coating of metallic zinc upon the iron can be appreciated.

To determine whether the ratio of the time of immersion required to produce a bright copper surface was in reality a measure of the thickness of the zinc coating, samples of galvanized sheets were obtained and tested. The weight of zinc per square inch area was determined by dissolving the zinc from the sheets without attacking the iron-zinc alloy. This can readily be accomplished by heating the galvanized sample, together with a piece of metallic iron, in boiling caustic soda until the generation of the hydrogen ceases. As might be expected, the ratio between the time of immersion required to show the presence of bright adherent copper and the amount of zinc present per unit area depends upon the uniformity with which the coating of zinc is spread upon the iron base. In the case of 14 pieces of galvanized sheet iron, for example, the average ratio found was 23, while the greatest variation in either direction was but 20. This test, therefore, so far as indicating the uniformity of the coating and measuring the thickness of the zinc are concerned, is fairly satisfactory; but alloy B is always indicated as iron, and hence, when the test is applied to sherardized articles, very erroneous and misleading results may be obtained.

The presence of the channels or pin holes caused by the free iron surface coming in contact with the zinc and causing it to pass into solution cannot be detected by the copper-sulphate method, as these pin holes down through the zinc to the iron fill up with black, spongy copper and cover up the bright copper spot at the bottom.

The purity of the zinc cannot be determined, as the bright copper particles precipitated by this method are so small that they are lost in the mass of black, spongy copper.

Finally, the fourth factor, the toughness or the ductility of the coating, cannot be determined, due to the same tendency of the spongy copper to cover up the bright copper deposits, which indicate cracks extending down through the zinc coating to the alloy or iron underneath.

Test for Detecting Pin Holes and Cracks.—The relation between the presence of pin holes in the zinc surface and cracks due to a brittle coating and the durability of the structure as a whole has not heretofore been studied, largely because no method of detecting these imperfections has been available. The following phenomenon serves as a basis for such a test. If a piece of zinc be placed in a strong solution of caustic soda heated to about 100° C. no action is noticeable. If now the zinc be touched with a piece of iron, hydrogen is liberated in great volume from the iron. Small cracks in the zinc coating may be easily detected in the same way.

Ordinary hot-galvanised ware is generally very free from imperfections of this kind, while wet-galvanized ware, on the other hand, is frequently very porous, generating hydrogen at numberless small points over its entire surface. Theoretically, the best electroplated surface should be that carrying the greatest weight of zinc per unit area, deposited at the slowest rate. That is, the lower the current density at the cathode in plating the less porous will be the deposited metal, and the thicker this dense deposit is the better protection will it be. A great many tests on electroplated zinc-coated iron were made, the samples varying in both these particulars. In every case, those deposited most rapidly were the most porous, and the results showed that the time of plating was more important than the weight of zinc per unit area; although there was a minimum below which it was not safe to go.

Tests for Determining the Combined Effect of Imperfections.—As the rapidity of hydrogen generation from zinc is a function of the presence of an alloy of zinc and iron, hence the more impure the zinc coating, the more impure will be its solution in acid. Accordingly, the impurity of the zinc, the presence of pin holes and cracks, and the thinness of coating are all factors which act in an accumulative way to increase the rate at which hydrogen is generated when the zinc surface is exposed to acid. This method has been developed by Mr. Charles L. Campbell in his thesis for the B.S. degree at the Massachusetts Institute of Technology, and found to give very concordant results. The apparatus employed may take any convenient form, it being but necessary to expose a known area of the zinc coating to a standard acid solution under uniform conditions and to measure the hydrogen generated per minute. In almost every case a sharp maximum is reached giving the resultant of all the different factors which make for rapid dissolution of the zinc. Thus, in a series of wet-galvanized sheets, those electroplated for 15 minutes reached a maximum of 7 cub. cm. in three minutes; those plated for 30 minutes a maximum of 14 cub. cm. in 10 minutes, while those plated for 45 minutes showed a rather poor maximum of 6 cub. cm. in 30 minutes. In many samples of sherardized product there were two maxima on the curve showing the amount of hydrogen generated per minute. This indicates that there is first an action between the outside zinc coating and the iron-zinc alloy, and later a well defined action between the alloy and the iron.

Service tests with galvanized iron are of necessity very slow at best, and the relation of the above phenomenon to the real durability of the material can be determined only after a number of years. Something can, however, be learned by the study of ware which has already been exposed for sufficient time to determine its durability, Most of the material available for the purpose was in the form of fence wire; from a study of these the following conclusions are drawn:

First, thickness of coating,—In every instance where a very durable fence was found, the coating of zinc proved to be relatively very thick. On the other hand, the wire fences which showed marked corrosion in from one to two years proved to have almost no zinc on the iron, the zinc color being due to a layer of alloy alone. It is doubtless true that the purity of the iron used in the wire itself plays an important part in determining the ultimate durability of a fence, yet in the opinion of the writer the thickness of the zinc coating calls for more immediate attention. The modern method of close mechanical wiping the wire as it emerges from the zinc-bath produces too often a wire covered not with zinc but only a thin layer of electro-negative iron-zinc alloy, which affords but little protection to the iron. To produce a wire with a liberal coating of zinc would, of course, cost more both on account of the extra zinc and on account of a somewhat smaller production per machine.

Second, purity of zinc,—It is probably a necessary consequence of hot galvanizing that the zinc becomes somewhat contaminated with dissolved iron. It is apparent that this should be kept at a minimum in order that the coating should be of maximum durability.

Third, flexibility of the zinc coating,—The important objection to placing a thick coating of zinc upon wire used for fencing is that such a coating cracks off when running through the machine. This objection applies only to those wires which are subjected to very sharp bends or turns. It is possible that by passing the zinc-coated wire through dies or under grooved rolls that the crystalline condition of the zinc could be destroyed and the flexibility and ductility materially increased.

To sum up the results of this paper:

1. The copper sulphate immersion test is of value in determining the uniformity of coating and relatively the thickness of coating in hot and in wet-galvanizing products; but it is worthless in the case of sherardized products, and gives no idea of other important factors involved in the durability of the structure.

2. By immersing a galvanized product in hot, strong caustic soda, the presence of any unprotected iron may easily be detected, however small such area may be.

3. The weight of zinc per unit area apart from the zinc-iron alloy may be analytically determined by dissolving the zinc from the plate through treatment with hot caustic soda, while in contact with metallic iron.

4. Theoretically, the rate at which hydrogen is evolved when the galvanized product is immersed in dilute acid should indicate its relative durability; inferior products should reach a maximum in a few minutes compared with a much longer time for better products.

5. In the very important matter of fencing wire, while the purity of the iron used is of consequence, a more immediate necessity is a heavier coating of zinc on the wire.

The flexibility of a zinc-coated wire may possibly be increased by mechanically working the wire in rolls or dies to destroy crystallization in the zinc coating.'—Dr. W. H. Walker.—*Electrochemical and Metallurgical Industry*, Oct., 1909, p. 440. (H.A.W.)

METALLURGY.

The Development of Heavy Gravitation Stamps.*—"Mr. W. Fischer Wilkinson introduced the paper by summarising its salient points.

Mr. S. J. Truscott said that in a previous paper, read in October, 1904,† Mr. Caldecott had enlarged upon the necessity and advantage of finer crushing. The paper that evening might be taken in continuity of that idea, especially as the author had expressed a desire in his former paper that it, being more or less general in treatment, should be followed by others giving details of actual achievements.

The author stated at the commencement of the present paper that the history of ore crushing, by means of gravitation stamps, showed a progressive increase in their weight and in their corresponding efficiency. In that advance South Africa must be taken to have maintained a very forward place. Although to those in this country the Rand appeared as a whole, it was nevertheless the fact that the mines there were distributed in well-marked groups, of which the Consolidated Goldfields was one, and it had to be stated that the credit for that advance in the direction of greatly increased weight of stamp was at the outset largely due to the engineering staff of the Consolidated Goldfields, of whom Mr. Caldecott was one.

Before making that step of moving forward to greatly increased weight, a series of trials was carried out at the Knights Deep battery, and they, as engineers, must acknowledge that trials made under such conditions must have their great regard. A portion of the battery was set apart, and a special staff was deputed to carry out the trials, and everything was arranged with the highest intelligence, so that the results were in every way trustworthy.

The first lines taken in those experiments were to try the effect of a double discharge as against a single discharge, and the effect of a preliminary very fine crushing. The results obtained were tabulated on p. 3, from which it was seen that with the same weight of stamp, the same drop, and the same number of drops per minute, under those conditions there was no advantage in either departure from the ordinary practice. Apparently there were other trials made which were not detailed, but it was stated that after those experiments it became obvious that, in order to crush more rock, a simple increase of stamp weight was the best course.

It appeared to him that that was a change of direction, that the experiments so far were after greater efficiency; in fact, on p. 2 it was stated distinctly that the object of the trials was to discover some means whereby stamp milling efficiency could be increased. But it appeared to him that the idea of crushing more rock was a departure from seeking after efficiency, and it seemed to be greater capacity which was now the object.

They must regard greater efficiency as consisting in the attainment of more work for the same consumption of power, but greater capacity arose from obtaining more work with a correspondingly greater amount of power consumed.

Then a series of tests was made to show the effect of increasing the weight. The results of those tests were, as was naturally to be expected, that with the heavier stamps there was more ore crushed. But the efficiency must be expressed in terms of the power consumed. It was only reasonable to consider that there would be extra power consumed in almost exact proportion to the extra weight lifted. Therefore they would expect that the extra amount crushed would be also proportional to the extra weight lifted.

To the statement on p. 5 he would add a new column, and set it parallel with that in which the duty was expressed. In that column he had put the figures which should be obtained if the extra amount crushed was proportional to the extra weight. It would be obvious that the first figure (5·88) remained the same.

Tons of Ore Crushed per Stamp per 24 Working Hours.

Actual.	Calculated.
5 88	5·88
6·58	6·20
6·74	7·53

Going to the second series of experiments, the 4 26 remained the same.

Tons of Ore Crushed per Stamp per 24 Working Hours.

Actual.	Calculated.
4·26	4·26
4·29	4·51
4·55	4·53
4·96	4·68
5·17	5·47
6·02	5·62

* See this *Journal*, vol. x., Sept., 1909, pp. 108-115.
† *Trans. Inst. M.M.* xiv, pp. 48—59.

The figures given were the results of the extra crushing which one would naturally expect by the increase of weight. There was no increase of efficiency; they were simply the results which one would expect by the increase of power consumed. It would be noticed that those figures were somewhat variable. Sometimes the calculated one was higher and sometimes lower than the actual one obtained.

In order to eradicate those variations the average was taken. Of the first series of experiments, the average of the actual tons crushed was 6·66; the average of the theoretical was 6·86. That was, in that case, they would have expected 6·86 to have been crushed, whereas 6·66 only was obtained. In the one below, the average came out for the actual duty 5·00, and what they would have expected was 4·96. That was slightly less. It would be seen that there was no increase of efficiency. There was an increase of capacity without increase of efficiency.

It was also to be remembered that there were other varying factors connected with it. Especially in the lower series, the amount of water had been increased considerably along the line. He thought it must be accepted that the flow of water through the box had influence upon the duty, upon the efficiency. The author agreed with that, because on p. 15 he said that the ratio of water fed had influence upon the tonnage crushed.

It might also be seen from this statement that where the amount of water used had been more, the actual figure crushed was greater than the theoretical calculated: and the reverse was also the case. That held through the whole series, and was exemplified in the last two cases on the page.

In the last figure but one 5·05 tons of water were used per ton of ore; that was the lowest of the whole series, and in that case the actual crushing was at its lowest when compared with the theoretical crushing. Taking the very last figure, where 6·30 tons of water were used, that was the very highest, and the actual crushing was at its highest as compared with the theoretical crushing.

It might be taken also that the increase of water was hardly measured in tons of water per ton of ore crushed; it was rather in the tons of water going through the box. Taking it in that way, there were 23 tons of water going through with the lightest stamp and 38 with the heaviest; that was an increase of more than 50%.

It had also to be mentioned, as bearing upon the work done, that if one referred to the last column in the statement on p. 5, where the amount per cent. +60 was given, it was seen that in the case of the last figure, where 6.02 tons of ore were crushed, the amount per cent. remaining of the +60 was 11·66, whereas with the lighter stamp with which everything had been compared it was 5·16. That was, in the case where the actual duty was comparatively high, it had to be discounted by the fact that it contained a good deal of stuff, more than usual, above the +60 mesh. He thought from that statement they could not say there had been any increase of efficiency; in fact, if there was a difference, there had been a decrease in efficiency. There had been an increase in capacity.

There was another point, connected with the preliminary fine crushing. He thought it was certainly the case, and conceded, that the long-established practice on the Rand was an approach towards efficiency, and that any departure from that practice must be also regarded as a departure from efficiency. So that, when they saw, as in column B, on p. 3, that ore of such fine stuff as was passed through rolls, set to half an inch, was crushed under stamps of more than usual weight, they must say that there was such a departure from general practice as must necessarily be accompanied by a departure from efficiency.

From that point of view he thought the experiment under column B could hardly be said to represent a fair case. He thought it more reasonable to assume that if in crushing that fine stuff a lighter stamp had been used the same duty might have been obtained, and a correspondingly greater efficiency.

It seemed to him also that that was a line to which more consideration might be given, that the ore as it left the crushers, where it was crushed say to 2 in., contained a good deal of stuff which was very small, and a good deal which was fairly big. If efficiency was sought, it might be along the line which took the coarser stuff to the heavier stamps, and the finer to the lighter stamps.

There were many mines upon the Rand now which had started with light stamps and which had recently added, or were adding, heavy stamps, so that there they had already a differentiation between heavy and light stamps.

It must not be gathered from those remarks that he disputed in any way the great advantages of the heavy stamps. He was as much in favour of the heavy stamps as most of those present. The advantages were greatly economical. If one could get 100 stamps to do the work previously done by 200 stamps, one had economy in all directions—of shafting, of administration, of supervision—and that economy was so large that naturally heavy stamps would probably be extended.

They had probably heard that the most recent achievement on the Rand was the case of the stamps of the West Rand Consolidated, where a trial run was made recently, and a duty of 15 tons was obtained, producing stuff for the tube-mill to work upon. He even thought that the latest report was that a duty of 17 tons was obtained. Those stamps weighed 1,890 lb.

In the City Deep there were now stamps of 2,000 lb. Their mill duty was guaranteed at 11 tons, with a probable ultimate amount of 20 tons, though that was not guaranteed. It seemed to him that the limit of heavy stamps had not been reached. Possibly it would be determined by whether the cam shafts and cams remained satisfactory.

He thought that stamps would become heavier until at last the cams and cam shafts were thrown out, and some other lifting device was obtained, or a heavier blow achieved in some other direction.

That statement, favourable to heavy stamps, would seem to be somewhat in contradiction of the fact that it was generally recognised that for the ordinary run of stuff going to the battery there was a blow which was most effective; but it was not so contradictory as it might appear, because, although the statement was true, it was dependent upon the condition that the diameter of the shoe and die was fixed. This had practically been the case; the diameter of the shoe and die was many years ago about 9 in., and he believed in the case of the City Deep the diameter was 9½ in., which represented about the same thing.

It seemed to him that now they were erecting heavy stamps, some trials should be made in the direction of increasing the diameter of the shoe and die, in which direction he thought some greater efficiency lay. If one increased the stamp without increasing the die, one got a needlessly strong blow, because it was an admitted fact, he thought, that there was a lighter blow which was equally effective.

It was interesting and opportune to say that in the case of the Dolcoath Mine, where pneumatic stamps were employed, they were used at first with an ordinary-sized die and were not satisfactory; the die was then increased to 12 in. diameter, and the stamps were now quite satisfactory.

Mr. H. S. Denny said that so much had been heard of the increased efficiency attaching to the corresponding increase in weight of the gravity stamp in the past few years, and so many of the data had emanated from the mines with which Mr. Caldecott was associated, that it was fitting he should come forward with a pronouncement on the subject before the Institution.

It might surely be taken as axiomatic that there was a critical point in the weight of a stamp which would satisfy all the contingent factors of capital outlay, operating cost, horse power consumed, crushing efficiency, maintenance, and repairs, short of which point or beyond which point there would be losses in economy.

Mr. Caldecott in his notes undertook to show, not that he had established this critical point, but that the increases in weight already carried out had resulted in very appreciable improvements in economy.

Whilst he, the speaker, did not for a moment dispute this statement, he must say that a close scrutiny of Mr. Caldecott's paper did not appear to provide the data essential to the proper substantiation of his contentions. They were told that with 1,605 lb. stamps 6·02 tons of ore were crushed per twenty-four hours, yielding a pulp product of which 11·66% remained on a 60-mesh screen. This was in itself a very extraordinary performance, but they were given to understand that the operating cost per ton crushed was less than that obtaining with lighter stamps, although in his summary of the advantages of heavy stamps Mr. Caldecott did not specifically make this plain. One could take it, however, that as the whole question was purely one of ultimate economy, Mr. Caldecott meant them to understand emphatically that the results obtained from the 1,605 lb. stamps did show a great economic improvement over the 1,250 lb. stamps.

The mere facts that there was a reduction in the size of the mill building and that 30% less shafting and other moving parts were needed and that less labour was required, did not in themselves constitute a final and convincing case for the heavy stamp. There were a great many other things that formed important counters in such a computation and from his point of view he would like to see Mr. Caldecott's statement supported by supplementary figures in which the following points would be dealt with.

1. Comparative statements of capital cost of a 1,250-lb. stamp battery as compared with a 1,600-lb. stamp battery of equal capacity, complete. The number of gravity stamps in the respective batteries would remain the same, whilst the cost of fine crushers for the lighter stamps would of necessity come into this statement.

2. A power curve illustrating the fluctuating efficiency of the respective batteries on varying numbers of stamps running, together with a statement of the actual consumption of power per ton of ore crushed and a grading analysis of the pulp produced.

3. Data as to the comparative time and labour involved in carrying out repairs to either battery, taking into consideration the heavier units of the bigger mill.

4. A statement showing the comparative effect of loss of time in hanging up a battery of the heavy stamps as compared with lighter ones.

5. A general statement showing that the advantage still lay with the heavier stamps, taking the lives of respective batteries into consideration and taking into account the initial capital outlay with redemption and interest charges properly apportioned, and figuring on the respective capacities of the two mills on equal products, and finally calculating in all those other factors of time and labour interwoven in the question.

It must not be forgotten that the framing and foundation and driving gear and component moving parts must all be correspondingly heavier and more expensive, and renewal units more unwieldy, and whilst one could readily grant that these points were of minor importance they must not be entirely overlooked.

Two points of the greatest importance that had always been a subject of discussion, and which were fraught with the greatest bearing on the capacity of the gravity stamp, were the size of the ore being fed into the mill and the coarseness of the screens used for the discharge. If the stamp mill were asked to do the work of either the stone breaker or the grinding machine, that work would be done at an economic disadvantage, as there were other machines in which these two operations could be much more efficiently carried out.

Mr. Caldecott said "fine breaking before milling on heavy stamps does little good," and he (the speaker) must confess that the figures in column B of the first table rather surprised him. Of course it was clear that with the heavier stamp it would not be economical to resort to so fine a preliminary crushing as that found most profitable with the 1,050 lb. stamp, but he was not prepared to find that all the advantage disappeared when the weight of the stamp was increased to 1,342 lb. According to Mr. Caldecott's figures, the duty per stamp per twenty-four hours with equal weights of stamps was higher in the case where 54·3% of the material remained on a 1⅜ in. screen than in the case where only 1·1% of the material remained on the same screen. This result seemed most extraordinary, and in order to show how remarkable it was he herewith appended some results obtained from a Rand mill by virtue of the interpolation of a fine-grinding plant between the coarse crushers and the battery.

The primary object of the installation of the fine-crushing plant on this mine was to permit of the mill being overhauled, 20 stamps at a time, without interfering seriously with the output per month. Two small jaw-crushers, electrically driven and designed to reduce the ore from 2½ in. to 1½ in., were installed. It became quite evident, after the first few days' work, that the introduction of this plant would have the desired effect. The plates and launders banked up with the additional material, and it was found necessary to make considerable alterations to the mill water service before the increased quantity of ore crushed in the mill could be properly handled. Without the fine breakers the mill duty on 400-mesh screens averaged under 5 tons per stamp per day. After the installation of the fine breakers the duty increased to 5·6 tons per stamp per day, equivalent to a 12% increase. The figures were calculated very carefully and might be taken as accurate. The average cost of milling under ordinary conditions over a period amounted to 2s. 11·657d. With the fine breaker plant the average was 2s. 11·177d., being a reduction of 0·48d.

per ton milled. The objects of the installation of the plant were achieved most successfully, and the whole mill was rehabilitated without prejudice to the monthly returns.

These figures were all carefully compiled and the results were so satisfactory as to leave no room for doubt regarding the efficacy of fine crushing when used in conjunction with light stamps. It might be argued, however, that the ore was in any case being fed in too coarse a condition to the mill, and he thought that when Mr. Caldecott said "hence the heavier the stamp the coarser the preliminary breaking admissible, and *vice versa*," he had hit on the real truth. *Vice versa* would then read: *the lighter the stamps the finer the preliminary breaking admissible.*

To follow this statement to its logical deduction, one found then that as Mr. Caldecott believed in the use of fine crushers with a light stamp, he must further believe that the use of the heavy stamp would do the same work that the crushers were designed to do for the lighter stamp, more economicolly. It appeared to the speaker that a great deal of the problem lay in this point, and personally he had the feeling that the limitation of the weight of the stamp would be met at the line of demarcation between the crusher and the stamp mill principles. It was difficult to imagine that ore could be reduced from $2\frac{1}{2}$ in. to $1\frac{1}{2}$ in. as efficiently and economically in a stamp mill as in a jaw or toggle breaker, because in the one instance one had anything but a positive discharge and positive feed, whilst in the other, one had both of these points absolutely defined, and furthermore, the power consumption in the case of the crusher was in direct ratio to the work performed, whilst in the case of the gravity stamp it was not necessarily so.

He made special reference to this matter because a reader of Mr. Caldecott's remarks might unwittingly get the impression that Mr. Caldecott intended to say that preliminary fine crushing was in no case necessary; but this was not so, and as there are many remote places where moderately light stamps would still be used on account of great decrease, the value of a preliminary fine crushing should not be lost sight of, even from this point of view.

Mr. Caldecott made no reference to the high speed stamps of the Morrison type installed and run on the Meyer and Charlton mine for many months in the year 1903. These stamps had a weight of over 1,600 lb., and, owing to their being operated by a crank shaft, it was possible to run them at as high as 135 blows, and they registered a duty of over nine tons per stamp per day for a considerable period.

It was quite clear that the increased weight was resulting in a more than proportionate increased duty, but there were other considerations that prevented one from arriving at any settled conclusion in the matter.

Mr. Caldecott said "it will be evident that the day of the stamp as a unit of crushing capacity has passed away," and in this everybody will agree with him for the reasons he had stated. Whether or not the principle of the gravity stamp would ever be discarded universally, was doubtful, but he, the speaker, did know that many attempts had been made in small plants to discard it, with the greatest success; that is to say, there were numbers of plants in the United States to-day in which the stamp mill found no place. The principle followed was coarse crushing, fine crushing, edge runners and tube mills, and, when considered from the all-important aspects of capital outlay and operating costs, it had been proved in more than one case that the stamp mill was not absolutely indispensable. So far, however, the results had been obtained only from small plants, and he knew of no case in which the engineer had the temerity to lay down a large capacity plant without the gravity stamp.

In conclusion, he thought that Mr. Caldecott, now that he had started the ventilation of this important matter, would do a very great service if he continued the subject in some of those more abstruse directions which the speaker indicated in his remarks, and as Mr. Caldecott was well placed to carry out the necessary investigation work, it was just as fit that he should continue the good work begun.

He, Mr. Denny, would suggest, however, if the result of increasing the weight of stamps were merely to do the work which would be done by the crusher in conjunction with the lighter stamp—and this was what in effect Mr. Caldecott claimed—then the matter required very grave consideration before they went further; for he, personally, was not fully satisfied as to the wisdom of such a step, and until they had further details he did not consider that they should be justified in assuming that the heavy stamp was an unmitigated good.

Mr. HUGH F. MARRIOTT said that it must be noted that the paper was really a record of the practice of one of the largest companies on the Rand, and did not include, especially so far as the history was concerned, a great deal of what had gone on concurrently amongst other companies. It must be seen now that the race for heavy stamps had begun in good earnest.

It would go on until the component parts of the machinery would not hold together any more. Since the author had written his paper, stamps had been designed up to 2,000 lb. in weight, and there was a a still further variation from what was shown on the diagram. The concrete, which had already replaced the wooden mortar blocks, was creeping up the superstructure until it had got half-way up the king-posts, and doubtless, before they had finished, wood would be eliminated altogether.

It was evident that stamp duty alone conveyed but little meaning to-day. It had already been stated by previous speakers that the West Rand Consolidated had crushed 15 tons per stamp per day, and in one case 17 tons had been crushed. It was not stated what mesh was used, but it was doubtless a very large mesh indeed.

This method of increasing the output brought to his mind a story which went round South Africa during the war. At a certain military hospital there was an Irish doctor, who was told by his superior officer that all the water given to the patients had to go through a Berkefeld filter. As this had only a limited capacity, which was not great enough, they did not know what to do. The doctor at length put a brawny native on to the filter, who worked at it till he blew the bottom of the candle out, and then they got as much water as they wanted, and also satisfied the authorities.

That was really what the stamp duty amounted to to-day. A screen with ten holes to the linear inch would give a certain amount of tonnage, and if the mesh were enlarged to three holes to the inch, as he understood had been done, a great deal more would go through without there being any real increase in efficiency.

There was only one way in which a true comparison could be made in the future, now that they had tube mills, and that was to consider the stamps and the tube-mills combined as one unit. The power required, the tonnage put through and the size of mesh to which the pulp was reduced, could then each be taken to demonstrate the standard of efficiency attained, provided that two out of the three were reduced to a fixed constant.

A point of interest was mentioned by the author on p. 14 with regard to the screen, because screening played a very important part, in fact the most important part, in all those discussions as to what stamps would do. The author coupled the work of that Institution with that of the Chemical, Metallurgical and Mining Society of South Africa, which had elaborated another system for the standardisation of screens.

It seemed to him a pity that the local society there had not yet recognised the decided superiority and simplicity of the standards that the Institution of Mining and Metallurgy had brought out. To compare the two types, the difference between them was that the South African Society measured with a micrometer the size of the hole in the screen, and reached their minimum of 50 holes to the inch, presumably the limit of accurate reading power.

The Institution of Mining and Metallurgy took a standard type of screen in which the diameter of the wire was equivalent to the linear width of the hole, *i.e.*, the open spaces totalled 25% of the entire screen surface. By that means the standard screen could be carried down to any degree of fineness possible in commercial screen manufacture. They were already made down to 150-mesh, and the 200-mesh standard would shortly be issued.

Now the South African Society, stopping at 50-mesh cut out altogether all the work done on the cyanide side of the question; the finest sands and slimes could not be measured by their standard at all. He therefore failed to see why they had adopted it, because the most important part of their work could not be measured by it.

The author also mentioned that by their (the South African Society's) system of screening, they could get a duplication of previous orders from the sc een maker. This meant that the screen maker would be bound, within certain limits of error, to manufacture the size required to pass the micrometer test. By the Institution's system, which was simplicity itself, it was open to purchase any good screening in the market, and then to test it against a standard set of sieves in order to obtain its standardisation number. It did not matter what size it was called by the maker. For the purposes of the user the standardisation number was all that was required. Therefore, screening could naturally be bought in a much cheaper market than if the method adopted by the South African Society were followed.

Mr. Walter McDermott said it struck him that there was not sufficient information given in the paper as to grading tests below 60-mesh, as this was necessary in comparing the efficiency of different crushing operations. The pulp which passed from a set of rolls through a screen of given mesh, was very different from the discharge of a stamp battery through the same screen. The paper had relation throughout to crushing for cyanide treatment; and therefore slime production and fine grinding of the sulphides was important: the stamp was to be followed by a tube mill.

It was interesting to see figures of careful tests given against two ancient fallacies: fallacies which many men, in many countries, for many years, had exposed; but which kept coming up fresh at intervals in different places. He referred to fine breaking before stamps, and increased screen surface. It has occurred to large numbers of men that it would be an advantage to lessen the work of stamps by break ing finer; but the practical experience of all the world is against it as a general proposition. So in regard to screen surface: it is obvious, it is scientific, and it is wrong, that this is of primary importance.

He remembered fully twenty-five years ago seeing an improved stamp mill in Colorado with double screens, of corrugated form, concentric to the dies, which quickly destroyed all illusions as to increased capacity expected. The very same idea was patented in the Transvaal ten years later, tried and abandoned. Over and over again men have built double discharge mortars; and after trial have blocked up one side, and returned to single discharge. The mere fact that the same mortar with the same screen will crush 10 tons per day of one ore, and 40 tons of another, shows that screen area is not the controlling factor which many imagine it to be.

The success of the heavy stamp seems to be more a result of the introduction of grinding after stamps than of any special application lately of science to ore crushing. Steam stamps, so largely used for over twenty years on Lake Superior, were tried in Dakota on gold ores, and in Montana on copper ores, and given up. High-speed pneumatic stamps were used on Lake Superior over twenty-five years ago. The utility of heavy stamps had increased with the use of coarser screens; that is, the stamp was only doing part of the work of fine crushing.

He did not agree with the conclusion that the day of the stamp mill, as a unit of crushing capacity, was past. It might be so in Johannesburg, from conditions affecting finances and ore treatment, but such conditions varied greatly over the world. In Australia, for much grinding work, pans had displaced tube-mills. Water classification and tube mills meant very fine grinding of the sulphides, desirable for cyaniding, but undesirable for concentration, as almost universally employed, for instance, in California.

He would have liked to see the screen sizes in the paper expressed in terms of the I.M.M. standard, and grading tests on the same standard given on the minus-60 products.

Mr. R. E. Commans said that he was pleased to hear Mr. Truscott's remarks, because he thought it very desirable to emphasise the fact that it was not increased efficiency that was gained by increasing the weight of the stamps, but economies in the erection and running of a mill caused by a reduction in the number of units.

He felt that, with a weight of 2,000 lb., the limit of cam-lifted stamps had almost been reached, and that, if the weight was to be further increased, some other form of lifting device would have to be employed. As stated in the paper, with a drop of 7 to 8 in., 100 drops a minute was the maximum number practically obtainable by cam-lifted stamps, and he was rather surprised that the author had not made any reference to the Morrison high-speed stamp, to which Mr. Denny had just referred, and which was installed and had been running continuously for over two years at the Meyer and Charlton mine.

These stamps were no freak, or the design of a man with no knowledge of the special requirements of a stamp mill, but were the outcome of a long series of trials and experiments on a large scale by Mr. Morrison, one of the leading mechanical engineers in this country, and Mr. Bremner, who had had many years' practical experience of the running of stamp mills on the Rand.

That more had not been heard of these stamps was, he considered, due to an unfortunate combination of circumstances, and not to any defect in the design and working of the stamps themselves, and he sincerely hoped that more and heavier stamps of this type might soon be installed by other companies. Mr. G. A. Denny, who was for many years manager of the Meyer and Charlton mine, stated that when some small improvements, which experience in running the trial 5-head battery had suggested, had been made, he was satisfied these stamps would more than favourably compare with cam stamps, and in his paper* on 'The Design and Working of Gold Milling Equipments,' spoke most highly of them.

The main object of the Morrison stamp was not to accelerate the fall of the stamp, but to obtain a greater number of falls by securing a quicker pick-up of the stamps. The distinguishing feature of the high-speed stamp was the lifting device, which enabled the number of drops to be increased some 30% to 35%, and which consisted of a hydro-pneumatic cushioning cylinder lifted by a crank and connecting rod. The stamps fall freely by gravity alone, and therefore, so far as the blow on the ore was concerned, it no way differed from a cam-lifted gravitation stamp of the ordinary type.

At the Meyer and Charlton, double the amount of ore was crushed per head by the high-speed stamps. The weight of the Morrison stamp was 1,600 lb., and the cam stamp 1,100 lb., and if he remembered rightly, the high-speed stamps crushed 9 to 10 tons, and the cam stamps 4·7 tons per head per day with an 8-inch drop, through 500-mesh screens, the horse-power per ton crushed being about the same in both cases.

Pneumatic stamps had been designed to increase the number of drops per minute, as well as the energy of the blow, but they had not come into general use, and required a large piston area to lift a heavy stamp, which makes them rather cumbrous.

With regard to the author's remark as to the need of some effective means of testing abrasion hardness, he thought that this might be done by means of the sand blast. The ordinary tests for hardness by scratching by the rebound of a small pointed steel cylinder, or the indentation of a polished specimen of the metal by the pressure of a hardened steel ball, were theoretically of interest, but were of no practical use in deciding the hardness and suitability of steel for ore crushing.

Mr. Alfred James said that possibly the greatest point in the paper was that it seemed to mark the passing of the stamp mill as a fine crusher. Only three or four years ago they were accustomed to hear of screens with 1,600 holes to the sq. in., they were told that they were now crushing through a 3-mesh, or nine holes to the sq. in. In fact, one gentleman had told him that he was now passing $1\frac{1}{4}$ in. cubes through his tube mills. So that it seemed that the stamp was now taking much the place that Mr. Denny was proposing to take with his rolls, that of coarse crushing.

He need scarcely say how much they were indebted to the author for his valuable and classic research, which would be useful not alone for the particular type of ore on which he had conducted his experiment. The title of the paper was 'The Development of Heavy Gravitation Stamps.' Perhaps it would be more accurately stated as 'The Development of Heavy Gravitation Stamps on the crushing of Rand Ores,' because he was sure that the author would not desire to use very heavy stamps to crush light porous ores.

One point which struck him, and which had been unnoticed, was where the author endeavoured to give the crushing efficiency of the blows, on page 10. He thought the author had omitted to take into account in his mathematics, the fact that the crushing power of the stamp, crushing a 2 in. cube of quartz, was not the duty of a stamp striking through $1\frac{1}{2}$ in., because he thought he might support his 2 in. cube of quartz under that weight of 2,190 lb. per sq. in. for a long period without crushing it.

But if they took it that the elastic limit of that cube was one-twentieth of an inch that was, if they pressed it to one-twentieth of an inch it then cracked, then they had the duty of that stamp expending itself in one-twentieth of an inch instead of $1\frac{1}{2}$ in., and therefore the force would be approximately 65,700 lb. instead of the 2,190 lb. per sq. in. which the author gave. It was a very moot point as to whether the striking (not the pounding) duty of the stamp was not done in less than one-twentieth of an inch. He thought they might take it that 2,190 lb. was not a correct statement of the force of the actual blow on the cube.

He would like to refer also to the statement of the author as to the remarkable efficiency that had been attained by the adoption of the new method of crushing. If they looked at the work for May, 1907, of the Simmer East, it would be found that whereas formerly they crushed, with 250 stamps with 8 to 1 of water, 5 tons per diem containing 11% of + 60, they now crushed, with only $6\frac{1}{2}$ to 1 of water, no less than $8\frac{1}{2}$ tons per diem, with only 1·61% of + 60, for exactly the same cost. So that they were getting a higher tonnage and a higher efficiency, as shown by the finer crushed material, at the same cost. That, he thought, was an advance of which the pioneers of that new method of crushing on the Rand might well be proud.

Mr. G. H. J. Hooghwinkel wished to draw attention to two points. First, with the increased weight of the stamps, the number of stamps on each cam shaft would probably decrease. The second consideration was the variation in the speed of the engine. Both would be met in the future by electrically driven stamps. The three-phase motor had a constant speed, and was therefore well adapted for work of that class, and electrical driving was also easy to apply to a sub-division of the cam shafts by means of several motors.

He had seen a new stamp mill in Cobalt about a fortnight previously on one of the larger mines, and they had their cam shafts, with five stamps on each shaft, driven by an independent motor. The weight of each stamp was about 2,000 lb., and the speed was 100.

Although he did not know the exact results, they were using hard metal there, and it would be noticed that the running was much smoother than with a steam engine. If the weights were still further increased, the probable solution would be found in a combination of the electric driving and pneumatic methods of lifting stamps, just as was being done with the Temple drill. An electric motor would probably drive the compressors for each unit, in which compressed air would be used as lifting power, and they would therefore get the advantages of the concentration of the power in the power station and also the advantages of the pneumatic lifting power to help, if still heavier stamps were to be used.

Mr. W. Fischer Wilkinson said that the part of of the paper which had especially interested him was

*Minutes of Proceedings Inst. C.E., vol. 166, 1905-6.

the comparison which the author had made between crushing with stamps alone and double-stage crushing with stamps and tube mills. He remembered when the Knights Deep and Simmer East joint plant was put up, one-half of the plant was devoted to stamps alone and the other half to stamps and tube-mills, and that it was very difficult at that time to say which was the better practice.

It was interesting, therefore, to find now that the author approved of double stage crushing, because for the same cost he obtained a finer product, and therefore, of course, a better extraction. Now the question as to which was the better really depended very much on a correct estimation of the cost of crushing, and he would like to ask the author whether interest on the capital expenditure of the different plants was included in these costs or not, because it was certainly very important that that should be considered in making a comparison between the two systems of crushing. One might get a higher extraction by spending more money on plant, but the interest on this additional expenditure might exceed the benefit gained by increased extraction.

Another smaller point in connection with costs to which he wished to draw attention was that the costs of the year 1907 were compared with those of 1909. It seemed to him that it was quite possible that in the interval between 1907 and 1909 the conditions on the Rand had changed, and therefore that the costs of 1907, in order to make a fair comparison with those of 1909, ought really to be adjusted to the new conditions. Labour and supplies were, he believed, considerably cheaper now than they were two years ago, and if that were so, Mr. Caldecott was doing an injustice to the single-stage crushing system of 1907.

The popular practice now on the Rand was stage crushing, crushing with stamps and tube-mills; but it must be remembered that there were engineers on the Rand who did not accept that as the best system. Mr. E. J. Way, for instance, the consulting engineer of the New Kleinfontein, was, last year at all events, in favour of single crushing, when one did not want to get a product finer than one containing from 10% to 14% coarser than + 60. Under such conditions Mr. Way maintained that the best and cheapest practice was to use fine screens in the mortar-box and do without tube-mills, though, if finer grinding was required, he thought a combination of stamps and tubes or similar grinding machines would perhaps be right.

After studying Mr. Way's views, he (Mr. Wilkinson) thought he would examine some of the returns from the New Kleinfontein, which was now milling on the single-stage system, and compare them with the costs of other mines on the Rand using tube-mills. He had looked up the last report of the New Kleinfontein and found that the reduction costs, which included all crushing and cyaniding, amounted to 3s. 3d. per ton milled, and that they obtained an extraction of 94·95%.

Then he looked up the costs of a neighbouring mine, the New Modderfontein, which was using tube-mills, and found that their reduction costs were just under 5s. and their extraction 97·4%; in other words their costs were considerably higher than those of the New Kleinfontein, but they had a better extraction equivalent in value to about 9d. per ton milled. The net result between those two systems was that the New Kleinfontein system of single crushing by stamps alone without tube-mills was about 1s. a ton cheaper than that of the neighbouring mine using tube-mills. The returns of several other mines using tube-mills that he had examined gave reduction costs of from 4s. to 5s. per ton with extractions of from 93% to 94%.

He was not prepared to say that there might not be some special reasons for the low costs at the New Kleinfontein, and he merely put these figures forward as an argument that they ought not to accept the coarse screen and tube-mill practice as the best without careful consideration. In comparing costs due regard must be paid to the interest on capital expenditure as well as to the percentage of extraction recovered.

Mr. HUGH F. MARRIOTT said he might point out that the New Kleinfontein mill was burnt by the Boers during the war, but they had saved Modderfontein.

The President said he hoped that those who held views upon the matter and had information, but who had not spoken that evening, would let the Institution have the benefit of their views by correspondence, as it was a subject to which much importance attached.

CONTRIBUTED REMARKS.

Mr. WM. H. SHOCKLEY: A point that does not seem to have been brought out during the discussion of this paper—though very probably familiar to most of the members—is that a decrease in the weight of a stamp may greatly increase the crushing capacity, even though all the other conditions remain unchanged. The first man to prove this to me was my mill superintendent, George Fleming, when he was in charge of the 10-stamp dry-crushing mill of the Mount Diablo Mining and Milling Co., at Sodaville, Nevada, about 1890. At that date we were trying to get through as much ore as possible, and had increased the weight of our stamps to 1,250 lb. by the use of top tappets.

Fleming noticed that the replacing of the old shoes by new always caused a greater increase in the crushing than the difference in weight seemed to justify, and suggested that we should true up the irregularly-worn old shoes and try them in place of new shoes. We tried this and found that the old shoes, after being cut off in a lathe so that their bottoms were flat, crushed almost as much as did the new shoes. After this we faced the shoes about every two weeks, and greatly increased our output by this simple and inexpensive change. We estimated the loss in crushing due to cupped shoes at nearly 20%. Our maximum output with this mill was nearly 1,350 tons per month, crushing through a 30-mesh brass wire screen.

Mr. W. TRURAN: I should like to endorse the remarks made by Mr. Walter McDermott—that it is not possible to make a broad statement as to any one class of crusher being the most efficient, so much depends on condition. What gives most satisfactory results in South Africa, might turn out to be a dismal failure in South America, for instance.

As an example of this I should like to mention the pneumatic stamp. This machine, as I think Mr. Commans pointed out, is by no means a new idea. I believe I am correct in stating that the pneumatic stamp generally in use now was the invention of the late William Husband, of the firm of Harvey & Co., Ltd., of Hayle, Cornwall; and at the Inventions Exhibition, held at South Kensington in (I think) the year 1886, one of these machines was exhibited, of which exhibit I was in charge. The first machine made had an oscillating cylinder, which has now been done away with.

These machines were, I think, first used abroad in any practical manner by the late William Smeddle, at the Babilonia Mine, in the Libertad District, Nicaragua, Central America. Some few years since

I was in charge of this mine, and the crushing machinery consisted of a pneumatic stamp; and I am bound to state that it was a source of endless trouble.

The complicated and delicate nature of the stamp necessitated constant supervision and very careful handling, and this in a country where no mechanics are available was the cause of a great loss of time and considerable worry. For the efficient working of this stamp it is absolutely essential that all working parts should be kept vertically and horizontally true, and in order to maintain this condition no alterations or repairs could ever be entrusted to a native, or even a white man who was not a trained mechanic. The packing rings in the cylinder and the side arms needed very careful attention, for once the stamp got the least bit out of truth, trouble and delay ensued.

In the case of repairs or replacement of wearing parts, work was greatly hampered by the cramped construction and lack of room in the machine, and around the frame, the enormous weight of the stem head, etc., and the number of disconnections necessary, all of which matters rendered the work a matter requiring considerable thought and care.

The stamp we had was, I must admit, not of the latest pattern, as no lubricators were fixed on the cylinder, and in order to lubricate the interior of the cylinder, melted pork fat had to be blown in through the air-holes in the cylinder by means of a kind of pea-shooter and in most cases the stamp *blew first.* In conjunction with amalgamation, I do not consider the pneumatic stamp a success, the plate surface being altogether insufficient for the capacity of the machine. In places such as Cornwall, and as a crushing machine where skilled labour is ready to hand, it is quite another matter, and the pneumatic stamp, I can well believe, is a most satisfactory and efficient machine."—FISCHER WILKINSON AND OTHERS.—*Bulletin of the Institution of Mining and Metallurgy.*—Nov. 11, 1909, pp. 9-28. (H. A. W.)

PRACTICAL NOTES ON DRY CRUSHING MILLS (W. Australia).—"*Milling.*—Three No. 5 Krupp ball-mills, running at 26 rev. per minute, and taking from 16 to 20 h.p. each, crush the ore. They are fed by a shaking feeder worked by a single armed cam on a countershaft, and giving up to $\frac{3}{4}$-in. stroke. There is nothing like a steady feed for a ball-mill, and this feeder does it well. Each mill is loaded with 2,350 lb. of steel balls, and will crush 40 tons daily through a 27-mesh screen. I have had experience with dry crushing stamps, rolls, and studied the Griffin mill, but the Krupp mill is undoubtedly the best dry crusher when capacity, wear and tear, power consumed, and ease in getting at parts are taken into consideration. Using Krupp steel liners, a mill will run for eight to ten months without renewals, excepting, of course, such minor repairs as broken bolts, bent scoop plates, and riddles, a plate off, and fine screens. English and German steel plates have been tried, but the latter are the best by far. We have a mill newly lined with Melbourne made liners, and they appear to be doing well. Four grinding plates are bolted to each of the ten mantle plates, also the long perforated plate. These are got ready on a spare set of mantles beforehand, and in twelve hours six men can strip a worn-out mill of outside casing, screens, mantles, and side liners, and then practically renew the mill. The steel consumption in balls is $3\frac{1}{2}$ oz. per ton crushed. Three are added each week. A remarkable point about the balls is that, on emptying a mill, seldom or never does one find a ball smaller than $1\frac{1}{2}$-in. diameter; I have three specimens of $\frac{3}{4}$-in. balls, and these are the only ones found during the last three years in our mill. What becomes of the smaller balls of under $1\frac{1}{2}$ ins.? Are they smashed up? And yet there are no traces of fragments. It is rather a mystery. Once daily—*i.e.*, providing the ore is dry—the fine screens are brushed with a wire brush, but oftener if damp ore is fed in. About 3-in. size is the right feed for a ball mill, and if the ore is very fine and soft the crushing is not so good, as the balls have a tendency to "bed" in the fine material. My opinion about the crushing is that a certain amount of ore is broken by the balls falling from one plate to another in the mill; but a great deal of grinding goes on by rubbing and rolling, as every stone taken out of a mill is quite smooth and rounded. The working of a ball-mill is entirely by sound, and a poor millman can easily cause a lot of trouble and lose tonnage by neglecting the feed. All bearings are lubricated by a light grease, and give no trouble. The spur wheels should run three years at least, the pinions about half that time. A strong fan should be running in every dry crushing mill to draw off the dust from the ball-mill; and the suction has a tendency to keep the fine screens clear. Dynamite fed into Krupp mills with the broken ore is apparently ground up, as it seldom explodes, and then only a fine screen might be blown out. There is so much room in the mill when anything explodes; far different to the Griffin mill, which generally has the bottom blown out. Milling costs 1s. $8\frac{1}{2}$d. per ton.

Grinding.—Much controversy has passed about the merits of pans and tube mills, but in all roasting plants here the pan is in use, while in the wet mills the pans and tubes are generally found together. In a dry crushing mill, the pan serves a double purpose —*i.e.*, as a grinder and amalgamator. It is a very efficient machine in both ways, as a ball mill product of which 40 per cent. will pass a 150-mesh screen, 90 per cent. will pass the same screen after passing the pan; and by feeding in the necessary Hg every day the coarse gold will be caught before the slime goes to the cyanide plant. The pan is an interesting machine. A 5-ft. pan running at 47 revolutions per minute absorbs about 5 h.-p.—*i.e.*, a pan with heavy shoes. Some people prefer each pan driven separately by belt and two pulleys, but the friction clutch is very satisfactory. Several pans may be driven by one belt, and little inconvenience is experienced in this connexion; whereas a lot of money is represented in, say, 16 belts driving 16 pans. The muller plate is attached to the yoke by means of a bridle, permitting the former to swing with ease. Eighteen hematite iron shoes are pegged on to the plate, and there are a like number of dies fitting into the bottom of the pan. The yoke and plate may be raised and lowered whilst in motion by the usual screw and hand-wheel. We find it beneficial to clean each pan twice a month, as the lime in our ore is deposited as a hard scale in all the spaces between shoes, dies, &c., and on the sides. A set of shoes and dies lasts from four to six months on roasted ore, and when half worn down a compensating weight of some 600 lb. is put on top of the plate. A pan can be cleaned under two hours, and this includes chipping the above-mentioned scale. A pan can be cleaned and newly shod in about four hours by two men. In many mills the sides of the pan are badly scoured by the sand, but after $5\frac{1}{2}$ years' run ours are as good as ever. A great deal of the good working of a pan depends on the man in charge, overloading meaning a big discharge of sand, and too little feed just waste of power and material. We don't separate our product before grinding, as is usually done, and experiments have proved just as good work by passing all the pulp through the pans. They grind somewhere about 10 tons each per day at a cost of 1s. 7·8d. per ton milled. I don't see much advantage in the central feed, and the side feed is very satisfactory; in fact. it is almost universal.

Settling the Pulp.—A plain long **V** box is a nuisance if not divided up by partition plates, the single **V** settlers, say, 6 ft. square at top and 7 ft. deep, with a tap at the bottom being the best. The latest settler in this centre has a plug in the bottom worked by short lever, while on one mine the settlers are worked by a rod and plug worked from an eccentric on a slow running shaft above. Taps at the best are rather a bother. The first row of settlers gets the fine heavy sand, and this should be returned for regrinding, or, if not, then the taps on this row should be slightly opened all the time to permit the stuff to escape to the agitators. Every two hours will suffice to run out the thick slime from the other settlers, but, of course, this just depends on the feed and settling capacity. It is necessary to rake down the slime on the sides of the settlers once a shift, or else it will set hard. The slime runs to the agitators by means of a launder, which is best if made of wood; iron launders soon scour and rot away.

Agitating.—Now-a-days we have the Brown tank, the open monteju, the A. Z., and the ordinary type of agitator. The latter is a tank, 22 ft. by 6 ft., with gear driven spindle and arms attached, running at 5 to 8 revolutions per minute, absorbing 2 to 3 h.-p., and taking 12 to 20 hours to treat a charge of pulp and is commonly in use. This agitator has its weak points, and will soon be superseded by others. The worm wheel and friction clutch is not so satisfactory as the bevel gearing, but still such gear runs for years without renewal. We run the slime into the agitators with about 1—1 consistency, and as it is running in lumps of KCN are put into the launder, thus the strength of the solution, ·08%, is in contact with the gold the moment it enters the vat. It is customary in large mills to have a lot of strong solution in a special tank, and run it in with the pulp as required, but the way mentioned is just as good, if not better. We find a good deal of concentration going on in the bottom of the agitators, the arms acting somewhat as a buddle; the heavy sand contains a little Hg from the pans, and has assayed up to £20 per ton. This stuff we re-grind and re-treat as usual. Our KCN consumption runs 1 lb. per ton of dry slime, and the costs of agitation is 1s. 4·7d. per ton milled.

Filter-pressing.—Many will have it that the filter-press is doomed to make way for the vacuum process; but not on this field in the treatment of fresh mill slime for years to come I am thinking. In a well-arranged plant, agitation, filter-pressing, and disposal of residue costs 2s. 8d. per ton, and the figures given in vacuum treatment for old dumps locally are about 2s. 6d. per ton, yet the question arises, will the vacuum process deal successfully with current mill slime? There doesn't appear to be much reason against this, but nobody is inclined to rush into change, and it would take much experimenting to prove that it would pay to discard the press and install the vacuum plant, although it is well known that the Ridgeway plant on the Boulder is doing this with good results; one mine here is now conducting tests in this connexion.

The filter-press is a costly machine, requires a lot of attention, has its weak points, but yet does good work, and its value in connexion with treatment in Kalgoorlie has been incalculable; in fact, it saved the mills from enormous trouble. The ordinary press made by Dehne-Martin has 50 frames for the slime cake, and a like number of solid plates covered with filtering cloth, which costs 1s. 9d. per yard. Only in large plants is the hydraulic closing apparatus in use; in fact, one mine with 20 presses has not got it working, the majority being screwed up by back nuts and hand wheel. To the layman the flow of pulp, solution, and air in the press is somewhat puzzling, but there is really nothing in it, as the various channels are easily traced, Each plate is provided with a tap over the launder, but these are a great bother, and are now discarded, the vent being plugged. A pair of men on contract can easily dump eleven presses per shift, and keep an eye on the cloths, &c., filling presses by monteju is out of date. We fill with a 3-throw pump with 12 by 10 in. plungers, and running at 20 revolutions per minute, the time taken being about 12 min. with pulp 1 to 1 thickness. This pump could deal with five presses at a time. At 60 lb. pressure a safety valve blows off so that no accident can occur. The pump gives little trouble. The plungers are of cast iron, and last about twelve months, while with a clean water jet greasy hemp packing lasts some time. The rich KCN solution from filling the presses runs to a special tank, through a clarifier, then to the extractor boxes. With a similar pump running at 13 revolutions per minute, the slime is washed for 30 minutes at 90 lb. pressure. The wash being shut off, compressed air at 90 lb. pressure is admitted to dry the cakes. This takes about 5 minutes, the slime then holding 20% moisture. From time to time plates are found to be broken in the presses. This is most likely caused during the filling when one frame is filled faster than the next one, through the channel being choked; also a shock, such as turning on the wash quickly, may possibly do it. These plates cost from £3 to £5 each. A badly filled press will not wash properly, and the solution follows the least line of resistance. In sampling, take a section of a cake about every tenth frame. Pressing costs 1s. 1d. per ton.

Disposal of Residues.—Under the line of presses is a horizontal belt, feeding an inclined belt elevator at 26°, in turn feeding a boom distributor. The main belts travelling at 300 ft. per minute give little trouble, yet at times they take fits and run to one side and throw off the slime where not wanted; even the wind affects them. The boom belt running at 950 ft. per minute throws the slime far out over the dump. This is driven by a 10 h.p. 3-phase motor running at 300 revolutions, and driving the boom by a short belt without gearings, and the way in which this machine behaves in heat and cold, bad dust and rain is really astonishing. In dumping 120 tons daily, 40 units at 3d. are used. To minimise the dust on the dump we hose it with salt water, which forms a crust on top. A belt may run for a day or two without trouble, then you may have days of constant attention needed. The canvas composition belts are greatly affected by heat and cold, the rubber belts stretch a good deal, and joints need much watching. The steel lace makes a good joint, but it wears out quickly, and if one side should wear through and catch anywhere when working it is likely that the belt will be ripped from end to end; all classes of belts will do this. To get over this trouble we make new joints at regular intervals, and also wrap some tough cloth over the ends of the belt at the joint, and the whole laced together as usual.

Canvas belt costs 7s. per foot, and the rubber from 10s. to £1 per foot. The hand type tightener is of little use, the automatic sliding weight being very good. Belt conveyors are easy to erect, but it is advisable to have plenty of attention devoted to them when running.

Precipitation and Clean-up.—Of course this is a big subject, yet my experience has always been without bother in this line. Good roasting in the mill, a little lead acetate added at the pans, a fairly strong solution in treatment, a trickle of extra strong solution as the rich solution enters the boxes, and a dose of acetate every other day or so, the cells kept well filled with zinc, and all is well. Occasionally a little lime comes down in the top boxes, and the acetate does not affect the bullion to any extent. In cleaning-up it is quite a matter of judgment as to how much zinc is to be put into the acid direct and how much to be washed. Acid of about 5 water to 1 acid is strong enough. The lead-lined tank should be connected with a fan to carry off the fumes. Heat is not necessary, and three hours in the acid is quite sufficient. From the tank the sludge should run into the montejn, and then into a lead-lined centre filling press. An hour's wash will do, and hot water is beneficial. Twelve to eighteen hours drying, roasting, and a good stirring at the end is all the better. About 50% borax and a little sand are sufficient fluxes. The tilting furnace is very handy for large lots, and the pot should last three or four smelts. A flat topped furnace is good to do the final refining in, as one can stand right over it and skim off base, etc. In sampling bars a drill bore in about ¼ in. at top and bottom at opposite ends is satisfactory enough.

Conveyors and Elevators.—The Archimedian type of screw conveyor works well on fine ore from the mills, and being enclosed makes no dust. The push conveyor also works well on this ore and that from the furnaces, but makes much dust. The double push conveyor will take along the feed for the roasters, and return any excess not required. The carriers are of the frictionless style, and the flights may be taken out or replaced while in motion. In roasting, the roast may be poor at times, but by the time it has reached the end of a conveyor it will be much better, due no doubt to the great rabbling, pushing, and exposure to the air. The power used varies a good deal according to the feed. For cold dry crushed ore the rubber belt with steel buckets is very serviceable. The belt is butt jointed, and the buckets placed 15 in., staggered, and is examined once a month. In elevating hot ore, the chain and bucket working in a steel housing is very satisfactory, though at the best of times it requires much attention in greasing, etc., and breakdowns are accompanied by much heat and dust. I hear lots of complaints about the elevators, but my experience with them is on the good side. The chain must be kept reasonably tight by the gear provided at the top. The wear and tear is remarkably small, and recently we renewed the bottom shafting after five and a half years' run. The elevator is examined about twice a year.

Driving Belts.—There are so many makes in use, and most of them of a good character, but of all the rubber, raw hide, leather, composition, and balata, I prefer the latter. It is made of the best cotton duck impregnated with balata, is expensive, stretches very little, and lasts a long time. If not run carefully it will open out, but the inside ply can be torn out if it gets too rough, although this takes some of its strength away. Where there is much heat it is not advisable to use it. Many millmen believe in butt joints made by steel laces or clips of various makes. I don't. The lap joint properly made is very strong, and the ends of the belt do not tear out as happens with the butt. Even in driving a dynamo, or a motor driving anything by belt, the lap joint makes no bump if planed down and laced neatly, although this is contrary to general practice. When a belt is stretched the laces may be cut out and the lap rivetted with copper rivets. Large belts are generally laced in place by means of clamps and rods. A little castor oil, which makes a good dressing for belts, is necessary in a dry crushing mill. In rope driving, a 2 in. cotton rope with a long splice will run for years without trouble, and little dressing is required.

In conclusion, it might be said that although a wet crushing mill is the healthiest and easiest to keep clean, yet a dry plant can be kept fairly free from dust by having fans, all crushing machines and conveyors well housed, plenty of windows and doors, and open roof where possible, but, of course, the machinery in the latter cannot be expected to last as long as in the former.—W. M. VON BERNEWITZ. *London Mining Journal*, Sept. 4, 1909, p. 299. (A. R.)

PURIFICATION OF MERCURY.—"The constant use of the mercury cathode in this laboratory necessitates the frequent purification of very impure mercury. According to the methods described in the text-books a great deal of time is required if anything like complete purification is desired. Furthermore, little is known of the relative efficiency of the methods, so that the worker simply chooses the one that strikes his fancy. It therefore becomes desirable to know how to obtain the purest mercury in the least time and with simple apparatus.

The usual methods are, first, to draw air through the metal contained in a wide inclined tube bent up at the end; second, to shake with mercurous nitrate, ferric chloride or potassium dichromate, in a separatory funnel; third, the method of L. Meyer,* to let fall in a fine stream through a long column of mercurous nitrate; fourth, to purify electrolytically by making the mercury the anode in a nitric acid solution; † and fifth, to distil. No one who has tried the first of these will think very highly of its speed or efficiency. The shaking in a separatory funnel requires no construction of apparatus and is probably the favourite method. The surface of contact between the metal and the solution is, however, relatively small and long shaking is obviously required to dissolve the impurities present in the mercury. Washing through a column of mercurous nitrate containing free nitric acid is excessively tedious, provided the opening of the funnel from which the mercury falls is sufficiently fine to give a thin enough stream. Moreover, this opening frequently becomes choked and the funnel must be removed and cleaned. Various automatic arrangements have been used to return the mercury to the funnel,‡ but they are more or less complicated and have no advantage in point of time. The electric purification is also time-consuming, requires efficient stirring and is not particularly effective.

For the removal of silver and gold, of course, distillation is necessary. This is usually done under reduced pressure in one of the various forms of still which have been proposed. Hulett and Minchin§

* *Z. analyt. Chem.*, *2*, 241 (1863).
† Wolff and Waters, *Bull. Bureau of Standards*, *3*, 623; *4*, 1 (1907)
‡ *E. g.*, Desha, *Am. Chem. J.*, *41*, 152 (1909).
§ *Phys. Rev.*, *21*, 388 (1905). The oxidation of the zinc or cadmium by the air is an important factor in the purification.

have shown that unless the mercury is distilled in a current of air and with no bumping, the more volatile metals such as zinc or cadmium are not removed. The distillation apparatus they describe yields mercury of a high degree of purity, as shown by their careful testing.

This is a modification of the L. Meyer method, which is very rapid and, as recent measurements show, very efficient, a degree of purity being obtained comparable with that of distilled mercury. Instead of the mercury being delivered from a funnel drawn out to a fine point, a separatory funnel is used, the delivery tube of which is slightly narrowed 0·5 cm. from the lower end. Over this end is bound with twine a piece of rather closely woven muslin. The mercurous nitrate solution is contained in a piece of glass tubing 1·5 m. long and 2 cm. in diameter. The narrow delivery tube at the bottom is bent up 25 cm. This is more than usual, as it is necessary to have the height of the mercury in the wide tube about 5 cm. so that the tiny globules which fall will have time to coalesce before they reach the small tube, otherwise the mercury will not be delivered dry, or it may even be swept out of the tube followed by the entire solution of mercurous nitrate.

The end of the tube of the separatory funnel over which the cloth is bound should dip below the surface of the mercurous nitrate solution. This diminishes the surface tension of the mercury so that the fine streams running through the cloth breaks up into very minute globules. Unless the surface of the mercury is clean the funnel cock should be closed just before all the mercury has entered the stem of the funnel, as the dirt thus carried into the stem would clog the cloth.

By this arrangement, instead of one stream of mercury, as in the ordinary form of the apparatus, we have several hundred streams, finer than is practicable with the usual drawn-out funnel, and a number of them may be choked by particles of solid amalgam or dirt, before the flow of mercury is sensibly diminished. The rate of flow need only be limited by the rapidity with which the globules coalesce on reaching the bottom. The rapidity of the washing and the large surface of mercury exposed are obvious.—J. H. Hildebrand.—*J. Amer. Chemical Society*, Aug., 1909, p. 934. (A. McA. J.)

Gold Mining in Korea.—"Korea is a highly mineralised country, possessing an excellent climate and an abundant supply of good and cheap labour. Its chief gold quartz mines are included in the American concession at Unsan, which was granted originally in 1895 for 25 years, and, as modified and extended, may be operated until 1954. At the Unsan mines a series of large quartz lodes, occurring in granite, are being mined successfully and profitably under American management.

The Unsan Gold Mines (Oriental Con. Mining Company) constitute the most important mining property in this part of Asia. While other Korean mining properties are now recognised as possessing dividend-paying resources, the Unsan mines have heretofore been the only properties operated continuously on any extensive scale by modern methods in the Empire. This company is situated in north-western Korea, about 60 miles south of the Yalu River, and at the present time has a total of 230 stamps in five different plants, crushing some 30,000 tons per month of low-grade gold ores. The character and value of the ore varies considerably at the several mines. It averages about 5 dwt. gold per ton, with very little silver. This low-grade ore is quite base, containing from 5% to 6% of gold-bearing sulphides.

The Kuk San Dong plant (40 stamps) treats an ore averaging 12s. in value per ton, being quite base and containing 8% sulphides of arsenic. Maibong plant (20 stamps) treats £2 ore, containing 3 or 4% sulphides of arsenic, iron, lead and zinc. Candlestick plant (10 stamps) treats £3 to £4 ore, containing as high as 15% sulphides. Taracol plant (80 stamps) mills 16s. ore, with 5% sulphides of iron, lead and zinc. Tabowie plant (80 stamps) treats 20s. ore, with 5% sulphides.

All the plants wet crush, amalgamate and concentrate about 1,000 tons per day of £1 ore. The total extraction on all values equals about 81% at the present time. About 2,500 tons of concentrates per month are cyanided at the several plants by the old 18-day leaching method, giving a total extraction of 83%.

Cost of Mining and Milling for 1908.—30,000 tons per month (20s. 10d. ore).

	s.	d.
Mining and development ...	5	0
Milling and concentrating ...	2	3
Cyaniding concentrates ...	0	6
Ore transportation	0	1
General expenses	2	0
Total expense	9	10

All of 4s. out of a total expense of 9s. 10d. is for cordwood and mining timber alone. Although we have cheap labour our wood and timber problem is serious. The company is now making arrangements to operate the two 80-stamp mills and plants by hydro-electric power, and through these changes reduce the cost of milling considerably. A railroad is also being constructed into the Yalu River timber country, and should, when completed, reduce the costs for wood and timber. During the coming year the costs, with electric power and cheaper timber, will, no doubt, reach a total of 8s. We will be able to handle any ore at a profit that will assay more than 2 dwt. per ton. It is very doubtful if the Oriental Con. Mining Company could carry on operations in America with only 230 stamps, where the cost of labour is high. The Alaska-Treadwell and Homestake Companies, U.S.A., with their 8s. to 16s. ore, are only able to operate through handling immense quantities of ore (3,000 to 4,000 tons per day) in their large mills.

Labour.—Our native labour consists of Koreans, Chinese and Japanese, about 8,000 on the concession being dependent upon the company for a living. Japanese are employed as carpenters, foundrymen and machinists, at 3s. to 5s. per day, and at this work are far better than the other Orientals. The Koreans are the most efficient miners and machine men (two Koreans being equivalent to one average European or American miner). As miners they receive 1s. and as machine men 2s. per day of 10 hours. Ordinary Korean coolies receive from 10d. to 11d. per day, and out of this they are expected to live. Their food (rice and fish) costs from 5d. to 8d. per man per day. Chinese are employed on the rock-crushing, tramways, and stone masonry work, and earn from 12d. to 15d. per day. By far the majority of Orientals employed are Koreans. The Korean miner possesses all the good qualities of a miner, with very few of his defects, being physically strong and very easy to handle. Generally speaking, a Korean miner's father and grandfather were miners before him, and his son will, as a rule, be a miner. They withstand hardship, such as water and bad ventilation, much better than the average white miner. When practicable, it is customary to employ Korean miners on contract work, and when this is done the results obtained per day by them are equal to the average American or Cornish miner.

Gold Extraction.—The ores treated contain only a fraction of an ounce of silver per ton, and therefore can be classed as low-grade base gold ores. With a 16s. ore, and with our present plants and treatment, the following results are obtained :—Milling 30,000 tons per month on 16s. ore—Values won by plate amalgamation, 46½% : values won by concentration, 41%. Cyaniding 2,500 tons per month on £4 concentrates—Values won by cyaniding (18-day leaching), 83%. Milling and cyaniding—Values lost in milling, 12·5% ; values lost in cyaniding, 6·1% ; total loss, 18·6%. The present method of treatment gives an actual extraction of 81·4 per cent. of the values. I have recommended improvements in concentration and cyaniding concentrates, resulting from my past four years experimental work in Korea. At the end of my tour to the various mining districts I shall remodel the old plants and bring them up to date. I have through all-sliming of our concentrates (no roasting), air agitation, vacuum filtering, obtained a total extraction of 93% with a 48-hour treatment. Average cost by this method per ton of concentrates is 13s. (per ton ore crushed 7d.) The average cost by the 18-day leaching method equal about 11s. (per ton ore crushed 6d.) Improvements in our concentration methods will lower our mill tails to about 18d. per ton, when milling 16s. ore. The improvements will show an increase on the present total extraction (81·4%) of from 6 to 7 per cent. Presently the company shall start retreating its old cyanide concentrate tailings dumps which have accumulated during the past six or eight years. They will average from 4 dwt. to 6 dwt. per ton, having been previously cyanided by the 18-day leaching method for an extraction of 80 to 83 per cent. These dumps contain 40 to 60% quartz sands, the remaining product being sulphides. The new plant for these dumps will reconcentrate into sands assaying 1 dwt., and sulphides valued at 12 to 15 dwt. per ton. The sulphides to be all-slimed in tube-mills in cyanide solution, air agitated, and vacuum filtered within my special combined agitator and vacuum-filter. This method will show a net profit of about 4s. to 5s. on each ton of dump as it stands. The extraction obtained on the sulphide equals 70%. The company at present is producing some £25,000 per month in bullion, and to date has produced about £2,400,000 from these low grade ores. I will say that this gold mining company is the only one operating in Korea at a profit at the present time. Its success has been largely due to the good management of Mr. H. F. Meserve, who has been its leader from the beginning. —By A. E. Drucker, Metallurgical Engineer to the Oriental Con. Mining Co., Korea. (A. R.)

Tube Mill Practice in Mexico.—" A tube mill was early recognized in Mexico for fine grinding. Krupp mills of standard types were largely used at first, but subsequently various American makes came into favour. There has been for some time considerable discussion as to the relative merits and efficiency of long tube mills and short tube mills, but the subject has not been demonstrated satisfactorily to any extent except to the partisans of the respective types. A few years ago at the El Oro mill the practice of introducing a ribbed lining, into which the pebbles became fixed and formed automatically a flint lining for the mill, was introduced and met with immediate success. This lining is quite generally used. Following this improvement the Ennis tube mill liner was invented and introduced at Guanajuato. The idea consists of removable bars properly secured by bolts which pass through the fixed lining in the shell. These bolts are countersunk so as to permit the wearing of the liner to the level of the fixed lining, which only becomes slightly worn between the ribs. These fixed plates have an indefinite life, estimated at at least five years. The obvious saving comes in the reduction of the weight of metal necessary for the restoring of the lining. In a tube mill 16 ft. by 4 ft., the old lining weighed 8 tons. The new lining will have the same weight for the first set, including plates and bars, but subsequently the bars will weigh only 3½ tons. The bars will last about 8 months, and about the same length of time as a set of the old time lining. Four of the tube mills at the Bustos mill, Guanajuato, are equipped with this device, and it is expected that others will be likewise equipped.

The use of quartz ore in place of flint pebbles has been introduced at El Oro and has been found practicable. It has certain disadvantages and limits, reducing the output and causing excessive wear on the silex lining. The best practice has been obtained by introducing a small amount of pebbles with the quartz pieces in the tube mills of the El Oro type, the pebbles by reason of their shape wedging between the ribs and forming the usual lining. The subject is being carefully worked out by H. B. Smith, the manager of the Guanajuato Reduction and Mines Co., and it is expected that some definite data on this important subject will be available soon.

The question of the best speed and proportion of pebbles to ore is being carefully studied in the different camps, and when this data becomes available it will furnish a definite standard in tube mill practice, which will be of interest everywhere." —*The Mining World*, July 3, 1909, p. 35. (C. B. S.)

MINING.

Capacity of Sinking Pumps.—" The capacity of a sinking pump is considerably increased by placing it very near the sump, so that it can readily maintain its supply of water, without drawing air."—*Queensland Govt. Mining Journal.* (C. B. S.)

Relation between Rock Temperature and Air Temperature in Mines.—" On the basis of an extensive series of calculations, E. Schmid (*Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, July 17) arrives at the conclusion that in very deep mines it will be impracticable to reduce the temperature of the ventilating current sufficiently by merely increasing its velocity, and that the only practicable method will be to cool the air by artificial means at the working face, as was done in driving the Simplon tunnel. — *London Mining Journal.* August 28, 1909. p. 276. (A. R.)

Accidents due to Electricity in British Coal Mines.—" The reports of H. M. Inspectors of Mines on coal mining show that in the various coal mining districts there is a disposition on the part of many owners and managers to extend the use of electricity as a motive power, especially in the Southern district, where it is used for pumping, haulage and the working of about a dozen coal-cutters. With regard to the latter, however, the Inspector advises erecting air compressors underground as far in-bye in the intake airway as it may be safe to work electrically and supply compressed air to the coal-cutters at the face. In the East Scottish district, where there were 126 deaths and 524 non-fatal accidents, two fatal accidents only were due to electricity. In the West Scotland district, of 85 deaths and 374 non-fatal accidents only one was supposed to be due to electricity. In the Newcastle district, where 42 electrically driven coal-cutting machines are used, there were no electrical accidents. In the Durham district 104 deaths and 570 injured were recorded, of which there was only one non-fatal accident due to electrical causes. In the Yorkshire and Lincolnshire district, with 111 electrical coal-cutters there was no accident attributable to electricity. In the Liverpool and North Wales district there were 155 deaths and 300 injured, one workman being killed by an electric shock of 500 volts. In the Midland district 91 electrical coal-cutters were at work with two fatal electrical accidents. In the Stafford district 111 men were killed and 423 injured, and only one non-fatal accident due to electricity occurred. In the Cardiff district 134 deaths and 423 injured were recorded, of which one non-fatal accident was attributed to electrical causes. In the Swansea district one fatal accident occurred resulting in the deaths of three workmen, due to electrical detonation of gelignite on refilling a partially blasted hole. In the Southern district, of 93 fatal and 277 non-fatal accidents one accident with one death occurred from the use of electricity. These data prove that the use of electricity underground is safe so long as proper precautions are taken, as many of the accidents which happen can be ascribed to ignorance or carelessness on the part of the workmen."—*Electrical Engineer*, Aug. 13, 1909, p. 182. (J. A. W.)

Sinking a Shaft by the Cement Process.—"Dobbelstein describes the sinking of a shaft through water-bearing strata, by the cement process, at the Liévin Colliery. On reaching the wet ground a concave steel bottom was built in the shaft, with covered orifices for eight boreholes round the periphery. Five of these holes were driven down to the solid sandstone and filled with cement milk, about 122 tons of cement being used. After seventy-five days the false bottom was removed and sinking recommenced; but, owing to the presence of uncemented fissures in the rock, and the fact that the cement had not set hard, the influx of water soon reached 3,300 gallons per hour, so that, by the time another 60 ft. of tubbing had been put in, the false bottom was replaced and supplementary boreholes were driven and cemented, 50 tons of cement being used. On continuing the sinking, it was found that the cement milk had penetrated the rock to a depth of 25 ft. below the bottom of the boreholes, and completely shut off the water from outside the ring of holes. The actual cost of the cementing process was about £1,000, or only one-eighth the expense of the freezing process" — *Mining Journal* (London). (C. B. S.)

Rope Cappings and Attachment to Drum.—Ample strength in the rope itself is, of course, of no avail if its attachment to the drum on the one hand, or to the cage on the other, is not proportionately strong.

The former attachment to the drum is comparatively easily provided for by taking advantage of what is known as coil friction. It is usual to purchase a rope of considerably greater length than is represented by the distance from the drum to the bottom of the shaft, so that when the cage is at the bottom there are still three or four complete coils left on the drum. This extra length not only provides spare rope to make up for the pieces which should be cut off at each recapping, but they also serve to secure the rope to the drum.

The coefficient of friction between a greased wire rope and a wood-lagged drum will probably be about 0·35, which means that one coil on the drum would enable a pull of 1 lb. to resist a strain of 9 lb., two coils 9 × 9, three coils 9 × 9 × 9, and four coils 9 × 9 × 9 × 9, or 6,561 lb. With four coils on the drum, therefore, and the end passing through the lagging secured with a force of, say, 50 lb., the rope is securely held, even if the load amount to as much as 140 tons.

One frequently finds that the rope end which is passed through the drum lagging is given two or three turns around the drum shaft, in which case the security is increased to an enormous extent, and there is not the slightest necessity for the two or three strong clamps which generally complete the arrangement. Yet at the other end of the rope we have been satisfied with an attachment only giving half the strength of the rope.

Too much care cannot be exercised in the selection, design and application of rope cappings. The forged steel conical socket, in which the prepared end of the rope is secured by means of white metal, when properly and carefully made, possesses a greater strength than the rope to which it is fitted.—G. H. Winstanley. *Queensland Government Mining Journal.* September 15, 1908. p. 465. (C. B. S.)

Record Driving.—"The Modderfontein B Gold Mines has achieved a notable record for the Rand in driving during the month of September. In a drive from the West Central shaft, a distance of no less than 334 ft. was accomplished in sixty-two shifts, which leaves far behind the previous best, which was achieved by the Van Dyk in sixty-two shifts just a year ago. Before the Van Dyk record was made, the Simmer Deep held the record, having with three machines driven 294 ft. in sixty-one shifts in April, 1908. In November of the same year 272 ft. were driven in the Vogel Deep with two machines. The Van Dyk record was won by one white man and five Kafirs working each shift, using two 3¼ in. machines. In the Modder B, two machines were operated by two machinemen; the average holes per round was 12·5; the average footage per day was 11·13 ft., and the size of the drive 6 ft. × 7 ft. In the Van Dyk, the average number of holes per round was twelve, and the average number of feet per round was 5·209."—*South African Mining Journal*, Oct. 2, 1909, p. 58. (A. R.)

MISCELLANEOUS.

Points on Adjusting Instruments. — "The following points on adjusting instruments are doubtless familiar to many field-men, but as they do not appear in any of the text or field-books that have come under the writer's observation, they may not be out of place. They possess the advantage that many of them can be made without the help of an assistant.

The Transit.—To Adjust the Standards.—Pick out some line, as the edge of a chimney, or the corner of a building, that should be plumb. Sight to a high point on it and depress the telescope, noting to which side of the line sighted, the line of collimation falls. Reverse the telescope, turn the slate around, and repeat. If the line of collimation falls the same distance to the other side the line sighted on is plumb, and the standard can be adjusted so the line of collimation follows it all the way down.

To Adjust the Line of Collimation.—Having adjusted the standards, set up over a point and set two others by foresight 200 and 400 ft. distant, thus giving three points in a straight line. Set up over the middle point sight to one of the others, reverse, and note the distance the line of collimation falls from the other. The vertical cross-hair is then moved over one-half the error, instead of one-fourth, as is customary, when the two outer points are set by a foresight and backsight.

Second Method.—Pick out some distant object for a foresight, reverse and find some near object on line. Turn the plate around and sight to the near object again. Plunge the telescope and note where the line of sight appears with reference to the distant object. This method of long and short sight makes the error more apparent, which should be taken into consideration in making the adjustment, and care used that the cross-hairs are not moved too much.

To Adjust the Telescope Level and Vertical Circle. Set the vertical circle so that its zero coincides with the zero of vernier. Pick out some object 300 ft. to 500 ft, distant cut by the horizontal cross-hair, reverse the telescope, turn the plate around, and again bring the cross-hair on the object sighted. If the zeros do not coincide, read the error, and move the vernier over one-half of it, repeating the operation until the zeros coincide in both positions of the telescope. When this point is reached the telescope is level, and the bubble should be adjusted to it.

The Level.—To Adjust the Horizontal Cross-Hair. —The bubble being adjusted so that it will reverse perfectly, drive two pegs in the ground 300 to 500 ft. apart, and set up as near one of them as possible to get a clear sight. Take a reading with the target and assuming and elevation for the peg of 100 figure and H.I. Move the rod to the other peg, take a reading and calculate its elevation. Move the instrument to the second peg, take a reading, and from it and the elevation found, calculate a second H.I. Move the rod to the first peg, and if the instument is in adjustment, the reading will give it an elevation of 100. If this reading is not obtained, set the target half way between the reading which is obtained, and the one which should have been, and adjust the horizontal cross-hair to it. This adjustment can also be used for the telescope level of the transit."—L. A. Palmer.—*The Mining World*, Aug. 21, 1909. (C. B. S.)

Corrosion of Reinforced Steel.—" It has been said that reinforced concrete should be avoided as it is a treacherous material to use owing to the fact that the metal corrodes, and being covered by concrete the extent of the corrosion can never be ascertained, and therefore many well-known engineers up to the present have avoided the use of the material owing to this impression. If they were right in their assumption, and the steel did corrode, and there was no remedy for it, then reinforced concrete would soon have had its day, for its weakness in this respect would become generally known, and it would naturally be avoided ; but from a series of experiments which the author has recently made, he is in a position to state definitely that no such fears need be entertained.

The results of these experiments—21 in number—have led to the following conclusions ;

(1) That rusty steel imbedded in concrete will in a very short time become bright, regardless of whether the concrete is in water or air. This point has, in the author's opinion, been conclusively proved by his experiments.

(2) That the application of cement grout to steel is an effectual safeguard against corrosion, but that the greatest care should be taken in the grouting process to see that every portion of the steel is well coated, and that before the steel is embedded in the concrete the cement grout is allowed to become quite dry upon the steel.

(3) That if the aggregate used for the concrete is not porous and the concrete is well mixed, the reinforcement being well embedded, no cement coating is needed. (Seeing that the application of a coat of cement grout is such an inexpensive procedure the author makes it a rule in carrying out work of this kind to have all reinforcement coated in this manner.)

(4) That no porous materials, such as coke-breeze or slag, should be used in connection with reinforced concrete work, if such concrete is intended to be under water or exposed to the air.

(5) That linseed oil or turpentine or probably any other coating except cement or lime applied to steel before its insertion in concrete facilitates rather than prevents the rusting of the metal.

(6) That it is of great importance to see that the reinforcing steel is well embedded in the concrete, so that every portion of it is covered with cement.

(7) That the best results were obtained when the aggregate consisted chiefly of broken stone or brickbats. Gravel would no doubt answer as well.

The author was surprised that such a good result was obtained with an aggregate composed of brickbats.

(8) That river sand, generally speaking, is not satisfactory for reinforced concrete work, where such work is required to be water-tight." — E. R. Matthews, Society of Engineers.—*The Mining World*, August 24, 1909, p. 223. (C. B. S.)

Solution of Gold in Cyanide. — Gold dissolves in cyanide solution in direct proportion to the area of metallic surface presented. The area of a sphere equals the square of the diameter multiplied by 3·1416 ($A = \pi d^2$) and the volume equals one-sixth of the product of the cube of the diameter and 3·1416 $\left(A = \frac{\pi d^3}{6}\right)$. Therefore, to take the simplest conditions, if a gold particle has a diameter of 1 mm., its volume will be 0·5236 cubic millimetres, and its area 3·1416 square millimetres. For a sphere of 2 mm. diam., the corresponding figures are 4·1888 and 12·5664. The ratio of volume to surface in the larger particle is as 1 to 3, while in the smaller it is as 1 to 6. At ½ mm. diameter the ratio becomes 1 to 12, and so on. The economical limit of size is one to be determined in the light of results.—*Mining and Scientific Press*, March 20, 1909. (K. L. G.)

Non-Cracking Glass.—" The Baccarat Works (France) has manufactured a new kind of glass which does not crack at a temperature of 100 degs. C., when sprinkled with water at 15 degs. C. This glass has been accepted for safety lamps as superior to Jena glass. The composition is as follows : 75 per cent. sand, 13 per cent. bicarbonate of soda, 9 per cent. manganese carbonate, 6 per cent. zinc oxide, 5 per cent. lead oxide." — *Rassegna Mineraria*, August 21.—*London Mining Journal*, Oct. 2, p. 13, 1909. (A. R.)

Reviews and New Books.

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

RAPID METHODS FOR THE CHEMICAL ANALYSIS OF SPECIAL STEELS, STEEL-MAKING ALLOYS, AND GRAPHITE. By CHARLES MORRIS JOHNSON. First Edition. 12s. 6d. (New York, N.Y., U.S.A.: John Wiley & Sons. London: Chapman & Hall, Ltd.)

"Nothing but praise can be accorded to this thoroughly practical work, whose 220 pages include innumerable useful tips on special points in connection with the analysis of 'special steels,' and of special metals and alloys used in their manufacture.

The advance during the last few years in the use of such metals as chromium, nickel, manganese, tungsten, cobalt, molybdenum, vanadium, tantalum, niobium, etc., and in the production of such metals and their ferro-alloys, for producing special properties in steel, has revolutionised the special steel industry and, incidentally, the methods employed in their analysis. This work, whose author is the chief chemist to the Park Steel Works of the Crucible Steel Company of America, gives details, and especially notes on what to expect and what to avoid, which cannot be obtained elsewhere.

An important feature of the book is the fact that the author appears to have not merely selected methods of recognised value, but has tested most of them himself, and has only recommended those which he himself knows to be reliable.

Although dealing mainly with special steels, there is much of value to the ordinary iron and steel or general analyst. Methods are given, for instance, for testing tungsten, molybdenum, and other powders: special tips are given for carbon, sulphur, phosphorus, and silicon determination; and a few notes useful to those engaged in the assay of ores are added.

Apart from its interest to the analyst, a perusal of the work shows how largely the iron and steel industry is now connected with 'non-ferrous' metallurgy, on account of the increasing use of other metals in steel manufacture. Each manufacturer has his own fancies as to metals to be added, and as to their proportions, and, although one may doubt whether so great a variety in composition is necessary or advisable, the difficulties of the analyst are growing daily, and can only be met by the publication of such works as that under review, written by men of experience and kept well up to date." — *London Mining Journal*, Sept. 25, 1909, p. 429. (A. R.)

INDEX OF MINING ENGINEERING LITERATURE. By Dr. W. R. CRANE, Dean of the School of Mines and Metallurgy, Pennsylvania State School, State College, Pa. Price $4. 812 pages. (New York City: Wiley & Sons.)

"This volume includes a complete and carefully compiled index of some eighteen engineering publications, including the mining journals, and the transactions of societies. In many cases the references are complete for all volumes from the first date of publication. The book represents a vast amount of research work and will be of great value to the mining profession. The reviewer has had the privilege of using Dr. Crane's card catalogue before publication, and he therefore has no hesitancy in recommending this publication most highly. It is to be hoped that annual appendices will keep the index up to date."—*Mines and Minerals*, Sept., 1909. (A. R.)

Bailey, C. H. First Stage Inorganic Chemistry (Theoretical). Edited by William Briggs. 4th Edition. Cr. 8vo., pp. 257. *W. B. Clive.* 2s.

Ball, Sir Robert S. The Earth's Beginning. New Edition. 8vo., pp. 400. *Cassell.* 7s. 6d.

Bausor, H. W. First Stage Inorganic Chemistry (Practical). Revised Edition. (Organised Science Series.) Roy. 16mo., limp. *Clive.* 1s.

Belden, A. W., Delamater, G. R., and Grovees, J. W. Washing and Coaking Tests of Coal at the Fuel Testing Plants, Denver, Colo., July 1, 1907, to June 30, 1908. (Bulletin U.S. Geological Survey.) 2 Plates and Engravings. 8vo., sd. *Wesley.* 1s. 6d.

British Standard Specification and Sections of Steel Fish Plates for British Standard Bull Head Railway Rails, etc. Folio, sd. *C. Lockwood.* Net 10s. 6d.

Burrows, J. S., and Randall, D. T. Results of Purchasing Coal under Government Specifications. With a Paper on burning the Small Sizes Anthracite for Heat and Power Purposes. (U.S. Geological Survey Bulletin.) 8vo., sd., pp. 44. *Wesley.* Net 1s. 6d.

Clowes, Frank, and Coleman, J. B. Quantitative Chemical Analysis. 8th Edition. 8vo., pp. 590. *Churchill.* Net 10s. 6d.

Kelsey, W. R. Continuous Current Dynamos and Motors and their Control. 2nd Edition. Cr. 8vo., pp. 354. *Tech. Pub. Co.* Net 7s. 6d.

Macfarlane, Walter. Laboratory Notes on Iron and Steel Analysis. Cr. 8vo., pp. 478. *Longmans.* Net 7s. 6d.

Marks, Lionel S., and Davis, Harvey N. Tables and Diagrams of the Thermal Properties of Saturated and Superheated Steam. 8vo. *Longmans.* 7s. 6d.

Maxim, James L. The Apprentice's Course of Experimental Physics and Mechanics. For Preliminary Technical Students and Secondary School Pupils. 12mo., pp. 126. *Longmans.* 1s. 6d.

Standard Specification for Ammeters and Voltmeters. Folio, sd. *C. Lockwood.* Net 2s. 6d.

Standard Specifications for Keys and Keyways. Folio, sd. *C. Lockwood.* Net 2s. 6d.

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Workshop Receipts for Manufactures and Scientific Amateurs. Vol. 2. New and thoroughly Revised Edition. Cr. 8vo., pp. 550. *Spon.* Net 3s.

Selected Transvaal Patent Applications.

RELATING TO CHEMISTRY, METALLURGY AND MINING.

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

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

(C.) 484/09. Henry James Shedlock Heather. An improved method of automatically isolating damaged electrical cables. 27.10.09.

(P.) 485/09. Richard Wild. Vacuum brake for mine cages or skips. 28.10.09.

(P.) 486/09. Charles Robert Bishop A new and improved lubricant mixture. 28.10.09.

(P.) 488/09. Richard Colson. Improvements in apparatus or means for use in surveying mine stopes and the like. 28.10.09.

(P.) 489/09. William Berthelson. An improved chuck for fastening drills in rock drilling machines and the like. 29.10.09.

(P.) 490/09. Fritz Wagner. Improvements in means for obviating the vibrations of main pressure actuated valves. 29.10.09.

(C.) 493/09. William Rees Bevan (1), Daniel Thomas Morley (2). Improvements in nut locks. 29.10.09.

(P.) 497/09. John Whitford (1), James Amos Mills (2). Improvements in means or devices for loading skips or other vehicles in mine shafts and the like. 1.11.09.

(P.) 499/09. Robert Drew. Improved holding jack for idle battery stamps. 1.11.09.

(P.) 502/09. Henry James Shedlock Heather. An improved method of automatically isolating damaged electrical lines or sections of lines. 2.11.09.

(C.) 503/09. John Scarisbrick Walker (1), Thomas Ashcroft Walker (2), Edwin Robert Walker (3). Improvements in or relating to valves for blowing engine compressors and the like. 5.11.09.

(P.) 504/09. Kenneth Oldham Powrie. Surveying instrument. 5.11.09.

(C.) 505/09. Charles Allen. Slime separator and classifier. 6.11.09.

(P.) 506/09. Walter Williams Wright. A gradual safety brake for use on mine cages, lifts and the like. 8.11.09.

(P.) 507/09. James Ernest Horsfield. Improvements in nozzles and the like. 8.11.09.

(P.) 509/09. Francis Joseph Watts (1), Fraser Frederick Alexander (2). Improvements in electrically actuated apparatus for cleaning and scouring amalgamating plates or surfaces. 10.11.09.

(C.) 510/09. Charles Desmarais (1), Michael John O'Brien (2). Core extractor for mining drills and the like. 10.11.09.

(P.) 511/09. Sidney Sherrard Osborn. Improvements in tube mill linings. 10.11.09.

(P.) 512/09. William Cullen (1), Eric Hartwig Weiskopf (2), British South African Explosives Co., Ltd. (3). Improvements in nitro-glycerine explosives. 10.11.09.

(C.) 513/09. Claude Albermarle Bettington. Improvements in and relating to apparatus for pulverising coal and other materials. 12.11.09.

(C.) 514/09. Harry August Stockman. Improvements in means or apparatus for disintegrating ores, minerals and other materials, and recovering the metal or other contents thereof. 12.11.09.

(C.) 515/09. Howard Robard Hughes. Drills. 12.11.09.

(C.) 516/09. Donald Barnes Morison. Improvements relating to cooling towers. 12.11.09.

(C.) 518/09. Frank Humphris. Improvements in and relating to toothed driving gear. 12.11.09.

(C.) 519/09. Bernhard Baron. Improved means for charging smoking pipes. 12.11.09.

(P.) 520/09. Thomas Henry Bradbury. Improvements in electric resistance furnaces. 12.11.09

(P.) 521/09. David Robert Colman. Improvements in means or apparatus for depositing mine residues or other material upon mine dumps or other depositing sites. 13.11.09.

(P.) 522/09. John Whitford (1), Joseph Amos Mills (2). Improvements in means for changing vehicles traversing mine shafts. 13.11.09.

(P.) 523/09. George Taylor Philip (1), Arthur Chichele Plowden (2). Improvements in or relating to couplings for trucks and other vehicles. 15.11.09.

(C.) 524/09. Frederick Godfried Carl Rincker (1), Louis Wolter (2). Improved method of and means for obtaining gas from tar oil and the like in gas producer plant. 16.11.09.

(P.) 525/09. Alfred George Newkey Burden. Improvements in guides for the stems of the stamps of stamp mills. 17.11.09.

(P.) 526/09. Edward Henry Croghan. Extraction of litharge from used cupels. 19.11.09.

(P.) 527/09. Sidney Rickman Adams. Improvements in means for regulating or shutting off the underflow from de-watering and classifying cones and the like. 19.11.09.

(P.) 528/09. Joseph Henry Dobson. Electric heat accumulator. 19.11.09.

(C.) 529/09. Allan Macpherson. Apparatus for generating and storing petrol and like gas. 19.11.09.

(C.) 530/09. Arthur Owen Jones. Improvements in or relating to coke ovens. 19.11.09.

(C.) 531/09. Arthur Owen Jones. Improvements in or relating to coke ovens. 19.11.09.

(C.) 532/09. Arthur Owen Jones. Improvements in or relating to coke ovens. 19.11.09.

(C.) 533/09. Arthur Owen Jones. Improvements in and means and appliances for discharging and conveying away the coke product from vertical coke ovens or gas retorts with base discharge. 19.11.09.

(P.) 534/09. Edmund Arthur Hamblin. An improvement in or relating to the method or manner of uncoupling railway engines, carriages, trucks or vehicles of any description. 20.11.09.

(P.) 535/09. Frederick Walter Cindel. Improvements relating to stamps. 20.11.09.

(P.) 536/09. George Watt. Tool for shaping rock drills. 22.11.09.

(P.) 538/09. John Wilkinson Kirkland. Improvements in electrical hoi-ting apparatus. 23.11.09.

(C.) 539/09. John Turns. An apparatus for the storage and compression of air gases and liquids under pressure. 23.11.09.

(P.) 541/09. Victor Frolich. Improvements in means for operating gravity stamps. 24.11.09.

(P.) 542/09. Hugh McMenamin. Improvements in means for feeding ore to the stamps of stamp mills. 24.11.09.

(P.) 543/09. Douglas William Stacey. An improved filter for cyanide solutions. 24.11.09.

(P.) 546/09. Charles Harrison Dixon (1), William Beaver (2). Mechanical finger for receiving and holding gravity stamps when idle. 25.11.09.

(C.) 547/09. Oscar Clarence Beach. Improvements in grinding mills. 26.11.09.

(C.) 548/09. Robert Lemmon (1), Robert Patrick Holmes (2). Automatic Filter press. 26.11.09.

(C.) 549/09. Claude Albermarle Bettington. Improvements relating to steam generators. 26.11.09.

(C.) 550/09. Paul Brenner (1), Otto Hoffmann (2). Improvements in a self acting valve for pumps and similar devices. 26.11.09.

(P.) 551/09. Kenneth Bingham Quinan. Improved means for facilitating the complete detonation of gelatinous nitro-glycerine explosives. 29.11.09.

(C.) 552/09. Edward James Mahood. Improvements in apparatus for raising and lowering the propeller in that class of agitating apparatus in which a propeller is used as the agitating medium. 30.11.09.

(C.) 553/09. Alexander Albert Holle. Improvements in steam and other fluid turbines. 30.11.09.

(P.) 554/09. Frederick Hudson Shepherd Shepherd (1), Justinian Myer Cohen (2). Improvements in apparatus for drilling or boring holes by hand or other power for mining and the like operations. 1.12.09.

(P.) 555/09. Gustavus Adolphus Sheeley. Improvements in linings for tube and similar mills. 1.12.09.

(P.) 556/09. James Wilson McNicol. Improvements in jockey or rope grips for mechanical haulage. 3.12.09.

(P.) 557/09 Alfred Sidney Colam. Improvements in side or end discharge trucks. 3.12.09.

(C.) 559/09. Loftus Gray. Explosive compound and process for making same. 3.12.09.

(P.) 562/09. Cecil Francis Webbe (1), Peter David Voigt Alexander (2). Improvements in jockeys or rope grips for mechanical haulage. 4.12.09.

(P.) 563/09. Hugh Ross (1), George Richard Mayor (2). Miss-fire proof paste. 6.12.09.

(P.) 564/09. Andrew Swan. An improved apparatus for the separation of liquids from finely divided solids. Particularly applicable to the treatment of gold slimes, ore slimes and the like. 6.12.09.

(P.) 566/09. Robert Allen. Improvements in apparatus for filtering or clarifying liquids. 8.12.09.

(P.) 567/09. Hans Charles Behr. Improvements relating to clutches suitable for winding engine drums. 8.12.09.

(C.) 569/09. Hugo Philip Crush. An improved method of and apparatus for filtering liquids. 10.12.09.

(C.) 570/09. Alfred Moffitt Sedgley. Improvements in centrifugal pump, filters and strainers. 10.12.09.

(C.) 571/09. Hugo Ruth. Improvements relating to reciprocating feed troughs. 10.12.09.

(C.) 572/09. Lewis Condict Bayles. Improvements in direct acting engines. 10.12.09.

(C.) 573/09. William Edward Bandfield. Improvements in the attachment of telegraph and similar line wires to insulators. 10.12.09.

(C.) 574/09. John Collins Clancy. Treatment of precious metalliferous ores. 10.12.09.

(C.) 575/09. Thomas Julian Barre. An improvement in valves. 10.12.09.

(P.) 576/09. David Gilmour. Improvements in fixing cam pulleys to cam shafts. 13.12.09.

(C.) 577/09. Henry Livingstone Sulman (1), Henry Howard Greenway (2), Arthur Howard Higging (3). Improvements in or relating to the concentration of ores. 15.12.09.

(P.) 578/09. Arthur George Taylor. Improved apparatus for interlacing wires. 17.12.09.

(P.) 579/09. Hugh McMenamin. Tube feeder. 17.12.09.

(C.) 580/09. Reginold Vanderzee Farnham. Improvements in gas producer plant. 17.12.09.

(P.) 581/09. William Charles Stephens. Improvements in valve mechanism for rock drills and other reciprocating engines. 17.12.09.

(P.) 583/09. Alexander John Arbuckle. Improvements in apparatus for classifying crushed ore products. 18.12.09.

(P.) 584/09. John Sacks. Improvements in the process for production and concentration of acetic acid. 18.12.09.

(P.) 585/09. Henry Wilfred Frewin. An improved amalgam trap. 20.12.09.

(C.) 586/09. Frank Ondra (1), Alfred Adair (2). Improvements relating to the treatment of zinc solutions, for the recovery of metals or metal compounds therefrom. 20.12.09.

(P.) 587/09. Jean Harte. Improvements in detonators. 21.12.09.

(C.) 591/09. Henry Malcolm Caldwell (1), Thomas Smith (2). Improvements in or relating to mears for governing and/or regulating pressure of gas or supply of gas; either with or without an indicator. 24.12.09.

Abstracts of Patent Applications.

(C.) 484/09. Henry James Shedlock Heather. An improved method of automatically isolating damaged electrical cables. 27.10.09.

The application relates to a device for automatically isolating faults on three-phase cables. The applicant proposes to use the Mertz-Price system of balanced current transformers for operating the trip coils, but omits the pilot wires and connects the secondaries of the current transformers in series with the trip coils directly across the lines.

(C.) 445/09. Edward Farrar. Improvements in classifying and concentrating apparatus. 30.9.09.

This application relates to a classifying and concentrating apparatus, including one or more deep and narrow channels which are of considerable length in proportion to their width, and a horizontally disposed plate or plates so adapted as to divide the stream or streams at any desired point.

(P.) 465/08. Charlton Frederic Bayly. Device for regulating the underflow of cones, spitzkasten and the like. 24.11.08.

This is a device for regulating the underflow of pulp from classifying cones, spitzkasten, etc., and consists of a flat iron side, fitting in a box attached to the apex of the cone or spitzkasten. The slide is fitted with a movable bush of the desired diameter of orifice, which is quickly replaceable when worn or a change of diameter is required, by partially withdrawing the slide, bringing the bush beyond the edge of the fixed box where change of bush may be effected.

(P.) 21/09. Frank Gowine Alfred Roberts (1), James Frederick Ferguson (2), Alwine Rupert Troye (3). Improvements in assay furnaces. 13.1.09.

This invention relates to a combined crucible and muffle assay furnace designed for the use of coal or similar fuel, in which the construction of the partition walls are so arranged that the heated gases from the separate combustion chambers serve to mutually heat both muffle and crucible chambers. This purpose is attained by passing the products of combustion through the heating chambers and returning them under the floor of the crucible chamber and along the side of the muffle chamber.

(P.) 57/09. William Arthur Caldecott. A new or improved substance for precipitating metals from their solutions. 3.2.09.

The above application relates to an improved substance for precipitating metals from their solutions, and consists of employing the product obtained by the application of sufficient heat to any carbonaceous matter capable of yielding hydro-carbon compounds and a residue of fixed carbon (such as coal, peat, tar and the like) in order to reform the hydro-carbon compounds, but insufficient to expel all the hydrogen.

The solution is brought into contact with the above substance in any approved manner, the metal being extracted by such contact, and recovered by subsequent burning and treating the resulting ash, or any other suitable method.

(P.) 105/09. Edward Macartney. Improvements in means for distributing tailings or the like on mine dumps, applicable also for other analogous purposes. 4.3.09.

This invention consists of a large and long Archimedean screw, operated by power and enclosed in a box inclined at any angle to give the desired elevation at the discharge end. This apparatus is laid into the tailings dump and projects over the edge of the dump. It may be fed by trucks dumping their contents into the lower open end of the box or may be in use for the full length of the haulage from the tank to the dump.

(P.) 298/09. John Bartle (1), John Miller Anderson (2). Block and tile liners for launders and tube mills. 19.6.09.

This application relates to specially prepared blocks for tube mill lining and tiles for lining launders. The composition of the above is stated as :—

	Per cent.
Slag (boro sodii silicate with base metal oxides and sulphides)	83·3
Iron Filings	8·3
Pot clay	4·2
Sodium borate	4·2
	100·0

In manufacture the slag is broken up and fed into crucible, the other ingredients are mixed and added together and the whole heated to 1,050° C. and run into moulds to whatever shape may be desired.

(C.) 322/09. A. A. Lockwood. Treatment of ores and carboniferous earths and to the treatment of oils to this purpose. 9.7.09.

This specification describes and claims the process of treating ores with an oily liquid and insoluble metallic salts, soap, magnetic iron oxide and sulphate of alumina.

(C.) 433/09. William Stansfield (1), John Joseph Hatt (2). Improvements in and relating to magnet windings of electro-magnetic apparatus. 24.9.09.

This invention has for its object the maintenance of either constant magnetisation or constant voltage in dynamo electric machinery. It is specially applicable to generators for lighting railway trains.

For these purposes the applicants make use of additional exciting coils in combination with resistances composed of selected materials having specially suitable temperature coefficients. They also describe and claim special arrangements of armature conductors in combination with the fields produced as above described.

(C.) 457/09. John Hugh Fortescue. Roller mill concentrate crusher. 6.10.09.

This refers to a roller mill for finer crushing of sands and concentrates consisting of three pairs of steel rolls, one pair above the other. The claims are for the "jigger" table screening apparatus separating sands from slimes, and for springs behind the rollers and set screws for adjusting same.

(P.) 487/08. Alexander John Arbuckle. Improvements in tanks or vessels for separating comminuted solid matter such as pulverised ore from liquid. 11.12.08.

This application relates to the construction of vats or vessels, the main features consisting in providing inside the vat or vessel a certain number of inverted hollow cones, so as to provide a greater settling surface for the deposition of the pulp under treatment, and also in combination with the above an arrangement of upright cones arranged between the uttermost inverted cone and the inside of the vessel. An angle of about 60° is given to the depositing or settling areas thus produced. The patent also includes the form of apparatus in which the vessel comprises an upper cylindrical portion and a lower inverted truncated conical portion containing an internal cylinder and a plurality of inverted truncated cones arranged inside the internal cylinder and cone, as well as an overflow launder to carry the clear liquids obtained during the working of the apparatus.

(C.) 472/09. Bernard Alexander Firth (1), Herbert Henry Ashdown (2). Improvements in or relating to shoes for mining stamps and the like. 16.10.09.

This application relates to the manufacture of shoes for stamp mills, and proposes the use of a grade of metal in the shank differing from that used for the body of the shoe, a comparatively soft metal being used for the former as being less liable to fracture, while a hard metal is used in the body to give greater resistance to wear.

The applicants propose to make the shanks separate pieces, and to secure them to the bodies of the shoes by casting or forging the latter around them and thus securing a permanent connection between the two portions. They claim that this method enables a selection to be made giving hard metal for the body of the shoe and soft tough metal for the shank.

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