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DISCUSSIONS AND CONTRIBUTIONS

The Micropanner—An Apparatus for the Gravity Concentration of Small Quantities of Materials

L. D. MULLER, B.Sc.

Report of discussion at October, 1958, General Meeting (Chairman: Mr. J. B. Dennison, President). Paper published in October, 1958, pp. 1–7

Mr. L. D. Muller said that there was one point which at the outset it was necessary to establish beyond any possibility of doubt. The micropanner was based almost entirely on Haultain's well-known superpanner and to Professor Haultain must always go the credit for developing that extremely valuable mineral dressing tool. The micropanner in no way represented an attempt to supersede the superpanner or its functions in the mineral dressing laboratory—for that would not be possible. It should be regarded as complementary to the superpanner in that it was designed to operate with weights of material below those normally used with that machine. It was, in fact, primarily intended for use with milligram quantities of materials and as such was directed to the mineralogy-petrography fields rather than to that of mineral dressing.

Some time ago the Mineral Dressing Group at Harwell was approached with a request that an attempt be made to concentrate, to a 100 per cent grade, some of the very fine zircon present in a vermiculite-type gneiss. The rock was stated to contain major mica, rutile, and kyanite, with about 0·1 per cent zircon. As the zircon was eventually required for age-determination studies, the request was made that rigorous precautions should be taken against the possibility of contamination by lead. It was thus thought preferable to exclude, at any stage, the use of Clerici solutions, which would otherwise have been used, since it had been found on analysis that Clerici solution contained about 0·1 per cent Pb; hence only mechanical gravity and magnetic separation could be used in that instance.

The superpanner did much of the initial work of separation and produced small but high-grade concentrates of the -50μ zircon. Unfortunately, in attempting to reclean the very small concentrates to the required 100 per cent grade, it was found that they tended to disappear by dispersing over the relatively large deck area of the superpanner. It therefore became obvious that a much smaller deck possessing finer controls, particularly with regard to wash water, was required. Thus the micropanner came to be developed. The fact that it eventually proved small enough to be operated on the stage of a stereoscopic microscope was almost incidental, but that had at times proved of value when dealing with very fine material.

A word of explanation should also be given for including in the paper a brief description of some of the more basic principles of separation as effected by superpanner and micropanner. Though those completely familiar with the superpanner and gravity tables might regard it as rather unnecessary, experience had shown that there were many who might wish to use the micropanner who were, in fact, quite unfamiliar with the subtleties of film-sizing, etc. Furthermore, a concise account of exactly why the panner worked had not been found. There were accounts of how it was operated, but there did not appear to be any description of the factors which actually controlled separation. All references which had been discovered, with the possible exception of a note by Edwards (ref. 8 of original paper), tacitly assumed that knowledge; even Haultain, in his first paper on the superpanner, made the same assumption.

Mr. S. W. F. Patching said that a number of techniques had been developed in the Mineral Dressing Group at Harwell for the purpose of assisting both mineralogical and ore-treatment studies. It was felt that others might be interested in the apparatus and methods devised, and three papers, the first of which Mr. Muller had now presented, were planned. It was hoped to submit the others in the near future.

As described, the micropanner did not represent a final design. Nevertheless, in its present form it had certainly well justified its construction and it was in regular use for both mineralogical and mineral dressing experiments. A point of design, for which improvements might be expected, was the motion and a start had already been made to obtain data for an attack on that problem. Not unexpectedly, perhaps, the study had already involved not only the superpanner, but also the concentrating tables. It was quite possible that further investigation of the deck forms might well repay the time and trouble spent on that aspect of design. The apparatus was not difficult to operate and it was not very costly to make. The prototype, which was on view, was constructed from Meccano parts. It was still usable equipment and was not preserved purely as a museum piece.

It was not easy to suggest the best use for the micropanner, but as the Mineral Dressing Group and others who might be induced to try it gained experience, it was hoped to produce other interesting applications. He, himself, had been particularly impressed with the separations made in the fine particle ranges below 30μ and by the small gravity differentials on which those operations could be successfully carried out.

Mr. C. C. Dell said that the micropanner might well become one of the standard pieces of equipment in a petrographic laboratory. By placing heavy minerals in order of their density, even if it could only be done imperfectly, the task of identifying them was greatly simplified. Mineralogists would welcome, too, a method which avoided the use of highly toxic dense liquids. The superpanner was necessary for removing the large bulk of gangue, while the micropanner had a clear role in placing heavy minerals in order of their density under the microscope stage. The superpanner could do that, of course, but not under the microscope stage. Furthermore, it could not be used so easily with heavy liquids without using a very large quantity.

Mr. Muller's technique clearly left little room for refinement, but the

speaker suggested that marker minerals of known specific gravity might be mixed with the feed if identification proved difficult. The specific gravity of any unknown mineral could then be easily bracketed between marker minerals. Another suggestion was that as an alternative to sideways shake for producing an open-bed structure, that structure could be produced by passing an upward current of water through the deck if the latter were made of porous ceramic. Nowadays, there were available very fine-grain porous ceramics the structure of which was such that they possessed surprisingly high porosity and would be quite suitable for the purpose. His own work on the stratification of fine coal indicated that some upward current always had an advantage in assisting stratification.

Mr. Muller, in reply to Mr. Dell, said that he had not considered using the micropanner as a means of identification on the basis of specific gravity, but by using marker minerals as suggested no doubt that use was possible. Neither had he considered the use of rising currents through a porous deck, the potentialities of which it was difficult to assess without further thought and experiment; probably the upward currents might be difficult to control. Further, in the operation of either the superpanner or the micropanner, it was essential to have the heavier minerals in contact with the deck, otherwise they would not be moved towards the head to form a tip. If they were continuously subjected to rising currents that might well interfere with the separation; in addition the problem of feeding an even and continuous supply of water along the base of a reciprocating deck would be difficult.

Mr. S. W. F. Patching said that he regarded the freedom of movement of particles in the bed as a part of the problem to be faced in investigating motion, and the function of the sideways motion on the micropanner, as well as the actual head motion, had been very much in mind. It had been thought that the types of motion which were put on to the panner were similar in basic principles to those of the Haultain panner and were adequate for keeping the minerals in suspension so that effective separation could take place. The point still remained, however, that for the accumulation of a head of heavy mineral it was necessary to have the heavy particles in contact with the deck, otherwise it would not be possible to achieve concentration.

Dr. E. Cohen* congratulated the author for having produced a machine which was not simply a development from Haultain's superpanner but represented a considerable mechanical improvement. The Haultain superpanner was in some respects a little beyond the control of the operator. It produced certain water movements which could not be suppressed and which often caused the loss of a concentrate after the latter had been laboriously produced by previous adjustments.

It was therefore perhaps surprising that the author had in principle retained the mechanisms that were so characteristic of the Haultain superpanner. One had in mind particularly the transverse shaking motion, the

*Lecturer in Mineral Dressing, Royal School of Mines.

only purpose of which was to keep the bed alive by preventing the particles from settling down on the deck. Since the sideways motion affected the water more strongly than the ore particles, there resulted generally a complex pattern of transverse waves which swept particles backwards and forwards, not always in the best manner for achieving a clean separation. He asked if the author had investigated the possibility of using a sideways vibration in place of the mechanical shake. A vibration of a very much higher frequency and shorter amplitude would tend to have the same effect of keeping the bed in suspension without causing lateral movement of the water. As a result, the order in which minerals arranged themselves on the deck would be less disturbed by such a mechanism.

The author compared the superpanner to a shaking table and it should be noted that to all intents and purposes it might, indeed, be treated as a section of a shaking table which could be used to simulate table performance in the study of tabling phenomena. He wondered if the author had considered the possibilities of introducing riffles on the micropanner deck to simulate the important reverse classification and stratification effects which occurred on the shaking table in addition to film sizing. Those effects might be helpful in producing an adequate separation of heavy minerals, because once a heavy mineral had found its way up the deck into a given pocket, it would tend to remain there and escape the downward flow of wash water.

He thought that a particular application of the micropanner would lie in investigating treatment of ores by means of table flotation, which was a rather neglected branch of mineral dressing. For example, table flotation had been introduced successfully at the Geevor mine for treating cassiterite ores and it could probably find wider use with other ores where density differentials between values and gangue were low. The small micropanner, which was so much more controllable than the superpanner, appeared ideal for laboratory testing of the amenability of ores to table flotation.

Mr. M. J. Cahalan said that, as Dr. Cohen had suggested, the micropanner might have a useful application for the study of some fundamentals of gravity separation. Regarding its use for separating minerals in order of specific gravity, however, there appeared to be serious limitations in using a piece of equipment of that nature in preference to heavy liquids. Although heavy liquids did, of course, possess certain drawbacks, by and large they were likely to be more precise. The shape factor was involved when making separations with the superpanner or the micropanner and considerable experience in concentrating samples on the micropanner was essential before valid conclusions could be drawn. It was, therefore, a tool that would require a considerable amount of experience on the part of the investigator, whereas heavy liquids were precise in themselves.

The use of heavy liquids to improve the concentration criterion was a novel feature of the work described. It might one day conceivably be the basis of a commercial process with some of the more exotic minerals. That would justify further investigation and it could certainly be included in the fundamental studies of gravity concentration in the use of the micropanner. He wondered what would be the effect of a change in viscosity related to the use of the heavy liquids instead of water.

Dr. D. R. Grantham asked what was the percentage recovery the author was able to get. Naturally, the answer would depend upon the specific gravity difference, but it was possible that the author might be able to give an indication.

Mr. J. R. Stevens,* replying to Mr. Cahalan, said that he had had the opportunity of submitting superpanner concentrates to the author for separation and could give an assurance that the time factor in the use of the micropanner as opposed to that using heavy liquids was very much in favour of the micropanner.

Dr. Cohen added that heavy liquids were excellent because they eliminated the size factor but they had limitations when dealing with minerals of fairly high density. Often, one did not merely want to separate heavy minerals from light minerals, but minerals which had a density of, say, 7 from those with a density of, for example, 5. Heavy liquids were fairly useless in that range, whereas the micropanner was independent of such limitation. It had, however, its own shortcomings imposed by particle size and particle shape and it was probably impossible to get a good recovery—say, 80 to 90 per cent recovery—of any given mineral unless all the mineral particles were of nearly the same size and shape. Generally there was bound to be an overlap between successive mineral bands, as might be seen in most of the illustrations given by the author.

It seemed that on the whole one could expect a good qualitative separation rather than a complete quantitative separation with most mineral mixtures.

Mr. Muller, in reply, said Dr. Cohen had suggested the use of vibration rather than side-shake on the micropanner. The superpanner was provided with a differential side-shake which could become quite violent, whereas on the micropanner the side-shake had been replaced by a much gentler sideways motion. Experience had shown that that motion did not appear to play a major part in keeping the bed dilated. However, the micropanner was operated at a relatively high rate of reciprocation, i.e. normally 350 to 550 strokes/min—a much higher rate than in the case of the superpanner. It was thought that that high rate of operation did more to keep the bed dilated than did the sideways motion. The high rate of reciprocation might well be regarded as a form of low-level vibration.

Mr. Cahalan had suggested that the micropanner might be used for fundamental studies of gravity separation. The application of the tool to such studies had not been envisaged but might well be useful. He agreed that heavy liquids were much more precise in use when it was desired to cause separation of minerals. As Dr. Cohen had pointed out, however, it was not possible with heavy liquids to deal with minerals having specific

*Senior Experimental Officer, Mineral Dressing Group, Atomic Energy Research Establishment, Harwell.

gravities beyond 5, although it might be possible to do something with heavy media. The effects of viscosity when using heavy liquids and its effect upon concentration criteria had not been considered.

Dr. Grantham had asked about the order of recovery obtainable on the micropanner. In separating the zircon from the vermiculite-type gneiss, no attempt had been made to obtain a high recovery. The specific task in that instance had been to obtain a 100 per cent grade. Only a small quantity of zircon had been required and there had been a reasonable amount of head material available. Too much attention had not, therefore, been paid to recovering all possible zircon, though the recovery had probably been of the order of 50 per cent. On that type of equipment recoveries were basically dependent upon existing gravity differentials and, in certain instances, including the first example cited in the paper, recoveries could be as high as 100 per cent at almost 100 per cent grade.

In that context it might be worth while recalling that the Lake Shore staff, who used the superpanner to a large extent in some of their work reported in 1936, claimed that it could be used quantitatively down to 14μ. In that instance, they were separating high-gravity minerals from normal gangue minerals and that claim would appear quite reasonable.

Sinking No. 2 Shaft Harmony Gold Mining Co., Ltd., O.F.S.

S. C. NEWMAN, B.Sc. (Eng.), M.A., ASSOCIATE MEMBER

Report of discussion at October, 1958, General Meeting (Chairman: Mr. J. B. Dennison, President). Paper published in September, 1958 (Transactions, *vol. 67, 1957–58), pp. 605–637*

The President explained that Mr. Newman was unable to be present, being engaged very much on the job at Harmony. The Institution, however, had the privilege of having the paper introduced by Brigadier Stokes, who was a director of the big group of which Harmony was a part.

Brigadier R. S. G. Stokes, in introducing the paper, said that Mr. Newman greatly regretted that he could not attend, but he had had to return to South Africa where he had taken up an appointment at Head Office. The paper had been well summarized in the synopsis, introduction and conclusions. Therefore, to avoid repetition, he proposed

to confine himself to giving members something of the South African background and to discussing those features which were most commonly subject to discussion.

It was appropriate to mention that circular shaft-sinking was introduced into South Africa by a Past-President of the Institution, the late Hugh F. Marriott, when he 'exported' the know-how, personnel and plans from the United Kingdom some 46 years ago. The fact remained, however, that all the big advances in technique which had been recorded, including the doubling of sinking speed, belonged to the last few years. Since the war some 60 new vertical shafts had been sunk or started upon the Witwatersrand gold fields, which now extended from Winkelhaak to Virginia, whatever might be decreed to the contrary by non-geological authorities.

Only four circular shafts—at Hartebeestfontein, Harmony and St. Helena—had as yet been sunk with concurrent equipment, but at Harmony alone had this practice been combined with mechanical lashing throughout. At Hartebeestfontein, shaft diameters were 21 ft and hand-lashing was thus economically practicable. At St. Helena, a grab was used only in the shallower depths. In the new shaft now being sunk, at Riebeeck, the Harmony practice with both concurrent equipment and mechanical lashing had, significantly, been adopted.

Concurrent equipment in circular shaft-sinking had long been recognized as a final objective by South African mining engineers. After all, it was this function, together with the ease of bratticing, which allowed the old rectangular timbered shaft to survive as long as it did. Initially, the 60 shafts mentioned were mostly rectangular. There had been a few elliptical, but new shafts were now exclusively circular, whether in the Klerksdorp or the more difficult Orange Free State area.

It would be of interest to refer to some of the main features of modern practice covered by the author, especially in regard to prospects of standardization.

Headgears and winders.—The erection of the permanent headgear and winders, before full-scale sinking, had become a *sine qua non.* There was certainly no standardization of engine types, but square and circular concrete headgears had now gained general acceptance.

Shaft sizes and compartments.—Diameters were now fairly well standardized at 24 or 26 ft for main shafts and 18 or 20 ft for ventilation shafts. Saaiplaas at 27 ft 6 in. was exceptional. There was, however, a wide variation in the arrangement of the rock, man and service compartments, which could not altogether be related to differences of underground condition.

Twin versus widely separated shafts.—When the question of sinking twin shafts was confined to that of providing two initial shafts for a new mining area, with some measure of exploration involved, opinions differed sharply. The decision to sink one pair of twin shafts only, might be speculative without adequate knowledge of zonal grade conditions.

Early extraction of shaft pillar.—The author had dealt most impartially with this keenly-debated question. The speaker's own view was that the 1000-ft diameter shaft pillar—tying up, say, 250 000 tons of ore—could

The Micropanner—An Apparatus for the Gravity Concentration of Small Quantities of Materials

L. D. MULLER, B.Sc.

Contributed remarks on paper published in October, 1958, pp. 1–7

Mr. F. B. Michell: While congratulating the author for having produced a piece of apparatus which should be a useful aid to mineral identification, particularly when small quantities only are available, I think it is also pertinent to call attention to the much maligned 'vanning shovel' as a rapid means of identification. In the hands of an experienced operator (and it is quite wrong to suppose it takes a lifetime to become proficient) it is possible to put minerals in the order of their specific gravities and to examine each band under a binocular microscope. Alternatively any desired cut can be removed by a pipette, such as is used with a superpanner, for further examination. This technique has been in use at Camborne School of Mines for some years, as it is much more speedy than the superpanner. Using very carefully controlled tests at a tin mine, scarcely any difference was found in the actual recovery between the vanning result and one obtained by a standard superpanner.

Dr. Cohen has mentioned the possibility of employing the micropanner for carrying out amenability tests for table flotation, but I think the size range usually suitable for this method of concentration is likely to be too large for a micropanner.

Over a number of years I have found the best method for the preliminary evaluation tests is simply to wash a conditioned sample on a large watch glass, a plaque, or a vanning shovel, 'pitching' the high specific gravity minerals forward and washing the floating minerals back with a small stream of water and carefully allowing them to overflow the pool. Flotation is often aided by impinging a small jet of air on to the surface as in commercial operation. In this way it has been found that results very closely approximating those obtained in plant practice can be realized.

OBITUARY

William Bullock died on 2nd March, 1958, at the age of 82.

He was born and educated in Norfolk, and from 1891 to 1896 was apprenticed to the Ceres ironworks at Kingston-on-Thames, Surrey, spending the final year as a draughtsman. He then began a long association with Fraser and Chalmers, Ltd., first as tracer and draughtsman in the mill department, Erith.

Mr. Bullock spent four years from 1900 to 1904 as engineer with Messrs. Lake and Currie, consulting engineers, gaining experience on his tours in Angoulême, West Africa, Western Siberia, and California, and in the designing of the Broomassie plant, West Africa, and the Nile Valley plant, Egypt. About this time he took a course in surveying and studied geology and mineralogy at the Birkbeck Institute in London.

Returning to the drawing office at Fraser and Chalmers in 1904, he was in charge of designing on mill work in the mining section until 1910, when he was transferred to the London sales department for four years. Mr. Bullock was then appointed chief of the mining and metallurgical section at Erith, and in the following eight years erected a gold crushing and cyanide plant in the south of France and visited installations in many parts of the U.S.A.

He worked for a year in 1918–19 with the British Sintering Co. in London, and from 1919 to 1925 was general manager of Sandycroft, Ltd., near Chester.

Mr. Bullock returned to Fraser and Chalmers Engineering Works at Erith in 1925, again taking charge of the mining and metallurgical section, and during the next twenty years in this position he inspected a number of low-temperature carbonizing plants in Great Britain, Italy, Germany, Belgium and France, and sintering plants in Norway and Sweden. He designed gold dredges for French West Africa and the Belgian Congo, copper concentrating and smelting plant for Russia and India, and gold plant for West Africa, Spain, Peru, the Belgian Congo and Yugoslavia. He also visited Rhodesia.

He retired from active work in 1945, but was retained as a consultant for his section at Erith until 1953. He lived near Hastings in Sussex, and for some time before his death had suffered ill health.

Mr. Bullock was elected an Associate Member of the Institution in 1913.

Alfred Fox died on 19th April, 1958, at the age of 79.

He was educated at the City of London School and received his professional training at the Royal School of Mines from 1896 to 1900, obtaining the Associateship of the School in mining and metallurgy.

He took up the appointment of assistant mining engineer at Cwmystwyth mines, Cardiganshire, in August, 1900, and was promoted mining engineer in the following year. He left for Peru in 1902 to join Caylloma Silver Mining Co., Ltd., as assistant mining engineer, and took charge of the amalgamating mill, but in 1903 was appointed general manager and chief engineer to the company, holding this position for eleven years.

Mr. Fox served with the B.E.F. in France during the 1914–18 war as captain in the Royal Field Artillery, 12th Division, and was decorated with the Military Cross. On demobilization in 1919 he joined Messrs. Graham Rowe and Co., Ltd., of Liverpool, as their chief engineer, and was engaged on the design, purchase and shipment of power plant and machinery for mines and estates in Peru, Chile and Bolivia. He remained with the firm until his retirement in 1933.

He was admitted to Studentship of the Institution in 1898 and was transferred to Associate Membership in 1904. He was also a member of the Institution of Civil Engineers, to whose transactions he contributed.

The Micropanner—An Apparatus for the Gravity Concentration of Small Quantities of Materials

L. D. MULLER, B.Sc.

Author's reply to discussion on paper published in October, 1958, pp. 1–7*

Mr. L. D. Muller: Mr. S. W. F. Patching, in his opening remarks, commented that though the micropanner was in regular use, further work was in hand to obtain data which might be expected to lead to an improvement in the deck motion and thus to a further increase in operating efficiency. As a result of this work a new driving cam has now been designed and this imposes an almost ideal motion on the deck. However, the cost of the modified cam may not justify its inclusion in the existing apparatus.

Dr. Cohen suggested that the transverse motion applied to the deck of both the superpanner and micropanner was a factor mitigating against the efficiency of separation. This suggestion has been followed up by operating the micropanner with no sideways motion, the relatively high rate of reciprocation being relied upon to maintain an open bed. First results showed promise but further work needs to be done along these lines.

I would like to thank Mr. F. B. Michell for his contributed remarks. The vanning shovel is, in experienced hands, a very useful tool for achieving a rapid *separation* of mineral species as an *aid* to identification, but it is not, in itself, a means of identification. The micropanner can, of course, be used in the same way as the vanning shovel but it is much more difficult, even with great experience, to use the vanning shovel to separate particles in the size range from 20μ down to 7μ which has been demonstrated to be readily achieved with a micropanner. A further point is that the quantities of material dealt with on a vanning shovel are usually larger than those commonly applied to micropanner operations and are, in fact, those normally associated with a superpanner. I rather assume, in fact, that Mr. Michell is really comparing the vanning shovel with a superpanner and not a micropanner. In that case it is of interest to note that Professor Haultain,† in his paper introducing the superpanner, although admitting to a strong liking for the vanning shovel and expressing a regret that it is not more widely used, nevertheless realized its shortcomings and found it desirable to produce another tool, namely, the superpanner.

*pp. 95–100, 224.

†*Trans. Canad. Inst. Min. Metall.*, **40,** 1937, 229–40.