There was another point. He was afraid Mr. Judge's remarks would lead one to believe that manufacturers had been very negligent in taking advantage of the opportunities offered, but that was not so. There was quite a considerable amount of material of that class being made in the country at present, such as asbestos sheets, tiles, ridging, gutters, and, if he was not mistaken, even corrugated sheets were being made here, and not very far distant from Johannesburg, also by a firm down at Durban, and, he believed, by one at Capetown. Their production was relatively small, and it was true the bulk of what was used here was imported. They knew the Government was very anxious to encourage industries, and, he believed, it was taking certain fiscal steps in that direction. At present users, they found, were not at all keen on using the local product if they could get an imported one. There was a certain amount of justification for that. They were pretty sure the imported article had stood the test of time, and they did not want to make an experiment. But, of course, everything had to go through the experimental stage, and he thought it was incumbent on users to give the local product a fair chance, in view specially of the fact that the price was not materially different. He believed, near the factory, they would get the local product as cheaply as the imported one. He did not think the price, as compared with galvanised iron, was quite so divergent; he thought it was probably nearer three times than five times as dear, and, in view of its extra life, he thought it was certainly better in most cases to use material of that nature rather than galvanised iron, which required frequent painting.

He thought Mr. Whitby's trouble was due to the importance which chrysotile had taken in place of the old actinolite asbestos, which, they were told, was of the non-hydrated variety. Its physical properties were certainly good; but the chrysotile was so much better for many purposes that everybody naturally preferred it. It had practically displaced the old original asbestos, if he might so term it, from the markets, He had had just the same trouble as Mr. Whitby complained of. He found the only way to get over it was to secure a sample of the old actinolite asbestos, which one could from any mineral dealer, and prepare it oneself.

MINERAL CONSTITUENTS OF RAND CONCENTRATES.

By R. A. Cooper.

Metallurgical practice on the Witwatersrand has recently turned from the method of removal of free gold from the ore by means of amalgamation to the attainment of the same object by a preliminary concentration on corduroy followed by a further cleaning of the concentrate by one or more passages over a table of the Wilfley type. The utlimate concentrate may then be treated with mercury to recover the gold; osmiridium being obtained from the tailing after barrel amalgamation and before final cyaniding or other treatment to recover the gold which may have escaped amalgamation.

In the absence of osmiridium the gold may be cleaned sufficiently to allow of direct smelting.

From the inception of corduroy and Wilfley concentration it became apparent that the concentrates were often very far from being the simple mixture of gold quartz and pyrites that association with ordinary ore samples or even black sands has led us to expect. We have long known from examination of rock specimens that occasionally pockets of such minerals as zinc blende and galena occur in the reef, the latter material being sufficiently heavy to accumulate in concentrates, but visual examination of picked specimens naturally fails to indicate the presence of minerals which even ordinary methods of analysis would hardly reveal in unconcentrated material. Minerals occurring in the reef in such minute quantities that they have appeared to be of only slight scientific and of no practical interest have suddenly become important constituents of the very considerable quantities of concentrates which we handle daily. Osmiridium, once regarded merely as a special curse visited upon assayers, is now of real economic interest. I am afraid that other minerals which I will discuss are quite capable of taking the place once occupied by osmiridium as a curse not only of assayers but also of metallurgists.

My first experience of one of these minerals was a sample taken from one of the mines of the Far East Rand; it was first noticed on the Wilfley tables just below the gold, and was christened the "Blue Streak."

Later an enthusiastic investigator brought in a large quantity of the material with the claim that it was osmiridium and could be obtained from one mine at least in bucketsful!

It proved, however, to be an interesting arsenide of cobalt and nickel, mixed with galena and pyrites—a fruitful source of trouble and expense during smelting operations, where its habit of producing matte and speise, the former rich in silver and gold and the latter in platinum metals and gold, is most undesirable. It is probably also a cause of much of the coated gold and sickened amalgam met with during barrel amalgamation, especially when the material is ground to an impalpable pulp before adding the mercury. Some of this arsenite dissolves in cyanide solutions, is precipitated on the zinc, and appears in acid-treated gold slime which therefore requires very careful roasting. We have often listened to very interesting papers on the treatment of arsenical ores without quite realising, I think, that we may be handling them here.

I have a bottle of this arsenical concentrate for your examination, and you will notice its bluish white colour when compared with the sample of pyritic concentrate and understand how easily it can be mistaken for osmiridium.

The analysis of the material is as follows:

	Per cent.
Arsenic	23.6
Cobalt	11.4
Nickel	3.6
Sulphur	23.7
Iron	22.8
Lead	6.8
Gold, Silver and Platinum Metals	8.1

This analysis corresponds to the mineral composition:—

	Per cent.
Pyrites FeS_2	42.3
Cobalt, Nickel, Iron Arsenide (Co Ni Fe) As	41.7
Galena PbS	7.9
Gold and Osmiridium	8.1

The arsenide therefore has the composition:—

	Per cent.
Arsenic	56.6
Cobalt	27.4
Nickel	8.6
Iron	7.4

This is an unusual monoarsenide corresponding to the mineral "Niccolite" (Ni 43.9%, As 56.1%), and I cannot find any reference to an occurrence in which cobalt predominates. The galena is present commonly as very perfect crystals of cubo-octahedral form. Occasionally a small amount of the arsenic is replaced by antimony; bismuth may also be present. This material appears to be present in some quantity throughout the reef, but so far as our present information goes it is very much more plentiful in those mines east of Benoni—the Far East Rand—than in any others.

Another extremely interesting mineral is found in the heaviest concentrates on many mines of the group extending from the Boksburg fault west to the Central Rand; up to the present investigations have not been carried out on concentrates from the more westerly mines.

This mineral is a variety of "Uraninite" and a concentrate carrying a large proportion of it is shown here. It has the black colour and brilliant lustre of polished jet and the concentrate is of the following composition:—

	Per cent.
Uranium Oxide	49.1
Thorium Oxide	1.6
Cerium Group Oxides	0.2
Yttrium Group Oxides	1.5
Tellurium	Present—not determined
Calcium Oxide	Traces
Magnesium Oxide	3.3
Bismuth Oxide	0.2
Silica	1.4
Combined water and gases (by difference)	3.5
Aluminium, Manganese, Phosphorus, Vanadium	Traces
Copper Oxide	0.5
Lead (Pb)	8.1
Sulphur	1.1
Iron	5.0
Arsenic	5.9
Cobalt	2.3
Nickel	1.4
Gold	6.6
Mercury	2.2
Platinum and Osmiridium	4.5
Zircon	1.6
Radium	142 milligrams per ton

The radium is calculated from the ratio U:Ra is $1:3.4 \times 10^{-7}$ (Lind and Roberts, 1920); the gases helium, argon and nitrogen have not been determined.

It appears that the whole of the lead is present as galena, and the cobalt, nickel and arsenic as the mineral previously described; the latter can be separated by chemical means. Mercury is probably present as small particles of amalgam not yet completely eliminated from the milling circuit.

It is uncertain at present whether the bismuth is a constituent of the uraninite or not, as some evidence points to the likelihood of more bismuth being present in some concentrates than the above analysis would allow for. On one mine in the Central Rand it was noticed recently that as the bars of mill gold solidified they extruded some bullion in a moss-like form.

This extruded material proved to contain the following:—

	Per cent.
Gold and Silver	76.0
Lead	18.4
Bismuth	4.3
Arsenic	0.8
Iron	0.2
Copper	0.3

This very easily fusible alloy, while still liquid, had been forced out by the solid and contracting gold, but it is too much to expect that it had all been so conveniently ejected and the bar of gold would be segregated and practically impossible to sample—thus providing an awkward problem to the unsuspecting official who had the task of reconciling mine and refinery assays.

Among the constituents of the uraninite concentrate is a small amount of tellurium. I have separated some in the metallic form, but it is very difficult to determine quantitatively owing to the extreme complexity of the concentrates.

The six platinum group metals interfere with its estimation forming the complex sulphocyanides mentioned as newly discovered compounds in a recent abstract in the *Journal*, while when mercury is also present a number of very curious reactions are obtained.

It appears, nevertheless, that the tellurium is present in combination with gold—a number of fairly obvious inferences can be drawn from this, such as losses of gold during assaying, but I do not think that this is likely to be serious unless local concentrations of the telluride occur somewhere and I do not wish to exaggerate the importance of the tellurium. It would be interesting to purify the uraninite by mechanical means—probably flotation would separate sulphides, arsenides, and metals from the oxide—and ascertain the true constitution of the pure mineral and its radioactive value. Some samples of pitchblende have five times the activity of the radium contained though the U : Ra ratio is constant.

As the concentrate shown here contains approximately 142 milligrams of radium per ton and the world's radium consumption is about 25 grams per annum it would require about 200 tons of concentrate to supply the demand, presuming almost complete recovery. However, this is probably not a practical line. I only mention it as interesting statistics.

Possibly another suggestion may be placed in a similar category: That our ventilation experts might consider placing a quantity of this concentrate in front of the ventilating fans and then determine the ionisation of the air in different parts of the mine to determine percentage air delivery to any given point. A preliminary survey of natural ionisation of the mine air due to radioactive matter in the rock would be necessary.

An auto-photograph made by the uraninite in 24 hours is shown—the fainter initials at one side were made by thorium oxide recovered from an East Rand concentrate.

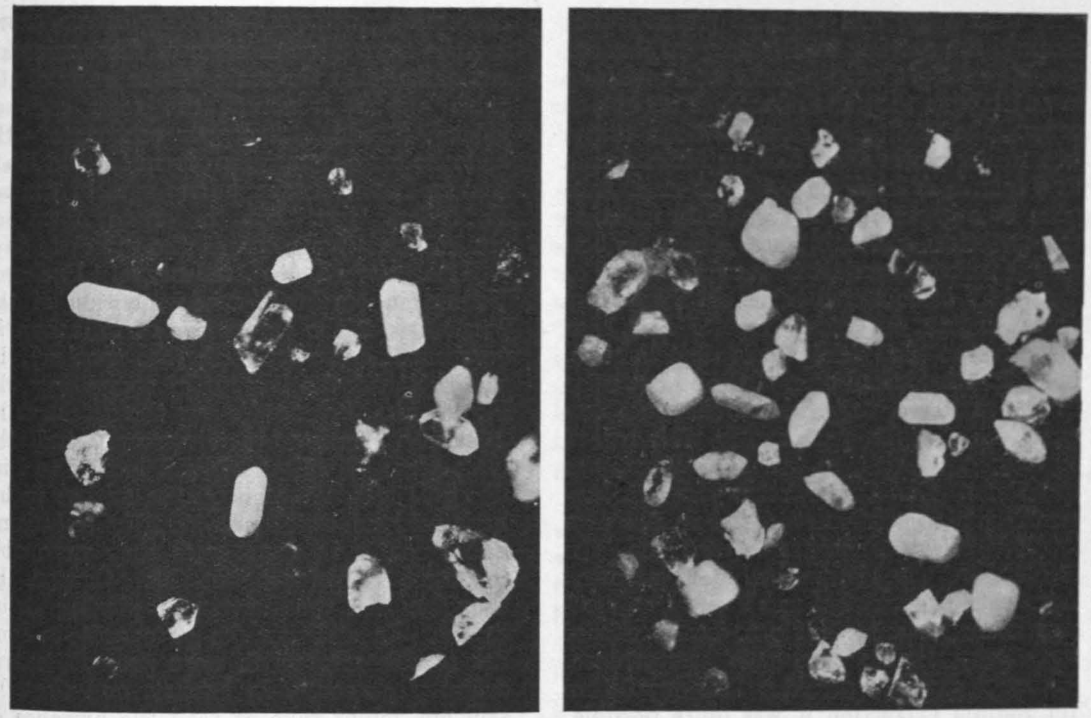
You will notice that I have mentioned the presence of zircon in the uraninite analysis, and you may be interested to see some photographs of crystals of this mineral. I have also some of the zircon here in a fairly pure state.

As they occur naturally the zircon crystals are delicately coloured various shades of pink and mauve, but this sample is white as it lost colour when heated during the process of separating it from crystals of chromite and of a titanium mineral which occur also in concentrates.

The zircon being insoluble in almost all reagents is difficult to separate from osmiridium during the estimations of the latter, particularly as zircon clings rather tenaciously to the surface of glass and requires a fairly strong jet of water to displace it.

The following is a list of elements which has so far been proved in reef and concentrate samples:—

Aluminium, antimony, arsenic, bismuth, calcium, carbon, cerium group, chromium, cobalt, copper, gold, hydrogen, iridium, iron, lead, magnesium, manganese, nickel, osmium, oxygen, palladium, phosphorus, platinum, potassium, radium, rhodium, ruthenium, silicon, silver, sodium, sulphur,



Zircon Crystals.

tellurium, thorium, titanium, uranium, vanadium, yttrium group, zinc, zirconium.

I think that we can take as read some thirty-eight known radio-active substances which we must presume to be present. But the gases helium, argon and nitrogen could safely be added to the list. Practically all of these elements are present in quite appreciable quantities in some of the usual concentrates.

It is interesting to know that some of the rare earths (thoria, ceria, etc.) occur in more than one mineral form in the reef. Sometimes very considerable amounts in acid-soluble form are found even in the absence of uraninite, and also there may be forms insoluble in any acids but decomposed at a good red heat by fused bisulphate.

The compounds of cobalt, nickel, arsenic, chromium, titanium, uranium, and rare earths shown here have all been prepared from samples of concentrate received at various times from reduction works—their origin is their only novelty, but the quantities shown will impress you with their comparatively high concentration as in each case the material was obtained from only one batch of material dissolved in the laboratory in the ordinary course for gold or osmiridium recovery.

I hope that as the result of this no chemist or assayer connected with the mines, on ordering fine chemicals, will be presented with a bucket of concentrate and requested to go ahead and prepare his own reagents.

While both the uraninite and the cobalt arsenide are found in a large proportion if not in all of the Witwatersrand mines it would be interesting to have some discussion from geologists or mining men on the subject of the differentiation between the mines east and west of the Boksburg fault. Perhaps also reduction officers will note the presence of very heavy black or white concentrate where their plants are equipped with concentrating machinery, and so add to our knowledge of the distribution of these minerals.

Since writing the above I have received an interesting specimen of "Millerite" or "Capillary Pyrites" taken from a cavity in the reef on the Far East Rand. This is practically pure nickel sulphide—a specimen of the mineral is shown.

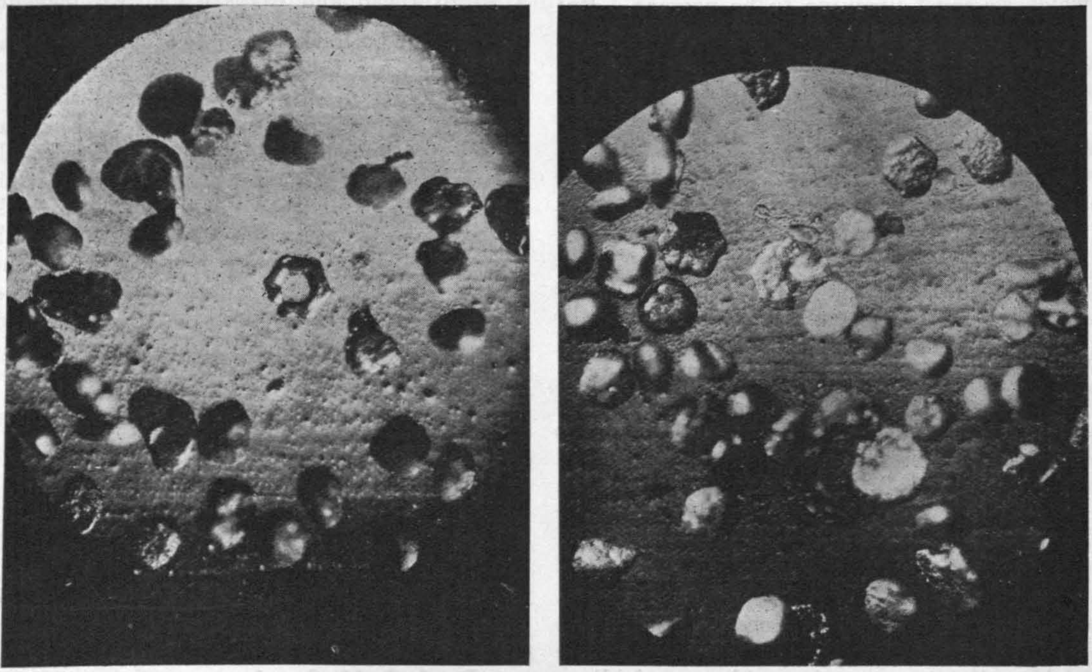
Photographs of osmiridium crystals are also shown.

Prof. G. H. Stanley proposed a very hearty vote of thanks to Mr. Cooper for his most interesting and valuable paper. Continuing, the speaker said it only emphasised the old saying that one could find anything in anything if they had enough of it; but, of course, the finding of some of these things was rather worse than looking for a needle in a bundle of hay. Mr. Cooper must have gone to a great deal of trouble in isolating the materials and substances which he had placed before them that evening. Some of them had come across some of those rare things before, on which reports had been made before the Society from time to time, but Mr. Cooper had carried their knowledge of the matter a very considerable step forward, he thought, particularly with regard to uranium, which, as far as he knew, was quite new. Mr. Crosse, some years ago, reported the occurrence of nickel in the days when Wilfley tables were used on the E.R.P.M. Osmiridium had been reported from time to time, but was then of no commercial importance; while to-day it was of very considerable economic importance. Although Mr. Cooper did not see any future for radium extraction it was quite possible, to his mind, there might be commercial possibilities for those concentrates too.

Just as a matter of interest he had brought along to the meeting two or three hand specimens. He dared say some of them had seen the same sort of thing before, showing the occurrence of some of those minerals not actually in the reef; but in some of the veins which traversed the reef, such as galena, blende, and copper carbonate. He had also some osmiridium from the old Rietfontein Mine, obtained long ago, of course. It looked just like a crude form of osmiridium from some of the mines to-day.

With regard to tellurium, Professor Young, in his book, made mention of the possibility of the occurrence of tellurium in very small amounts. He (the speaker), he thought, had the honour of suggesting the idea to him, because he saw the specimen he referred to under the microscope, and the little piece of yellow mineral looked to him like gold telluride, though the author in his book said he could not identify tellurium. Subsequently in some cases they were able to detect tellurium, but Mr. Cooper, he thought, had the honour of placing it on record. In addition, he gave quite a long list of elements which were present, extraordinary elements, in banket, and then he said one might take as read the presence of 38 others; he did not know whether they should take that seriously, or on what evidence he made the statement.

Then again with regard to argon and helium, it was quite likely they were present,



Osmiridium Crystals.

but he did not know whether Mr. Cooper had isolated or identified them. He might tell them that. Furthermore, he thought it would be of extreme interest if he would outline the methods used to separate those elements. Sometimes some of them came across concentrates from other districts; some of those contained unusual things, too. He had been sometimes pretty sure that some of those out-of-the-way things were present, but he had not had time to investigate them further. He thought, however, if Mr. Cooper could tell them how it was done, it would be of use to some of their members. He thought that was all he could say at the present stage. He might have something more to say at a later date. In the meantime he thought members would join with him in heartily thanking Mr. Cooper for his paper.

Mr. H. A. White said he would only briefly second the vote of thanks to Mr. Cooper for his paper, not because his admiration for the paper was small, but because he knew they had something more attractive there that night. The researches they had had explained to them certainly supported the remarks made by Mr. J. R. Williams to the Society some fifteen or twenty years ago, and that was one could not name a solitary mineral which was not somewhere to be found in banket.

It was the investigation of what might be called residual phenomena such as those dealt with by Mr. Cooper that most likely the future advance of science would depend, and therefore in researches of that kind they had great hopes of practical utility arising therefrom sooner or later.

Mr. F. Wartenweiler, said he would like to add his tribute to the excellence of Mr. Cooper's paper. Mr. Cooper did not state that his researches had extended over a considerable period, one or two years. It was due to Mr. Cooper's natural love for research and to his knowledge of the subject of the rare elements that the long list was brought to the light of general knowledge.

RESCUE WORK ON MINES.

By R. R. Sayers.

The President said that Dr. Sayers, of the United States Bureau of Mines, was present that night. He believed he had been on a tour round the world. He had pleasure in calling on him to say a few words with regard to rescue work on the mines. He was an expert on that subject.

Dr. R. R. Sayers said it was with real pleasure that he was able to be there with them and to talk to them, not only just to be there amongst them but also to be in this country. He did not come there to teach them anything, he came to learn. They here had done more than any people in the world in connection with miners' phthisis and its prevention. Dr. Orenstein had kindly shown him the methods used here and had made it easy for him to see a great deal in a short space of time.

To try and tell them in a few minutes what was being done in the United States would be very difficult, and he knew they had a long programme. So he would limit his remarks.

The United States Bureau of Mines, when it was organised and authorised by the Congress of the United States, had two purposes: One was to deal with health and safety on the mines, and the other was the production and utilisation of minerals. He had to do with the safety and health of the mines. The personnel of the medical division of the Bureau of Mines was detailed from the Public Health Department. They had at the present time six medical men and about an equal number of mining engineers, with three or four chemists and other assistants working in connection with health, and many had been working in connection with safety. As they could see, that was practically investigation. They dealt with the problems of miners' phthisis, lead poisoning, high temperatures, and humidity; with fatigue, and with efficiency, taking it the other way round; with changes in the atmosphere, such as decrease in oxygen, increase in carbon dioxide, the presence of poisonous gases, such as carbon monoxide, hydrogen sulphide, and a host of others he could name. They had carried out many investigations in connection with those.

Another operation the bureau dealt with was the teaching of first aid and the use of mine rescue apparatus on mines. They had 20 mine rescue and first aid stations belonging to the United States Bureau of Mines; ten of those were stationed in railroad cars. Those cars were moved over a district for the purpose of teaching, and of going to the scene of disaster, should one