The Mining Magazine

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EDITORIAL

HOWEVER extensive the literature, there is always room for a new contribution which either sheds further light on a subject or is able to present it in a new way. "Simple Determinative Mineralogy," by H. R. Beringer, a former lecturer at the Camborne School of Mines, published by Mining Publications, Ltd., the proprietors of THE MINING MAGAZINE, which makes its appearance this month, is a useful addition to the books on mineralogy of a really practical nature and should be of value to the prospector as well as the student.

RAILWAY developments in Central Africa have been closely followed in these columns, the extension of means of communication into the great continent being of much importance in the opening up of potential mineral fields. It is satisfactory to record, therefore, the placing of a contract in this country for the construction of a railway connecting Chambishi and Mufulira in Northern Rhodesia. This new line will be 19¾ miles in length and will be carried over the Kafue River by a new bridge of three spans of 75 feet each.

THE formation of a local association in Southern Rhodesia is announced by our Johannesburg correspondent. The new body has for its primary objects the promotion of the interests and the maintenance of the status of the Institution of Mining and Metallurgy in Northern and Southern Rhodesia, as well as the fostering of professional and social intercourse between local members of that body. Those connected with the formation of the new association include many engineers well known both in South Africa and in this country.

A LITTLE known aspect of Faraday's important researches is that covering investigations in metallurgy. Sir Robert Hadfield, in a paper to the Royal Society, published in connexion with the recent centenary celebrations, deals fully with this branch of the great scientist's work. As the result of an examination of the contents of a box containing Faraday's specimens of steel and alloys Sir Robert has been able to show that extensive work had been done on the effects of alloying many different elements with iron. While it is true that nothing of lasting value came out of this research, it is apparent that Faraday's inquiring mind had anticipated similar labours by metallurgists who followed him.

SUPPORT for some means of stabilizing silver prices continues to grow, largely owing to the persistent propaganda of those who hold the view that the restoration of the metal to a place in the world's monetary system would be an important step towards creating the confidence necessary to combat the present depression. Reference was made here last month to a conference convened by the China Association to consider the situation created by the fall in silver prices. At this meeting it was unanimously resolved that the governments concerned should be urged to call an early conference to discuss this matter. Sir Robert Horne, who presided, made it plain that increase of silver prices alone could not render stabilization impotent by causing over-production, as such a large proportion of the world's output comes from base-metal producers as a by-product.

IN the last issue of the MAGAZINE reference was made to what was then believed to be a new European tunnelling record which had been set up in connexion with the Manchester Corporation Haweswater Scheme, an advance of 181 feet being recorded in one week. It has since transpired that in driving the 610 metre deep adit on the Stantrg mine, in Yugoslavia, a distance of 459·3 feet was driven in a period of 15 days during September, 1930, equivalent to a weekly footage of 214·2. Even this figure has now been surpassed in the Haweswater tunnel, their most recent achievement being equal to a weekly footage of 220. On the Manchester project the work is being done by Holman drifters, using Sullivan mechanical slushers, whilst at Trepca the drills used were made by Ingersoll-Rand, the mucking being carried out with a Butler mechanical shovel.

TWO papers presented at the recent centenary meeting of the British Association made extended reference to the present position in this country of the "oil-from-coal" industry and oil fuel developments. The first, by Mr. H. T. Tizard, Rector of the Imperial College, dealt with the progress of hydrogenation and he was able to say that recent work pointed

to the conclusion that it would soon be possible to produce a heavy oil from coal at a cost which, while not much lower than the cost of producing petrol, would make available a valuable source of supply for heavy-oil engine plants. Sir John Cadman, in the second paper referred to, dealt with recent developments in oil utilization, referring particularly to the rapid increase in the number of oil-fired steamships and motor vessels. He considered oil to be the fuel of speed, the vitalizing power of modern transport.

Petrology and Ore-Genesis

The centenary meeting of the British Association, to which reference was made in the MAGAZINE last month, concluded at the end of September. The Faraday celebrations and the commemoration of the fiftieth anniversary of the present Natural History Museum combined with the Association's centenary to attract many notabilities from other countries and all the meetings were very well attended. The reference in these columns last month made note of several of the discussions before the Association which were likely to be of especial interest to members of the mining profession, but generally these took the form of symposia rather than real discussions, summarizing advances made during the past year in the various subjects, little that was really new arising from them. In the geological section, however, the discussion on the genesis of ores in relation to petrographic processes contained much interesting matter and more extended reference to this item of the proceedings is justified.

Problems of ore-genesis and the study of the means by which mineralization takes place are rather viewed askance by practical mining men, who are often inclined to take the philosophical view that ore is just where it is and that talk about the reasons as to why ore is where it is does not really affect the situation. Practical geologists, of course, take a contrary view and are inclined to think that the indifference of many mining companies toward research on their chief asset—the ore-body—is, in fact, a disservice to themselves, the hasty removal, for "economic" reasons, of the first of their finds often destroying much valuable evidence that might have been applied to the search for new prospects. The present trend of thought on ore-deposition brings the study of its effects more closely into contact with petrography, ore-deposits being considered as local concentrations in which valuable minerals are in greater concentration than in average rocks. As Professor Cullis pointed out in opening the discussion on this subject at the British Association meeting, "these concentrations, being naturally-formed mineral aggregates, cannot logically be distinguished from rocks." This point of view has been well expressed by Professor Niggli and the translator of his book "Ore-Deposits of Magmatic Origin"—Dr. H. C. Boydell—in his preface to the work, expresses this view-point as one which envisages as necessarily connected phenomena rock differentiation, earth tectonics, emplacement, the subsequent production of ore-bearing solutions as a later or last stage of differentiation, and, finally, the deposition of ore within a recipient rock structure. In his contribution to the present discussion Professor Niggli emphasizes the fact that the genetic description of an ore-body should take three points into consideration—first, the primary geochemical concentration process; secondly, the mineral paragenesis consequent on the original process, and, thirdly, subsequent alterations within the geological body, alterations which may have accompanied the process of formation or be due to metamorphism or to weathering processes. The same worker also pointed out that the extent and importance of sedimentary deposits could only be fully estimated by attempts to reconstruct the land and water distribution and the climatic factors which obtained at the time of their formation. Another important contribution to this discussion was that of Dr. A. Brammall, who, while a supporter of the Nigglian view-point, goes much farther, holding the opinion that differentiation alone, working on fixed quantities of initial magma, does not cover the whole case, as both the assimilation and fusion (palingenesis) of existing rocks must be involved to explain some of the many departures from existing general rules connecting ore-deposits with igneous rock types. Dr. Brammall's work on the West of England granites is well known and this has led him inevitably to the conclusion that these rocks are essentially hybrid, containing from 2·5 to 16·3 per cent. of assimilated basic igneous rocks, differentiation and assimilation having proceeded simultaneously until viscosity has put an end to both. As the result of this work it has been suggested that all the

Hercynian granites, from Spain to the West of England, have originated by palingenesis in the roots of deep-sunk orogenic folds.

Among the interesting points arising from this intensive study of the granites of Devon and Cornwall are the conclusions—first, that the barium oxide content of the granite can be used as a delicate basis for checking the quantitative importance of shale assimilation and, secondly, that spectroscopic evidence has led to the conclusion that a large proportion of the biotite in the granites is derived from assimilated pyroxene-bearing basic igneous rocks, chromium, nickel, cobalt, molybdenum, lead, silver, gold, strontium, and iridium being traceable to the hornblendic basic xenoliths. Assays for gold and silver in these granites show an average for granite to contain 1·2 grains per ton of gold and 21·3 grains of silver, whereas a demonstrably hybrid amphibole-bearing pegmatite contains 64·8 grains per ton of gold and 117·9 grains of silver. Prospectors who have spent long periods in granite or granite-gneiss country searching for a source for the constantly-occurring colours of gold must see that a hybrid granite magma may often be the source itself. The main conclusion to be drawn from the discussion seems to be the fact that there is general agreement that the problems of ore-deposition are only parts of the problems of igneous petrology.

Diesel-Electric Traction

A possible revolution in railway transport in this country may be regarded as a good reason for introducing a topic which superficially may not appear to be of direct concern to the mining community. Its effect not only on transport facilities but also on the coal mining industry—which may still be regarded as the basic British industry—is, however, sufficiently far-reaching to appeal to a wider circle than those immediately affected. Those readers of the MAGAZINE who study the report of the Weir Committee on the electrification of the main-line railways of Great Britain will find it contains the important conclusions that only a wholesale electrification scheme could be contemplated and that such a scheme would cost a sum amounting to over £300,000,000. In addition, it was estimated that this expenditure, after a construction period set at twenty years, would only give a return of 6·7 per cent., which would, it is admitted, allow of little or no reduction in transport costs. As this is one of the most vital needs of the country at the present time it is, therefore, not surprising that more attention is being given to the internal combustion engine, especially the Diesel type, using a heavy oil which is both cheaper and safer than petrol. The use of Diesel-electric traction on rail cars is now well past the experimental stage and the increasing attention which is being paid to this type of power unit was very evident at the exhibition just concluded at Olympia.

The type of internal combustion engine which is usually called after its inventor, Dr. Diesel, made its appearance in the concluding decade of last century and much of the development of this engine took place on the Continent. The main feature of the engine lies in the use of cylinder compression to develop such temperatures that injected oil is ignited, the expanding gases providing the motive power. From its invention the development of the Diesel engine has proceeded rapidly and units are now constructed capable of producing as much as 25,000 h.p. It has to be remembered, however, that in competition with the steam engine the Diesel engine has an important defect. The merits of the steam engine are its high over-load capacity, maximum torque at low revolution, flexibility of speed, and good acceleration—in fact, a steam engine is a constant-torque engine, whereas a Diesel is a constant-speed unit. This was the fact which led to the failure of those early experiments to couple a Diesel unit directly to the driving wheels of a locomotive, although it is considered that the use of supercharging may be the first step towards overcoming the difficulties of direct coupling. In practice, however, the difficulty has been avoided by the use of connecting media between the power unit and the wheels. Such media are either or both gear transmission and electric transmission units, the solution of the problem lying in the acceptance of the Diesel engine as a prime mover pure and simple. As such it has important advantages, those of low cost, small running and maintenance charges, high speed, reliability, easy starting, and freedom from vibration, noise, smell, smoke, and fire risks. As for the relative merits of two-stroke and four-stroke systems, although there seems to be a tendency in favour of the two-stroke for large units, the four-stroke seems to be more in favour for the purposes of locomotion. Research on this type of engine has constantly been in the

direction of simplification and the improvement of mechanical injection pumps—the so-called airless-injection system—has been a notable factor in this direction.

Bearing in mind that the desired end of locomotive development—or railway development, for that matter—must be the provision of cheaper transport facilities, it is obvious that the Diesel-electric locomotive is one means to that end. Such a locomotive would certainly have a greater initial cost than the steam locomotive it is designed to replace, but its running costs, allowing for interest and depreciation, would only be about half. At present the use of powdered fuel on steam locomotives is another attempt to provide greater fuel economy and the continued use of home supplied fuel is naturally of paramount importance. The development of processes in this country, however, having the aim of producing cheap oil from coal are extremely important in this connexion, as Diesel-electric traction using home-produced heavy oil seems to have important advantages over complete electrification of the railways, at any rate for short branch or suburban lines.

Copper

The decision of Great Britain to allow its currency to depart from the gold standard immediately resulted in a rapid advance in the price of metals, an adjustment of values to the depreciated pound sterling. Although the position has since suffered a relapse, followed by another advance, an examination of the present figures shows that after all allowance has been made to bring present prices on to a gold basis the values of the principal base metals show a decline. The position as regards copper has been emphasized by the decision of the Rio Tinto Company not to make any interim dividend payment on its ordinary shares this year. It is true that many factors other than price considerations have adversely affected this company, notably affairs in Spain, where a demand for taxes on profits and dividends covering the years 1923–25 has made a serious drain on its available resources. In addition the ore position at Rio Tinto is regarded as being far from satisfactory, as it is feared that the continued decline in the copper content of the ore will mean a gradual increase in production costs, a factor which was one of the main reasons influencing the decision of this company to invest in Northern Rhodesia. Nevertheless the uncertainty as regards the position of copper is extremely important to many mining men and it is well worthy of some examination.

During the latter half of August and the beginning of September an important factor affecting the copper situation became very apparent in the United States. The official price set by Copper Exporters was persistently underquoted by customs smelters and other outside interests, all of whom were pressing metal for forward delivery at 7 cents per pound, a figure at which many of the large companies in the United States can only be producing at a loss. In spite of this fact, however, the production in that country during August was nearly equal to that of July, being just under 39,000 tons. It is probably true that the relative amount of cheap copper available is only small when compared with available stocks, but it is still enough to meet the present poor demand, and consequently has immediate effects on the market situation, creating an utter lack of confidence in the position. A similar situation was apparent on the British markets during the same period, free offerings and absent buyers forcing prices ever downwards, with the result that new low records for the metal were created daily. It has become increasingly evident, therefore, that steps will have to be taken to curtail copper supplies unless economic factors take control of the situation.

In view of the prevalent state of affairs outlined here it would seem that the chief interest for the next few weeks will be in the decisions of the conference of producers which is to be held in New York this month. Representatives of Canadian, Belgian, Rhodesian, and United States interests will be present and it is intended to consider the details of a scheme to restrict the output of copper to 90,000 tons a month, which is estimated to entail a cut of 28 per cent. The present world consumption of copper is about 100,000 tons per month and the lower figure chosen as a basis for agreement makes allowance for the production of other countries, such as Russia, Germany, and Japan. Although copper outputs have to a certain extent been previously restricted, it is now evident that much firmer measures are intended to deal with the situation and copper will join the other metals—tin, zinc, and lead—in coming under artificial control, whether for the benefit of the industry or not remains to be seen.

REVIEW OF MINING

Introduction.—After what has seemed an unduly protracted period of uncertainty Parliament has been dissolved and a general election is to take place on October 27. The National Government has made a united appeal to the country and the general opinion that such a Government will receive the mandate it desires tends to maintain commercial confidence. Since the departure of this country from the gold standard metal prices have been somewhat erratic, but the tendency generally is towards improvement.

Transvaal.—The output of gold on the Rand for September was 872,053 oz. and in outside districts 43,971 oz., making a total of 916,024 oz., as compared with 916,425 oz. in August. The number of natives employed on the gold mines at the end of the month totalled 209,424, as compared with 209,409 at the end of August.

The report of the New Modderfontein Gold Mining Company for the year ended June 30 last shows that the ore reserves have suffered another decline, decreasing to 6,789,000 tons, averaging 8·0 dwt. over a stoping width of 49·9 in., from 7,431,900 tons, averaging 8·6 dwt. over 50·2 in. Once again this is considered to be largely due to the lower proportion of payability of ore developed on the South Reef and Upper Leaders in comparison with the Main Reef Leader. The ore milled during the year amounted to 1,933,700 tons, yielding 838,082 oz. of gold, worth £3,554,118, silver and osmiridium recovered bringing the total up to £3,368,550, equal to 36s. 11d. per ton. Working costs amounted to £1,550,782 and the working profit to £2,017,768, dividends paid during the year absorbing £1,750,000, equal to 125 per cent.

For the year ended June 30 last the ore reserves of Sub Nigel show an increase of 241,000 tons, the fully developed reserves being estimated at 1,206,000 tons, averaging 17·3 dwt. over a stoping width of 27 inches. The value is lower by 0·7 dwt., but the width is higher by 4 in., in order to conform to current stoping practice. The ore milled was 378,000 tons, 333,551 oz. of gold being recovered. The revenue amounted to £1,413,214, working expenditure being £707,568 and the working profit £705,646. Dividends declared during the year absorbed £450,000, equal to 6s. per share.

The returns of the East Geduld mine for September show a steady improvement in operating results. Ore crushed during the month amounted to 42,000 tons, working costs being estimated at £47,230 and revenue at £44,626, the absorption of gold in the plant being still considerable. The development report for the last quarter shows an advance of 2,399 ft., of which 1,490 ft. was sampled, 965 ft. being payable, having an average assay value of 16·6 dwt. over 43 in.

The Mines Department of the Union Government has invited applications for the leasing of areas adjacent to the Sub Nigel mine on the farms Grootfontein and Daggafontein, the ground available together representing 6,333 mining claims. Tenders for this ground are returnable on February 1 next.

The accounts of Northern Platinum Exploration, Ltd., covering the year ended June 30 show that no operations were carried out on the company's properties, these being in charge of a caretaker. In order to bring the holding in Potgietersrust Platinums, Ltd., to market value a sum of £20,382 has been written off, lowering the value of the company's available balance, in cash and investments, to £33,667.

Shareholders of Transvaal Gold Mining Estates have been informed that no dividend could be declared this year.

Southern Rhodesia.—The output of gold from Southern Rhodesia during August was 43,292 oz., as compared with 44,765 oz. for the previous month and 46,152 oz. in August, 1930. Other outputs for August were: Silver, 5,892 oz.; coal, 51,847 tons; chrome ore, 8,962 tons; asbestos, 1,412 tons; mica, 2 tons.

The report of the Sherwood Starr Gold Mining Company for the year ended June 30 last shows that the ore reserves have risen to 151,300 tons, but the value has declined from 66·7s. to 46·6s. per ton. The ore milled during the year was 56,000 tons, 1,800 tons less than was treated in the previous year, the increase in the percentage of concentrates produced and the limited capacity of the roasters necessitating the reduction. In addition 46,532 tons of current slimes and 54,154 tons of accumulated slimes were re-treated and the total revenue for the year was £138,464, as compared with £132,966 in the previous year. Working costs increased from 22s. 10d. per ton to 24s. 3d., but the profit also rose from 23s. 2d. per ton to 25s. 3d., the gross working profit being

£70,698. Dividends paid during the year absorbed £30,000, equal to 30 per cent.

The report of the Toronto (Rhodesia) Syndicate for the seven years to December 31, 1930, show that the working of the mine by tribute ceased in April last, but that negotiations are proceeding with the object of re-letting it. The response of shareholders to the reorganization scheme sanctioned in 1927 proved so poor that no shares were allotted, but these will again be offered when a favourable opportunity occurs.

Northern Rhodesia.—Shareholders of Rhokana Corporation were informed last month of an accident at the N'Changa West Mine, where a rush of water occurred which reached the shaft. Although this will cause some delay in the development of N'Changa West, it will, it is stated, in no way affect operations at N'Kana, which is expected to provide the major part of the production in the earlier operating stages at the commencement of the new year.

Nigeria.—During the year ended March 31 last the production from the Fedderi areas of Tin Fields of Nigeria, Ltd., was 58 tons, as compared with 59½ tons in the previous year, while in addition 38¼ tons was produced from the areas of Rukuba Tin Mines, Ltd., which are under tribute. The price realized for the concentrates was only £68 5s. 10d. per ton, as compared with £113 17s. 5d. obtained in the previous year, and the year's working resulted in a loss of £161, reducing the balance carried forward to £48.

The report of Ribon Valley (Nigeria) Tinfields, covering the year ended March 31 last, shows that 206¼ tons of tin concentrates was produced, the operations for the period mentioned showing a profit of £3,942. After writing off the debit balance brought in, there remains a sum of £61 to be carried forward.

Gold Coast.—The return of the Ashanti Goldfields Corporation for September shows the monthly profit to have been a record one at £39,599, in addition to which £6,753 was received on account of the gold premium, which was only available during the latter half of the month. September is also the last month of the financial year for this company, and the net profit for the period is estimated at over £400,000, equal to more than 100 per cent. on the issued capital.

A circular to shareholders of Taquah and Abosso Mines states that arrangements have been made whereby the New Consolidated Gold Fields, which has acquired a substantial interest in the company, will assist in extending its operations. The Gold Fields company will be represented on the new board, of which Mr. J. H. Batty becomes chairman, Mr. G. W. Campion continuing his connexion with the company as technical adviser.

Australia.—The accounts of the Broken Hill Proprietary Company for the year ended May 31 last show a net profit of £83,257, after providing £232,752 for depreciation and £64,659 for debenture interest. Operations at Broken Hill ceased on June 30, 1930, where sufficient staff has been retained to look after the plant. The production of the Newcastle steelworks shows only a slight reduction on that of the previous year. As was announced in the MAGAZINE for January last, the company has decided to investigate gold-mining propositions brought to their notice, but so far these investigations have been without tangible results.

Advice from Australia is to the effect that the net profit of Amalgamated Zinc (De Bavay's) for the first half of the current year was £3,497. It is stated that the negotiations with regard to the inauguration of a paper industry in Huon Valley, Tasmania, are being continued.

A circular to shareholders of the Wiluna Gold Corporation issued last month stated that during August 23,279 tons of ore was treated, yielding bullion worth £26,370, working costs in Australian currency being £24,278. It is further stated that Mr. C. O. Lindberg, who is investigating the position at the mine, has suggested that the assistance of a flotation expert would be desirable, and Mr. T. Owen, formerly of the American Smelting and Refining Company, has been engaged. The management have reiterated their confidence in the deep-seated origin of the Wiluna deposits.

New Zealand.—Recent investigations by Government geologists into the huge cemented gravel deposits in the Tuapeka district of Otago are stated to have revived the interest of mining men and an Australian syndicate has engaged experts to go into the matter.

India.—A progress report issued by the Indian Copper Corporation, covering the first half of 1931, shows the mine production to have been 79,153 tons of ore, development having kept pace with depletion. The ore treated by the mill was 79,089 tons, averaging 3·26 per cent. copper, the recovery being estimated at 97·25 per cent., milling costs during the period showing a reduction of

12 per cent. as against the previous year. The output of the smelter was 2,105 tons of refined copper, over-all operating costs being 38·7 per cent. less. At the rolling mill costs were also lowered by approximately £2 per ton, sales being well maintained, the output of yellow metal sheet for the period amounting to 1,581 tons.

Shareholders of the Mysore Gold Mining Company have been informed that recent rockbursts in the stoping section of the mine have so seriously interfered with the monthly output of gold that it is deemed advisable to postpone the declaration of any dividend until the results of the whole year's work are ascertained.

Burma.—The report of the Tavoy Tin Dredging Corporation for 1930 is the first issued since the absorption of the Northern Tavoy, Theindaw, and Thingandon companies and shows that the new company now possesses a fleet of six dredges, all of which are in excellent condition. The ground treated during the year amounted to 1,472,581 cu. yd., the output of tin concentrates being 318¾ tons, while 12 tons was produced from tribute, the whole realizing an average price of £130 per ton of metal. The year's working resulted in a loss of £1,925, the total loss for the year being £4,669, after transferring £22,231 from reserve account.

Malaya.—During the year ended June 30 last the output of tin by the Renong Tin Dredging Company amounted to 539·9 tons from the treatment of 1,221,894 cu. yd. of ground by the two dredges on the Rasa property. Continued exemption has been given from working the Gombak Valley property, activities on which have been confined to the close-boring of certain areas. The profit for the period under review was £13,983 and £10,463 was distributed as dividends, equal to 5% on the ordinary shares, the balance carried forward being increased to £22,493.

At an extraordinary meeting of Anglo-Eastern Tin held last month it was resolved that the capital should be increased by the creation of 100,000 new ordinary 2s. shares, the subscription of which has been guaranteed.

Dutch East Indies.—The report of the Government Banka Tin Mines for 1930 shows that profits amounted to £870,000, as compared with £1,785,000 in the ten months covered in the 1929 report. Production increased from 168,737 to 219,400 quintals and working costs rose from Fl. 79·74 per quintal to Fl. 86·91, while the selling price fell from Fl. 239·38 to Fl. 172·12.

Mexico.—During the year ended June 30 last the operations of the El Oro Mining and Railway Company resulted in a profit of £9,766, receipts as interest from the Inversiones Company and other sources raising this to £38,766. The total profit, after allowing for exchange losses and expenses, amounted to £34,203 and, after adding the sum of £11,486 brought in, there was an available total of £45,689, from which a dividend of 7d. per share is to be paid. During the period under review 170,955 tons of ore was raised at the Noria mine of the Inversiones Company, 172,209 tons, averaging 20·77 oz. of silver and 12·03 grains gold per ton, being sent to the mill. The ore reserves at this mine were estimated at the end of the year to be 201,011 tons, averaging 18¼ oz. silver per ton.

Cornwall.—It is proposed to resume production at South Crofty as soon as the necessary arrangements have been made.

Spain.—The report of the Tigon Mining and Finance Corporation for the year ended March 31 last states that by the end of the current year the output of sulphur from the mine in Spain should amount to 2,000 tons per annum, when it is estimated that it would be self-supporting. On the Chilean properties production has ceased, considerable stocks being available.

François Cementation Company.—The accounts of the François Cementation Company for the year ended March 31 last show a trading profit of £63,964, increased by dividends from subsidiary companies to £67,544. After making allowances for depreciation, payment of preference dividends, and other items, a balance of £44,330 was carried forward. The most important new work undertaken by the company is that being done at Haweswater in connexion with the Manchester Corporation water supply scheme.

Murex.—The trading profit of Murex, Ltd., for the year ended June 30 last was £48,666, other items bringing the gross profit up to £82,872. After making various allowances and adding the sum of £26,776 brought in, there was an available total of £86,219. Dividends paid during the year absorbed £49,660, equal to 35 per cent., and, after making provision for depreciation, etc., the sum of £28,908 was carried forward.

CHROMITE IN SIERRA LEONE

By W. H. WILSON, A.R.S.M., A.I.M.M.

In this article the author describes the chromite deposits of the Kambui Hills, in the Province of Kenema.

INTRODUCTION.—In spite of its almost unique range of usefulness, chromite, the one and only commercial source of chromium, is not a well-known mineral, and this preliminary review of its composition and uses, together with other particulars, which in a paper dealing with a specific deposit of any of the better known minerals might be superfluous, may here serve as a suitable preface and guide for those who have not had an opportunity to study this mineral.

Chromite contains, in varying proportions, chromium sesquioxide (Cr_2O_3), protoxide of iron (FeO), alumina (Al_2O_3), silica (SiO_2) and magnesia (MgO). Commercially valuable ore contains a minimum of 40% chromic oxide (Cr_2O_3), and although ore containing as much as 55% Cr_2O_3 is mined in New Caledonia, by far the major proportion of the world's production contains 48% or less of chromic oxide. The proportion of the other constituents varies in different ores, but the following scale gives the common lower and upper limits :—FeO, 12%–21% ; Al_2O_3, 6%–21% ; SiO_2, 1%–9% ; MgO, 9%–16%. It is a black mineral, with a sub-metallic to metallic lustre, has a specific gravity of 4·1–4·5, a hardness factor of 5·5, and is extremely refractory and obdurate. Occurring as magmatic segregations in ultra-basic igneous rocks, usually peridotites altered to serpentine and talc, it is commonly found massive, with a perfectly crystalline, compact structure, disintegrating on weathering into typical octahedral crystals.

Of recent years the uses of chromite have increased and in the future it is certain to find further applications.[1] As ferrochrome, an alloy of chromium and iron, containing at least 60% of the former, it is added, together with nickel, to certain alloy steels. These can be divided into three classes : Corrosion resisting, or stainless steels ; steels of high tensile strength ; and high temperature, or heat resisting steels, all of which have an immense range of usefulness. Nickel and chromium are also being increasingly used in cast iron. For the manufacture of ferrochrome, which is produced from chromite in the electric furnace, only the better grades of chromite, containing a minimum of 45% chromic oxide, can be employed, as difficulty is experienced in producing ferrochrome containing the requisite minimum of 60% chromium from lower grades of ore. In addition, the iron oxide content must not exceed one-third of the chromic oxide content.

Chromium plating is earning a well-deserved position of importance, owing to its beauty and durability. Chromium sulphate and chromic acid are used in the plating solution.[1] Compounds of chromium have numerous other uses. H. A. Doerner[2] states that the chemical trade requires an ore containing from 50 to 55% chromic oxide, while F. E. Keep[3] states that, "chrome ore of as low a value as 13% chromic oxide is used in the manufacture of chemicals, bichromates, chrome yellow etc."

There is an increasing demand for chromite for refractory bricks and cement. For this purpose a minimum chromic oxide content of 40% is necessary and a low silica and iron content desirable. The ore, moreover, must possess certain mechanical characteristics, including that of remaining solid and uncracked when subjected to heat.

Chromite is usually used as it comes from the mine, without dressing. Certain low-grade ores are, however, water concentrated, to raise the grade to a marketable value. The bulk of the world's chromite is produced in Rhodesia, South Africa, and New Caledonia. The United States is the largest consumer of the mineral, with a negligible production. The mineral is sold on a chromic oxide content basis, the price rising a little more rapidly than the proportionate percentage increase of Cr_2O_3. In 1929, 47% ore was valued at 22 dollars per long ton

[1] Anon., "The Growing Demand for Chromium," *South African Mining and Engineering Journal*, vol. xl, part 1, p. 268, May 4, 1929. Johannesburg.

[1] "A Modern Electro-Plating Plant." *Nickel Bulletin*, vol. iv, no. 1.

[2] H. A. Doerner, "Beneficiation of Low-Grade Chromite Ores." Report of Investigations 2999. United States Bureau of Mines.

[3] F. E. Keep, "The Geology of the Chromite and Asbestos Deposits of the Umvukwe Range, Lomagundi and Mazoe Districts." Southern Rhodesian Geological Survey Bulletin No. 16.

and 51% ore at 23½ dollars, while the current quotation (August, 1931) is £4 or 19 dollars per ton c.i.f. for good 48% ore. The present basis allows a bonus of 2s. per unit for every 1% above a standard value of 48% mineral.

Chromite Deposits in the Province of Kenema, Sierra Leone.—In reviewing the history of this recently-discovered chromite area, it should be said that Mr. J. D. Pollett, of the Sierra Leone Geological Department, found the first chromite as boulders lying on a bush path crossing the Kambui Hills and further prospecting resulted in the discovery of an outcrop of good-grade chromite and of widely distributed detrital chromite. These discoveries were announced in the Reports of the Geological Department for the years 1927–9 and in the 1929 Report the following statement, since translated into fact, occurs:—"No detailed examination of this part of the country has been made and it is practically certain that several other deposits of chromite will be found when the district is more carefully examined."

Acting under the direction of Major A. D. Lumb, Senior Mining Geologist of the United Africa Company, by whose kind permission this paper is being published, Mr. T. Hirst made a short tour of the locality, obtaining sufficient data to confirm the possibility of the existence of chromite deposits. During the following year the area was vigorously prospected, two large deposits being discovered by the author, in addition to the original deposit discovered by the Geological Dept., which proved on development to be of considerable size. Other small deposits were located, which on examination proved to be valueless and of which no further mention will be made.

The Kambui Hills.—The following is a description of the geological formation in which the chromite deposits occur (Fig. 1). The Kambui Hills consist of a low ridge about 40 miles in length and attaining in places a height of 1,500 ft. above sea level. They are composed of an ancient series of Schists—the Kambui Schists [1]—lying at a steep dip of from 60° to 70° W., and striking approximately N. 30° E. (Mag. 1930). Although the schists are of a width of from 1 to 1½ miles, the width of the range is somewhat wider, since the schists graduate on the western side into a series of hills composed of granite and on the eastern side slope gently down to a granite plain, lying some 500 ft. above sea level.

A dense, hard, grey hornblendic schist is the predominant rock type of the hills, and this is of sedimentary origin. The chromite deposits, however, are associated with a series of irregular intrusive dykes of ultra-basic igneous schists, consisting largely of serpentine rock and soft decomposition rocks—talc, anthophyllite, and chlorite schists—lying near the eastern contact of the sedimentary hornblendic schist and the granite.

Fig. 1.—Plan of part of the Kambui Hills, showing the site of the Chromite Deposits.

Surrounding the schists is an intrusive biotite granite, which passes in the contact zone by assimilation of the schists to biotite and hornblende gneisses. Outliers of schists exist in the granite as far as 2 miles from the actual contact and intrusions of granite are found far into the schists, in which veins of quartz and pegmatite are also common.

Midway along the range of hills, at a position 8° 3′ N. Lat., and 11° 13′ W. Long., the three larger chromite deposits occur in the ultra-basic igneous schists, which are

[1] N. R. Junner, "Geology of Sierra Leone." The Mining Magazine, Jan., 1930.

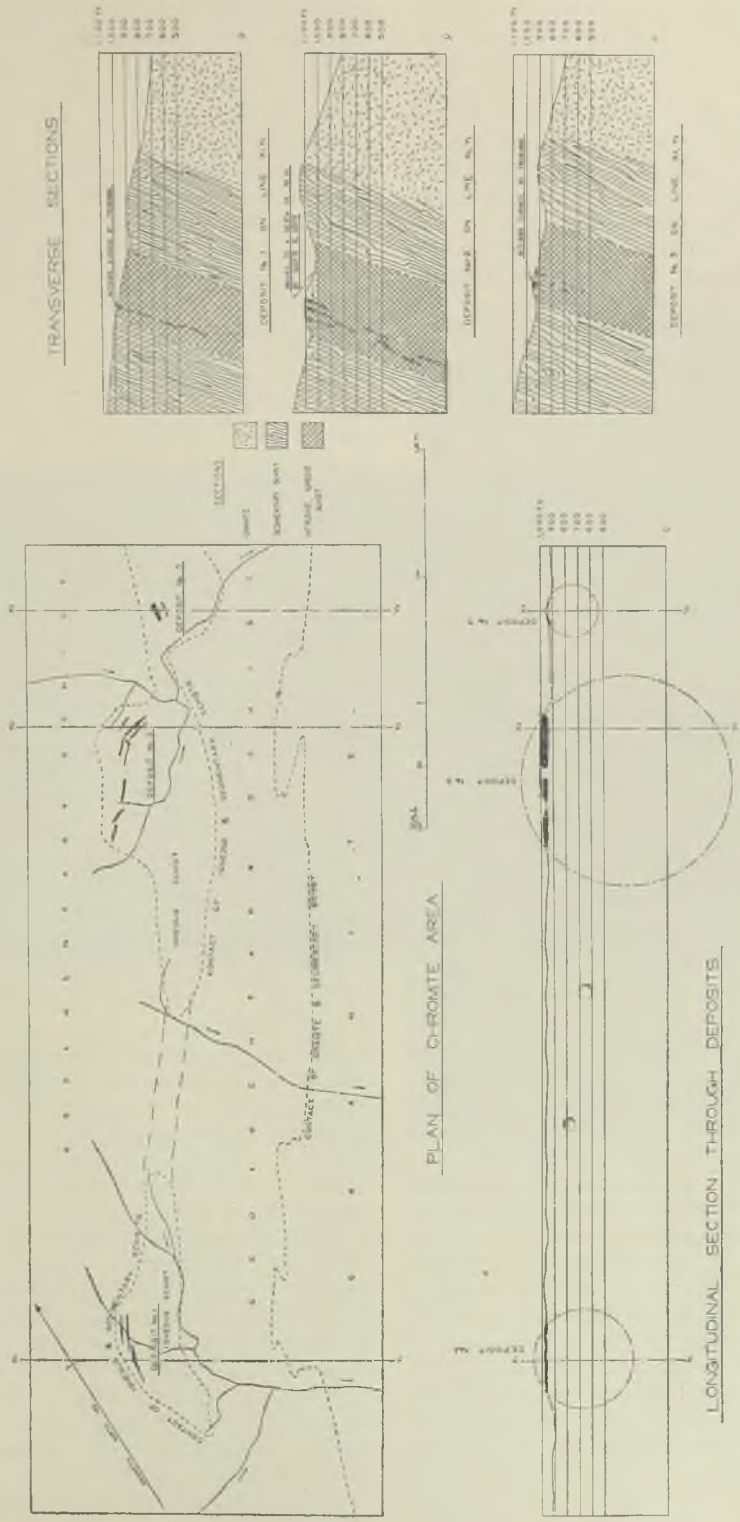


FIG. 2.—GEOLOGICAL PLAN OF THE CHROMITE DEPOSITS: THE BROKEN CIRCLES IN THE LONGITUDINAL SECTION AND THE UNSHADED PORTIONS IN THE TRANSVERSE SECTIONS REPRESENT POSSIBLE EXTENSIONS OF THE CHROMITE LENSES.

of a width of from $\frac{1}{4}$ to $\frac{1}{2}$ mile at this region. The deposits lie parallel to the strike of the adjacent rocks and are close together, the distance from end to end of the deposits approaching 1 mile. Three miles distant is a motor road, six miles along which is the railway station of Hangha, 180 miles via the Sierra Leone Railway from Freetown, the port and capital of the colony.

Dense forests cover the hills, which although rendering prospecting difficult, promise an endless supply of timber for use when the deposits are opened up.

THE CHROMITE DEPOSITS.—Details of the formation, mode of occurrence and grade of the three large deposits are shown in Fig. 2.

from chromite to talc being abrupt and the walls of the deposit smooth and hard. Outcrops of serpentine occur in the bed of a stream near the deposit. The chromite is mineralogically pure, and contains no entrained impurities, such as talc; it is coarse grained, perfectly crystalline, and of a black colour, with a sub-metallic lustre. A typical analysis of the mineral gave :—

	%
Sesquioxide of chromium	47·72
Protoxide of iron	13·98
Alumina	20·30
Silica	1·92
Magnesia	15·98
	99·90

FIG. 3.—OUTCROP OF CHROMITE (20 FT. WIDE) ON DEPOSIT NO. 1. THE MEN ARE STANDING AT THE EXTREME EDGES OF THE OUTCROP.

Deposit No. 1.—This deposit consists of a series of dyke-like lenses, of uneven shape and thickness, lying along a line parallel to the strike of the schists and dipping at the same angle, i.e. N. 30° E. and 60° W. respectively. The lenses have a total length of 500 ft., and widths varying from 12 ft. to 23 ft. Outcrops have been exposed by trenching, but as no underground exploration, or boring, have yet been undertaken, the depth is entirely a matter of surmise and is discussed later in this paper.

The deposit occurs in the ultra-basic igneous schists, near the contact of these rocks and the sedimentary schists, and may be regarded as a flattened, irregular formation of lenses, lying in the hanging wall of the intrusive rocks. On either side of the chromite is a soft, talcose rock, the transition

Deposit No. 2.—Separated from No. 1 deposit by a distance of 1 mile, in another development of the igneous schists, is the second, or No. 2 deposit, also consisting of a series of dyke-like lenses, approximately in line, of total length 1,000 ft. and widths varying from 3 ft. to 23 ft. In places the lenses have a parallel formation, but maintain the same alignment. Considerable local variations occur in the strikes and dips, but the average corresponds with those of the schists—N. 30° E. and 60° W. The deposit lies near the contact of the intrusive and sedimentary schists, close to the hanging-wall of the former series. In addition to surface exploration by deep trenching, shafts and adits prove that, at a depth of 50 ft., the widths of the deposit are maintained.

A very soft, decomposed, brown, talcose schist surrounds the deposit. This schist is free from chromite, except between the parallel lenses, where it is interspersed with chromite crystals and has a somewhat granular appearance. Occasional nodules of serpentine are found in the talc, which is crossed by bands of quartz-schist and by numerous quartz veinlets. Small outcrops of serpentine occurring near the chromite are also intruded with quartz veins. Certain of the chromite lenses are shattered and contain soft, brown talc in the fissures; but the majority are sound and unbroken. Perhaps one-half of the chromite is of good grade—coarse-grained, hard, and black. The other half, comprising certain entire lenses and portions of others, is composed of chromite rendered friable and of greyish appearance by films of talc occurring in the interstices between the crystals. An analysis of typical mineral gave :—

	%
Sesquioxide of chromium .	45·75
Protoxide of iron . .	14·40
Alumina	15·50
Silica	8·65
Magnesia	14·70
	99·00

Deposit No. 3.—Lying on a prolongation of the line of No. 2 deposit, at a distance of 700 ft., and in the same development of the igneous schists, is the third, or No. 3 deposit, consisting of two parallel dykes or lenses, of length 140 ft., and maximum widths of 20 ft. and 7 ft. respectively, separated by an interval of 50 ft. The strike of the deposit is N. 12° E. (Mag.), and the dip 70° W., corresponding with the schists, which are bending towards the north at this point and trend N. 12° E. to N. 5° E., as compared with N. 30° E. in the region of deposit No. 1. As with the other deposits, it occurs close to the hanging-wall of the intrusive schists.

Surrounding the deposit is a hard, brown talc schist and between the dykes is a banded zone, composed of a hard, grey rock consisting of a talcose mineral and granules of chromite in varying proportions, with partings of soft, decomposed brown talc. Large outcrops of serpentine occur near the deposit, intruded by large and small veins of quartz and pegmatite. No underground exploration or boring have yet been undertaken on this deposit.

The chromite is black, lustrous and unshattered. Certain faces of cleavage planes, exposed by trenching and blasting away the weathered surface ore, measure as much as 9 ft. across. A typical analysis of the ore, analysed for chromic oxide content only, gives this figure as 43·5%.

Mode of Origin of the Chromite Deposits.—In considering the genesis of the chromite, the relative age of the three series of rocks associated with the deposits—the sedimentary schists, the intrusive igneous schists, and the granites—is one of the primary

Fig. 4.—Chromite Outcrop (23 ft. wide) on Deposit No. 2, the position of the men showing the extreme edges of the outcrop.

factors. It is clear that the sedimentary schists are the oldest rocks and have been intruded by the granites and it remains to determine the position of the intrusive schists as pre- or post-granite. These schists are found only in the sedimentary schist belts and not in the granite, which indicates that they are of pre-granite origin, and this is substantiated by the fact that they are intruded by veins of quartz and pegmatite, obviously of contemporary age with the granite.

FIG. 5.—CHROMITE OUTCROP ON DEPOSIT NO. 3 EXPOSED ALONG THE STRIKE.

It has already been shown that the deposits are in the form of series of nearly vertical, dyke-like lenses, lying in the igneous schists near the contact of these schists with the sedimentary schists and parallel to the strike and dip of these rocks. The possibility of the chromite having been intruded into this position, plausible as it might appear after a superficial examination, is remote, since chromite has a very much higher melting point than that of the surrounding rocks, which would therefore be liquid at a temperature far below the melting point of chromite. The theory of the formation of chromite as intrusive masses has never been strongly supported, and is admirably disproved by F. E. Keep,[1] who also gives particulars of eminent geologists who condemn the theory.

If the theory of magmatic segregation, generally accepted for the formation of other chromite deposits, is adopted, the igneous schists must have been intruded as a chromium-rich ultra-basic magma from which the eutectic chromite, by virtue of its high freezing point, crystallized in advance of the rest of the magma, and descended by gravity to form flattened, bedded aggregates, or masses of crystals, at the bottom of the intrusions, but prevented from making contact with the wall rocks by the rapid solidification of the outer margin of the magma, cooled by the wall rocks. A further fall in temperature would have solidified the bulk of the magma.

An essential condition of this proposed theory of origin is that the basic magma should have been intruded into a horizontally bedded series of rocks, and the deposits formed as horizontal, flattened beds or masses. To fulfil this condition the igneous schists must be of pre-granite age and have been intruded when the sedimentary rocks were in their original horizontal position, the gigantic upheaval, possibly contemporaneous with the intrusion of the granites, lifting the entire series of rocks into their present position. Complete evenness and

FIG. 6.—CHROMITE OUTCROP ON DEPOSIT NO. 3.

[1] F. E. Keep, *op. cit.*

symmetry of the deposits would be prohibited by many factors, among which are: The uneven formation of the intrusive magma, with consequent unequal rates of cooling; uneven bedding, upon which the chromite crystals, descending through the molten magma would come to rest; subsequent additional intrusions of magma into the liquid primary magma during the chromite crystallization period, which by disturbing the eutectic conditions both as regards composition and temperature, would result in interruptions in the segregation of the chromite. This last factor would tend to cause the formation of parallel deposits separated by magma solidified by the cold exterior rocks during the time taken for the re-establishing of the eutectic conditions necessary for the crystallization of the chromite.

It is evident that considerable distortion of the deposits has occurred since their formation. Certain exposures show folding, following the folding of the igneous schists, whilst minor faulting is frequent, both lateral and vertical displacements of a few feet being displayed in the deposits. The shattered state of certain of the lenses may have been caused by the expansion of the igneous schists accompanying their decomposition, or to more general and violent movement, entailing the bending of the entire series, during subsequent disturbances. The chromite-talc contact faces are highly polished and indicate considerable differential movement between the chromite and the wall rocks.

The nature of the igneous rocks has already been dealt with, but an interesting feature in connexion therewith is the presence in the talc schists of short, thick lenses of much decomposed amphibole asbestos, which is also well developed in certain places on the hanging-wall side of the chromite lenses, where it attains as much as 1 ft. in thickness.

Considerations of the possibility of the extension of the deposits to depth must be based upon the mode of origin, and in the ensuing discussion the theory of magmatic segregation, the details of which have been given, is adopted.

Continuation of the Chromite Deposits to Depth.—Exploration of the deposits at depth has been curtailed by the shallowness of the water table. Water was struck in No. 2 deposit at a depth of 50 ft., at which level several tunnels and adits were driven through the deposit, proving the widths of the lenses to differ considerably from the corresponding surface dimensions, but to maintain an average equal to the average of the surface widths. No underground work has yet been undertaken with the two other deposits.

The depth of the deposits will be less than the original depth by the amount of mineral that has been weathered away and lost. Owing to the hardness of the chromite and the softness of the surrounding talc-schists, weathering has taken place by the outcropping and breaking off of boulders of ore. All of the deposits are surrounded and covered with large tonnages of detached

Fig. 7.—Native Labourers engaged on the development of the Chromite Deposits.

boulders of chromite, but taking into account the large size of the outcrops, this detrital ore represents the denudation of only a few feet, and points to the fact that the deposits have been recently exposed.

Following the theory that the deposits are magmatic segregations, it is not unreasonable to suppose that the lateral dimensions of the deposits are equal. It might be assumed that the depth of the deposits is qual toe the exposed lengths, and it may even be found, if the whole length of the deposits has not yet been exposed, that the total length and depth of the deposits may be in excess of the exposed lengths. For such lenticular deposits the estimation of tonnages is far from easy. Including detrital ore, about 80,000 tons of chromite has been proved, but there is little doubt that beneath the surface many times this tonnage of chromite is awaiting development and exploitation.

NOVEL FEATURES OF A NEW COPPER REFINERY

By W. M. GOODWIN

In this article the author gives details of some of the new equipment of the Canadian Copper Refiners at Montreal East.

The latest electrolytic copper refinery to come into operation is that of Canadian Copper Refiners, Limited, at Montreal, Canada. The tanks were filled early last Spring, slightly less than a year after the first sod was turned, and for some months the plant has been turning out copper, gold, and silver regularly, its capacity being 75,000 tons of copper yearly. The slimes plant is disproportionately large as there is much more than the usual amount of gold, silver, tellurium, and selenium in the blister copper from Noranda, Quebec, the chief source of supply.

Canadian Copper Refiners is owned by three companies, Noranda Mines, Nichols Copper Company, and British Metal Corporation. The plant was built and is operated by Nichols Copper Company and in both phases the advantage of this close connexion with a well-established refinery staff is clearly evident. Nevertheless only a handful of the present employees have been brought from the refineries in the United States, practically the whole of the operatives having been hired locally and trained on the spot. The company has already branched out into the fabrication of copper, having acquired a substantial interest in the new rolling-mill of Canada Wire and Cable Company, which adjoins the refinery.

The refinery is modelled essentially upon the plants built recently by the Nichols Copper Company in the United States, but there are a number of features that distinguish it, some of which mark advances in refinery practice. These will be described briefly. The ground plan of the plant, indicated in Fig. 1, permits the whole operation to be carried out under one roof—a concession to the Canadian winter. The section, Fig. 2, in conjunction with the plan, shows how provision has been made to double the capacity by extending the 60 ft. bays which flank the central 24 ft. bay containing the solution pumps and furnaces.

The novel arrangement of the floor in the tank house 18 inches below the top of the tanks, as illustrated in Fig. 2, has already proved its utility by affording ready access to the tanks and easy inspection. The commercial cells, 432 in number, are 16 ft. 7 in. by 3 ft. 7½ in. and 4 ft. 1¼ in. deep, with 5 in. concrete walls, lined with 8 lb. 6% antimonial lead. The bus bars are 13½ in. by 3 in. in section and are the largest

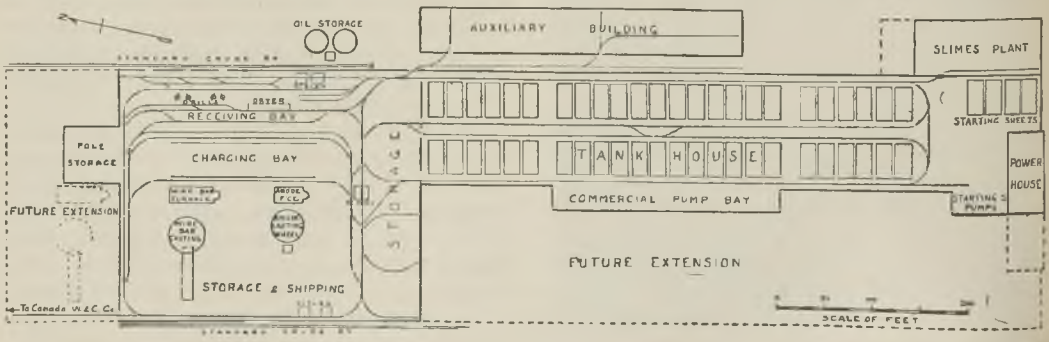


FIG. 1.—OUTLINE PLAN OF PLANT OF CANADIAN COPPER REFINERS, LTD.

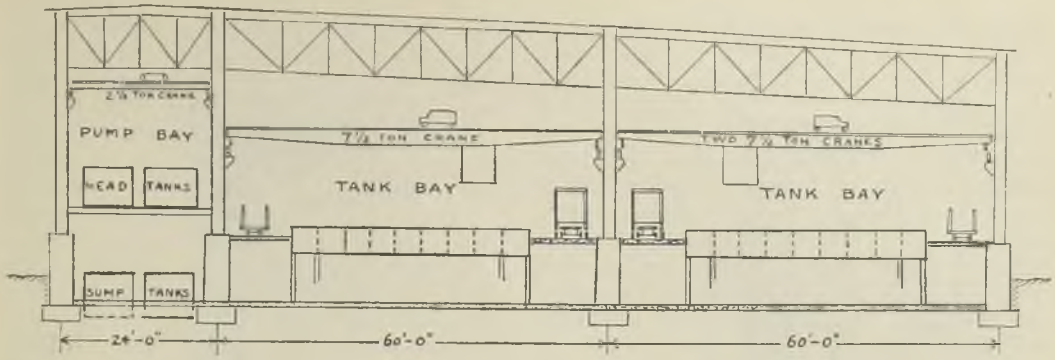


FIG. 2.—CROSS-SECTION OF THE TANK HOUSE: NOTE POSITION OF FLOOR AND OF PORTABLE CATHODE-WASHING MACHINES.

now in use, having been rolled from 5,500 lb. castings 10 ft. 6 in. by 22 in. made at Laurel Hill. The tanks are designed for a current density of 17 amperes per square foot. The basement beneath the tanks presents a rather unusual appearance as it has 7 ft. minimum headroom and practically a clear floor except for gutters in the concrete leading to a sump. "Weep holes" at 18 in. centres in the concrete bottoms of the tanks provide the means of detecting immediately and locating accurately leaks in the lead lining.

The portable cathode washing machines illustrated in Fig. 3 constitute an experiment that has been proved highly successful. They run on broad-gauge tracks, straddling the narrow-gauge tracks that serve the whole plant, in the central aisle of the tank house and are placed at the ends of the tanks from which finished cathodes are to be discharged. In place of the dripping cathodes being carried lengthwise of the building to a stationary washing tank, the maximum distance required in this case is 50 ft. The device is essentially a lead-lined steel box on wheels fitted with conveyor chains on which the cathode suspension bars rest. A rack of 21 cathodes is lowered on to these chains at the receiving end and carried forward at a rate of $3\frac{3}{4}$ ft. per minute through the central sprayer section, where water sprays from above and strong jets from the sides impinging on the sheets and loops remove all acid and sulphate. At intervals along the floor of the aisle are $2\frac{1}{2}$ in. hydrant connexions for the incoming wash-water and 6 in. connexions for the discharge, connected by hose to the machine. At the discharge end the bottom, protected by overlying rails, slopes upward so that the cathodes gradually assume a position near the horizontal and finally drop in succession in a pile on a cathode car beneath.

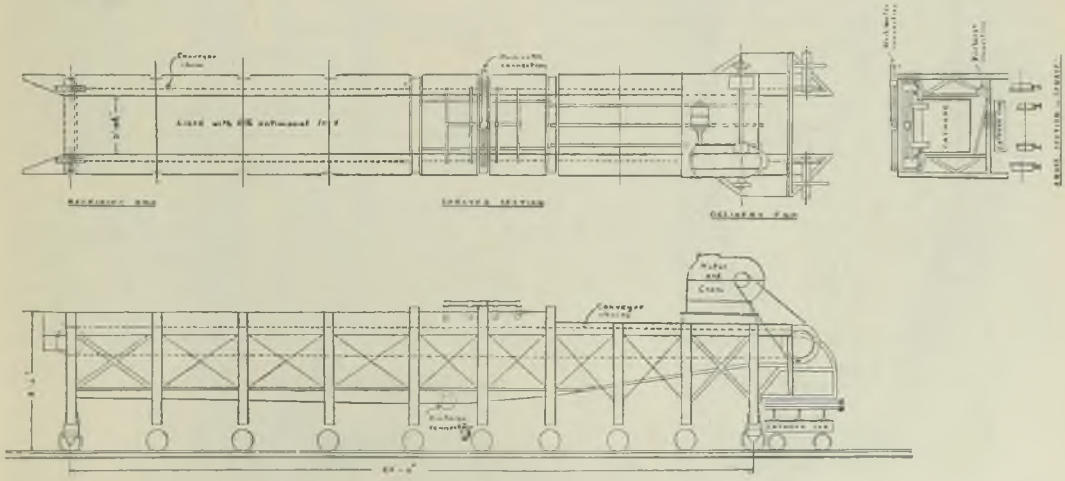


FIG. 3.—CATHODE-WASHING MACHINE.

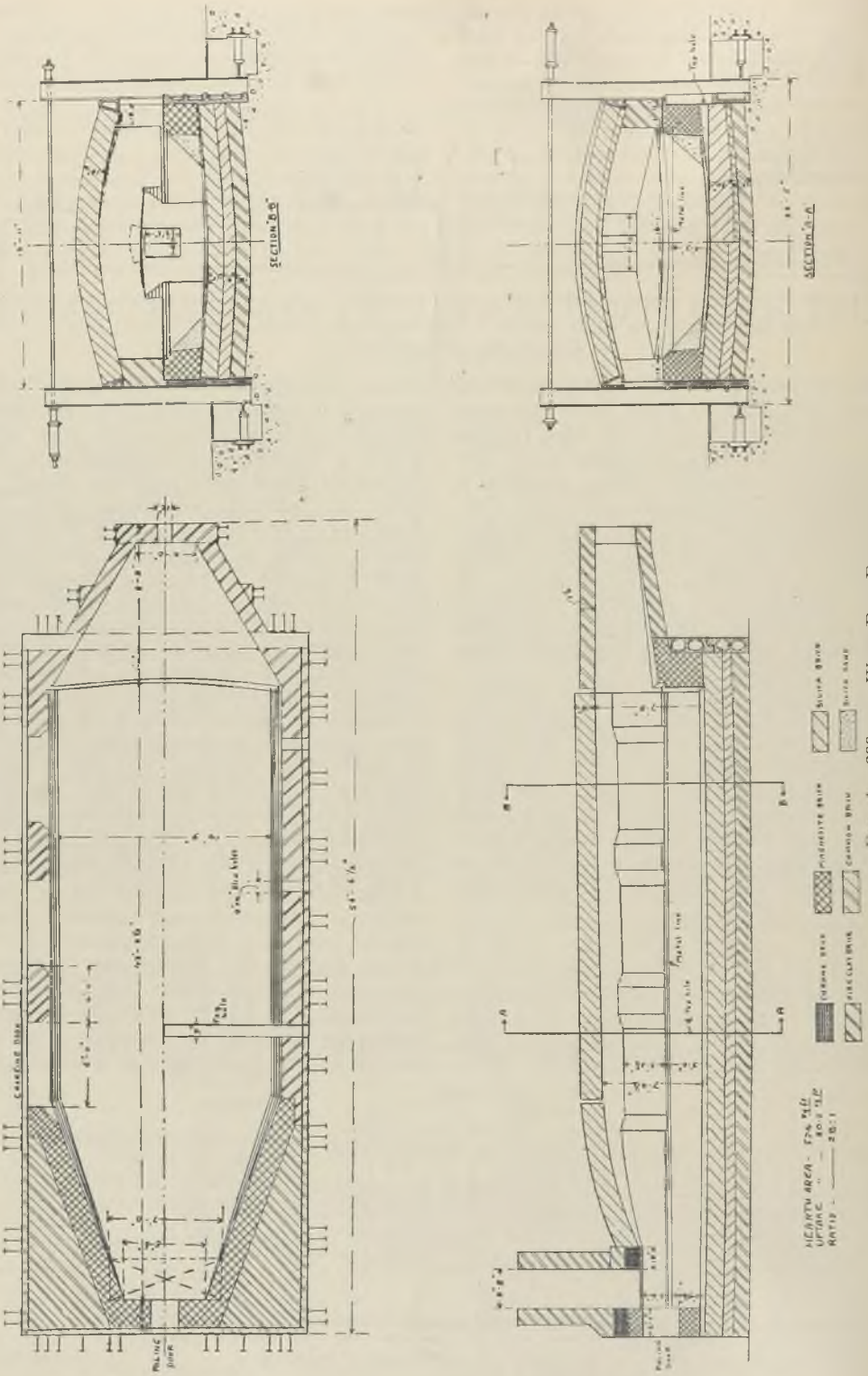


FIG. 4.—300-TON WIRE-BAR FURNACE.

The slimes department has the usual flow-sheet with the exception of a provision to cope with the unusual amount of selenium and tellurium derived from the Noranda ore, a considerable proportion of the high gold values in that ore occurring, apparently, as tellurides with associated selenides. The slimes, after roasting, are put through a caustic potash leach to remove these impurities, in addition to the usual acid leach. At present the comparatively large amounts of selenium and tellurium are run to waste, due only to the lack of an adequate market.

The anode furnace is small (100 tons capacity) as the Noranda copper is cast as anodes at the smelter. All furnaces are fired with fuel oil piped from an adjoining oil refinery. The wire bar furnace, illustrated in Fig. 4, is of the usual type. The bottom consists of 24 in. of silica brick upon 12 in. of firebrick, resting on a cement foundation without air or water cooling. The side-walls and bridge-wall are of magnesite brick to two courses above the metal line and firebrick from there up to the arch, except at the poling end, where the magnesite brick is carried up to the roof. The main roof arch is 18 in. thick, of silica brick. The firebox is entirely of firebrick. The verb at the poling end is of chrome brick, as well as two courses above the poling door. The ruling dimensions are shown in Fig. 4. The furnaces are served by a Morgan floor-type charging machine, the arm of which has been furnished with a parallel link connexion to keep the "peel" and its load of cathodes level in all positions.

The new refinery is running smoothly in all essential respects. As it has been built with the greatest possible economy consistent with equipment of the best quality, and as it enjoys a number of advantages with regard to its location, its sources of supply and its facilities for marketing, it promises to constitute a highly profitable investment for its owners.

THE ESTIMATION OF ANTIMONY AND ARSENIC

By J. E. CLENNELL, B.Sc., A.I.M.M.

(*Concluded from September issue, page* 153)

Experimental Results.

Standardization of the Permanganate on Metallic Antimony.—The permanganate used in the majority of the tests detailed below was approximately decinormal, viz. 1 cc. = 5·577 mgm. Fe or (theoretically) 1 cc. = 6·080 mgm. Sb.

Pure finely divided antimony was taken, the results being as follows:—

Test No.	*Antimony mgm.*	H_2SO_4 *cc.*	HCl *cc.*	$KMnO_4$ *required cc.*	1 *cc.* $KMnO_4$ = *mgm. Sb*
1	200	15	2	32·9	6·08
2	200	17	15	32·9	6·08

Attempts to use larger quantities of antimony were not very satisfactory. A white crystalline precipitate appeared on cooling the H_2SO_4 solution, which dissolved on dilution to a clear liquid. On adding $KMnO_4$, however, a white turbidity again appeared, making the end-point doubtful. This turbidity did not entirely dissolve in HCl, nor in H_2SO_4 of which additional quantities were added during the titration. The results obtained are given below.

Influence of Iron on the Titration of Antimony.—All previous investigators[1] appear to have assumed that the whole of the iron present would be in the ferrous state after solution in H_2SO_4 under the conditions of the test and would consequently be titrated along with the antimony by permanganate. If this were the case, the necessary correction could be made by a separate determination of the iron in the same or in another portion of the sample. The following tests, however, show that these assumptions are incorrect. Nearly the whole of the iron is converted to the ferric state, whatever may have been its original condition and, consequently, the

Test No.	*Sb. mgm.*	H_2SO_4 *cc.*	HCl *cc.*	*Water cc.*	$KMnO_4$ *required cc.*	1 *cc.* $KMnO_4$ = *mgm. Sb.*
3	500	22*	15	250	81–82	6·17–6·10
4	500	25	15†	250	80·7	6·20

* *Test No.* 3. 17 cc. H_2SO_4 in dissolving; 5 cc. in titration.
† *Test No.* 4. 5 cc. HCl before, 10 cc. during titration.

[1] Except A. H. Low (loc. cit., p. 33).

presence of iron causes only a slight error in the titration.

Test No. 1.—200 mgr. pure antimony and 138 mgr. pure iron wire were dissolved together in 17 cc. conc. H_2SO_4. The antimony dissolved before the iron and finally the H_2SO_4 solution contained a dense yellowish precipitate, which, however, dissolved on dilution, addition of HCl, and heating nearly to boiling. The reagents added were 15 cc. conc. HCl and 220 cc. water, making a total volume of about 250 cc. After cooling, this required 33·1 cc. $KMnO_4$, equivalent to 201·25 mgm. Sb. Assuming that 32·9 cc. $KMnO_4$ was required for titration of the antimony, the remainder, 0·2 cc., corresponds to the ferrous iron present and represents 1·11 mgm. or about 0·8% of the total iron.

Test No. 2.—200 mgr. pure antimony and 718 mgr. ferrous ammonium sulphate were dissolved in 17 cc. conc. H_2SO_4. The mixture dissolved rapidly, forming a yellowish white precipitate. 15 cc. conc. HCl and 220 cc. of water were added, and cooled. This required 33·3 cc. $KMnO_4$, corresponding to 202·5 mgm. Sb. Assuming the ferrous ammonium sulphate to have contained 102·24 mgm. Fe, the excess 0·4 cc. $KMnO_4$ corresponds to 2·23 mgm. ferrous iron or 2·18% of the total.

Test No. 3.—300 mgm. of powdered ferrous sulphide (FeS), without addition of antimony, was boiled with 17 cc. conc. H_2SO_4, forming a white turbid liquid. This was finally diluted with 15 cc. HCl and 220 cc. water and required 1·1 cc. $KMnO_4$, corresponding to 6·13 mgm. Fe. Assuming 300 mgm. of FeS to contain 190·5 mgm. Fe, this would indicate that 3·2% of the total iron was finally present in the ferrous condition.

Test No. 4.—250 mgm. iron filings, without addition of antimony, was boiled with 17 cc. conc. H_2SO_4 and treated as in *Test No.* 3 and it required 0·6 cc. $KMnO_4$, corresponding to 3·35 mgm. Fe, indicating that 1·34% of the iron was finally in the ferrous condition

Test No. 5.—300 mgr. of a sample of Rio Tinto iron pyrites was treated as in *Test No.* 3. The material had the following composition.

Iron .	40·90%	Lead . .	1·23%
Sulphur .	46·46%	Insoluble .	2·14%
Zinc .	2·02%	Water . .	1·09%
Copper .	1·54%		

A yellowish-white emulsion was formed, which dissolved, on dilution and heating, to a clear deep yellow solution, with a small whitish residue. This required 0·8 cc. $KMnO_4$, corresponding to 4·5 mgm. ferrous iron, or 3·65% of the total iron present.

Summary of Results on Influence of Iron.

Test No.	*Added Fe. mgm.*	*Sb. mgm.*	*Form in which iron was originally present.*	*Per cent of Total Iron finally as Fe″.*
1	138	200	pure iron wire	0·8
2	102·2	200	Ferrous ammonium sulphate	2·18
3	190·5	—	Ferrous Sulphide	3·2
4	250	—	Iron Filings	1·34
5	122·7	—	Ferric Sulphide	3·65
			Mean	2·23%

It is evident that the assay cannot be corrected by a determination of the total iron, but for rough purposes, the presence of even a considerable percentage of iron may be safely ignored.

Influence of Other Foreign Metals on the Titration of Antimony.

Test No. 1.—The following were dissolved together in 17 cc. conc. H_2SO_4 :—

Pure antimony . . .	200 mgm.
Pure granulated tin . .	50 ,,
Pure lead foil . . .	50 ,,
Pure copper foil . . .	50 ,,

This mixture dissolved to a clear green liquid which, after cooling, was diluted with 220 cc. of water and 15 cc. HCl. This required 33 cc. $KMnO_4$, corresponding to 200·64 mgm. Sb, or an excess of 0·32% over the theoretical amount. The lead sulphate formed a slight turbidity in the diluted solution.

This test shows that the titration of antimony is not affected by the presence of tin, lead and copper in the proportions used.

Influence of Bismuth.

Test No. 1.—200 mgm. of pure metallic bismuth, finely ground, was dissolved by heating with 17 cc. conc. H_2SO_4. A white precipitate formed at first, which later dissolved to a clear colorless liquid. On cooling, a crystalline precipitate separated, which dissolved completely in water. 15 cc. conc. HCl and 220 cc. water were added. The addition of $KMnO_4$ gave an immediate colour, showing that bismuth has no reducing effect.

Test No. 2.—200 mgm. of pure antimony and 200 mgm. of pure bismuth were dissolved together in 17 cc. conc. H_2SO_4 and treated as in *Test No.* 1. Required 32·8 cc. $KMnO_4$, corresponding to 199·4 mgm. Sb, showing

that the presence of bismuth has practically no effect on the titration.

Influence of Copper.—As the statement had been that copper in large quantity interferes with the titration of antimony by this method, this point was specially investigated. A fresh permanganate solution was used. This was standardized on antimony as follows:—150 mgm. pure antimony, dissolved in 17 cc. conc. H_2SO_4, diluted with 160 cc. water and 15 cc. conc. HCl required 24·9 cc. $KMnO_4$ or 1 cc. $KMnO_4 = 6·024$ mgm. Sb.

Test No. 1.—1·2 gm. copper sulphate, containing about 300 mgm. Cu was dissolved, together with 150 mgm. antimony, in 17 cc. conc. H_2SO_4. After boiling, a whitish residue remained, which dissolved to a green solution on diluting. After cooling, this was diluted with 220 cc. water and 15 cc. conc. HCl and required 24·9 cc. $KMnO_4$, equivalent to 150 mgm. Sb, showing that no interference was caused by the presence of copper amounting to double the amount of the antimony.

Attempts to dissolve relatively large amounts of metallic copper, as foil, in presence of antimony were unsatisfactory, as prolonged boiling and fresh additions of H_2SO_4 were necessary and the final solution gave no definite end-point. Unsatisfactory results were also obtained by dissolving in a mixture of H_2SO_4 and HNO_3, the titration of the antimony showing a very low result.

Test No. 2.—200 mgm. of pure antimony was dissolved by heating with 17 cc. conc. H_2SO_4. After cooling, the solution was poured into 100 cc. water containing 4 gm. copper sulphate (i.e., about 1 gm. Cu) in solution. After cooling, 15 cc. conc. HCl and 120 cc. water were added, and the whole titrated. The end-point was shown by a violet colour in the green solution, with 33·5 cc. $KMnO_4$, corresponding to 203·7 mgm. Sb.

This test shows that copper in very large excess has some effect on the titration, in increasing the apparent amount of antimony. In the above case, the amount of copper was approximately 5 times that of the antimony.

Relation Between the Iron and Antimony Standards of Permanganate.—The solution used in the foregoing tests was standardized on ferrous ammonium sulphate as follows:—1·1052 gm., representing 157·38 mgm. Fe was dissolved in dilute H_2SO_4. This required 28·1 cc. $KMnO_4$, hence

1 cc. $KMnO_4 = 5·601$ mgm. Fe, or $1·003 \frac{N}{10}$.

Two antimony standards were made, at an interval of about a month, using in each case 200 mgm. pure antimony, 17 cc. conc. H_2SO_4, 15 cc. conc. HCl and 220 cc. water, the results being:

$KMnO_4$ required cc.	*1 cc. $KMnO_4$ = mgm. Sb.*	*Factor Fe × f = Sb.*
32·8	6·098	$f = 1·089$
32·9	6·079	$f = 1·085$

The theoretical factor, based on the atomic weights Sb = 121·77, Fe = 55·84 is

Fe × 1·0903 = Sb.

A. H. Low (Technical Methods of Ore Analysis (1911), pp. 29, 30) gives Fe × 1·075 = Sb, based on Sb = 120·2 and Fe = 55·9. The experimental figure corresponds more closely with the newer atomic weights.

Effect of Varying Hydrochloric Acid.

Series No. 1.—In each of the following tests 200 mgm. of pure antimony was dissolved in 17 cc. of conc. H_2SO_4. The solutions were acidified with varying quantities of conc. HCl, as shown later, and diluted to a constant volume of 250 cc. In *Test No.* 1, a white turbidity occurred after adding $KMnO_4$, which rendered the end-point somewhat doubtful. In the other tests the solution remained clear throughout and the end-point was quite sharp.

Assumed standard: 1 cc. $KMnO_4 = 6·098$ mgm. Sb.

Test No.	*Conc. HCl added cc.*	*$KMnO_4$ required cc.*	*Sb. found mgm.*
1	5	32·3	197·0
2	10	32·7	199·4
3	15	32·8	200·0
4	20	32·8	200·0

Series No. 2.—In each of the following tests 200 mgm. of pure antimony was dissolved in 15 cc. conc. H_2SO_4. After adding conc. HCl as shown below the solutions were diluted to a constant volume of 100 cc. In the absence of HCl, no definite end-point was obtained. In *Test No.* 2, with 1 cc. the end-point was uncertain.

Assumed standard: 1 cc. $KMnO_4 = 6·079$ mgm. Sb.

Test No.	*Conc. HCl added cc.*	*$KMnO_4$ required c.c.*	*Sb. found mgm.*
1	0	?	?
2	1	32·8–33·1	199·4–201·2
3	2	32·8	199·4
4	3	32·9	200·0
5	4	32·95	200·3
6	5	32·9	200·0

These tests show that a certain minimum of HCl is necessary for a satisfactory titration, but that increase of HCl beyond this point has little or no effect within reasonable limits.

Test in which HCl was Added only at End of Titration.—This was made in imitation of the method suggested by Thibault (previously mentioned). 150 mgm. pure antimony was dissolved in 17 cc. conc. H_2SO_4 and diluted with 220 cc. water. The solution was nearly clear, but gave a white turbidity on addition of $KMnO_4$. After 20 cc. of $KMnO_4$ had been run in, the solution was cleared by adding conc. HCl drop by drop with stirring, and the titration then completed. 24·3 cc. $KMnO_4$ were required, representing 148·2 mgm. Sb., assuming 1 cc. $KMnO_4$ = 6·098 mgm. Sb.

Attempts to substitute tartaric acid for HCl were unsuccessful. The solution remained clear throughout the titration, a slight brown colour showing at first, which disappeared later, but a very large amount of $KMnO_4$ was consumed and the end-point was quite indefinite, the colour fading almost immediately.

Estimation of Antimony in Stibnite.—The material used gave the following analysis :—

Antimony (Sb)	65·6%
Sulphur (S)	28·2%
Iron (Fe)	2·45%
"Insoluble" and undetermined	3·75%
	100·00

Antimony in this analysis was determined by the iodide-thiosulphate method as detailed later.

The following tests were made by the sulphuric acid-permanganate method, the material for assay being crushed to pass 60-mesh.

Test No. 1.—250 mgm. of the stibnite was heated in a boiling tube with 15 cc. conc. H_2SO_4. A yellowish white turbid liquid was formed, which finally became clear. Some sulphur volatilized and condensed in the upper part of the tube. After cooling, the contents were washed out with 30 cc. water, cooled, 2 cc. conc. HCl added, and further diluted with water to a total volume of about 100 cc. Solution required 27·1 cc. $KMnO_4$. Assuming 1 cc. $KMnO_4$ = 6·08 mgm. Sb, this represents 164·77 mgm. Sb or 65·9%.

Test No. 2.—280 mgm. of stibnite was heated with 17 cc. conc. H_2SO_4, boiled until a clear solution was obtained, cooled, diluted to a total volume of about 250 cc., with addition of 15 cc. conc. HCl. Required 30·2 cc. $KMnO_4$, representing 183·62 mgr. Sb, or 65·58%.

Test No. 3.—This was made on a sample of nearly pure antimony sulphide. The material was in the form of a fine black powder. 280 mgm. was dissolved in 17 cc. conc. H_2SO_4 and treated exactly as in *Test No.* 2. Required 33·1 cc. $KMnO_4$ = 201·25 mgm. Sb, or 71·87%. [Theoretical for Sb_2S_3 = 71·7%.]

No allowance for the interference of iron was made in any of the above 3 tests. The results show that antimony may be determined in comparatively pure specimens of the native sulphide, the assay closely approximating that obtained by the usual method as given here :—

Check Estimation of Antimony in Stibnite by the Iodide-Thiosulphate Method.—500 mgm. of the same sample of Stibnite that was used in *Tests* 1 *and* 2 above was dissolved in 25 cc. conc. HCl with addition of 3 gm. solid iodine. After dilution, the excess of iodine was expelled by prolonged boiling. After further dilution, the liquid was made strongly alkaline with NaOH and H_2S passed in ; the hot solution was then filtered and the residue (A) washed with hot water. The residue was further treated as shown later (see A). The filtrate was acidified with HCl, warmed, filtered, and washed with hot water. This filtrate (B) was further treated together with the residue A.

The residue, consisting of the bulk of the Sb_2S_3, was dissolved in HCl with addition of 0·5 gm. $KClO_3$, diluted to 150 cc., boiled for half an hour with further additions of HCl, diluted, cooled, about 3 gm. KI added and titrated with standard sodium thiosulphate.

Required 71·7 cc., equivalent to 326·25 mgm. Sb, or 65·39% Sb, assuming I cc. thiosulphate = 4·76 mgm. Cu. = 4·56 mgm. Sb.

(*A*).—The residue A was dissolved in hot dilute HCl and the solution mixed with the filtrate (B). On adding HNO_3 there was an evolution of iodine. The solution was therefore further treated for separation of iron and elimination of excess iodine, and the liquid finally titrated with KI and thiosulphate. 0·25 cc. was required, representing 1·84 mgm. Sb, or a total of 328·09 mgm., representing 65·62% Sb.

Summary of Results on Estimation of Antimony in Sulphides

Sample	Amount taken	Sb. present theoretical		Method	Sb. found	
	mgm.	mgm.	%		mgm.	%
Stibnite	250	164·05	65·62	$KMnO_4$	164·77	65·9
Stibnite	280	183·74	65·62	,,	183·62	65·58
Pure Sb_2S_3	280	200·76	71·70	,,	201·25	71·87
Stibnite	500	328·09	65·62	$Na_2S_2O_3$	Standard.	

Influence of Mineral containing Iron on the Titration of Antimony in Stibnite.—300 mgm. of stibnite and 200 mgm. of Rio Tinto iron pyrites (40·9% Fe) were dissolved together in 17 cc. conc. H_2SO_4, cooled, and diluted with 220 cc. water and 15 cc. conc. HCl. The turbid solution became clear on dilution and warming. Required 32·7 cc. $KMnO_4$ = 198·8 mgm. or 66·26% Sb. [If 0·55 cc. be deducted, as representing the reducing power of 200 mgr. of the pyrites, then 32·15 cc. $KMnO_4$ represents 195·44 mgr. or 65·15% Sb.]

Titration of Antimony Originally Present in the Antimonic Condition.—It is evident from the reaction that all antimony titrated by permanganate must be in the antimonious condition; any that is originally in the antimonic state must be reduced to the antimonious condition.

For this investigation, antimony pentoxide Sb_2O_5, was prepared by evaporating pure antimony with conc. HNO_3. The dry residue was then gently ignited over a bunsen burner or at the mouth of a muffle until no further red fumes were evolved, the product being a yellow powder.

Test No. 1.—270 mgm. of antimony pentoxide was boiled with 17 cc. conc. H_2SO_4. A white emulsion was produced which was not cleared on dilution with 15 cc. conc. HCl, and 220 cc. water, nor did it become clear on warming. After cooling 8·9 cc. $KMnO_4$ were required, apparently representing 54·3 mgm. Sb in the antimonious state, out of a total of 203·2 mgm. theoretically present (assuming Sb_2O_5 = 75·27% Sb).

Test No. 2.—For comparison, 250 mgm. of antimonious oxide (Sb_2O_3) containing theoretically 208·85 mgm., or 83·54% Sb, was dissolved and titrated as in *Test No.* 1. The solution was slightly turbid, but cleared on dilution. Required 34·4 cc. $KMnO_4$ = 209·12 mgm., or 83·65% Sb.

[An attempt to reduce the antimony pentoxide by adding 0·5 gm. tartaric acid to the H_2SO_4 used in dissolving was not successful; much charring took place and the mixture remained brownish even after long boiling. The end-point with $KMnO_4$ was uncertain, owing to this colour, and much too high.]

Test No. 3.—300 mgr. of antimony pentoxide (= 225·8 mgm. Sb) and 500 mgm. of pure granulated tin were dissolved together in 17 cc. conc. H_2SO_4, a clear colourless solution being obtained. After cooling and diluting with 15 cc. conc. HCl and 220 cc. water, this required 34·8 cc. $KMnO_4$ = 212·2 mgm. Sb, showing that most of the Sb had been reduced to the antimonious condition, presumably by the nascent hydrogen or sulphur dioxide evolved from the tin.

Test No. 4.—300 mgm. of antimony pentoxide and 1 gm. of pure granulated tin were dissolved and titrated as in *Test No.* 3. Required 37·0 cc. $KMnO_4$ = 225·6 mgm. Sb, showing practically complete reduction.

Antimony in the antimonic condition (at least in the form of the higher oxide) may thus be quantitatively reduced to the antimonious state by boiling with conc. H_2SO_4 and metallic tin, the excess of tin having no influence on the permanganate titration. The method would probably not be applicable in presence of iron as the latter would be, partly at least, reduced to the ferrous state.

Titration of Arsenic by the Sulphuric Acid-Permanganate Method, and Influence of Arsenic on the Titration of Antimony.—Arsenic appears to behave in this reaction precisely in the same way as antimony. After dissolving in conc. H_2SO_4, all the arsenic is in the arsenious condition and is converted to the arsenic state by titration with permanganate, in accordance with some such reactions as the following:—

(1) $2As + 3H_2SO_4 = 2As(OH)_3 + 3SO_2$.

(2) $5As(OH)_3 + 2KMnO_4 + 3H_2SO_4 + 2H_2O = 5As(OH)^5 + K_2SO_4 + 2MnSO_4$

according to which $2KMnO_4$ is equivalent to 5As or 1 gm. $KMnO_4$ = 1·186 gm. As., hence

Fe standard of $KMnO_4 \times 0{\cdot}6712$ = As;

1 cc. $\frac{N}{10}$ $KMnO_4$ = 3·748 mgm. As, and Sb standard of $KMnO_4 \times 0{\cdot}6156$ = As.

Standardization of Permanganate on Arsenic Element.—200 mgr. of pure finely ground elementary arsenic was dissolved in 17 cc. conc. H_2SO_4, cooled and diluted with 15 cc. conc. HCl and 220 cc. water. During titration with $KMnO_4$ a reddish brown colour appeared, which disappeared slowly on agitation and might have been mistaken for the end-point. The true end-point is, however, quite unmistakable and is marked by a definite pink colour, which persists for some time. The same appearance of a brownish tint occurred in all tests made on arsenic solutions in absence of antimony, but not when both elements were present.

Required 53·4 cc. $KMnO_4$ or 1 cc. $KMnO_4$ = 3·745 mgm. As.

This agrees closely with the figure calculated from the antimony standard, namely :—

1 cc. $KMnO_4$ = 6·079 mgm. Sb = 6·079 × 0·6156 or 3·742 mgm. As.

Assuming 1 cc. $KMnO_4$ = 5·601 mgm. Fe and the factor Fe × 0·6712 = As, the standard should be 1 cc. $KMnO_4$ = 3·759 mgm. As.

In the following tests the experimental standard, 1 cc. $KMnO_4$ = 3·745 mgr. As has been used, unless the contrary is stated.

Tests on Arsenious Oxide (As_2O_3).

Test No. 1.—150 mgm. of pure arsenious oxide was dissolved in 17 cc. conc. H_2SO_4, cooled, poured into 100 cc. water, 15 cc. conc. HCl added, then diluted with water to a total volume of about 250 cc. Required 31·1 cc. $KMnO_4$ = 116·5 mgm. As. (Theoretical contents of 150 mgm. As_2O_3 = 113·62 mgm. As).

Test No. 2.—200 mgm. of pure antimony and 150 mgm. of arsenious oxide were dissolved together in 17 cc. conc. H_2SO_4 and treated exactly as in *Test No.* 1. Required 63·4 cc. $KMnO_4$. Assuming that 200 mgm. Sb require 32·9 cc. of $KMnO_4$, then 150 mgm. As_2O_3 consume 30·5 cc., or 30·5 × 3·745 = 114·2 mgm. As (Theor. 113·62).

Test No. 3.—100 mgm. pure antimony and 100 mgm. arsenious oxide were dissolved in 17 cc. conc. H_2SO_4 and treated as in *Test No.* 1. Required 36·8 cc. $KMnO_4$. Assuming that 100 mgm. Sb require 16·45 cc. $KMnO_4$ then 100 mgm. As_2O_3 require 20·35 cc., equivalent to 76·2 mgm. As. (Theor. 75·75 mgm. As.)

Test No. 4 (duplicate of No. 3).—Required 36·6 cc. $KMnO_4$. Assuming that 100 mgm. Sb require 16·45 cc. $KMnO_4$, then 100 mgm. As_2O_3 require 20·15 cc., equivalent to 75·46 mgm. As.

Mean of *Tests* 3 *and* 4, 1 cc. $KMnO_4$ = 75·83 mgm. As.

Test No. 5.—200 mgm. pure antimony and 100 mgm. arsenious oxide were dissolved together in 17 cc. conc. H_2SO_4 and diluted with 15 cc. conc. HCl and 220 cc. water. Required 53·8 cc. $KMnO_4$. Assuming 200 mgm. Sb require 32·9 cc. $KMnO_4$, 100 mgm. As_2O_3 require 20·9 cc. = 78·27 mgm. As. (Theor. 75·75 mgm.)

Note.—In all but one of these tests, the amount of arsenic found is somewhat higher than theoretical. There is no evidence of any loss by volatilization or conversion to AsH_3, nor of any oxidation to the arsenic condition during the dissolving process.

The results of the above 5 tests are summarized as follows :—

	Quantities taken			*Found*	*Per cent of*
Test	As_2O_3	*As.*	*Sb*	*As*	*Theoretical*
No.	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*As. %.*
1	150	113·62	—	116·5	102·5
2	150	113·62	200	114·2	100·5
3	100	75·75	100	76·2	100·6
4	100	75·75	100	75·46	99·6
5	100	75·75	200	78·27	103·3

Tests on Realgar.

Test No. 1.—300 mgm. of the finely ground native mineral was heated with 17 cc. conc. H_2SO_4. Everything dissolved to a dark brown liquid, with a slight deposit of sulphur in the upper part of the tube. After cooling, the solution was poured into 50 cc. water, tube rinsed with 50 cc. water, cooled, 15 cc. conc. HCl added, and 120 cc. water, to a total volume of about 250 cc. Required 54·4 cc. $KMnO_4$ representing 203·73 mgm. or 67·91% As. [Theor. for As_2S_2 = 70·1%.]

Test No. 2.—200 mgm. stibnite and 150 mgm. realgar were heated together with 17 cc. conc. H_2SO_4 and treated as in *Test No.* 1. A clear brownish solution was obtained in H_2SO_4, which became slightly turbid on cooling, but cleared again on dilution. Some sulphur separated. Required 49·3 cc. $KMnO_4$. Allowing 21·5 cc. for 200 mgm. of stibnite, the remainder 27·8 cc. represents 104·11 mgm. As in 150 mgm. realgar or 69·4% As.

Test on Arsenic Pentasulphide.

200 mgm., treated as in *Test No.* 1 for realgar, gave a clear colourless solution, which required 22·1 cc. $KMnO_4$ = 82·76 mgm., or 41·38% As. (Theoretical for As_2S_5 = 48·32% As.)

Tests on Mispickel.

The sample used consisted of the nearly pure finely-ground mineral. A determination by the zinc oxide ignition method [A. H. Low, *loc. cit.*, p. 47, also "Select Methods of Metallurgical Analysis," Naish and Clennell (1929), p. 91] indicated 44·3% As. (using titration with KI and thiosulphate). Theoretical for FeAsS = 46·02% As.

Test No. 1.—300 mgm. mispickel was dissolved in 17 cc. conc. H_2SO_4. This gave a whitish emulsion which, after cooling, was poured into 50 cc. water, 15 cc. conc. HCl added, and tube rinsed with 50 cc. water. On heating this mixture nearly to boiling, a clear yellow solution was obtained, with a little siliceous residue. A further 120 cc. water was then added, cooled, and titrated. Required 32·2 cc. $KMnO_4$ = 120·6 mgm. = 40·2% As. (a brownish colour developed during titration, as in other arsenical solutions).

Test No. 2.—300 mgm. mispickel was dissolved in 17 cc. conc. H_2SO_4, cooled, and diluted with 220 cc. water and 15 cc. conc. HCl. The mixture was titrated without previous boiling and showed a whitish turbidity throughout, also a brownish tinge, the end-point being somewhat doubtful. Required 33·9 cc. $KMnO_4$ = 126·96 mgm. As. = 42·32% As.

Test No. 3.—200 mgm. mispickel dissolved in 17 cc. conc. H_2SO_4 was diluted with 220 cc. water, heated just to boiling, whereby the solution became clear, with small siliceous residue, cooled to room temperature, 15 cc. conc. HCl added, cooled again and titrated. Required 23·3 cc. $KMnO_4$ = 87·26 mgm. = 43·63% As.

Test No. 4.—300 mgm. mispickel treated exactly as in *Test No.* 3 required 32·2 cc. $KMnO_4$ = 120·6 mgm. = 40·2% As. (result identical with that of Test No. 1).

Test No. 5.—300 mgm. mispickel treated as in *Test No.* 3, but as a small dark residue, apparently undecomposed mineral remained after boiling with H_2SO_4 and diluting, this was collected and boiled with a further quantity of H_2SO_4. The united solutions required 32·5 cc. $KMnO_4$ = 121·7 mgm. = 40·6% As.

Note.—These tests indicate that there is apparently some loss of arsenic at some stage in the operation. As it was supposed that this might be due to volatilization of $AsCl_3$ on heating the diluted solution, the addition of HCl was made only at the end of the operation in *Tests* 3, 4 *and* 5. The percentage found was, however, only slightly increased.

Mean of the five tests = 41·39% As.

Tests on Mixtures of Stibnite and Mispickel.

As it had been found that 300 mgm. stibnite treated as usual, required 32·2 cc. $KMnO_4$ it is assumed in the following tests that 200 mgm. would require 21·5 cc.

*Test No.*1.—200 mgm. stibnite and 100 mgm. mispickel were dissolved together in 17 cc. conc. H_2SO_4 to a whitish emulsion, cooled, poured into 50 cc. water, 15 cc. conc. HCl added and the tube rinsed with 50 cc. water. On heating nearly to boiling, a clear yellow solution with small siliceous residue remained. 120 cc. water was added, cooled and titrated. Required 31·8 cc. $KMnO_4$ = 10·3 cc. representing 38·57 mgm., or 38·57% As. in the mispickel.

Test No. 2.—200 mgm. stibnite and 200 mgm. mispickel dissolved and treated as in *Test No.* 1 required 41·8 cc. $KMnO_4$ = 20·3 cc. representing 76·02 mgm. As., or 38·01% As in the mispickel.

Test No. 3.—200 mgm. stibnite and 200 mgm. mispickel dissolved in 17 cc. conc. H_2SO_4, diluted with 160 cc. water, heated just to boiling to clear, cooled, 60 cc. water and 15 cc. conc. HCl added, required 42·1 cc. $KMnO_4$ = 20·6 cc. representing 77·15 mgm. As, or 38·57%.

Mean of three tests, 38·38% As.

Note.—The result in presence of antimony appears to be still lower than in the case of mispickel alone. Further investigation is needed to elucidate the cause of these discrepancies. It is remarkable that no apparent loss of arsenic occurred in the treatment of elementary arsenic or of arsenious oxide. There may possibly be some volatilization as sulphide during the boiling with H_2SO_4 as it was noticed that elementary sulphur frequently deposits in the upper part of the tube.

General Conclusions.

(1) Antimony and arsenic may be estimated by the sulphuric acid-permanganate method with a fair degree of accuracy, not only in alloys but in sulphide ores such as stibnite and realgar. In the case of mispickel the results are somewhat low. When both elements are present, the titration represents the combined equivalent of Sb and As.

(2) Tin, lead, bismuth, and copper in ordinary amounts do not affect the titration and antimony may be accurately estimated in presence of these metals.

(3) Iron affects the result only to a slight extent, as the metal is chiefly in the ferric state after solution in concentrated sulphuric acid.

(4) A certain minimum amount of hydrochloric acid must be added before titration. Excess HCl beyond this amount does not appear to affect the result.

(5) The degree of dilution, within wide limits, has no influence on the result.

(6) Antimonic oxide (Sb_2O_5) may be reduced to antimonious by solution in conc. H_2SO_4 in presence of metallic tin and the antimony subsequently titrated by permanganate.

Acknowledgment.—The writer again wishes to express his indebtedness to the authorities of the Chelsea Polytechnic for facilities accorded in carrying out these researches.

BOOK REVIEWS

The Scientific Fundamentals of Gravity Concentration. By JOSEF FINKEY. Translated by C. O. ANDERSON and M. H. GRIFFITHS. Paper covers, 295 pages, illustrated. Price $1. Bulletin No. 1, Vol. II, School of Mines and Metallurgy, Rolla, Missouri.

Many books have been published which deal with the principles of gravity concentration but never before has the subject been dealt with so scientifically, with such a consideration for ordered knowledge, and with such a display of that type of genius which is "an infinite capacity for taking pains," as in the present work. Exhaustive numerical examples and detailed mathematical treatment have no terror for the author, the scientific fundamentals of gravity concentration being examined and explained in detail. In this book, nearly three hundred pages of closely packed calculations are illustrated by well chosen diagrams and curves. There is something for all tastes, although the theorist is catered for particularly. The practical value of so much theory is vouched for by the fact that the considerable expenses of translation and publication have been undertaken by the Missouri School of Mines.

In the preface, the author states that his work is "not intended to supplant but to supplement" other handbooks and text-books. It is certainly a most valuable supplement. The work suffers from a defect common in books of this nature, as no appendix is given to summarize the symbols and units used. This is all the more to be regretted in the present case as units are often used which are not often those met with in ore dressing practice, and are not the fundamental units of the metric system (e.g. on page 46).

It is interesting to note that even for ideal conditions, mathematical treatment sometimes gives results which are contrary to experimental facts. In the more specific application of pure mathematics to practical problems, the added difficulty of inaccurate assumptions complicates the problem. For example, the use of riffles on shaking tables (page 264) has a definite effect on influencing stratification of the feed, quite apart from merely increasing the coefficient of friction of the surface. In some roughing tables, the predominant effect of the riffles is to assist stratification and thus allow the added wash-water to exert a transverse sluicing action on the material between the riffles. Similarly, whether finer classified products (page 276) contain "less than the average metal content of the pulp", or not, depends on the relative friabilities of the gangue mineral and the valuable mineral, and cannot be treated as a general principle. On the other hand, the able mathematical analysis of the laws underlying classification, jigging and tabling should be of the greatest value to research workers and experimentalists in these branches of ore dressing, particularly in the treatment of coal and non-metallic minerals. It is interesting to note that Professor Truscott's well-known text-book on ore dressing, published in 1923, appears to be unknown to the author of this work, to whom undoubtedly it would have been of the greatest assistance, particularly in connexion with points such as those just mentioned.

B. W. HOLMAN.

Geochemische Migration der Elemente, und deren wissenschaftliche und wirtschaftliche Bedeutung erläutert an vier Mineralvorkommen: Chibina-Tundren—Smaragdgruben; Uran-Grube Tuja-Mujun—Wüste Karakumy. By Prof.

Dr. A. Fersmann. 1929, Teil I (mit 22 Figuren im Text und 4 Tafeln mit 11 Abbildungen); 1930, Teil II (mit 17 Figuren im Text und 8 Tafeln mit 20 Abbildungen). Halle (Saale): Wilhelm Knapp.

The application of geochemistry to the fundamental problems presented by rock- and mineral-complexes is fully demonstrated in this treatise, which incorporates four substantial papers on (1) the nepheline-syenite complex of Chibina, Kola Peninsula, (2) emerald mines in the Urals, (3) the uranium-vanadium mines of Tuja-Mujan, Turkestan, and (4) the sulphur deposits of the Karakumy Desert, Central Asia. Each of these papers engages principles which could redeem many a manageable problem from the cockpit of competitive opinion. The first paper is wholly petrological; the rest apply petrological methods to economics; all are of the highest interest, and the first is brilliant.

(1) Prof. Fersmann's outlook is best exemplified by his interpretative work on pegmatites associated with the Chibina complex, which presents parallels with Pilandsberg (Transvaal), Langesundfjord (Norway), Sierra de Monchique (Portugal), etc. From the wealth of field-observations and analytical data (including analyses of 30 rocks and 26 rare minerals) he draws many important conclusions, one of which is of special interest: Whereas early precipitations from granite-magma are melanocratic and (18, pp. 70–71) include both schlieren and segregations, the rest magma collecting upwards to produce leucocratic rocks; the early products from the Chibina nepheline-syenite magma were leucocratic, the later were melanocratic and included true pegmatites and "banded" facies. The implication therefore is that instead of the sinking of early mafic crystals we have the sinking of iron-rich rest-magma, from which "banded" products (p. 71) could arise.

The problem of the ultimate origin of nepheline-syenite magma is reviewed in the light of Chibina data, which illumine, but do not solve it. It is unfortunate that in the rock-analyses "CaO" includes unspecified amounts of baryta and strontia, both of which appear to be concentrated in the rarer minerals.

(2) The emerald-zones are confined to two bands of crystalline schist between granite and a pyroxenite-dunite massif with a gabbro margin. The bands surround the granite, which is traversed by veins of pegmatite, albitite, oligoclasite, and aplite. The emeralds are confined to a hybrid biotitic marginal zone of albitic veins.

(3) The geochemistry of surface and thermal waters acting on Karst ground leads to the conclusion that the V_2O_5 was, in part, derived from limestone and concentrated in residual "terra rossa"; in part, it was introduced metasomatically, with U_2O_8, copper, and barium.

(4) The association of the sulphur with flint, concretionary opal, and chalcedony is shown to be directly related to climatic factors and geochemical processes peculiar to desert regions.

A. Brammall.

☞ Copies of the books, etc., mentioned under the heading "Book Reviews" can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London, E.C.2.

NEWS LETTERS

BRISBANE

August 18.

Work and Production at Mount Isa.—Official statistics for July from the Cloncurry field contain the first returns from the Mount Isa mine. These show that the bullion railed to the coast in June contained 880 tons of lead, worth £10,189, and 70,754 oz. of silver, valued at £4,038. The consignments for July contained 1,951 tons of lead of the value of £8,728 while the combined returns for the two months show that there was an average of 77 oz. of silver in each ton of bullion. The values are based on the average prices of the metals produced for each month. At the mill, up to July 31, there was treated 73,565 tons of ore, the concentrates from which totalled 15,189 tons. The local mining warden explains that owing to the fact that the smelter plant did not come into operation till some weeks after the mill had been started, as well as to the adjustments which had to be made to the plant subsequently, the figures in the return do not show the real relationship between the quantity of ore treated and the yield of metals therefrom. At the end of July large quantities of concentrates were still held in the storage bins and, according to the report of the mining warden, returns for succeeding months should indicate a gradual increase in the quantity of bullion produced. The ore treated was obtained from the Black Star, the Black Rock, and the Rio Grande lodes. The production

previously estimated has been obtained without difficulty and lead values have corresponded with the estimates. Owing to over production of ore required for the treatment plants, operations in the Black Rock carbonate stopes were temporarily suspended during July and the supply of high-grade carbonate ore was drawn wholly from the Rio Grande section. The development of sulphide ore on the main haulage level in the Black Rock section was continued during July by diamond drilling and driving. The main ore-body has been indicated to date over a length of 400 ft. and the foot-wall ore-body over a distance of 350 ft., with ore of average grade in the north and south ends of both lodes. On the main haulage level development work was continued in both the hanging-wall and foot-wall lodes, proving a continuation to at least 200 ft. south of Lawlor's shaft. At this point cross-cuts are being put down east and west in order to develop parallel lodes previously located by diamond drilling. An electrically-driven pump with a capacity of 10,000 gallons a minute has been installed for the purpose of returning the water from the tailings dam to the mill. This will admit of a larger quantity of water being utilized and thus conserve the supply in the Rifle Creek dam.

Cloncurry Copper.—In spite of the exceptionally low price still ruling for copper, considerable quantities of the ore continue to be railed each month from the Cloncurry mineral field, North Queensland. In July the consignments totalled 1,686 tons. As a result of reconstruction work carried out in relation to the working on tribute of the Mount Oxide, Orphan, and Dobbyn mines as a group, larger supplies of ore will in the future be regularly despatched from those leases. From the Mount Oxide, owned by the Mount Elliott Company, there is being produced weekly 50 tons of ore, the copper contents of which range as high as from 30 to 48%, while a fair quantity of 20% dump ore is also being railed. At the Orphan mine, near the terminus of the Mount Cuthbert railway, about 120 tons of 14% material is being mined each week and it is expected this quantity will be shortly increased to 200 tons. The tributers in the Dobbyn are operating on a lode 30 ft. wide, yielding at present ore averaging 11% of copper. The privately owned Trekelano mine, near Duchess, is also on a lode 30 ft. wide, with no foot-wall, and is producing about 100 tons of ore weekly.

Australian Gold Mining.—Reports by Government officials submitted to a recent conference of State Premiers on the question of relieving unemployment indicate that there is in Australia a great field for capital and labour in gold mining. It is stated in one of these reports that the industry is now in as good a position as in 1914. The Victorian Government has assisted 8,000 men to go out as gold seekers and other States are also doing much in the same direction. Federal experts have been busily engaged in making a survey of possible fields of exploitation. It was pointed out at the conference that the use of electrical power would cheapen the cost as well as lessen the capital requirements and the main point resulting from the enquiries of experts is that by such use more fields could be exploited. New finds of gold in the different States continue to be reported, although no discoveries of a sensational nature have been made in the past month. In both Queensland and Victoria there have been increased outputs of gold during the first seven months of the year. Stone estimated to yield 5 oz. of gold to the ton is being mined at Haydon Hill, in the Gardon district of Victoria, and very rich specimens have been obtained from another mine in the same locality. The output of the Wiluna mine, in Western Australia, including the exchange premium, increased from £30,200 in May to £39,500 in June, notwithstanding that continuous running of the power plant had not then been maintained. It was expected that a steady power supply would be secured early in this month.

Exchange Premium on Gold.—While the present rate of exchange is a severe handicap on those who have to import or consume commodities which cannot be, or are not, produced in this country, it is proving a boon to the gold-mining industry. As an instance, figures supplied by the deputy master of the Royal Mint at Perth, Western Australia, the largest producer of gold among the States of the Commonwealth, show that a substantial amount has been paid, chiefly to the gold-mining industry, as the result of the operations of the high-ruling rate of exchange on purchases of gold in Australia. The figures cover the year 1930 and the first six months of the current year. In that period £191,428 was paid as exchange premiums through the Perth mint on behalf of the various banks and approximately £175,185 was paid to the banks otherwise than through the mint.

In the Financial Emergency Bill, which has just become law, an amendment was made providing for a sliding scale of payments, falling as the exchange drops, so that when the rate returns to par the full bounty of £1 an ounce will be restored. It is claimed in support of the change that the reduction is justified because the present exchange rate is equivalent to a premium of about 24s. an ounce.

Palmer Gold Dredging.—The Palmer River Gold Company, N.L., after overcoming many difficulties, is now in full swing with its gold-dredging enterprise in the remotely situated area of Strathleven, on the Palmer River, in the Cape York Peninsula, North Queensland. The company, before it could get its machinery on the dredging site, had to make its own road from the railhead at Laura, a distance of 84 miles, and to transport over that road, which ran through rough, virgin country, the dredging plant, weighing 300 tons. During the four weeks ended July 4 the newly erected dredge, working 420 hours, treated 28,700 cu. yd. of material, for a return of nearly 110 oz. of gold, having a mint value of £581. The property has lately been visited by Mr. H. Theodore (representing a London financial organization), who made a general survey of the dredging area and plant and cabled to his principals a price which he suggested should be paid for their purchase. He is now on his way back to England, where he suggests a company should be formed, with a capital of half a million pounds, to make the purchase, effect certain modifications to the plant which he considers necessary, and carry on the enterprise. Before leaving Brisbane Mr. Theodore asked the Queensland Government for a reservation, for at least six months, of a mineral area on the Palmer River, but the nature of the reply to his request has not for the present been made known.

Central Australian Gold.—Last month particulars were given in this column of an exceptionally rich gold reef which had been discovered at Tennant's Creek, in Central Australia. This find is 240 miles north of Alice Springs, the terminus of the railway which connects a part of this territory with Adelaide, in South Australia. Since then a small company has been formed in Melbourne and taken an option over 130 acres of gold-bearing land about 44 miles north-east of Alice Springs. The property is said to cover an area of one mile along the line of lode, which outcrops at two places over a distance of three-quarters of a mile. Samples taken from the lode, which is 30 ft. wide with no walls in sight, have assayed 3 oz. of gold per ton. Mr. T. S. Hoge, of the Sydney Museum, who last month returned from a three months' tour through the interior of Australia, says enormous mineral wealth is to be found there. Apart from gold he states, mica occurs in huge quantities, and lead and silver are in abundance. Yet another attempt is to be made to locate a gold reef said to have been discovered in Central Australia by the late Mr. L. H. Lassetter nearly forty years ago. The story of "Lassetter's find" has led to many expeditions, the most recent of which was one last year, when Mr. Lassetter himself lost his life through starvation in an endeavour to again find the rich auriferous outcrop originally discovered by him. The latest expedition has been organized by the Central Australian Gold Exploration Company, Ltd. The members of the expedition go by train to Alice Springs, and then travel by camels, which are expected to be used to cover a distance of 300 miles.

IPOH

September 3.

General Conditions.—The tin mining industry now knows what appears to be the worst of its own case and there is a fairly general recognition of the necessity for such drastic measures as are being taken. The cut for the quota period of three months now commencing is to be 60%, and the immediate effect of this certainty is that mines are arranging for reduction of their labour force. In Perak the advantages of grouping have been generally understood and widely used by producers. In Selangor it would seem that this policy has been less generally adopted. At the beginning of this month, which also begins the second quota period, the Government has taken the wise course of awaiting sufficiently full statistics of the actual production for the full six months of the first quota period, so that the proportion of restriction necessary may be determined upon well established data. It was hoped by many that 50% cut would meet the case, but the decision to restrict 60% has been announced. The price of the metal has tended to improve and it must be obvious that a 10% rise in price is better in effect to the miners than a similar increase in the quantity of ore they can sell, having due

regard to the fact that ore won and sold is an irreplacable asset realized. Assistance in these difficult times is now offered by the Perak River Hydro-Electric Power Company in the form of a scale of reduced charges on the basis of units taken. This is the only basis suitable to the conditions of work in this country for most methods of mining including dredging. The rate is approximately two cents per horse power hour, with no fixed minimum charge and the terms are subject to a fortnight's notice. The dredges were least adversely affected by the former method of charging, so the new scale is of assistance to those who most need such help. The severe restriction of output is expected to cause the discharge of labour on a scale that necessitates provision for repatriation of some proportion of those discharged. A questionaire was circulated in August to producers asking whether reduction of labour was contemplated and how many of those paid off would be likely to want to return to China. The grievous state of that country would make it seem unattractive even for its own people, but unemployed labour cannot be allowed to stay in such a country as British Malaya. A new ruling permits producers to transfer the whole or any part of their quota to another producer subject to the written consent of all the principals concerned and to the approval of the Deputy Controller to whom proposals must be submitted.

Excavators.—Limited use has so far been made of these in mining in Malaya, but the possible applications have not been fully tried out. A recent suggestion is to employ a pontoon equipped with grabs, which can be of any desired capacity, for excavation and recovery of values on a very uneven and pockety limestone bottom. This suggestion offers great elasticity in operation, especially as to depth, and if well run should permit a high rate of recovery from ground in which a bucket dredge would be able to dig only a small proportion of the ground. The size of grab can be varied to suit the ground so that the rate of treatment can be adjusted to permit quick handling of poor ground and more careful treatment where values are higher. If desired such a method could locally be made preliminary to complete cleaning up with pumps and monitors. The capital outlay and cost of maintenance would both be considerably less than in the case of a bucket dredge of equal capacity, and the cost per yard would depend on circumstances and the rate of work decided upon. The application of a dragline excavator to mining an alluvial deposit was outlined in the MAGAZINE for January last.

Recent Developments.—In spite of the bad times several new producers have made considerable progress during the past twelve months. Among these may be mentioned the Chemor River Tin Company's new equipment using hydraulic elevators where, in spite of restriction and the poor prices ruling, a margin of profit has been maintained. The workings are on the contact of granite with schist and limestone and though the proposition is generally alluvial there are irregular vein-like or lenticular aggregations of sulphides and arsenides containing variable percentages of tin ore with high local enrichments which have to be developed by shafts and driving on the values. Another occurrence of unusual interest is in the Tepah district of South Siam where the steep shoulder of a hill, in schist country, contains numerous veins with over 1% of tin ore in much of the tonnage so far developed and with higher values locally. In this case shales and sandstones have been highly metamorphosed and in the enriched portions contain much tourmaline and some topaz associated with the tin ore.

Statistics.—The total of tin exported from Malayan ports in August was the lowest for any month of the current year. This total, at 6,076 tons, is nearly 1,600 tons less than was exported in July, and 3,700 tons below the highest total for any month of the current year, namely, 9,719 tons in February.

Gold Mining.—It is satisfactory in these times to refer to any prosperous form of activity in mining and the record of the Raub Australian Gold Mining Co., Ltd., provides this satisfaction. The production is steadily maintained at a little over 1,800 oz. per month for the first seven months of the current year, and at the 37th annual general meeting held on July 23 it was announced that the total distribution of profits for the year ending March 31, 1931, would be £40,000. The net proceeds of the sale of gold for the year had been £93,934 providing a record.

In the Batang Padang district of Perak the gold won to the end of July 1931 is only 1,318 oz., averaging under 190 oz. per month, and compares with a monthly average of 465 oz. for the whole of 1930. The reason for this decline is the reduced activity in tin mining, most of the gold in this district being recovered by tin workers.

JOHANNESBURG

September 3.

Lost Gold Reef Believed Found.—Prospectors are said to have discovered in the Waterberg bushveld a gold-bearing reef which has been traced through ant-heaps for over 60 miles. It is stated that the reef carries high values running up to 3 oz. per ton, but is very "patchy." This reef may be the one which was discovered and lost by Lieut. du Toit of the Staats Artillery many years ago in the days of the South African Republic. The story goes that du Toit was constructing what is now known as the Great North Road for a postal service consisting of a cart drawn by two oxen. Somewhere in the bushveld near Potgietersrust he found indications of a marvellous deposit of gold. He went to Pretoria to notify the discovery, but on his return to the bushveld could not find the place again. He had not pegged it and had no landmark to indicate the spot. About 50 years ago gold was struck on the farm Welgevonden and was worked. Rock assaying up to 75 dwt. was found on the surface in loose formation, but the origin of this gold remains a mystery. It has long been known that alluvial gold and fairly rich specimens of quartz are to be found over a wide area in the Waterberg district. The rocks composing the Waterberg System comprise sandstones, quartzites, grits, and conglomerates in the upper division, and shales, soft sandstones, and conglomerates in the lower division, followed below by a volcanic series of lavas, tuffs, breccias, and agglomerates with interbedded shales and sandstones. In places the rocks have been disturbed by faulting and folding and basic igneous rocks are occasionally found as intrusions in the strata. These are of later age than the well-known Red Granite phase of the Bushveld Complex, of which, however, A. L. Hall considers that they may possibly represent a very late incident. The fact that the country has not been more extensively examined is, it is suggested, largely due, among other deterrent conditions, to the prevalence of malaria.

N'Kana Mine, Northern Rhodesia: Ball-Mills in the Concentrator House.

A Prospector's Promising Find.—Seven years ago, George Thornborrow, a Rhodesian prospector, discovered a gold-bearing reef about 4 miles to the north of the Legion mine, which lies beyond the Matopos and about 100 miles south of Bulawayo. He said nothing about the discovery as he had no money and carried on with other propositions, which at any rate gave immediate return financially. Later Thornborrow decided to return to the reef near the Legion mine. The reef is said to be about 2,500 ft. long and for about 1,000 ft. at one end the "ancients" had worked it extensively. He found some of their old earthenware pots and their smelters, while nearby were ancient ruins. At surface the reef is only 2 in. wide, but 20 ft. down it is 2 ft. wide

and carries visible gold. Several small nuggets have been found on the property. It is also reported that a rich gold strike has been made on Futi Surprise, about 16 miles from Gwelo. This property was at one time known as Ben Nevis and Mr. Hollings within recent years recovered a considerable amount of gold in the neighbourhood. The present discovery is 900 ft. from where he made his original find. The reef was struck at the east end at a depth of 30 ft. at a spot where Mr. Rix, manager of the Globe and Phoenix, suggested a shaft should be put down when he examined the property in 1928. The owners are prominent men in Gwelo and they have formed a syndicate. Pegging is taking place in the vicinity and it is thought that the strike extends over 1,500 ft.

Rhodesia's New Institute.—Some of the leading geologists and mining engineers in Rhodesia met in Salisbury recently and decided to form a local association. The initiative was taken by Mr. Digby Burnett and his suggestion was accepted with much enthusiasm. The new body has for its primary objects "the promotion of the interests, and the maintenance of the status, of the Institution of Mining and Metallurgy in Northern and Southern Rhodesia; facilitating professional and social intercourse between local members, associates and students; and the rendering of assistance where necessary." Messrs. F. P. Mennell, W. Wallace, G. Musgrave, E. A. Prior, J. Murdoch Eaton, A. S. Rome, Digby V. Burnett, and Major Ewan Tulloch are associated with the association. Apart from the protection which the new organization will afford to an often credulous public against spurious practitioners in the mining and engineering profession, and apart also from the value of the organization in the more sectional way, it gives promise of conferring a real benefit on the economic and national side of mining, as, for example, in the application of the high technical knowledge its members will bring to bear on such knotty problems as the remodelling of decrepit mining laws.

ABENAB MINE, SOUTH-WEST AFRICA: POWER PLANT, MILL, AND HEADGEAR.

VANCOUVER

September 8.

Bridge River.—Consequent on the successful results obtained at the Pioneer mine this district is now receiving a large measure of attention, several new organizations being engaged in exploratory work on prospects located within the north-westerly extension of the Pioneer-Lorne diorite formation. In regard to the Pioneer, the increasing length of ore that has been encountered at depth, due to the westerly rake of the diorite-serpentine contact, augurs well for the future. The property was recently examined by Mr. Ira B. Joralemon, who, in his report to the directors, emphasizes the importance of the persistence of the present ore-body and the zone of contact to greater depth. He stated that by using only the developed length of ore on the 9th (1,000 ft.) level as a basis for estimate,

every new 125-ft. level will make 45,000 tons of ore, but if, as expected, ore should continue to the serpentine contact on this horizon, the total length of ore there will be 1,790 ft., indicating nearly 80,000 tons of possible ore per 125 ft. in depth. Should this condition persist to the 10th level, the length of ore at that horizon would be 2,060 ft., and the tonnage of ore between the 9th and 10th levels, 86,500 tons. Mr. Joralemon stated further, that he was particularly impressed with the ore that has already been developed as well as with the probabilities that greater values would be encountered at depth. Total operating costs, he considered, should approximate and the Lorne Gold Mines, Ltd., 400,000 shares. In this report it is stated that $35,000 has been expended to date on repairs, betterments, and underground development. On the King vein the ore-shoot has been opened for a length of 217 ft. at a height of 162 ft. above the main tunnel level, and in a rise from this point values have been proved to extend for a distance of 400 ft. Diamond drill prospecting has located the vein at several points on the tunnel horizon, but core recoveries proved unsatisfactory. Development on the "Shaft" vein encountered rich ore to a height of 45 ft. above the tunnel. The lode subsequently pinched but was recovered later and now

Monitor Installation on French Creek, Revelstoke, B.C.

$4·00 per ton, a figure made possible by the fact that hydro-electric power costs only 0·25 cent per k.w.h., and timber $10 per 1,000 f.b.m. The new shaft, which has been raised from the 9th level is now approaching the 5th level. When communication is effected with that point, it will be possible to commence sinking below the 1,000-ft. as well as to continue with the shaft rise to surface. This company has recently declared its third quarterly dividend of three cents per share, equivalent to 12% per annum. A progress report, covering operations at the Lorne mine since control of the property was acquired by Bralco Development and Investment Co. in April last, has been recently issued. A new company, known as Bralorne Mines Ltd., was formed ; having a capital of $1,000,000, the Bralco Company holding 600,000 shares shows a width of four ft. in the back of the raise at 100 ft. elevation. Exploratory work is being performed by the Bridge River Consolidated Mines, Ltd., on the properties formerly known as the "Forty Thieves" and "Why Not" groups. On the first-named, where a new tunnel has been started, it is expected that some promising surface showings will be intersected at a distance of some 60 ft. from the portal. On the "Why Not," an old cross-cut tunnel is being extended. Bridge River Exploration, Ltd., is a recent incorporation with holdings that cover the extension of the Pioneer-Lorne formation, as well as the downward extension of veins that outcrop on the property of the Bridge River Consolidated, which lie to the south. Exploratory work with two crews has already started, and it is understood that an extensive

programme of development is contemplated. Preliminary work on the Pioneer Extension group, adjoining the Pioneer mine to the south-east, and owned by P.E. Gold Mines, Ltd., has advanced to the stage that warrants the driving of an adit tunnel to develop some promising leads that have been uncovered by surface sluicing and trenching.

Big Bend District.—Having contended with adverse ground conditions for the past two seasons, which necessitated a cut through hard glacial clay ranging from 10 to 30 ft. deep for a distance of 600 ft., French Creek Development Company reports that productive operations have now commenced on its placer bench leases. The property is situated on French Creek, a tributary of the Columbia River, and about 70 miles north of Revelstoke. Since the big rush of the "sixties" the area has been well known to hand miners who are reputed to have won more than $3,000,000 of placer gold from the shallow gravels of the creek. In later years prospecting of the bench areas led to the discovery of extensive deposits of auriferous gravels and several "Old River Channels," and in 1927 the present company was formed to acquire these leases. In addition to 150 ft. of tunnelling on one of the pre-glacial channels, 34 test pits have been sunk, showing gold values ranging from 50 cents per cu. yd. in the upper gravels to $1·00 at a depth of 10 ft. and in excess of $5·00 at 20 ft.—results that create a very favourable outlook for profitable operations. The present installation consists of two No. 6 Hendy Giant monitors, equipped with 7 in. nozzles, having an average capacity of 3,000 cu. yd. per day, and operating at an estimated cost of 5 cents per cu. yd. This low figure is in a large measure due to the abundant water supply available, which also develops power to operate a sawmill of 12,000 ft., board measure, capacity per day. A section of the glacial deposit appears in the foreground of the accompanying picture, through which it was necessary to make a lengthy cut in order to install the sluice box at bedrock level in the ancient channel. Channel dimensions, as illustrated, average more than 50 ft. in width, carrying a pre-glacial deposit almost 50 ft. deep. Sufficient gravel has not yet been treated to serve as a basis for the estimation of mean recovery values, but the results of preliminary testing have satisfied the operators that a long period of profitable operations is assured.

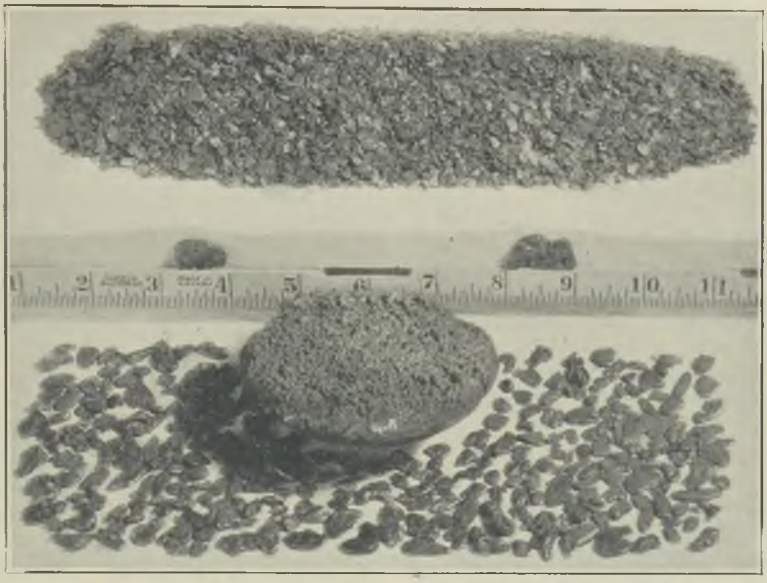
Nelson.—Reno Gold Mines, Ltd., reports a bullion recovery for July amounting to $14,425 from 944 tons treated. Development work furnished a large percentage of the mill feed and, although this ore is materially diluted by overbreak in the rock wall, a large proportion of it can be worked at a profit. During the month development work which consisted principally of advancing Nos. 1, 4, and 5 levels amounted to 305 ft. On No. 4 level, where the good grade of ore has been maintained, the primary shoot has now been developed for a length of 400 ft. Good progress is now being made with the No. 5 (Mill level) tunnel which was retarded at the commencement by boulders and caving ground. As recent development warrants the installation of more permanent equipment, it has been decided to purchase another 528 cu. ft. oil-driven compressor thereby permitting a more intensive development programme to be followed and thus advancing the time when the mill can be enlarged to handle an appreciable tonnage.

Placer Mining.—It is expected that placer gold production will record an appreciable increase this season. Although the new finds on Rainbow Creek in the Omineca and Barnes Creek in the North Okanagan districts have failed to realize their early promise, present indications are that the better known Atlin and Cariboo deposits will contribute considerably augmented returns. In the former district an operator on McKee Creek is stated to have obtained a clean-up exceeding 600 oz. of gold to the middle of August and on the Ophir lease, Ruby Creek, a recovery of more than $10,000 was recently recorded by three hand-miners, the proceeds of their work since November last. In the Cariboo, hydraulic operations by the Cedar Creek Mining Company on the south bank of Cedar Creek are meeting with notable success; while, on the opposite bank, the Cedar Creek Placer Gold, Ltd., reports that its drilling tests have located the old residual channel at moderate depth and proved the presence of a rich deposit. It is possible that productive operations may commence on this property before the close of the season.

Taku River.—Considerable interest was aroused by the recent visit of Mr. Noah A. Timmins to the coast. Prominent among Mr. Timmins' interests in British Columbia is the Whitewater group, situated on the Tulsequah River and about 30 miles above

the head of Taku inlet. This region was the scene of considerable exploratory activity during 1929, but, consequent on the depression of the metal and stock markets, experienced undeserved neglect last season. Early this year the Whitewater property was bonded on behalf of Mr. Timmins, and an extensive programme of diamond drilling is now in progress from which, it is understood, some very attractive results have already been obtained. The formation consists of a fine grained doleritic rock cut by rhyolite and felsite dykes. Mineralization is chiefly stibnite in association with which a high gold content is reported.

property to its present owners for $760,000. The new company was successful from the start. High grade ore-bodies were soon found and mining carried to a depth of 2,400 ft. Up to 1919 its total profits exceeded $4,000,000, but in later years it has been difficult to do better than produce sufficient revenue to cover operating expenses. The decision to close the mine has been taken on the recommendation of the general manager, Mr. Gomer P. Jones, who has been associated with the Nickel Plate for over 30 years, during which time over 14 million dollars in gold has been produced. Since the exhaustion of ore reserves in



PLACER GOLD FROM FRENCH CREEK MINE, REVELSTOKE, B.C.

Osoyoos.—The announcement that the Hedley Gold Mines will immediately suspend all further operations at the Nickel Plate mine and dispose of the plant signifies the exhaustion of a property that has held a prominent position in the annals of British Columbian mining for the past 30 years. Discovered in 1898, it was bonded in the following year on behalf of the Marcus Daly estate. In its early development the Nickel Plate ore-body was difficult to trace underground and four years elapsed before the mine was brought into production. In 1908 a lean zone was encountered and as diamond drilling failed to give satisfactory results the Daly estate, having made a profit of more than one million dollars, sold the

November last the mine has been subjected to a thorough diamond drilling campaign both with a view to discovering new ore-bodies and the continuation of known ones, but these explorations have proved unsuccessful.

TORONTO

September 16.

Mineral Production of Canada.—The mineral production during the first six months of 1931 was valued at $95,689,288, as compared with $116,360,409 for the corresponding period of last year, a decrease of 17·8%. The metallic output was valued at

$61,717,841, as compared with $75,031,606. More gold, platinum metals, zinc, arsenic, and bismuth were produced than during the same period of 1930, but the lower prices prevailing for the base metals resulted in a falling off in their output. The quantities and values of the principal metals produced were as follows :—Gold, 1,273,303 fine oz., $26,321,508 ; copper, 149,277,041 lb., $13,705,822 ; nickel, 40,690,562 lb., $9,047,131 ; lead, 146,419,830 lb., $4,034,971 ; zinc, 133,679,776 lb., $3,404,824; silver, 11,701,718 fine oz., $3,287,481. The coal output was 5,891,588 short tons, valued at $20,519,520, a decrease of 17·7% in quantity and 20·6% in value. Natural gas production was slightly less, but the quantity and value of crude petroleum produced was larger. The total value of the non-metals other than fuels amounted to $5,313,580, as compared with $7,630,047. The production of asbestos and gypsum was considerably reduced.

Sudbury.—The International Nickel Company expects to complete the programme of expansion inaugurated five years ago before the end of the year. It has involved a total expenditure of some $50,000,000. Operations at present in progress include the completion of work on the new Orford separation process building, the installation of a hydro-electric transformer station for receiving power from Abitibi Canyon, and the reconditioning of Frood No. 4 shaft. At present the Orford process building is practically completed and will be ready for operation early in November. The head-frame on No. 4 shaft at the Frood is now completed, and re-timbering operations are progressing. In connexion with development of Frood No. 3, the original No. 1 shaft has been converted into a central ventilation shaft, and has been completed to all working levels. A duplicate fan-system capable of putting 275,000 cu. ft. of air per minute through the more than 10 miles of Frood workings will be shortly installed for additional ventilation purposes. The Ontario Refining Company of Copper Cliff, operating on a basis of about 5,000 tons per month, showed a total production during the first year of its operations ending June 30, of 57,336 short tons of refined copper. With the exception of about 5,000 tons of blister copper, representing custom offerings from Trail, B.C., and from the Sherritt-Gordon mine, Manitoba, the total output is from Sudbury ores. Since work on the new precious metals refinery was completed early this year, the recovery of valuable by-products up to the end of June includes 27,764 oz. of gold, 1,316,168 oz. of silver, and 8,335 lb. of selenium, which will substantially increase the revenues of the International Nickel Company. Prospecting is being actively carried on in the Schist Lake and Three Duck Lake district in Yeo and Chester townships and several encouraging gold discoveries are reported. The latest of these discoveries is the Cryderman, located at the south end of Three Duck Lake, and consisting of a strong vein carrying commercial values in gold over an average width of from 3 to 4 ft. The vein has been stripped for 20 ft., but owing to the heavy overburden little work is being done.

Porcupine.—The gold mines of the Porcupine field during August produced $1,692,709 from 267,256 tons of ore, which compares with $1,673,144 from 259,972 tons treated in July. The mill of the Dome Mines is treating about 1,500 tons of ore per day, values running between $6 and $7 a ton. An important discovery has been made on the 16th level, where the vein has yielded assays of $15 per ton over a width of 30 ft. and lateral drilling has been started to strike the downward extension of this vein on the 18th level. During August the recovery of bullion amounted to $302,719, as compared with $299,280 for July. During the eight months ending with August, production reached a total of $2,360,339, or a monthly average of approximately $295,042. The rate of production of the Hollinger Consolidated has been somewhat reduced, as the mill is now drawing supplies from the lower-grade section on the surface. Mine development is proceeding on an extensive scale, good values have been opened up on the lower levels and before the end of the year the treatment of higher-grade ore is expected to increase the recovery considerably. The new mill of the McIntyre-Porcupine is now treating approximately 1,700 tons a day. Losses in tailings by the old process were formerly between 40 and 50 cents per ton and initial results from the new mill indicate that this figure can be considerably reduced. The most interesting underground development is the opening of a new ore on the Platt Vet claim nearly half a mile from the main workings, which constitutes a large addition to the ore reserves. The management is planning the extension of workings to greater

depth. Plans are under consideration for a large winze to be started from the 4,000 ft. level and to be continued to 5,000 and possibly 6,000 ft. The mill of the Vipond Consolidated is handling ore at the rate of 8,500 tons a month. During the six months ending June 30 bullion was produced to the value of $327,958 from 51,474 tons. New development is proceeding from the main shaft which has been put down to the 1,400 ft. level and cross-cutting and driving are being pushed in various directions. Recent development on the lower levels of the Coniaurum have shown improvement in ore values. Vein No. 7 has been cut on the 2,500 ft. level, the deepest working in the mine, with values reported to run from $10 to $15 over drive widths. At the Canusa the new pilot mill is in operation on a scale of about 35 tons daily and underground development is proceeding satisfactorily. A mineral zone some 700 ft. wide has been located on the old McMahon claims southwest of the Dome mine. A shaft will be put down to a depth of 150 ft. and exploration carried on at that level.

Kirkland Lake.—The output of the mines of the Kirkland Lake area during August was valued at $1,758,015, from the treatment of 150,763 tons of ore, as compared with $1,867,275 from 146,907 tons in July. Production is being well maintained by the Teck-Hughes, the ore being supplied to the mill running between $14 and $15 per ton. During the greater part of this year cross-cutting and driving have been actively proceeding on the lower levels below the 26th, but a large amount of work remains to be done on these horizons. On the 26th level, ore has been opened up which is stated to run between $20 and $30 to the ton. Preparations are under way for deeper mining, involving the sinking of a new shaft from the 29th level to a proposed depth of about 3,125 ft. The Lake Shore has lately increased its ore reserves by important new discoveries, the latest find being on the 2,700 ft. level, where an ore section covering a width of 66 ft. and averaging better than $15 to the ton has been located. Average mill-heads, which were reduced owing to the treatment of large quantities of low-grade ore, have returned to normal and recovery now approximates $15 to the ton. The mill of the Wright-Hargreaves is treating an average of 750 tons of ore daily with recovery of more than $11 per ton. Official estimates, based on current operations, anticipate a total output for the current year of close on $3,750,000, which will be the largest production in the history of the mine. By October 1 new crushing equipment will be installed, which will bring mill capacity up to nearly 800 tons. Development operations are putting new ore in sight. On the 2,700 ft. level the downward extension of the main vein system has been encountered, some of the ore yielding high assays. A rich ore shoot has also been located above the 2,700 ft. horizon. Work on the Moffatt-Hall is being watched with keen interest as, if it succeeds in developing a profitable mine, it will prove that the field extends further to the eastward than has been supposed, and will encourage the opening up of a number of other properties. So far the results have been satisfactory. Driving on the main vein at the 300 ft. level is now proceeding, disclosing a width of 7 to 8 ft. of commercial ore. The mill at the Sylvanite is handling about 275 tons of ore daily, with gross earnings in the neighbourhood of $85,000 monthly. The shaft is being put down from the 2,500 ft. level to an objective of 3,000 ft. and when completed five new levels will be opened up. The Barry-Hollinger is carrying its workings to lower levels with encouraging results. High-grade ore is being developed on the 1,875 ft. level. The vein has been driven on for 140 ft., and values of $16 to the ton have been obtained. Work, on the Kirkland Townsite property adjacent to the Wright-Hargreaves will shortly be commenced with a view of encountering the continuation of the Wright-Hargreaves vein system. Kirkland Lake gold mines during August produced $52,000, with the mill treating approximately 150 tons of $12 ore daily. A new ore shoot encountered on the 2,700 ft. level has been followed for 175 ft. showing an average width of 5 ft., assays averaging $15 to the ton. At the Macassa steady progress is being made in development. The ore zone located in underground work from the adjoining Kirkland Lake gold property has been followed for 120 ft., showing good values all the way. On the Lee claims shaft sinking has been completed to a depth of 125 ft., and driving has encountered a vein carrying commercial ore.

Rouyn.—In accordance with the policy adopted when the low price of copper rendered its production unprofitable, the Noranda continues to devote much attention to gold mining. Its output of gold is stated to be approximately $500,000 monthly.

The sinking of No. 3 shaft is making steady progress through ore stated to average 4% copper and $6 in gold to the ton. Drills put down to a depth of 3,500 ft. are reported to have been in good ore all the way but information is not available as to the actual values obtained or the extent of the ore zone indicated. Development below the 1,000 ft. level is proceeding satisfactorily. Granada Gold Mines is making good progress in its deep development programme. The winze being put down from the 600 ft. level is now down to 800 ft. During the process of sinking values were obtained averaging from $15 to $20 to the ton in gold, the grade showing improvement at the lower horizon. Production at the Siscoe Gold Mines for the month of August was valued at $76,832, as compared with $82,437 in July. Output for the eight months ending August totalled $494,103, compared with $367,266 for the full year 1930. Adanac Gold Syndicate, which holds some 800 acres east of Granada Mines in the Rouyn district will shortly begin a campaign of diamond drilling, surface explorations having disclosed mineralized zones with good gold showings. Brownlee Gold Mines is meeting with favourable results in the development of its property adjoining the Noranda, where a mineralized zone carrying gold has been encountered in a small shaft.

Patricia District.—Production is well maintained by the Howey gold mine, where the mill is treating 750 tons of ore per day, the recovery in August being approximately $70,000. The broken ore reserves for the supply of the mill are estimated at approximately 160,000 tons and this amount is being increased month by month, so that no difficulty will be experienced in increasing the tonnage. Sorting equipment was recently installed at the mine, which has enabled the management to increase the value of its mill-heads. Values of ore are showing improvement as the work proceeds downward. Extensive development and exploration work has been under way for some time in the Red Lake area. Some 7,000 tons of ore of an average grade of $24.40 gold per ton has been taken out and arrangements are now being made to ship this to a neighbouring mill for treatment. Mining operations will be continued so that another shipment will be ready when the returns from the first consignment have been received. The importance of the discovery made by Jack Munroe on Mackenzie Island has been confirmed by a survey by Dr. M. E. Hurst, provincial geologist, who states that good showings of visible gold have been opened up. The mineralization has been exposed in test pits over widths of 9 and 14 ft. Active exploration is now being carried on by diamond drilling.

PERSONAL

Arthur J. Bensusan has returned from Brazil.

Bernard Beringer has left Peru for Colombia.

Sydney Bray has left Cyprus and is proceeding to Northern Rhodesia.

J. Coggin Brown is returning to Burma.

W. H. Collins is home from Nigeria.

Bernard F. Davis is home from Colombia.

R. T. Hancock has returned from Venezuela.

W. A. Hardy has returned to India.

E. Homersham is returning from South Africa.

F. T. Ingham has returned to Malaya.

A. J. W. Legge, is returning to Sierra Leone.

R. J. Lemmon has returned from South Africa and the Belgian Congo.

V. F. Stanley Low has left for Panama.

W. S. McCallum is expected from New Zealand.

Frank Merricks has been appointed as the representative of the Commissioners of the Exhibition of 1851 on the Governing Body of the Imperial College.

F. A. Moss has left Los Angeles for Western Australia.

J. N. Ong has left California for Northern Rhodesia.

H. G. Scott has left for Melbourne.

S. M. Sneddon is home from Malaya.

C. H. White is now in France.

John D. Williams has returned from Brazil.

W. J. Wilson has left for Nigeria.

E. W. Wright is leaving for Nigeria.

F. J. Wydler-Hollis has returned from South Africa.

Arthur E. Taylor, of Messrs. John Taylor and Sons, died suddenly of heart failure on October 3, aged 56.

C. F. W. Kup, managing director of the St. John Del Rey Mining Company since 1915, died suddenly on September 28, at the age of 54. He had been in the service of the company since 1895, becoming its secretary in 1913, and last year visited Brazil in connexion with the centenary celebrations.

Frederick W. Thomas died, at his home in Camborne, on September 30 after several months' illness, aged 68. Mr. Thomas was secretary of Dolcoath in the cost-book days, subsequently occupying the same position in the limited liability company. In 1914 he left Camborne and became secretary of Messrs. Williams Harvey & Co., being later on appointed managing director, a position he held till his retirement about three years ago.

TRADE PARAGRAPHS

Elbof Geophysical Co. announce that their London Office is now at 790, Salisbury House, London Wall, E.C. 2, the telephone number being Metropolitan 3801.

Demag A.G., of Duisburg, Germany, publish the September issue of their *Demag News* which contains an article describing the use of belt conveyors for underground workings.

Head, Wrightson, and Co., Ltd., of Stockton-on-Tees, issue new editions of their catalogue relating to the Colorado convertible-discharge ball-mill and to the Kirkless slurry separator.

Hans Renold, Ltd., of Manchester, and the **Coventry Chain Co., Ltd.,** of Coventry, which are now allied, issue an up-to-date catalogue of their products which is fully illustrated and contains many valuable data.

Thomas Locker and Co., Ltd., of Warrington, publish a new catalogue of their products. This covers some 96 pages and is fully illustrated to describe both woven wire and perforated metal screens together with wedge wire screens for all purposes.

Hopkinsons, Ltd., of Huddersfield, issue a new catalogue of their parallel slide valve which is suitable for use in pipe systems whether for steam, boiler-feed water or cold water, air, or oil. They are made in either cast iron or steel depending on the pressures to be withstood.

Burn Silent Gears, Ltd., of Caxton House, S.W. 1, state that the company has been formed to take over the rights of the Silent Burn Gear, including those previously held by Stothert & Pitt, Ltd., of Bath, and Burn Transmissions, Ltd. In co-operation with James Howden and Co., Ltd., of Glasgow, the new company are in a position to manufacture and supply the gear for its many applications, which include the transmission of 50,000 h.p.

Imperial Chemical Industries, Ltd., of Millbank, London, S.W. 1, report the visit of a number of principal mine-owners in the country to their Billingham works to inspect the hydrogenation plant which is working there and is converting daily 15 tons of coal into petrol. They also send us the September issue of their *I.C.I. Magazine* which contains an article by Mr. Dinwoodie on the firing of a heading in connexion with the quarrying work of the Buxton Lime Firms Co., Ltd.

Robey and Co., Ltd., of Lincoln, state that in connexion with the recently established European tunnelling record which the contractors to the Manchester Corporation Waterworks Haweswater Scheme achieved, their straight line Diesel air-compressors (S.L.O.C. type) produced all the compressed air and ran day and night without any trouble and also that Robey forced lubrication, horizontal, totally enclosed Diesel engines ran continuously, generating both electric light and power.

Mining and Industrial Equipment, Ltd., of 11, Southampton Row, London, W.C. 1, report the following new orders: —For England: One 3 ft. by 5 ft., type 39, Hum-mer screen for coke, one 6 ft. diam. Raymond separating plant for limestone, one Rovac " Unicell " backwater filter and repulping trough for backwater filtration, one 4 ft. by 7 ft., type 60, Hum-mer screen for slack coal, one 4 ft. by 5 ft., type 39, Hum-mer screen for slack coal, one No. 4 Usco pulverizer for soap, one 17 sq. ft. Rovac filter for caustic lime sludge, one 8 ft. by 7 ft., type 39, single body tandem Hum-mer screen for coal, and one 6 ft. by 22 in. Hardinge ball-mill for coke breeze. For France: One 2-roller Raymond mill for limestone. For Holland: One No. 00 Raymond pulverizer for lime. For Belgium: One No. 1 Raymond pulverizer for litharge and one, type 37, Hum-mer screen for granular furnace slag. For America: Two 6 ft. by 36 in. sectionalized Hardinge ball-mills for gold ore. For Australia: One 8 ft. by 72 in. Hardinge ball-mill for quartz ore. For Germany: Two 4 ft. by 7 ft., type 39, single body tandem Hum-mer screens for coal.

Bureau of Information on Nickel of the Mond Nickel Co., Ltd., Imperial Chemical House, Millbank, S.W. 1, in their *Nickel Bulletin* for September, have an article describing nickel alloy steels in dredging equipment which contains references with illustrations to such parts as links and pins, tumblers, etc. They also draw attention in a separate communication to two new important nickel alloys which are finding special applications. These are respectively " Hypernik " and a nickel-copper silicon alloy. The first named is approximately a 50/50 composition of nickel and iron which has been developed in the United States for electrical applications where moderately high permeability is required together with low hysteresis loss and medium electrical resistance. It has been largely used in radio work, but is perhaps of greater importance in connexion with the construction of current transformers, metering instruments, and suchlike. The other alloy is really a Monel Metal, silicon being employed to modify the alloy in certain of its applications. The improvements in this alloy have been treated in a paper which was presented before the Autumn Meeting of the Institute of Metals, entitled " Nickel-Copper Alloys of High Elastic Limit " by Messrs. Jones, Pfeil and Griffiths.

Edgar Allen and Co., Ltd., of Sheffield, in a recent issue of *Edgar Allen News* direct attention to the mining specialties which become available as a result of the working arrangement which has been arrived at between themselves and the **Allis-Chalmers Manufacturing Co.,** of Milwaukee. Under this arrangement, the works in Sheffield are manufacturing various machines to their designs, so that customers will have the advantages of the combined experience of the two organisations. The new range of equipment of Edgar Allen construction now offered includes:— Superior McCully Gyratory Crushers, Superior Jaw Crushers, Fairmount Crushers, Crushing Rolls, and Vibrating Screens. A recent addition is the Newhouse crusher, which has been in process of development for several years, and is now submitted to the crushed stone and mining industry as a machine fully developed and suitable for the hardest stone or ore that may be encountered. This machine is of the gyratory type, but without the usual gears and belt pulley. The eccentric is revolved by being direct connected to a vertical motor located on top of the spider. The suspension of the crusher by cables from the framework of the building eliminates expensive foundations and reduces installation costs. A short rapid crushing stroke gives it high capacity with a high percentage of the finished product of desired shape and size.

SHIPPING, ENGINEERING, AND MACHINERY EXHIBITION

The eleventh Shipping, Engineering, and Machinery Exhibition was held at Olympia from September 10 to 26, as announced in the MAGAZINE last month. It contained a number of interesting exhibits, of which the following are of most interest to mining men :—

Tangyes, Ltd., of Birmingham, had an exhibit comprising one vertical three-cylinder 200-240 b.h.p. oil engine, direct coupled to a generator and a number of smaller oil engines.

Evershed and Vignoles, Ltd., of Chiswick, W. 4, were showing their well-known electrical testing equipment such as Meggers and also the Evershed-Midworth distant repeater for remote control.

Norris, Henty, and Gardners, Ltd., of Patricroft, had an exhibit of oil engines of smaller sizes. These are made in ranges of 8½ to 248 b.h.p. in the horizontal type and 54 to 300 b.h.p. in vertical.

Thos. Firth and John Brown, Ltd., of Sheffield, displayed examples of their stainless steel products, including turbine blading, pump shafts and spindles, and a variety of steel castings and forgings.

Mond Nickel Co., Ltd., Imperial Chemical House, Millbank, London, S.W. 1, demonstrated by means of selected products the applications of nickel and its alloys in the engineering industry generally.

Perman and Co., Ltd., of 82–83, Fenchurch Street, London, E.C. 3, were showing Kromhout engines of the Diesel type, including three, two and single cylinder units from 500 to 6 b.h.p. respectively.

Reavell and Co., Ltd., of Ipswich, presented an exhibit of their vertical and rotary air-compressors as, for example, a two-stage compressor of 500 cu. ft capacity suitable for supplying air for pneumatic drills.

National Gas Engine Co., Ltd., of Ashton under Lyne, were showing a six crank vertical oil engine of 150 b.h.p., direct coupled to a 100 k.w. dynamo which is representative of a range of from 15 to 600 h.p.

G. D. Peters and Co., Ltd., of Slough, had a comprehensive exhibit to demonstrate their well-known plastic arc welding apparatus which includes colour tipped electrodes such as was described in the MAGAZINE for May last.

William Beardmore and Co., Ltd., of 36, Victoria Street, London, S.W. 1, were showing a 320 h.p. high speed Diesel engine, direct coupled to a 210 k.w., d.c. generator, running at 800 r.p.m., the engine being a six-cylinder type.

Blackstone and Co., Ltd., of Stamford, Lincs., presented a range of high speed Diesel engines, notably a vertical 6-cylinder engine developing 55–60 b.h.p. also four, two and single cylinder types, and one single cylinder horizontal.

W. H. Dorman and Co., Ltd., of Stafford, were showing representative examples of their light Diesel and petrol and paraffin engines, such as are used for driving portable air compressor units, one such being actually coupled to a Holman set.

Pulsometer Engineering Co., Ltd., of Reading, had a number of pump installations for marine purposes, the principal one being shown working. The firm also manufacture sinking pumps and others specially interesting to mining men.

Atlantic Engine Co. (1920), Ltd., of Wishaw, Scotland, were showing a high speed Diesel engine, such as are made in three, four, and six-cylinder types in h.p. from 50 to 105 and also petrol-paraffin engines such as are made in types of 5 to 150 h.p.

Quasi-Arc Co., Ltd., 15, Grosvenor Gardens, London, S.W. 1, had a stand demonstrating the equipment and supplies necessary for their system of arc welding, which was referred to in some detail in these columns in the MAGAZINE for February last.

Crossley Bros., Ltd., of Openshaw, Manchester, were showing both vertical and horizontal types of their well-known oil engines including the vis-a-vis engine recently described here, which is being used in a number of mining properties as a source of power for air-compressors and such like.

Gleniffer Engines, Ltd., of Anniesland, Glasgow, displayed high speed Diesel engines, which operate normally between 700 and 900 r.p.m., in six and four cylinder units. These engines are suitable as prime movers for dredging and excavating machinery and they are made in h.p. ranging from 45 to 160.

Broom and Wade, Ltd., of High Wycombe, were demonstrating both stationary and portable types of air-compressors suitable for direct coupling or belt or gear drive from oil engines or electric motors, including a patent sleeve valve type of compressor direct coupled to a Lister Diesel engine.

Lacy-Hulbert and Co., Ltd., of Beddington, Croydon, displayed high speed air-compressors direct coupled to petrol engines, electric motors, etc., with output up to 80 cu. ft. per minute, suitable for pressures up to 150 lb. per square inch; also portable petrol and electric driven air-compressors.

Rotary Air Compressor Co., Ltd., of 12, Victoria Street, London, S.W. 1, were showing a Demag rotary compressor of 464 cu. ft. per minute displacement suitable for a final pressure of 100 lb. per sq. in. when running at 980 r.p.m. Another type of 605 cu. ft. displacement at a pressure of 40 was also shown.

Nor-Rust Liquid Lead Co., Ltd., of Iddesleigh House, Caxton Street, London, S.W. 1, were demonstrating Nust, which they claim to be the first absolute anti-corrosive known that can be applied in one coat. Nust is stated to have a definite reaction to iron and steel which causes a positive amalgamation with the metal.

Stream-Line Filter Co., Ltd., of 45, Horseferry Road, London, S.W. 1, had a comprehensive exhibit to demonstrate the application and value of their Hele-Shaw filter, which is already well-known in principle and of which by far the most important application is the filteration of heavy lubricating oils in power-plant systems.

J. and H. McLaren, Ltd., of Leeds, presented several examples of the McLaren-Benz Diesel engine, one such having six cylinders and developing 180 b.h.p., and another of the same number developing 90 b.h.p. together with smaller types. These engines among other uses form convenient prime movers for excavating and dredging machinery.

Alfred Herbert, Ltd., of Coventry, beside their No. 6 Atritor unit pulverizer were showing a Modave dust arrester, which has been specially designed for cleaning flue gases and is therefore applicable in metallurgy. It operates by bringing the gases into intimate contact with films of running water which catch the dust and carry it away to settling tanks.

Automotive Products Co., of Brock House, Langham Street, London, W., were displaying Hercules light engines in six and four cylinder types. These engines develop 60 b.h.p. at 1,000 r.p.m., 85 b.h.p. at 1,500 r.p.m., and 102 b.h.p. at 2,000 r.p.m. in the case of the 6-cylinder models, and are

suitable for crane, excavator and dredge drives, also for pumps and air-compressors.

Drawing Office Material Manufacturers' and Dealers' Association, of 168-169, Windsor House, London, S.W. 1, occupied a large stand displaying all necessary equipment for drawing offices and also surveying instruments. The organization, which represents a number of manufacturers, covers the field of mine and colliery surveying equipment and exhibited a number of theodolites suitable for such work.

Transporting Machinery and Engineering, Co., Ltd., of 76, Victoria Street, London, S.W. 1, exhibited a wide range of materials-handling plant, notably a portable belt conveyor which has specially constructed features, such as: No driving belt, no chains, no long shafts and has either electric motor or internal combustion engine drive. Features of the "Bleichert" aerial ropeways were demonstrated by cinematograph films.

Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., of Newcastle-upon-Tyne, were making a special feature of the new Armstrong-Sulzer type Diesel engines of 250 h.p. which form part of the Diesel-electric unit which is proposed for railway traction and has already, in fact, been so used on certain railway systems and is likely to find increasingly wide applications, as is discussed elsewhere in this issue.

Murex Welding Processes, Ltd., of Walthamstow, London, E. 17, which comprises Alloy Welding Processes, Ltd., and Premier Welding Co., Ltd., occupied a large stand demonstrating their arc welding equipment. Electrodes of distinctive types marketed by each of the old companies will remain unaltered but in each of those cases where electrodes of similar characteristics have been produced a new type has been evolved having the best characteristics of each.

Petters, Ltd., of Yeovil, had several examples of their Atomic Diesel engines such as have been described in these columns from time to time, the main exhibit being a 160 b.h.p. four-cylinder vertical engine and also a 24 b.h.p. twin-cylinder engine. A special feature of these engines is that they operate on the two-stroke cycle and are consequently without complex valve mechanism. The engine is very flexible and will run at slow speeds for long periods without attention.

Diskon Gear, Ltd., of 64, Victoria Street, London, S.W. 1, were showing an entirely new type of infinitely variable and reversible speed gear which is sufficiently interesting to merit some detailed consideration and it is illustrated in figures 1, 2, and 3. As will be seen from these, the gear employs rolling contact between hard steel surfaces and is in a position of neutrality, i.e. with the output shaft at rest, in figure 1. It will also be seen that the disc which is rigidly coupled to the input shaft drives the output through an epicyclic train of gears. Figures 2 and 3 show the relative position of the gear train in relation to the input shaft and the resulting movement of the output. The speed of the output shaft varies as the gear train is moved away from the centre. Features which make it additionally interesting are that it is proof against damage by misuse. When loaded beyond a certain point the gear automatically stalls by putting itself in to the neutral position. It is specially suitable for use in applications requiring variations of speed or power, particularly when the power source is not itself flexible, such as an a.c. motor. Among such applications may be mentioned

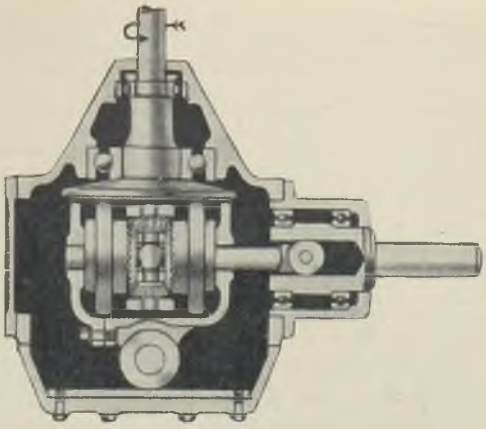


FIG. 1.

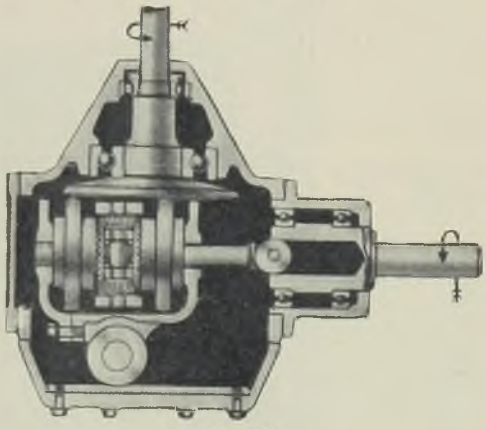


FIG. 2.

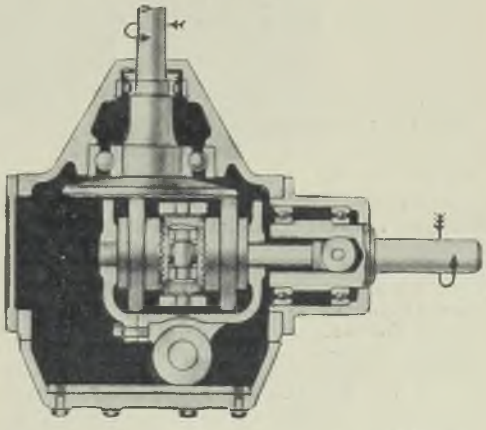


FIG. 3.

its use in winches and hoisting machines, conveyors, and crushing machinery.

Davey Paxman and Co., Ltd., of Colchester, were showing their latest type six-cylinder totally enclosed heavy-duty oil engine, capable of 300 b.h.p. when running at 600 r.p.m., which was shown direct coupled to a 200 k.w., d.c. generator. They were also showing a high speed Diesel engine manufactured

by their associated firm Aveling and Porter, Ltd. This is a four-cylinder vertical valve-in-head type capable of developing 50 b.h.p. at 1,200 r.p.m. and was shown coupled to a 27 k.w. motor.

Ruston and Hornsby, Ltd., of Lincoln, had as a principal exhibit a 200 k.w. generating set. The engine is a 5-cylinder unit of the well-known Ruston type running on crude oil. On an adjacent stand the **Ruston-Lister Marine Co., Ltd.,** of Imperial House, Kingsway, London, W.C. 2, were showing light Diesel engines, the product of the recently affected alliance between Ruston and Hornsby, Ltd., and R. A. Lister and Co., Ltd., of Dursley, in a range covering from 5 to 300 b.h.p. The exhibit included a 4-cylinder high speed type running at 900 r.p.m. and yielding 64 b.h.p.

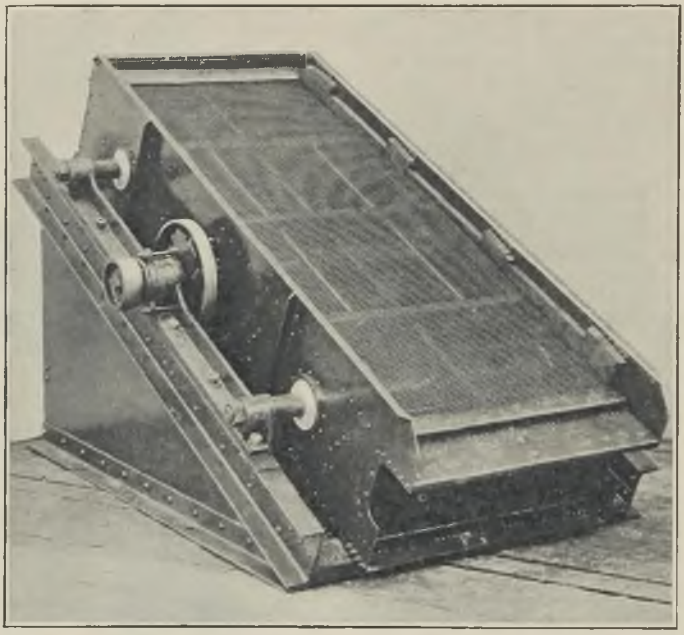
Rubber Growers' Association (Inc.), of 2-4, Idol Lane, London, E.C. 3, staged an exhibit to demonstrate the importance of rubber in the engineering industries which included a section allocated to the application of rubber in the mining industries, in which its anti-abrasive and anti-corrosive properties as well as its shock and vibration absorbing qualities are of value. In connexion with this exhibit they publish a book covering some 40 pages entitled " Rubber in Engineering," giving some detail with regard to these applications such as the lining of launders, ball-mills, and suchlike.

Mirrlees, Bickerton, and Day, Ltd., of Stockport, and the **Mirrlees Watson Co., Ltd.,** of 45, Scotland Street, Glasgow, were joint occupants of a stand devoted to Diesel engines and pumps. The engines included a six-cylinder, 128 b.h.p., high speed Ricardo type engine and the pumps included centrifugal types and non-choking. The firm also manufacture bore-hole pumps and had particulars available of one such, which is a six inch two-stage pump capable of delivering 35,000 gallons of water per hour against a total head of 78 feet. It is driven by a 35 h.p. vertical-spindle motor which runs at a speed of 980 r.p.m.

A NEW SHAKING SCREEN

In order to obtain efficient separation and high outputs with small screen areas numerous types of high-frequency vibratory screens have been developed from time to time, particularly in the United States. With these screens, either a rectilinear oscillating motion, perpendicular to the screening surface, is brought about by cams or electro-magnets, or the screening surface is set in approximately circular or elliptic oscillation by another kind of eccentric action. It is this latter principle of circular oscillations that is employed in the universal vibratory screen manufactured by **Fried Krupp Grusonwerk,** of Magdeburg, Germany.

For the design of this screen new developments in oscillation technology have been brought into service with a view to providing a high-performance screening machine which should fulfil all the requirements of practice in regard to fine and coarse screening. Referring to the accompanying illustration, the motion is imparted by way of the centre of the three supporting shafts and this motion is an approximately circular one (in the vertical plane). The motion is as it were repeated both above and below the centre line by reason of the fact that the two other supporting shafts are mounted in cylinders of thick rubber which act as buffers. (In the illustration these rubber buffers, of which two are visible, appear white.) The unbalanced pulley mechanism which contributes the movement referred to is belt driven from the pulley which is seen extending from the centre shaft.



KRUPPS' UNIVERSAL OSCILLATING SCREEN.

Owing to the employment of these circular oscillations which have an amplitude of $\frac{1}{16}$th to $\frac{1}{8}$th in. and a frequency of 1,800 to 2,000 per minute, the sieving action per square foot of screen area is of the very highest efficiency. According to the mesh size, the screening surface takes the

form of a rigid bottom or of a stretched, vibrating sieve. The driving shaft runs in heavy roller bearings, its end journals, and hence also the drive pulley, making no oscillatory motion.

If a particularly sharp separation of the material is required this can be obtained by means of a circular oscillatory movement counter to the direction of feed travel, the screen being set at a steep angle. In this case the material is frequently turned over and is held back on the screening surface for an appreciable period. In the case of wet screening, also, where water is supplied from sprinklers, the universal vibratory screen gives a first rate performance. Depending upon the nature of the material and the degree of fineness required, the screen is set at an inclination varying between 0° and 40°, adjustment of the telescopic tubes which fix the angle being readily carried out while the screen is in action. The screen box of all machines can take up to three super-imposed screens, the coarsest mesh being on top.

The high specific output of the universal vibratory screen permits the screening areas to be heavily charged, giving, in spite of this, clean separation of the undersize, as the turning-over movement of the material upon the screen brings all parts of it in contact with the screen's surface in rapid succession. The screen is made in sizes (approx.) 2 ft. by 4 ft. 11 in., 2 ft. 8 in. by 6 ft. 6 in., and 3 ft. 3 in. by 8 ft. 2 in.

METAL MARKETS

Copper.—The quotation for electrolytic copper in New York was easy during the past month, receding from 7·75 cents to 7·25 cents per lb. f.a.s. In London, Standard values, after a period of unsettlement, were stimulated by the British abandonment of the gold standard and the consequent depreciation in sterling, but the net gain, on balance, proved to be small, partly owing to the world-wide depression and partially because of the subsequent recovery in the sterling exchange. Expressed in gold currencies, Standard values are actually down on the month. An international meeting of producers is to be held to endeavour to secure a further reduction in output. They are still holding enormous stocks.

Average price of Cash Standard Copper : September, 1931, £31 11s. 1d. ; August, 1931, £32 12s. 3d. ; September, 1930, £46 6s. ; August, 1930, £47 11s. 4d.

Tin.—The American quotation for tin last month fell steadily from 27·12½ cents to 22·50 cents per lb., and this probably about indicates the real trend of the market, though in London sterling prices, after falling from about £121 to £111 spurted to £132 when Britain went off the gold standard. Subsequently, on continued world trade depression and the sterling recovery, the London quotation eased again to £123. The world industrial outlook remains rather gloomy, but tin values may be kept up to some extent by the drastic control which producers are now exerting over output, though of course such methods are economically unsound.

Average price of Cash Standard Tin : September, 1931, £117 17s. 10d. ; August, 1931, £114 19s. 1d. ; September, 1930, £132 14s. ; August, 1930, £135 1s. 2d.

Lead.—Dull conditions prevailed on the London market early in September, but when sterling began to slide considerable buying developed on the part of consumers and prices were rushed up, only eventually to recede again. Opening the month at about £11 5s., prompt fell to about £10 10s. by the middle of September, but spurted to £15 10s. after Britain went off the gold standard, finally closing at about £14 3s. 9d. At one time lead quotations in London advanced out of all proportion to the readjustment necessary on account of the exchange position, but they finally closed the month without any appreciable movement in relation to gold values. In America the quotation kept steady at 4.40 cents per lb.

Average mean price of soft foreign lead : September, 1931, £11 19s. 6d. ; August, 1931, £11 19s. 4d. ; September, 1930, £17 17s. ; August, 1930, £18 4s. 8d.

Spelter.—Opening September at about £11 10s., prompt values were rather easy during the early part of the month and were quoted at £10 7s. 6d. on September 18 just prior to the abandonment by Britain of the gold standard. Prices then rose, £13 16s. 3d. being quoted for prompt on September 25, but a subsequent relapse brought the quotation down to £12 17s. 6d., with forward values commanding a premium (as had been the case throughout the whole of the month). Gold equivalents actually registered a loss on the month in which connexion it may be noted that the American price was marked down from 3·80 cents to 3·65 cents. The stocks held by the members of the International Cartel are reported to have been reduced further during August.

Average mean price of spelter : September, 1931, £11 16s. 4d. ; August, 1931, £11 14s. 7d. ; September, 1930, £15 18s. 5d. ; August, 1930, £16 4s. 2d.

Iron and Steel.—The British pig-iron market received a sudden stimulus in the latter half of September as a result of the depreciation of sterling. Both home and foreign buying expanded as a result of this and although large stocks of surplus material are held which will probably delay any large-scale resumption of operations at idle plant, the outlook is undeniably much more cheerful Cleveland minimum prices remained steady, with No. 3 foundry priced at 58s. 6d. per ton. Hematite moved up sharply and at the close of September ruled at about 65s. per ton for East Coast Mixed Numbers. Imports of Continental pig-iron and steel were sharply checked by the fall in the exchange and Continental producers are now reluctant to quote in sterling in view of the losses which they have sustained already by the devaluation of the pound. It is likely that the British steel industry will soon begin to benefit from the changed conditions. Its present situation is extremely gloomy, however, most mills being badly in need of fresh orders.

Iron Ore.—There has been very little business transacted during the past month, but the devaluation of sterling has led to a critical situation. Many ironmasters both here and on the Continent have long-term contracts based on sterling, and although they are very well satisfied with the turn of events, the mines are likely to be very seriously affected. For the time being quotations are purely nominal.

Antimony.—English regulus was marked up during the month to £40 to £42 10s., whilst at the close Chinese regulus was quoted around £25 5s., ex warehouse, with forward shipment from the East entirely nominal.

Arsenic.—Cornish white is very scarce and prices are nominal at £21 to £22 per ton f.o.r. mines. For the present Mexican is not quoted here owing to exchange difficulties.

Bismuth.—During September the official price fell to 4s. 9d. per lb. for 5 cwt. lots and over, but

LONDON DAILY METAL PRICES.

Copper, Tin, Zinc, and Lead per Long Ton; Silver per Standard Ounce; Gold per Fine Ounce.

	COPPER.				TIN.		ZINC (Spelter).	LEAD.		SILVER.		GOLD.
	Standard.		Electro-lytic.	Best Selected.				Soft Foreign.	English.			
	Cash.	3 Months.			Cash.	3 Months.				Cash.	For-ward.	
Sept.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	d.	d.	s. d.
11	30 1 10⅜	30 18 1½	34 10 0	31 10 0	115 6 3	117 16 3	10 17 6	10 16 3	12 5 0	13 1/16	13⅛	84 9½
14	29 10 7⅜	30 8 1½	34 0 0	—	114 11 3	117 1 3	10 15 0	10 13 9	12 0 0	13	13 1/16	84 9½
15	29 6 3	30 1 3	34 2 6	30 10 0	113 16 3	116 6 3	10 18 9	10 12 6	12 0 0	13	13 1/16	84 11⅛
16	28 11 3	29 8 9	34 0 0	—	110 17 6	113 7 6	10 12 6	10 11 3	12 0 0	13	13 1/16	84 10½
17	28 4 4½	28 19 4½	33 0 0	—	111 11 3	114 1 3	10 6 3	10 8 9	12 0 0	12⅞	13	84 11½
18	27 14 4½	28 9 4½	33 0 0	29 5 0	111 1 3	113 11 3	10 7 6	10 13 9	12 0 0	12⅞	12⅞	84 11½
21	32 16 3	33 11 3	36 10 0	—	118 17 6	121 7 6	11 15 0	12 12 6	14 0 0	14⅜	14⅜	84 9½
22	30 12 6	31 7 6	36 10 0	32 0 0	117 18 9	120 11 3	12 5 0	12 15 0	14 5 0	14⅜	14⅜	99 7
23	32 8 9	33 6 3	38 0 0	—	119 18 9	122 16 3	12 12 6	13 5 0	14 15 0	16 1/16	16⅛	100
24	33 6 3	34 6 3	38 15 0	—	126 12 6	130 8 9	13 0 0	14 10 0	16 0 0	15⅞	16	103 5
25	35 11 3	36 13 9	43 10 0	37 10 0	132 7 6	136 12 6	13 16 3	15 10 0	16 10 0	19⅛	19 1/16	114 9
28	33 18 9	35 3 9	41 10 0	—	125 2 6	129 12 6	12 17 6	13 15 0	15 5 0	16⅞	16 1/16	108 1
29	33 17 6	35 8 9	41 10 0	36 10 0	122 12 6	126 12 6	12 12 6	14 8 9	15 15 0	16⅛	16 1/16	105 3
30	33 8 9	34 8 9	41 0 0	—	122 18 9	126 17 6	12 17 6	14 3 9	15 10 0	16 1/16	16⅛	105 3
Oct.												
1	32 8 1½	33 5 7½	40 10 0	—	120 7 6	124 3 9	12 6 3	13 2 6	14 10 0	15 1/16	16 1/16	103 8
2	32 6 3	33 6 3	39 15 0	35 15 0	122 2 6	125 12 6	11 17 6	13 0 0	14 10 0	15 1/16	16⅛	104 3
5	34 13 9	35 13 9	41 10 0	—	125 17 6	130 12 6	12 0 0	13 5 0	14 15 0	17⅛	17 1/16	108 6
6	33 3 9	34 3 9	40 15 0	36 5 0	124 11 3	128 13 9	12 0 0	12 15 0	14 5 0	16⅞	17	108 3
7	33 16 10½	34 16 10½	41 7 6	—	124 3 9	128 6 3	12 3 9	12 15 0	14 5 0	16⅞	17	105 8
8	34 9 4½	35 10 0	41 7 6	—	125 2 6	129 3 9	12 7 6	12 15 0	14 5 0	17 1/16	17⅛	107 8
9	34 8 9	35 9 4½	41 7 6	37 0 0	127 15 0	129 17 6	12 13 9	12 18 9	14 5 0	17⅛	17 1/16	107

when sterling went off the gold standard this was raised to 5s. 4d., which is the current quotation.

Cadmium.—Quotations for this metal have appreciated owing to the fall in the £ and some substantial sales have been effected. After rising to about 2s. 3d. to 2s. 4d. per lb., the current price is about 2s. 1½d. to 2s. 2½d. per lb., according to quantity.

Cobalt Metal.—For the time being the official quotation is made in American dollars at 3·75 dollars per kilo.

Cobalt Oxides.—Quotations are very nominal owing to the fluctuating value of the £, but black is somewhere about 4s. 10d. per lb. and grey 5s. 8d. to 5s. 9d. per lb.

Chromium Metal.—Values have been adjusted to about 3s. 1½d. per lb.

Tantalum.—At the moment it is very difficult to give a quotation for this metal, but somewhere in the neighbourhood of £40 per lb. probably represents the current value.

Platinum.—Wide variations in prices have been seen in our market, but basically the value has not altered. Current quotations are about £9 12s. to £9 19s. per oz.

Palladium.—About £4 5s. to £4 10s. per oz. is the current quotation.

Iridium.—Quotations are variable according to exchange movements, but at the moment sponge and powder stand at about £23 per oz.

Osmium.—Business has been slow owing to the uncertainty of prices. At the moment about £13 per oz. is named.

Tellurium.—In the absence of demand prices are nominal.

Selenium.—Quotations have been withdrawn temporarily pending a clearer outlook as regards the value of sterling.

Manganese Ore.—Hardly any new business has been transacted during the past month, and despite the devaluation of sterling quotations are nominally no higher at 10½d. to 11d. per unit c.i.f. for best Indian, 9d. to 9½d. c.i.f. for second grade Indian and 9d. to 9½d. c.i.f. for washed Caucasian.

Aluminium.—The home trade price has been advanced to £95 per ton, less 2%, for ingots and bars owing to the depreciation in the £, and for the time being export quotations are nominal. It is rumoured that the European Consortium intends quoting in gold £'s and Swiss francs in order to be able to ensure stability of prices.

Sulphate of Copper.—English material is now quoted at about £17 10s. to £18 per ton, less 5%.

Nickel.—After years of stability quotations have moved rapidly in keeping with the altering values of sterling and, after rising to £220 to £225 per ton, now stand at £215 to £220, according to quantity.

Chrome Ore.—Prices have remained unchanged basically, but individual orders are treated on their merits and subjected to such increases as are necessitated by exchange considerations. Nominally good 48% Rhodesian ore remains at 80s. per ton c.i.f. and 55 to 57% New Caledonian at 95s. to 100s. c.i.f., plus the extras mentioned above.

Quicksilver.—Quotations here have advanced owing to the depreciation in the £, the present value being about £21 per bottle, net, for spot material.

Tungsten Ore.—Hardly any business has been done during the past month and only the vaguest ideas of values are obtainable. Forward shipment from China seems to be somewhere about 15s. to 16s. per unit c.i.f.

Molybdenum Ore.—Values have been revised to the new level of sterling, 80 to 85% concentrates standing at about 36s. to 38s. per unit c.i.f.

Graphite.—Business is slow and quotations nominal at about £15 to £16 per ton c.i.f. for 85 to 90% raw Madagascar flake and much the same for 90% Ceylon lumps.

Silver.—This market was without any particular developments during the early part of September, spot bars opening at 12⅞d. on September 1 and closing at 12 15/16d. on September 19. With the suspension of the gold standard in this country, however, prices advanced rapidly and some heavy buying was seen, some of which was of a speculative nature. Towards the end of the month a rather easier tendency developed, spot bars closing at 16 3/16d. on September 30, after having touched 19½d. on September 25.

STATISTICS

PRODUCTION OF GOLD IN THE TRANSVAAL.

	Rand.	Elsewhere.	Total.
	Oz.	Oz.	Oz.
September, 1930	860,311	42,865	903,176
October	884,632	41,929	926,561
November	844,038	40,715	884,753
December	867,202	41,290	908,492
January, 1931	873,872	40,704	914,576
February	800,991	38,946	839,937
March	869,331	41,667	910,998
April	840,259	42,078	882,337
May	867,949	42,330	910,279
June	855,073	42,677	897,750
July	872,198	44,645	916,843
August	870,822	45,603	916,425
September	872,053	43,971	916,024

TRANSVAAL GOLD OUTPUTS.

	August.		September.	
	Treated Tons.	Yield Oz.	Treated Tons.	Yield Oz.*
Brakpan	98,000	£151,481	96,500	£148,560
City Deep	80,000	20,629	77,000	20,013
Cons. Main Reef	67,700	22,814	66,300	22,503
Crown Mines	267,000	84,196	264,000	83,436
D'rb'n Roodepoort Deep	48,200	15,228	46,800	15,109
East Rand P.M.	160,500	43,009	156,000	41,743
Geduld	86,600	27,586	84,200	26,881
Geldenhuis Deep	74,200	16,949	72,500	16,941
Glynn's Lydenburg	6,200	2,594	6,100	2,594
Government G.M. Areas	204,000	£403,519	203,000	£403,979
Kleinfontein	48,800	10,158	49,200	9,955
Langlaagte Estate	78,000	£110,535	82,000	£112,656
Luipaard's Vlei	31,000	£32,998	30,500	£32,843
Meyer and Charlton	18,300	£18,059	17,600	£17,767
Modderfontein New	166,000	66,816	164,000	65,014
Modderfontein B	76,500	22,668	74,000	22,103
Modderfontein Deep	44,700	22,614	44,200	21,976
Modderfontein East	72,500	21,527	72,500	21,518
New State Areas	82,000	£170,290	83,000	£171,364
Nourse	72,000	21,389	70,000	21,107
Randfontein	235,000	£266,474	230,000	£262,721
Robinson Deep	98,500	28,476	97,500	28,140
Rose Deep	62,500	12,612	61,000	12,634
Simmer and Jack	74,100	20,812	76,800	22,183
Springs	71,000	£144,950	73,000	£150,279
Sub Nigel	36,500	30,526	36,000	30,198
Transvaal G.M. Estates	16,400	5,269	16,000	5,085
Van Ryn	45,000	£43,111	45,000	£42,750
Van Ryn Deep	62,000	£95,599	66,000	£97,889
West Rand Consolidated	94,500	£106,305	91,500	£103,601
West Springs	72,800	£74,657	72,400	£74,450
Witw'tersr'nd (Knights)	64,000	£53,913	62,000	£52,895
Witwatersrand Deep	36,600	11,569	36,800	11,694

* September values in S.A. currency.

COST AND PROFIT ON THE RAND, Etc.

Compiled from official statistics published by the Transvaal Chamber of Mines.

	Tons milled.	Yield per ton.	Work'g cost per ton.	Work'g profit per ton.	Total working profit.
		s. d.	s. d.	s. d.	£
June, 1930	2,651,970	28 2	19 7	8 7	1,141,197
July	2,706,900	28 5	19 8	8 9	1,184,107
August	2,693,100	28 3	19 6	8 9	1,174,828
September	2,653,250	28 5	19 8	8 9	1,160,430
October	2,741,080	28 5	19 7	8 10	1,212,822
November	2,628,800	28 4	19 7	8 9	1,145,097
December	2,661,200	28 6	19 9	8 9	1,160,548
January, 1931	2,721,316	28 3	19 8	8 7	1,171,456
February	2,481,600	28 6	20 1	8 5	1,045,980
March	2,718,400	28 2	19 9	8 5	1,151,017
April	2,592,800	28 7	20 1	8 6	1,105,711
May	2,751,400	27 10	19 6	8 4	1,149,105
June	2,698,100	28 0	19 7	8 5	1,140,399
July	2,771,400	27 10	19 6	8 4	1,155,466
August	—	—	—	—	1,159,382

NATIVES EMPLOYED IN THE TRANSVAAL MINES.

	Gold Mines.	Coal Mines.	Diamond Mines.	Total.
September 30, 1930	205,061	14,706	5,767	225,534
October 31	206,778	14,482	5,032	226,292
November 30	205,030	13,973	4,748	223,751
December 31	203,473	13,763	4,607	221,843
January 31, 1931	209,442	13,865	4,325	227,632
February 28	209,777	13,740	4,333	227,850
March 31	207,239	13,436	4,106	224,781
April 30	206,770	13,242	4,030	224,042
May 31	207,109	13,305	3,689	224,103
June 30	207,209	13,286	3,345	223,840
July 31	208,155	13,512	1,817	223,484
August 31	209,409	13,563	1,705	224,677
September 30	209,424	13,276	1,626	224,326

PRODUCTION OF GOLD IN RHODESIA.

	1928	1929	1930	1931
	oz.	oz.	oz.	oz.
January	51,356	46,231	46,121	45,677
February	46,286	44,551	43,385	42,818
March	48,017	47,388	45,511	42,278
April	48,549	48,210	45,806	43,776
May	47,323	48,189	47,645	43,731
June	51,762	48,406	45,208	44,118
July	48,960	46,369	45,810	44,765
August	50,611	46,473	46,152	43,292
September	47,716	45,025	46,151	—
October	43,056	46,923	45,006	—
November	47,705	46,219	44,351	—
December	44,772	46,829	46,485	—

RHODESIAN GOLD OUTPUTS.

	August.		September.	
	Tons.	Oz.	Tons.	Oz.
Cam and Motor	24,800	9,803	24,800	9,803
Globe and Phœnix	6,200	5,244	6,064	5,185
Lonely Reef	7,400	3,290	7,500	3,350
Luiri Gold	1,083	£4,286	—	—
Rezende	6,400	2,652	6,400	2,633
Sherwood Star	4,800	£8,754	4,600	£9,251
Wanderer Consolidated	15,400	3,724	14,900	3,278

WEST AFRICAN GOLD OUTPUTS.

	August.		September.	
	Tons.	Oz.	Tons.	Oz.
Ariston Gold Mines	4,571	£6,662	—	—
Ashanti Goldfields	12,610	14,477	12,633	15,302
Taquah and Abosso	9,859	£14,957	9,854	£14,864

AUSTRALIAN GOLD OUTPUTS BY STATES.

	Western Australia.	Victoria.	Queensland.
	Oz.	Oz.	Oz.
September, 1930	32,034	1,992	429
October	39,687	1,685	628
November	33,708	2,174	436
December	42,097	3,105	260
January, 1931	27,306	—	405
February	38,370	4,458*	458
March	34,946	4,482	898
April	38,891	3,250	732
May	38,255	4,196	784
June	47,507	3,194	893
July	38,785	—	1,220
August	52,501	—	—
September	38,173	—	—

* Jan. and Feb.

AUSTRALASIAN GOLD OUTPUTS.

	August.		September.	
	Tons	Value £	Tons.	Value £
Associated G.M. (W.A.)	5,010	8,270	5,218	8,046
Blackwater (N.Z.)	3,550	6,811	3,869	8,674
Boulder Persev'ce (W.A.)	7,304	16,210	7,426	18,762
Grt. Boulder Pro. (W.A.)	10,171	26,692	9,585	26,219
Lake View & Star (W.A.)	17,062	28,836	—	—
Sons of Gwalia (W.A.)	13,050	15,434	12,576	14,742
South Kalgurli (W.A.)	9,006	15,589	8,761	16,078
Waihi (N.Z.)	18,652‡	{ 5,979* / 43,008†	17,771§	{ 5,780* / 38,733†

* Oz. gold. † Oz. silver. ‡ To August 22. § To Sept. 19.

GOLD OUTPUTS, KOLAR DISTRICT, INDIA.

	August.		September.	
	Tons Ore	Total Oz.	Tons Ore	Total Oz.
Balaghat	3,700	2,110	3,600	2,107
Champion Reef	8,400	5,435	8,120	5,456
Mysore	11,948	5,809	14,170	7,003
Nundydroog	9,003	5,975	10,248	6,725
Ooregum	11,953	5,612	12,050	5,908

MISCELLANEOUS GOLD, SILVER, AND PLATINUM OUTPUTS.

	August.		September.	
	Tons	Value £	Tons	Value £
Chosen Corp. (Korea)	9,670	15,095	9,900	15,150
Frontino Gold (C'lbia)	3,890	15,584	3,720	16,180
Fresnillo	81,341	10,189*d*†	—	—
New Goldfields of Venezuela	5,670	1,880*	6,159	—
Oriental Cons. (Korea)	16,416	91,363*d*	16,699	96,837*d*
Remance	—	—	2,800	3,835
St. John del Rey (Brazil)	—	40,800	—	44,000
Santa Gertrudis (Mexico)	31,526	53,151*d*	—	—
West Mexican Mines	1,750	32,000*d*	—	—

d Dollars. * Oz. gold. † Loss

PRODUCTION OF TIN IN FEDERATED MALAY STATES.

Estimated at 72% of Concentrate shipped to Smelters. Long Tons.

January, 1931	5,450	July, 1931	4,757
February	5,470	August	5,375
March	4,461	September	2,449
April	4,510	October	—
May	5,089	November	—
June	4,813	December	—

OUTPUTS OF MALAYAN TIN COMPANIES.

In Long Tons of Concentrate.

	July	August	Sept.
Ayer Hitam	148⅝	—	101¼
Batu Caves	30	38	27
Changkat	55	95	70
Gopeng	72	37	32
Hongkong Tin	133	9⅝	131½
Idris Hydraulic	33½	34	27½
Ipoh	17⅛	23⅞	24
Kampar Malaya	78	32	16
Kampong Lanjut	73	90	45
Kamunting	237	197	158½
Kent (F.M.S.)	36	28	34
Kinta	23½	18	13⅜
Kinta Kellas	—	—	—
Kramat Tin	95	95	—
Kuala Kampar	46	21	29
Kundang	18	10	7
Lahat	17½	17½	16
Lower Perak	116	—	—
Malaya Consolidated	27½	39⅝	—
Malayan Tin	153	102	85
Malim Nawar	25	27	22
Pahang	262	221	123
Penawat	81½	—	65⅝
Pengkalen	68	13⅛	55⅛
Petaling	114½	87	69
Rahman	71½	71½	40
Rambutan	10½	4	12
Rantau	14	17	28
Rawang	150	122	40
Rawang Concessions	60	68	30
Renong	27⅜	37	38
Selayang	14½	15	15⅝
Southern Malayan	151½	120	84½
Southern Perak	20⅜	—	30½
Southern Tronoh	39	—	30
Sungei Besi	47	58	32
Sungei Kinta	18	23	33⅜
Sungei Way	77½	32⅜	74⅜
Taiping	22	21	20
Tanjong	—	—	35⅜
Teja Malaya	18½	—	—
Tekka	29	44½	22
Tekka-Taiping	76	51	51
Temengor	9½	7½	9½
Temoh	—	—	—
Tronoh	81	72	60
Ulu Klang	—	—	23⅜

OUTPUTS OF NIGERIAN TIN MINING COMPANIES.

In Long Tons of Concentrate.

	July	August	Sept.
Anglo-Nigerian	47	44½	48¾
Associated Tin Mines	200	247	227
Baba River	4	4	4
Batura Monguna	—	1¾	—
Bisichi	41	39	43
Daffo	6	6½	—
Ex-Lands	48	54	50
Filani	—	3½	—
Jantar	22	22	23
Jos	13	13	—
Juga Valley	6	8½	9
Kaduna Syndicate	20	21	—
Kaduna Prospectors	13	17	—
Kassa	11	10	11
London Tin	140	144	200
Lower Bisichi	4	4½	—
Naraguta Extended	—	—	—
Nigerian Consolidated	—	7½	11
Offin River	3	3½	3½
Ribon Valley	14	16	14½
Tin Fields	6	—	5⅜
United Tin Areas	16½	16½	18
Yarde Kerri	4	5	4

OUTPUTS OF OTHER TIN MINING COMPANIES.

In Long Tons of Concentrate.

	July	August	Sept.
Anglo-Burma (Burma)	38½	—	—
Aramayo Mines (Bolivia)	244	169	190
Bangrin (Siam)	92½	101⅜	111½
Beralt	34*	34*	32½
Consolidated Tin Mines (Burma)	116	180	140
East Pool (Cornwall)	48½	48½	—
Fabulosa (Bolivia)	58	45½	—
Kagera (Uganda)	10	6	16
Kamra	60	54½	—
Malaysiam Tin	6½	6½	8½
Mawchi	211*	209*	—
Patino	1,306	992½	—
Pattani	69	150	—
San Finx (Spain)	22*	21*	—
Siamese Tin (Siam)	190½	214	190½
Tavoy Tin (Burma)	50	75	62
Tongkah Harbour (Siam)	54	40	65
Toyo (Japan)	75½	68	66

* Tin and Wolfram.

COPPER, LEAD, AND ZINC OUTPUTS.

		August	Sept.
Broken Hill South	Tons lead conc.	4,199	5,692
	Tons zinc conc.	4,583	6,110
Burma Corporation	Tons refined lead.	5,880	5,880
	Oz. refined silver	460,000	460,000
Electrolytic Zinc	Tons zinc	—	—
Indian Copper	Tons copper	354	351
Messina	Tons copper	801	717
Mount Isa	Tons lead bullion	2,264	2,286
Mount Lyell	Tons concentrate	3,755*	—
North Broken Hill	Tons lead conc.	4,900	—
	Tons zinc conc.	4,530	—
Rhodesia Broken Hill	Tons V_2O_5	27½	34½
	Tons slab zinc	—	—
Roan Antelope	Tons concentrates	4,790	6,660
San Francisco Mexico	Tons lead conc.	3,571	3,808
	Tons zinc conc.	3,345	3,536
Tetiuhe	Tons lead conc.	1,010	675
	Tons zinc conc.	2,177	2,201
Trepca	Tons lead conc.	3,632	2,972
	Tons zinc conc.	3,385	3,787
Zinc Corporation	Tons lead conc.	—	—
	Tons zinc conc.	—	—

* To Sept. 9.

IMPORTS OF ORES, METALS, ETC., INTO UNITED KINGDOM.

		July.	August.
Iron Ore	Tons	176,247	154,739
Manganese Ore	Tons	7,150	4,466
Iron and Steel	Tons	231,017	201,920
Copper and Iron Pyrites	Tons	21,283	25,697
Copper Ore, Matte, and Prec.	Tons	3,141	2,871
Copper Metal	Tons	14,932	14,362
Tin Concentrate	Tons	5,316	5,530
Tin Metal	Tons	1,134	586
Lead Pig and Sheet	Tons	30,301	16,503
Zinc (Spelter)	Tons	13,312	7,920
Zinc Sheets, etc.	Tons	1,903	2,599
Aluminium	Tons	685	869
Mercury	Lb.	69,796	95,446
Zinc Oxide	Tons	636	1,421
White Lead	Cwt.	13,829	16,655
Red and Orange Lead	Cwt.	2,700	3,824
Barytes, ground	Cwt.	45,152	37,685
Asbestos	Tons	1,993	723
Boron Minerals	Tons	147	607
Borax	Cwt.	18,683	28,956
Basic Slag	Tons	2,635	2,633
Superphosphates	Tons	1,341	655
Phosphate of Lime	Tons	23,343	34,542
Mica	Tons	95	114
Sulphur	Tons	3,446	12,457
Nitrate of Soda	Cwt.	88,530	51,760
Potash Salts	Cwt.	80,293	454,596
Petroleum : Crude	Gallons	30,646,530	31,774,442
Lamp Oil	Gallons	19,474,085	17,629,876
Motor Spirit	Gallons	80,357,342	81,105,620
Lubricating Oil	Gallons	9,013,335	10,101,059
Gas Oil	Gallons	5,516,757	8,080,657
Fuel Oil	Gallons	35,564,137	51,911,440
Asphalt and Bitumen	Tons	20,427	7,992
Paraffin Wax	Cwt.	88,419	87,149
Turpentine	Cwt.	11,685	87,416

OUTPUTS REPORTED BY OIL-PRODUCING COMPANIES.

In Tons.

	July.	August.	September.
Anglo-Ecuadorian	21,354	20,662	19,854
Apex Trinidad	50,070	46,450	42,970
Attock	1,818	1,483	1,628
British Burmah	4,495	4,410	4,285
British Controlled	38,763	46,648	—
Kern Mex	912	971	957
Kern River (Cal.)	3,068	3,027	2,883
Kern Romana	877	996	1,048
Kern Trinidad	4,751	5,037	4,721
Lobitos	28,107	26,250	25,260
Phœnix	71,862	64,565	50,433
St. Helen's Petroleum	5,266	5,127	5,389
Steaua Romana	80,830	80,550	85,580
Tampico	2,418	2,801	2,727
Tocuyo	2,155	2,026	1,924
Trinidad Leaseholds	17,400	18,800	18,600

QUOTATIONS OF OIL COMPANIES' SHARES.

Denomination of Shares £1 unless otherwise noted

	Sept. 10, 1931.			Oct. 10, 1931.		
	£	s.	d.	£	s.	d.
Anglo-Ecuadorian		5	6		6	0
Anglo-Egyptian B.	1	3	9	1	3	9
Anglo-Persian 1st Pref.	1	3	6	1	3	3
,, ,, Ord.	1	10	0	1	18	0
Apex Trinidad (5s.)		6	6		8	9
Attock		11	3		11	3
British Burmah (8s.)		3	0		3	0
British Controlled ($5)		1	3		1	6
Burmah Oil	1	17	6	2	1	3
Kern River Cal. (10s.)		1	6		1	6
Lobitos, Peru		15	0		16	9
Mexican Eagle, Ord. (4 pesos)		6	6		6	6
,, ,, 8% Pref. (4 pesos)		7	0		7	0
Phœnix, Roumanian		4	0		4	0
Royal Dutch (100 fl.)	12	12	6	15	12	6
Shell Transport, Ord.	1	15	0	2	1	3
,, ,, 5% Pref. (£10)	10	0	0	8	10	0
Steaua Romana		4	3		4	0
Trinidad Leaseholds		15	0		18	9
United British of Trinidad (6s. 8d.)		3	0		3	0
V.O.C. Holding		18	9		19	0

PRICES OF CHEMICALS. October 10.

These quotations (some of which are affected by the devaluation of the pound sterling) are not absolute; they vary according to quantities required and contracts running.

		£	s.	d.
Acetic Acid, 40%	per cwt.		15	9
,, 80%	,,	1	14	3
,, Glacial	per ton	56	0	0
Alum	,,	8	7	6
Aluminium Sulphate, 17 to 18%	,,	6	15	0
Ammonium, Anhydrous	per lb.		1	0
,, 0·880 solution	per ton	15	10	0
,, Carbonate	,,	27	10	0
,, Nitrate (British)	,,	16	0	0
,, Phosphate, comml.	,,	40	0	0
,, Sulphate, 20·6% N.	,,	5	10	0
Antimony, Tartar Emetic, 43/44%	per lb.			10
,, Sulphide, golden	,,			9
Arsenic, White (foreign)	per ton	22	10	0
Barium, Carbonate, 94%	,,	4	10	0
,, Chloride	,,	11	0	0
,, Sulphate, 94%	,,	6	15	0
Benzol, standard motor	per gal.		1	3½
Bleaching Powder, 35% Cl.	per ton	7	0	0
Borax	,,	15	10	0
Boric Acid	,,	25	0	0
Calcium Chloride, solid, 70/75%	,,	5	5	0
Carbolic Acid, crude 60's	per gal.		1	5
,, ,, crystallized, 40°	per lb.			5⅜
Carbon Disulphide	per ton	16	10	0
Citric Acid	per lb.		1	1½
Copper Sulphate	per ton	18	10	0
Creosote Oil (f.o.b. in Bulk)	per gal.			4½
Cresylic Acid, 98-100%	,,		1	9
Hydrofluoric Acid, 59/60%	per lb.			6
Iodine	per oz.		1	0
Iron, Nitrate 80° Tw.	per ton	6	10	0
,, Sulphate	,,	2	2	6
Lead, Acetate, white	,,	35	0	0
,, Nitrate (ton lots)	,,	28	10	0
,, Oxide, Litharge	,,	28	10	0
,, White	,,	38	10	0
Lime, Acetate, brown	,,	7	0	0
,, ,, grey, 80%	,,	12	0	0
Magnesite, Calcined	,,	8	5	0
Magnesium Chloride	,,	5	10	0
,, Sulphate, comml.	,,	3	15	0
Methylated Spirit Industrial 61 O.P.	per gal.		2	1
Nitric Acid, 80° Tw.	per ton	23	0	0
Oxalic Acid	per cwt.	2	2	0
Phosphoric Acid. S.G. 1·500	per ton	29	15	0
Pine Oil	per cwt.	2	5	0
Potassium Bichromate	per lb.			5½
,, Carbonate, 96/98%	per ton	28	0	0
,, Chlorate	,,	33	0	0
,, Chloride 80%	,,	9	5	0
,, Ethyl Xanthate	per 100 kilos	7	0	0
,, Hydrate (Caustic) 88/90%	per ton	40	0	0
,, Nitrate	,,	19	17	6
,, Permanganate	per lb.			6½
,, Prussiate, Yellow	,,			8½
,, ,, Red	,,		1	8
,, Sulphate, 90%	per ton	10	10	0
Sodium Acetate	,,	20	0	0
,, Arsenate, 45%	,,	20	10	0
,, Bicarbonate	,,	10	10	0
,, Bichromate	per lb.			3½
,, Carbonate (Soda Ash) 58%	per ton	6	0	0
,, ,, (Crystals)	,,	5	5	0
,, Chlorate	,,	30	0	0
,, Cyanide 100% NaCN basis	per lb.			8
,, Ethyl Xanthate	per 100 kilos	6	10	0
,, Hydrate, 76%	per ton	14	10	0
,, Hyposulphite, comml.	,,	9	2	6
,, Nitrate (ordinary)	,,	9	0	0
,, Phosphate, comml.	,,	13	0	0
,, Prussiate	per lb.			4½
,, Silicate	per ton	9	10	0
,, ,, (liquid, 140° Tw.)	,,	8	10	0
,, Sulphate (Glauber's Salt)	,,	2	15	0
,, ,, (Salt-Cake)	,,	2	17	6
,, Sulphide Conc., 60/65%	,,	10	10	0
,, Sulphite, pure	per cwt.		14	0
Sulphur, Flowers	per ton	12	0	0
,, Roll	,,	12	0	0
Sulphuric Acid, 168° Tw.	,,	4	5	0
,, ,, free from Arsenic, 140° Tw.	,,	3	0	0
Superphosphate of Lime (S.P.A. 16%)	,,	3	9	0
Tartaric Acid	per lb.		1	0½
Turpentine	per ton	55	0	0
Tin Crystals	per lb.			10½
Titanous Chloride	,,			10½
Zinc Chloride	per ton	9	10	0
Zinc Dust, 90/92%	,,	20	0	0
Zinc Oxide (White Seal)	,,	35	0	0
Zinc Sulphate	,,	10	10	0

SHARE QUOTATIONS

Shares are £1 par value except where otherwise noted.

GOLD AND SILVER:	Sept. 10, 1931. £ s. d.	Oct. 10, 1931. £ s. d.
SOUTH AFRICA:		
Brakpan	2 18 0	3 1 3
City Deep	5 6	5 6
Consolidated Main Reef	18 9	1 0 6
Crown Mines (10s.)	4 9 6	5 1 0
Daggafontein	2 13 0	2 13 9
Durban Roodepoort Deep (10s.)	15 6	16 0
East Geduld	2 17 6	3 3 0
East Rand Proprietary (10s.)	13 9	13 3
Geduld	4 1 3	4 8 0
Geldhenhuis Deep	8 6	9 6
Glynn's Lydenburg	5 0	5 0
Government Gold Mining Areas (5s.)	1 11 6	1 14 0
Langlaagte Estate	1 4 6	1 6 0
Meyer & Charlton	18 9	18 9
Modderfontein New (10s.)	2 10 0	2 13 9
Modderfontein B (5s.)	9 6	11 0
Modderfontein Deep (5s.)	18 9	18 0
Modderfontein East	1 7 0	1 8 9
New State Areas	2 3 9	2 12 6
Nourse	16 9	17 0
Randfontein	1 5 3	1 6 9
Robinson Deep A (1s.)	15 0	15 6
" " B (7s. 6d.)	9 6	9 6
Rose Deep	5 3	5 9
Simmer & Jack (2s. 6d.)	3 3	3 6
Springs	3 3 0	3 11 6
Sub Nigel (10s.)	3 2 0	3 7 6
Van Ryn	9 6	10 6
Van Ryn Deep	19 6	1 0 0
Village Deep (9s. 6d.)	2 6	2 3
West Rand Consolidated (10s.)	10 0	10 6
West Springs	12 3	13 0
Witwatersrand (Knight's)	11 0	11 0
Witwatersrand Deep	4 6	3 9
RHODESIA:		
Cam and Motor	1 2 6	1 5 6
Gaika	3 6	3 6
Globe and Phœnix (5s.)	11 6	12 6
Lonely Reef	14 0	16 3
Mayfair	4 6	4 0
Rezende	18 9	1 0 0
Shamva	1 0	1 0
Sherwood Starr (5s.)	13 9	13 9
GOLD COAST:		
Ashanti (4s.)	1 12 3	1 16 0
Taquah and Abosso (5s.)	4 0	4 6
AUSTRALASIA:		
Golden Horseshoe (4s.) W.A.	2 3	2 6
Great Boulder Propriet'y (2s.), W.A.	1 0	1 0
Lake View and Star (4s.), W.A.	8 0	8 0
Sons of Gwalia, W.A.	3 9	4 0
South Kalgurli (10s.), W.A.	11 6	11 9
Waihi (5s.), N.Z.	13 6	15 0
Wiluna Gold, W.A.	7 0	7 6
INDIA:		
Balaghat (10s.)	2 9	2 6
Champion Reef (10s.)	6 6	6 9
Mysore (10s.)	6 6	7 9
Nundydroog (10s.)	13 6	15 9
Ooregum (10s.)	2 6	2 9
AMERICA:		
Camp Bird (2s.), Colorado	3	3
Exploration (10s.)	2 0	2 0
Frontino and Bolivia, Colombia	11 3	10 0
Mexican Corporation, Mexico (10s.)	3 6	3 9
Mexico Mines of El Oro, Mexico	1 6	1 6
Panama Corporation	10 6	9 0
St. John del Rey, Brazil	18 6	18 6
Santa Gertrudis, Mexico	6 9	7 9
Selukwe (2s. 6d.), British Columbia	1 9	1 9
MISCELLANEOUS:		
Chosen, Korea	2 6	2 3
Lena Goldfields, Russia	6	6

COPPER:		
Bwana M'Kubwa (5s.) Rhodesia	3 3	3 3
Esperanza Copper	13 9	13 9
Indian (2s.)	9	9
Loangwa (5s.), Rhodesia	2 3	1 9
Luiri (5s.), Rhodesia	1 3	1 0
Messina (5s.), Transvaal	5 0	6 0
Mount Lyell, Tasmania	12 6	15 0
Namaqua (£2), Cape Province	4 6	4 6
Rhodesia-Katanga	10 0	10 0
Rio Tinto (£5), Spain	14 10 0	16 15 0
Roan Antelope (5s.), Rhodesia	7 6	9 6
Tanganyika Con.	15 6	17 0
Tharsis (£2), Spain	2 1 3	2 0 0

LEAD-ZINC:	Sept. 10, 1931. £ s. d.	Oct. 10, 1931. £ s. d.
Amalgamated Zinc (8s.), N.S.W.	5 0	6 3
Broken Hill Proprietary, N.S.W.	8 0	9 6
Broken Hill, North, N.S.W.	1 10 0	2 1 3
Broken Hill South, N.S.W.	1 2 6	1 7 6
Burma Corporation (10 rupees)	6 3	8 6
Electrolytic Zinc Pref., Tasmania	12 6	12 6
Mount Isa, Queensland	7 6	6 3
Rhodesia Broken Hill (5s.)	9	1 0
San Francisco (10s.), Mexico	8 0	7 6
Sulphide Corporation (15s.), N.S.W.	4 9	6 3
ditto, Pref.	7 6	8 0
Zinc Corporation (10s.), N.S.W.	12 6	17 6
ditto, Pref.	2 10 0	2 10 0

TIN:		
Aramayo Mines (25 fr.), Bolivia	17 6	17 6
Associated Tin (5s.), Nigeria	4 3	4 3
Ayer Hitam (5s.)	11 6	10 6
Bangrin, Siam	11 0	11 6
Bisichi (10s.), Nigeria	4 6	4 3
Chenderiang, Malay	1 6	1 6
Consolidated Tin Mines of Burma	1 9	2 0
East Pool (5s.), Cornwall	6	6
Ex-Lands Nigeria (2s.), Nigeria	1 3	1 3
Geevor (10s.), Cornwall	2 0	2 0
Gopeng, Malaya	1 12 6	1 12 6
Hongkong (5s.)	14 0	14 0
Idris (5s.), Malaya	6 9	6 6
Ipoh Dredging (10s.), Malay	13 0	13 0
Kaduna Prospectors (5s.), Nigeria	4 6	4 0
Kaduna Syndicate (5s.), Nigeria	12 6	11 6
Kamunting (5s.), Malay	5 0	4 6
Kepong, Malay	10 0	10 0
Kinta, Malay (5s.)	6 6	6 6
Kinta Kellas, Malay (5s.)	5 6	5 6
Kramat Pulai, Malay	1 0 0	1 1 9
Lahat, Malay	5 0	5 0
Malayan Tin Dredging (5s.)	16 3	15 6
Naraguta, Nigeria	6 6	6 3
Nigerian Base Metals (5s.)	6	6
Pahang Consolidated (5s.), Malay	5 0	5 3
Penawat ($1), Malay	1 0	1 0
Pengkalen (5s.), Malay	10 0	10 0
Petaling (2s. 4d.), Malay	8 0	8 0
Rambutan, Malay	5 0	5 0
Renong Dredging, Malay	12 6	13 0
Siamese Tin (5s.), Siam	7 3	7 6
South Crofty (5s.), Cornwall	2 3	2 6
Southern Malayan (5s.)	9 0	9 0
Southern Perak, Malay	1 5 0	1 5 0
Southern Tronoh (5s.), Malay	6 0	6 0
Sungei Besi (5s.), Malay	7 0	7 0
Sungei Kinta, Malay	9 0	9 0
Tanjong (5s.), Malay	7 6	7 0
Tavoy (4s.), Burma	3 6	2 9
Tekka, Malay	13 0	13 0
Tekka Taiping, Malay	11 0	11 6
Temengor, Malay	1 6	1 6
Toyo (10s.), Japan	1 0	1 6
Tronoh (5s.), Malay	12 0	12 0

DIAMONDS:		
Consol. African Selection Trust (5s.)	6 3	6 3
Consolidated of S.W.A. (10s.)	2 9	2 6
De Beers Deferred (£2 10s.)	2 15 0	2 17 6
Jagersfontein	13 9	12 6
Premier Preferred (5s.)	1 5 0	1 5 0

FINANCE, ETC.:		
Anglo-American Corporation (10s.)	10 9	8 6
Anglo-French Exploration	7 0	8 9
Anglo-Continental (10s.)	2 3	2 3
Anglo-Oriental (Ord., 5s.)	6 6	5 6
ditto, Pref.	8 6	7 6
British South Africa (15s.)	15 9	17 6
Central Mining (£8)	6 10 0	5 5 0
Consolidated Gold Fields	15 0	14 6
Consolidated Mines Selection (10s.)	5 0	5 9
Fanti Consols (8s.)	5 3	5 6
General Mining and Finance	14 6	13 0
Gold Fields Rhodesian (10s.)	2 9	2 0
Johannesburg Consolidated	1 0 0	1 2 6
London Tin Corporation (10s.)	11 6	11 0
Minerals Separation	2 2 6	2 0 0
National Mining (8s.)	3	3
Rand Mines (5s.)	2 13 9	2 12 0
Rand Selection (5s.)	9 6	8 6
Rhodesian Anglo-American (10s.)	7 6	8 9
Rhokana Corp.	3 7 6	3 17 6
Rhodesian Selection Trust (5s.)	7 6	7 0
South Rhodesia Base Metals	2 0	2 0
Tigon (5s.)	3 6	3 0
Union Corporation (12s. 6d.)	2 15 0	2 18 9
Venture Trust (10s.)	4 0	3 6

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section we give abstracts of important articles and papers appearing in technical journals and proceedings of societies, together with brief records of other articles and papers: also notices of new books and pamphlets, lists of patents on mining and metallurgical subjects, and abstracts of the yearly reports of mining companies.

THE GEOLOGY OF THE KATANGA

In June, 1930, G. V. Douglas published in the MAGAZINE some observations on the geology and mines of the Belgian Congo, while in April last G. C. Barnard considerably clarified the present knowledge of Central African stratigraphy by his provisional correlation of the rocks of South and Central Africa, which also appeared in these pages. In *Economic Geology* for August, M. Robert contributes an outline of the geology and ore-deposits of Katanga and full extracts from his paper are given here.

The author states that his notes summarize the main features of the rock formations and ore deposits. The information was gained during the geological investigations of the region carried on under the direction of the writer for the Comité Special du Katanga.

GENERAL GEOLOGY.—*Alluvial and Superficial Deposits.*—Alluvial deposits occupy large and continuous areas in the basins of the Luapula, Lufira, and Lualaba Rivers and connect with narrower, more local, belts along the principal affluents of these streams. Over the surface of the Kundelungu, Manika and Biano highlands, which form the uplands of central Katanga and rise to elevations greater than 1,500 metres above the sea, lies a discontinuous mantle of superficial deposits, largely arenaceous, comprising: (1) Strips and smaller residual patches of beds belonging to the Lubilash System; (2) formations of post-Lubilash age.

Upon the Kundelungu plateau, in the area drained by the Lufukwe River, occur silicified, fossiliferous, lacustrine limestones of upper Tertiary or possibly Quaternary age.

Lualaba-Lubilash System.—Beds of the Lualaba-Lubilash System that retain their original horizontal attitude cover the whole of the Congo Basin and outliers of rocks belonging to the same system occupy large areas in the north-west part of the province of Katanga. Other outliers occur to the east, in elongated depressions generally parallel with Lake Tanganyika. The fossils found in the beds of the Lualaba-Lubilash System range from Permian to upper Triassic (Rhaetic). The system is divisible into three series. These, from top to bottom, are as follows:

Lubilash Series.—Principally soft, friable sandstones and lenticular conglomerates. Species of the small phyllopod *Estheria* have been found in these beds.

Lualaba Series.—Essentially red, yellowish, brown, green, black, and variegated argillites and shales, in part bituminous, carrying fishes and Entomostraca of upper Triassic and lower Jurassic age.

Lukuga Series.—Sandstones, black shales, and coal measures, with a glacial or fluvio-glacial conglomerate at the base. The fossil flora of these beds has been studied by Professor A. Renier, who has identified *Glossopteris browiana*, Brogniart, var. *indica*, S himper; *Nummulospermum*, sp.; *Phyllotheca* sp. or *Schizoneura* sp.; *Noeggerathiopsis* cf. *Hislopi*, Bunbury; *Cyclodendron leslii*, Seward. Professor Renier regards this flora as closely related to the middle Ecca of the Karroo System.

The beds of the Lualaba-Lubilash System were deposited on a well peneplained surface and rest unconformably upon the underlying rocks. This peneplanation was accomplished during the long period of erosion that intervened between the deposition of the Kundelungu Series and the beginning of Lualaba-Lubilash deposition. The Lualaba-Lubilash deposits are of continental type and are the equivalent of the Karroo System of South Africa.

Kundelungu and Schisto-Dolomitique Systems.—As the post-Archean beds making up the systems older than the Lualaba-Lubilash System are unfossiliferous, their positions in the general stratigraphic column are not determinable. All that can be said is that they are older than the Permian. They comprise two systems which, in descending order, are, the Kundelungu System, and the Schisto-Dolomitique System.

The constitution of these two systems is shown in the following table, the divisions being arranged from top to bottom in the order of increasing age:

KUNDELUNGU AND SCHISTO-DOLOMITIQUE SYSTEMS

Kundelungu System	Upper Series	1. Sandstones 2. Arenaceous shales 3. Calcareous shales (300–500 m.) 4. Pink limestone (10–20 m.) 5. The *petit* conglomerate (10–30 m.)	(1000–1500 m.)	
	Lower Series	1. Arenaceous limestones (300–500 m.) 2. Calcareous shales (200–1000 m.) 3. Kakontwe limestone (100–200 m.) 4. The *grand* conglomerate (tillite 350 m.)		
Schisto-dolomitique System			*Central region*	*Border region*
	Shaly-cherty Series (Mwashia)		Shales and calcareous shale (100–500 m.) Black pyritic shale (100 m.) Silicified horizon (10–100 m.) Cherty oolite, with specularite	Felspathic quartzite and shales, including black shale Cherty oolite with specularite
	Dolomitic Series		Dolomitic shales and dolomite (500–600 m.)	Dolomitic shales; dolomite, with shales, conglomerates, and felspathic quartzites.

The sedimentary beds of the Kundelungu and Schisto-Dolomitique Systems rest unconformably on the old beds of the basement.

Cristallophyllien and Kibara Systems.—Fundamental Platform.—These fundamental rocks at their bases consist of the Cristallophyllien system, composed of mica schists, gneisses, several quartzites, ferro-magnesian rocks, and batholithic granitic intrusives, which in places grade into gneissic granite and gneiss. In some localities, the intrusive granitic masses, with associated pegmatites, have displaced or assimilated the ancient sedimentary rocks known as the Kibara System.

Kibara System.—This group of rocks lies on top of the Cristallophyllien System. It is composed of conglomerates, shales, phyllites, black carbonaceous pyritic shales, and grayish blue limestones and dolomites.

Structure.—Such sedimentary rocks as are involved in the Archæan platform are everywhere strongly folded. As these beds are resistant to erosion, the folds are expressed topographically as successions of nearly parallel strike ridges. Further tectonic disturbances took place at the close of the Kundelungu period. They were characterized by lateral compression, intense and very intricate folding, reverse faulting, and overthrusts. In southern Katanga, the general effect of these movements was to produce a curved uplift of folded and faulted beds. In general, this uplift extends in a north-westerly direction from the vicinity of Sakania, on the Northern Rhodesian border, past Elisabethville and Likasi, and thence swings westward. It is along this uplift that the great copper deposits of the Belgian Congo are distributed.

After the post-Kundelungu folding and faulting, followed a long period of erosion during which was formed the peneplain upon which the beds of the Lualaba-Lubilash series were deposited.

Later, the region was dislocated by faulting, with the formation of rift valleys or grabens, such as those of Tanganyika and Kamolondo.

Age Relationships.—The upper part of the general stratigraphic column referred to above as the Lualaba-Lubilash system is now definitely known by means of fossils to be of Permo-Triassic-Rhaetic Age. The Kundelungu and Schisto-dolomitique systems, although without fossils, are also fairly definitely placed. The systematic studies carried on in the Katanga from 1920 to 1928 have enabled definite correlation of the horizontal beds of the Kundelungu system in the North of the Katanga and those of the folded area of the Meridional Katanga. These studies have given rise to the detailed separations shown in Table I. This column, used in the Katanga since 1923, has proved dependable, notwithstanding the absence of fossils, in the area of the Katanga.

The work of Gray proves that this stratigraphic column, when carried into Rhodesia, gives excellent results. Dr. Gray recognizes in Rhodesia, even in detail, the series and beds of the Kundelungu and Schisto-Dolomitique systems of the Katanga.

In the Katanga, the lower part of the Schisto-dolomitique system (of which the Série des Mines is only a silicified horizon) appears only in the anticlines, and its base has not been completely observed.

The studies in Rhodesia permit the column to be extended downwards; the Roan system of Rhodesia represents the lower part of the Schisto-dolomitique system, which appears only in part in Katanga.

The inferior group, consisting of the Cristallophyllien and the Kibara systems, has not been sufficiently studied to establish its age.

Ore Deposition.—*Stages of Mineralization.*—The origin of the copper deposits of Katanga constitutes a complex problem which will require many additional observations before a satisfactory solution can be reached. Various hypotheses have been offered which differ in many respects, although most of them contain some elements of truth. The present attempt to construct from available information a consistent hypothesis of origin recognizes the following stages or types of mineralization:

1. (*a*) Deep-seated mineralization by impregnation.
   (*b*) Vein deposition.
2. Mineralization by oxidation and supergene enrichment.
3. Syngenetic sedimentary deposition.

Each of these stages or processes will now be discussed briefly, with the citation of examples.

Deep-Seated Mineralization by Impregnation.—The first, or deep-seated, mineralization in Katanga must have begun during the formation of the earliest folds in Kundelungu time and have been completed before the end of the intricate folding and faulting which gave rise to the curved uplift of southern Katanga. The rocks were extensively permeated by ore-bearing solutions and the sulphides of copper and iron were deposited by replacement of other minerals, particularly along certain horizons in the lower or dolomitic series of the Schisto-Dolomitique system. The solutions are believed to have been of magmatic origin.

The deposits of this first period of mineralization, as brought within the range of observation by upthrust wedges or slices in the intricately folded and faulted structure of southern Katanga, are generally of too low tenor in copper to be workable. Their principal economic significance at present lies in the fact that by enrichment and secondary concentration they have given rise to most of the large copper deposits that are being worked in the Belgian Congo at the present time.

Vein Deposition.—At the close of the great final folding which affected the beds of the Kundelungu System, there was a period of mineralization during which the ore-bearing solutions traversed fissures that cut through the Kundelungu beds. This period probably followed the first uninterruptedly. The ores of the vein-forming period carry chalcopyrite, with pyrite, sphalerite, and galena. To this period also belong the uranium deposits of Kasolo and Luiswishi. A part of the Kambove deposit also, where traces of sphalerite have been found, probably was formed during this period. In some of the limestone cut by the veins, magnesite (giobertite) has been formed by hydrothermal action, and monazite has been reported by Professor Schoep. The mineralization of this period was probably effected at a lower temperature or greater distance from the magmatic source than that of the first period, as indicated by the occurrence of lead and zinc.

The most typical occurrence of this group is the Kipushi deposit (Prince Leopold Mine), situated close to the Northern Rhodesian border, west of Elisabethville. Here the ore-bodies, in the Kakontwe limestone, of the lower Kundelungu, are enlargements, by replacement, of fissure veins. Probably belonging to this same period of

mineralization are small veins of chalcocite in limestone at the Lenoir quarry, near Fungurume.

Evidently deposition during this second period of hypogene mineralization may, under favourable conditions, have enriched the deposits formed during the first period of mineralization. It is thus possible that, in the intensely folded zones of southern Katanga, important sulphide deposits may be found in which the later mineralization, characterized by the presence of lead and zinc, has been superimposed on the low-grade mineralization of the first period.

Mineralization by Oxidation and Supergene Enrichment.—The hypogene deposits of the first and second periods have been greatly modified by oxidation, enrichment and migration. Not only have originally lean masses been enriched to form the great bodies of oxidized ore, but copper has been carried by solution into rocks not originally mineralized. Characteristic minerals of the zones of oxidation and enrichment are malachite, chrysocolla, cuprite, melaconite, cornetite, brochantite, liebethenite, heterogenite, chalcocite, linnæite, bornite, and occasionally a little chalcopyrite, especially in the deeper zones.

In the folded region of the southern Katanga, these oxidized enriched ores occur in anticlinal wedges and slices of the more or less silicified and dolomitized limestones and calcareous shales of the Schisto-Dolomitique system, which, prior to the folding and faulting, had undergone the deep-seated mineralization by impregnation, of the first period. These mineralized masses of strata, wedged into the anticlines, are generally separated from other similar masses and from the underlying beds, containing deposits of the first period of mineralization, by unmineralized fault breccias. Their enrichment is largely due to the descent of copper-bearing solutions from parts of the masses which have been removed by erosion.

The deep oxidation and enrichment of the Katanga copper ores indicate the former existence of a water-table much deeper than that of the present. Solution cavities found in the limestones, found far below present water-level, point to the same conclusion. Such lower water-table must have been coincident with a period when the region had a much dryer climate than that now prevailing. If, as appears fairly certain, the Katanga copper ore-bodies represent masses that have been torn, by faulting, from a former connexion with the silicified and mineralized bodies of the first period of mineralization and then enriched, it may be concluded that large masses of rock affected by the mineralization of the first period are present at greater depth. Such material, however, is probably of rather low grade.

Syngenetic Sedimentary Deposits.—On the Kundelungu plateau there may be observed at various localities, as, for example, at Sampwe, Lofoi, and Lukafu, outcrops of beds in which certain layers or horizons, up to 10 cm. in thickness, carry malachite and azurite. In some of the sandstones, particular layers are mottled with grains or small bunches of chalcocite. These mineralized horizons are confined to the upper series of the Kundelungu and intercalated between the beds of argillaceous and arenaceous shales which underlie the thick-bedded felspathic sandstones at the top of the series. In the Gombela-Katete region, one of these mineralized zones, up to a meter in thickness, occurs within the greenish gray, calcareous shale of the upper Kundelungu.

In northern Katanga the Kundelungu beds, with their mineralized horizons, are practically horizontal. In the Gombela-Katete highlands, however, they are folded.

The mineralized zones in the upper Kundelungu are believed to be of sedimentary origin and syngenetic, the copper having been derived from the disintegration of deposits formed during the first period of deep-seated mineralization. These older deposits had been exposed in part, by erosion, and were undergoing oxidation before the deposition of the upper series of the Kundelungu.

MICA IN BIHAR, INDIA

The *Bulletin* of the Institution of Mining and Metallurgy for September contains some notes by B. G. Luff on the mica industry in Bihar, India. After dealing with the uses of mica the author goes on to give an account of the particular occurrences. He says that the country rock is a mica schist in which are found pegmatite bodies, nearly always of lenticular form. As the schist shows no signs of alteration at or close to the contact and the pegmatite must have cooled without serious movement or disturbance for the large crystals of mica to have formed, it would seem that the pegmatite magma was injected at the same time as the schist was metamorphosed and that thereafter both rocks cooled down together.

The pegmatite lenses generally strike approximately E. and W., have a steep dip, and vary in thickness from a few inches up to 100 ft. or more from schist wall to schist wall. At times the lenses have a pitch along the strike, and frequently there are inclusions of schist within the pegmatite. The pegmatite consists of felspar, quartz, muscovite, and biotite, with some tourmaline and garnet. Very occasionally there is a show of iron pyrites or mispickel. The mica occurs generally on or close to the schist wall, more generally the foot-wall, but as it is often difficult to tell which is hanging-wall and which foot-wall, owing to the irregularity of the lenses, this rule is not very reliable. Frequently there is a quartz core in the pegmatite and there are often segregations of mica crystals close to this. In some cases the mica is more or less evenly distributed in the pegmatite and when this is the case it often pays to open-cast the lens and then only if it is wide enough. At times even that is not remunerative owing to the small size of the mica in a massive vein.

The mica occurs as crystals up to several square feet in area and 5 or 6 inches thick normal to the cleavage. The average size of the books is very much smaller than this and many are only a few square inches in area and half an inch thick.

The pegmatite lenses are up to 1,500 ft. in length along the strike, but generally not more than 200 ft. to 300 ft. down the dip, at which depth they pinch out, leaving only a very thin stringer of quartz and felspar. It is often found that this stringer leads to another lens and frequently at the point of opening out there are rich pockets of mica. These pockets also occur at irregular intervals

in some mines without showing any indication before they are reached by driving or sinking.

Owing to the irregular distribution of the mica in the pegmatite it is not possible to test veins by bore-holes, nor is it possible to sample the rock to find the mica content. This has prejudiced the employment of capital in development of the industry. It is frequently said that mica is not found in depth, but the real meaning of this statement is that it has not yet been found in depth owing to lack of money for testing, as this testing can be no more than a gamble. Certainly it has never been proved that mica is not found in depth, as the deepest mine is only about 600 ft.

Mica is at times of little or no value, as only mica with a perfect or nearly perfect cleavage is of value. Some mica if split does not do so cleanly, but tears the films. Such mica is known as *jetahi*, and is nearly valueless. Sometimes the mica, probably owing to pressure deformation, is broken into pieces or strips so small as to be worthless. Mica that is of use also varies considerably in value according to colour, hardness, whether stained or not, spotted with iron or other impurities, flat or ridged or wavy, or if it contains air bubbles which give it a silvery appearance. Some pieces contain inclusions of tourmaline or quartz which render it valueless if the films are penetrated. Quartz sometimes occurs in thin layers between the films of mica and can be removed by the sorters by opening up the mica sheets and shaking out the quartz.

It is difficult to say exactly when the recovery and sale of mica in Bihar first reached the status of an industry, but it was probably between 40 and 50 years ago. The founder of what is now the largest single mica-mining firm in India was then a worker on the Indian Railways and conceived the idea of setting up in business as a mica trader. For a good many years he bought mica from coolies who found it on or very near the surface, and only comparatively large sizes were purchased. This is proved by the fact that in later years, when dumps first began to be worked, very large quantities of small mica, which now has considerable value, were recovered. It would seem that this pioneer was able to buy mica from coolies who did not know its value, and could sell it at a good profit, as may be inferred from the fact that he not only improved the amenities of the places where he or his agents lived by sinking wells, making tanks, planting trees, etc., but also amassed a considerable fortune.

Present Mining Methods.—Owing to the impossibility of proving the value of deposits by boring, and the uncertainty of deposits, even if explored by drives, cross-cuts and winzes, or rises, it has been the practice for many years, in fact since the beginning of the industry, to expect development to pay for itself and make a profit. It is only very recently, and even then only with the largest concerns, that deposits have been systematically developed with a view to removing the greater part by stoping. The blocks are generally of very small size and mines are not approved if development does not pay for itself and make a profit. Before dealing with underground work, consideration is given to other methods of extraction, viz., surface workings (known as *upperchella*) and opencasting.

Upperchella.—The workings in which this is carried on are mere scratches on the surface and rarely exceed 20 ft. in depth as, if over that depth, they have to be registered as mines, have second outlets, and be periodically inspected by the authorities. It is the practice of landowners who have no interest in the mica trade to allow coolies to dig for mica on their land for a small monthly fee. The mica is disposed of by the coolies to dealers.

Open-cast Workings.—This method of working is employed where the vein is massive; that is, where mica is found over most, or the whole width, of the pegmatite, which may be 100 ft. or more. In general the work is by means of platforms about 20 ft. high in which holes about 3 ft. diameter and 12 ft. to 15 ft. deep are excavated by chiselling or by blasting with dynamite. There is only room in the bottom of these holes for one man and he uses when chiselling a specially short-handled hammer (6 lb.). When it is required to drill a hole for blasting the holder generally squats in the bottom of the hole and the hammer man wedges himself higher up, a long drill being used. The large holes are blasted with 80 to 100 lb. of country-made blasting powder. This method is economical in India owing to the cheapness of labour. It costs from Rs. 15 to Rs. 20 to make one of these holes and Rs. 16 per 100 lb. of blasting powder, an immense amount of rock being broken. It takes from 10 days to 15 days to make a hole, depending on the depth and hardness of the rock.

After blasting, the mica is picked from the débris, which latter is removed by contract at so much per truck (1 to 2 annas) according to the distance from the dumping point. The universal method of removing the débris is by means of the *chapra*, which is a large hoe-shaped tool. This is used to scrape the débris into iron pans about 18 inches in diameter, which are then carried to the trucks on the heads of women or boys. Women can now only be employed on open-casts or other surface work.

Generally speaking, the massive veins of open-casts produce large quantities of small mica which is used almost exclusively for the manufacture of splittings. The cost of recovery of the rough uncut mica will vary from R. 1 to Rs. 3 per maund (82 lb.) for labour and explosives.

Underground Mining.—All the mines of this class are started as surface workings which appear rich. The deposit is followed down by incline shafts on the vein. These shafts are seldom straight and haulage troubles soon arise. In previous times the shafts were so irregular that all débris had to be removed by passing it up from hand to hand in iron pans; but, where possible, a windlass is now used even if the shaft is not vertical, the buckets then sliding on wooden runners.

Where capital and more intelligent supervision are available, the irregular workings from the surface are abandoned and an adit is put in or a vertical shaft sunk to cut the vein below the old workings. When this has been done a drive is made on the vein following the mica and winzes are sunk every 25 ft. or 30 ft. if on mineral. If the winzes become barren they are stopped. Another level connecting the winzes is driven with a pillar of 20 ft. or more between the levels, provided the ground appears to be productive at the level. If it is barren the winzes are carried down until mica is found, when the next level is driven. If possible another adit is driven to cut one of the lower levels, so as to avoid water trouble. If this is not possible it is often found necessary to instal a boiler

and steam pump. Where there is a vertical shaft a steam hoist is often used, although few mines are deeper than 300 ft.

The boilers are generally of the vertical cross-tube type, but in some cases locomotive-type boilers are used up to 16 h.p. The hoists are of 4 h.p. generally, and tipping buckets are used with them of ½ cu. yd. capacity, being hand-tipped into trucks at the surface. Headframes are almost all of rough timbers and about 15 ft. high. In a few recent cases they have been constructed of iron pipes bolted together with plates, the pipes being plugged with wood where the bolts pass through, to prevent their collapse.

Underground the buckets are generally detached from the hoisting rope, put on to a platform truck and pushed along the level to be filled from a chute, or by hand from a winze, as the débris comes up either by windlass or passing from hand to hand, or else filled from a heap of débris on the floor of the level by the usual *chapra* and iron pans. When filling from chutes it used to be the practice to have an open chute at the bottom of a winze from a higher level and to throw rock into the chute when a truck was underneath. Drives are generally 7 ft. high by 5 ft. wide, but the dimensions vary slightly according to the productiveness or otherwise of the face. Winzes on the vein are of the same dimensions but vertical haulage shafts are generally bigger, though seldom more than 9 ft. by 8 ft. inside timbers.

In all but a few cases holes are hand-drilled by daily wage coolies, a "pair" of coolies consisting of two hammer men and one holder. Hammers of from 6 to 7 lb. weight are used, and one pair will drill two holes each 30 inches deep in one shift of 4½ hours, besides removing by chiselling the loose rock from the previous shift's blast and picking the mica from the broken rock. Chisel-bit drills are used and one of the great difficulties experienced is to prevent coolies from using blunt drills. This could be overcome if payment for the depth drilled could be used, but the coolies will not take to such a system, partly from conservatism and partly because the drill is liable to jam in the hole if it hits a book of mica at any angle except normal to its surface. Great trouble is then found in removing the drill from the hole. Coolies work 2 shifts daily and are paid from 5 to 7 annas per shift.

In a few mines portable compressors are used to operate jackhammers, and this speeds up the advance of the face, but it is found necessary to put 3 or 4 coolies on each jackhammer as they are of poor physique. Recently a column and cradle for holding jackhammers has been tried and will probably reduce the labour cost of air-drilling as well as reducing the wear of jackhammers, as with 4 coolies all pushing the jackhammer it is seldom in line with the drill steel. Cross bits are used with hollow hexagonal drill steel, all drill sharpening and shanking being done by hand owing to the distance of all the mines from any headquarters. This factor militates against the use of a compressed-air drill sharpener. Machine drilling up to the present is dry. It has been found economical, as far as hand-drilling is concerned, to use cheap country-made drill-steel rather than expensive imported steel, which latter would doubtless give better results in the hands of experienced drill-sharpeners.

Air drilling is used mostly in barren development faces where there is less trouble from jamming drills and the holes can be made 3 ft. to 4 ft. deep. The work is sometimes done on contract according to the footage advance. In most cases, the holes are inspected, charged and fired by the Company's shot firer.

Stoping is generally overhand, the débris being left in the stope after removing the mica and resting on a line of stulls or a pillar of barren rock. Excess of broken rock is drawn off into the level below to leave room for the stoping coolies to work, but generally there is no excess of débris owing to the small size of the blocks left after development in relation to the winzes on each side of them. Sometimes underhand stoping is used, in which case the useless débris has to be removed from the mine to the dump and the stope kept open by timbering. As the stoping width is seldom more than 5 ft. this latter does not cause any trouble while actually working, but only later when the timbers rot.

Except in stopes and shafts, not much timber has to be used unless there has been water percolation, and most of the levels are without support. Where adits are under loose ground sets are generally about 4 ft. apart with lagging, and in certain cases spiling has been used by the writer for driving under dumps or old workings filled with débris or other loose ground. The timber used is mostly *sekhua* (*sal*) which is hard and close-grained and will resist rot well if cut at the right time of year (September to November). A quantity of timber is cut at all seasons of the year and used green; this rots after 2 or 3 years and has to be replaced. Timbers are nearly always used in the round state after barking, and local carpenters (*barhis*) are employed. They use the saw very little and do most of their work with the *bashila*—an adze.

The comparatively recent application of more modern mining methods and the demand for small mica for making splittings has made the re-opening of many abandoned mines a commercial proposition. A vertical shaft is sunk or an adit driven to connect with the old workings, and the deposit is followed down to a greater depth than previously. Trouble is generally experienced with water during the monsoon season owing to the extensive surface workings and in many cases the mines have to be closed down for four months of the year. Even where the water can be dealt with throughout the year no mines have so far been carried down to any considerable depth and, as stated before, few mines are deeper than 300 ft. Although the rock generally becomes barren in depth, and often the pegmatite pinches out, there is every possibility that it would again make good at a lower level. The testing of this has only been prevented by financial considerations. It has been well proved that lenses of pegmatite are connected horizontally by quartz stringers; and it would appear probable that similar connexions occur in a vertical plane.

The most usual form of illumination in the mines is candles, although in some cases simple oil lamps are used consisting of a piece of cotton wick floating in oil or wax in an earthenware pan.

Details are also given of the preparation of mica for the market.

THE USE OF ORE SCRAPERS

The importance of scraper mucking in reducing hand work to the minimum is emphasized by A. R. Lawrence in the *Canadian Mining Journal* for September. The author says that the use of the scraper has been long known to mining, but recent developments of its use have been very extensive. They are the results of attempts to solve individual problems of mining, each of which has been different from others in respect of the character of the ore, the mine layout and equipment, and the quantities of ore involved.

In the Minnesota and Michigan mining districts the scraper is used not only for the transfer of ore, but for the distribution of waste fill, handling of development muck and even in shaft sinking, as at the Champion Copper Mine. No two mines have exactly the same scraping method. The method and scraper equipment used in any one mine is usually the product of experience in handling that particular type of ore, the design having been changed from time to time to meet new and changing conditions. This development of the scraper is in line with the development of

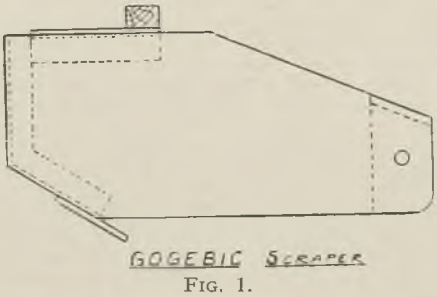


FIG. 1.

rock drills, mine cars, chute gates, and other mine equipment, each successive change of which has marked a step forward in the reduction of the cost of mining.

The use of the scraper has usually been associated with slicing, and indeed the mining methods of most of the iron mines of the upper Michigan Peninsula are top-slicing or sub-slicing methods, particularly the mines of the Marquette District where the scraper received its early impetus. The ore of this district is generally soft, but there are places where it is hard. During the last few years there has been an evolution of underground storage capacity, which now has widespread application. Before this time the cycle of operations, mucking-drilling-blasting, was often not completed and miners were held up each shift because the previous round had not been removed. Now, by the insertion of storage rises or drives, the miner scrapes his muck to the nearest rise and, having it out of the way, is free to go ahead with timbering, drilling, etc., without further interruption. A small scraper and hoist are used for this purpose, while a large scraper and hoist are used for transferring the storage ore to ore-cars or ore-pocket as the case may be. The solution of this problem was made possible by the use of the scraper and many of the great improvements in the design of scrapers can be traced to this change in mining methods.

Scrapers also find use in bringing waste from foot-wall cross-cuts and chambers to act as stope filling. Scraper hoists are used for hoisting timber and supplies up supply rises and even on surface scrapers are used for loading gravel into trucks, levelling off waste heaps, excavating foundations, etc.

In Canada there are few mines where the rock is soft enough to permit the wholesale use of slushing methods. Hard ore which breaks into large irregular chunks does not lend itself so readily to scraping. Hard ores call for heavier scraping equipment, which lacks the flexibility and easy transfer ability of the small slusher. Hard rock slushers have a tendency to permanence and are usually set up where they can operate on the same drag for long periods. Scraping or slushing in Canada has found its chief use in ore-bodies which are too flat to permit back or shrinkage stoping.

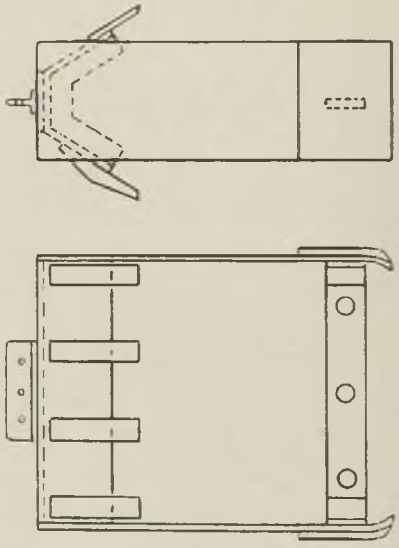


FIG. 2.—QUINCEY REVERSIBLE SCRAPER.

Wherever shrinkage stoping is possible and the broken ore can be transferred direct from the stope to the mine cars without intermediate handling, scraping is not indicated. At the Montreal mine, Montreal, Wis., difficulty was experienced with the ore packing at certain times and it was very hard to get it out of the chutes. To remedy this condition the ore is allowed to run free to the floor of the drive out of the box-holes, and is loaded into cars with 25 h.p. slushers and hoe type scrapers at a saving over chute loading of 7 cents per ton. The loading drive has the additional advantage of acting as a storage for ore if the tramming or hoisting is interrupted and the method of loading is safer. While waiting for cars the hoist operator spreads the pile of ore at the base of each opening along the drive, and when the $2\frac{1}{4}$ ton cars are in place they are loaded at the rate of 1 per minute. (15 car trains.) At this mine the development muck also is handled with a scraper and Osana slide. The mucking crew can set up, muck a round of 35 tons, tram it, and remove the slide in less than 3 hours. (3 men.)

In a recent article, summarized in the MAGAZINE for July, M. A. Roche reports that all the ore

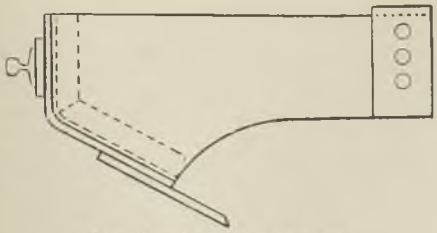


FIG. 3.—ATHENS SCRAPER.

at the Flin Flon mine is loaded into cars from what are called "Scram" drives entirely by the scraper method—to the complete elimination of chutes with their attendant dangers, cost and maintenance.

The scrapers used in the soft-ore mines of the Iron Ranges are developments of the familiar box type with its straight back and long slide plates. The hoe type is also used and modifications of these two give scrapers all the way between. These may be recognized by the local nomenclature such as the Gogebic (Fig. 1), Quincy (reversible) (Fig. 2), and Athens (Fig. 3). These scrapers, as a rule, are light, they grab the load quickly and are easily moved from place to place.

In the copper country of Northern Michigan the rock is usually hard and is comparable to the gold ores of Northern Ontario. At the Calumet and Hecla, in the flatter stopes, they use scrapers for moving the broken ore down the foot-wall. And in the deep levels of the Calumet and Hecla conglomerate, where no chutes are provided, scrapers are used for loading cars by means of a long platform over the track. There is a notable difference in the design of scrapers as one goes from the soft ore mines of the iron country to the hard ore of the copper country. The scrapers are larger, heavier, and there is a corresponding increase in the horse power of the slusher hoists. The hoe-type scraper is more evident, with its characteristic cutting edge and sharp corners. (Fig. 4).

Sometimes these scrapers are fitted with short side plates, which help to retain more muck, and sometimes the back plate is arced, or bent, in order to obtain more capacity. In any case, it is noteworthy that the design of the later scrapers is not a case of copying the features of a certain standard type, but includes a consideration of all the varying details to obtain the most efficient performance. Matson has defined the ideal scraper as one which satisfies the following requirements: Be self-loading; get into corners readily; handle the largest possible load with low sliding resistance; get around obstructions; be well enough balanced to remain erect on the back pull, and be light and compact.

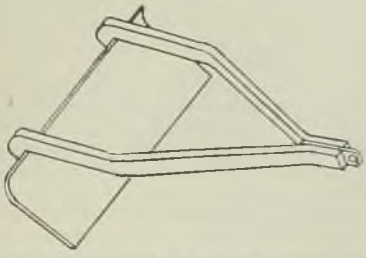


FIG. 4.—HOE-TYPE SCRAPER.

It might be added that the design should be simple enough that it can be fabricated without undue expense in the mine shops.

The Sullivan people, who have done a lot of work on scraper design, state that one of the chief considerations of scraper design has been the angle the cutting edge makes with the level of the muck. Theoretically this angle is given by the resultant of the dead weight and the pull. Such an angle (30°) gives the most effective digging qualities to the scraper (Fig. 5), but when the scraper is fully loaded, this digging should cease. In practice, however, in coarse rock, this sharp angle does not permit the cutting edge to get under the large pieces of rock, the scraper tends to ride over them and dumps itself. An angle of 50° (Fig. 5) seems to allow the scraper to get a better hold on the large chunks and fill itself more easily.

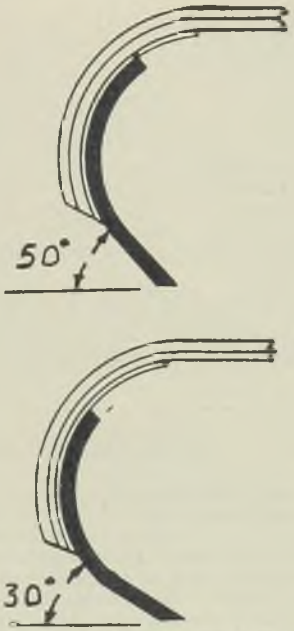


FIG. 5.—CUTTING-EDGE ANGLES.

Another consideration, which Mendelsohn says is of great importance, as regards scraping their rock, is the necessity of stopping the penetration of the cutting edge when the scraper is full. This may be done by bending the upper part of the back plate forward so that the pressure of the muck against this part causes the scraper to tilt upward and let the cutting edge ride over the muck. This also increases the capacity of the scraper by preventing rock from sliding over the back. The amount of curvature or angling of the back plate is a function of the coarseness of the ore and must be determined empirically—too much curvature prevents filling the scraper easily, too little causes the scraper to get stuck.

A third consideration is the distribution of weight in the scraper. There must be enough weight to back up the work of the cutting edge, and when the construction is such that the weight is insufficient, even though the scraper is strong enough, additional weight must be added. This is often done by bolting a piece of heavy rail or other weight on to the back

of the back plate. Too much weight at this point however operates to disadvantage in loading, making it difficult to get the initial hold on the rock.

Scraper Sheaves.—The scraper sheave presents as important a problem as the scraper itself. Where the installation is a light one and the loads are not great—a small cheap sheave is popular, especially where, due to the method of mining, sheaves are often lost. Under these conditions a cast iron sheave, without even any provision for regular lubrication is often used. Sometimes brass bushings are provided. Advancing from this are the refinement of grease cups, roller bearings, manganese-steel sheave wheels, etc. Where the installation is a heavy one, all the factors such as : Proper size of wheel for the diameter of cable used ; the number of sheaves ; weight ; lubrication, and material must be given consideration. Such sheaves are built to last for years.

Scraper Ropes.—The answer given by an operator to the question of how he selected a scraper rope, was " The cheapest rope." It would be difficult to find harder conditions for a rope to work under than scraping conditions. Lashing, jerking abrasion and crushing are just ordinary strains for a scraper rope. Flexibility is a paramount requirement, especially in the tail rope. The pull rope must be strong enough to stand all the pull that the hoist can deliver in the form of a jerk right up to the stalling point of the hoist. Rope manufacturers have given this problem much attention. Most of the mines in Michigan use plough-steel ropes.

Scraper Hoists.—Air hoists are rapidly being superseded by electric hoists even where the ventilation provided by air hoists is a consideration. A very good discussion of the details of slusher hoists both as regards construction and operation may be obtained from the catalogues of the manufacturers. Electric hoists have improved greatly in recent years. In Michigan the smaller hoists use direct current and the large hoists use alternating current. A.c. hoists up to 75 h.p. are now in regular use. The small hoists cost proportionately more to maintain than large hoists. Armature trouble is the chief item. The d.c. hoists also cost more per h.p. and use more power than a.c. However at one mine where they used a large a.c. hoist the relatively slow return trip of the scraper was in marked contrast to the return trip of the d.c. powered scrapers and brought forcibly to mind the constant speed feature of a.c. motors.

The cost of installing equipment such as transformers, cables, plug boxes etc. is a factor to be taken into account when considering a.c. hoists, especially in cases where direct current is available from underground trolley lines.

Perhaps the principal achievement in the scraping business recently is the economical handling of hard blocky ore in a large way. A great deal of credit is due the operators who in recent years have accomplished so much. It has been proved that the scraper is a tool which can be used by the ordinary miner. He takes to it easily and finds he is relieved of the most arduous of all tasks underground, hand shovelling. Scraper haulage is most efficient when the mine layout is arranged for it. Given plenty of tonnage, as Roche has said, the larger the scraper the cheaper the cost. With scraper haulage, hand shovelling and hand tramming is reduced to a minimum ; there is a margin of ore storage against unforseen contingencies, and the cycle of drilling-blasting-mucking is assured.

TREATMENT OF WILUNA CONCENTRATES

Bulletin 6 of the School of Mines of Western Australia, containing reports by W. G. Clarke and B. H. Moore on investigations conducted in the metallurgical laboratory, gives details of research on the roasting and cyanidation of flotation concentrates from Wiluna Gold Mines, Ltd. A sample of these concentrates was forwarded to the laboratory with a suggestion that, in investigating the treatment, special attention might be given to—

1. The most suitable temperature of roasting, especially with regard to the starting and finishing heats.

2. The advisability of washing with water, or other solution, prior to cyaniding.

3. The consumption of chemicals for cyaniding.

The sample of concentrates, weighing 100 lb., was consigned in two sealed tins, which, on receipt, were emptied, the two lots thoroughly mixed and sampled for analysis and assay. A partial analysis of this sample of concentrates is as follows :—

	%
Silica, SiO_2	22·85
Arsenic, As	9·02
Sulphur, S (total)	23·45
Calcium oxide, CaO	3·35
Magnesium oxide, MgO	3·77
Manganese, Mn	0·83
Copper, Cu	present
Chlorine, Cl (water-soluble)	0·17
Gold, Au	57·2 dwt. per ton (2,000 lb.)

Previous investigations by the authors and others had definitely established the fact that it is impossible to secure a satisfactory extraction by cyanidation of the raw concentrates, either with cyanide alone or with the aid of cyanogen bromide. Therefore, no further work was carried out in this direction.

Roasting.—In all roasting operations, the charge of concentrates was hand-rabbled at frequent intervals during the roasting period. During the roasting of this concentrate three stages are noticed as the temperature is gradually raised from cold to the finishing temperature, during which the observed phenomena are as follows :—

Stage 1.—Sublimation of arsenious oxide, As_2O_3, first visible at 340° C. and rapid at 400° C., and partial oxidation of pyrite.

Stage 2.—Further oxidation of pyrite between 420° C. and 500° C. ; ignition of the sulphur at 450° C., causing a rise of temperature to 500° C. without the aid of external heat ; charge very mobile at this stage.

Stage 3.—The charge swells up and becomes very voluminous and fluffy in character between 500° C. and 650° C., probably due to liberation of carbon dioxide, CO_2, by decomposition of calcium and magnesium carbonates, which dissociate below 600° C.

These observations led the authors to the following conclusions :—

1. In order to insure as complete removal as possible of arsenic by oxidation to and sublimation

as arsenious oxide, it was essential that the roasting temperature be maintained at approximately 400° C. until sublimation of arsenious oxide ceases; otherwise there would be an increased tendency to form arsenates which are stable at high temperatures and might possibly lock up some of the gold.

2. To avoid sintering and the possibility of very serious volatilization of the gold due to excessive heating at this stage, the oxidation of the pyrite, when once commenced, should be allowed to proceed without the application of external heat.

As a result of the work carried out it was evident that a remarkable feature of the results obtained was the fact that, whether the concentrates were roasted according to the conditions of Stage 2 or of Stage 3 up to 650° C., the extraction obtained by the subsequent cyanidation under conditions which are commercially practicable was practically constant, the only great difference in the results being in the quantities of cyanide and lime consumed. This constancy of extraction, or production of residues of constant grade, pointed to the possibility that this unextractable portion of the gold was present in the raw concentrates in some combined form which is stable up to 650° C.

Roasting to 800° C. in Stage 3 does not result in any further elimination of arsenic, but considerably increases the extraction of gold by cyanidation; this result lending support to the view that arsenic is not the controlling factor in preventing a high percentage extraction from being obtained. Apparently, this high-temperature finish liberates a further portion of the combined gold, but the authors have been unable to determine the state of combination in which the gold exists. This high-temperature product does not require washing before cyanidation, filters rapidly, and consumes only very small quantities of cyanide and lime during cyanidation. The possibility of concentrating this portion of the gold by flotation was investigated so as to permit of microscopic examination of the concentrate, but without success. Even after sulphidization of the cyanide residues with sodium sulphide for sixteen hours, flotation failed to effect any concentration of gold in the froth.

In an endeavour to determine why this large and practically constant amount of the gold remains undissolved, which it was considered possible might be locked up and rendered insoluble in cyanide solution by stable arsenic compounds formed during roasting, a sample of calcine was heated to bright redness with 50%, by weight of sodium carbonate and afterwards ground, boiled with water, and washed. The arsenic content of the calcine was reduced from 2·22% to 0·40%. This treated product was then cyanided by agitation with 0·25% KCN solution for forty-eight hours without any increase in gold extraction over that obtained from a calcine containing 3% of arsenic. This test, therefore, in conjunction with the impossibility of obtaining a satisfactory extraction from Stage 1 calcine, pointed to the improbability of arsenic being the principal cause of the failure to obtain a high extraction.

Analysis of the raw concentrate showed the presence of 0·83% of manganese. It was considered that treatment of the roasted concentrate with a saturated solution of sulphur dioxide would remove any possible harmful effect on gold extraction that might be due to the presence of manganese minerals, or to a superficial protective film on the gold particles. (This pre-treatment was successfully introduced by Mr. S. B. McCluskey at Fresnillo in the treatment of manganiferous silver ores.) This preliminary treatment, however, was unsuccessful in increasing the gold extraction.

Summarizing the results obtained:—

1. *Production of Flotation Concentrates.*—The elimination of calcium and magnesium carbonates from the flotation concentrate is of distinct advantage in the subsequent roasting and cyanidation of the product. It is possible that with production of a clean concentrate containing a minimum of calcium and magnesium carbonates, the necessity for finishing the roast at a high temperature would be avoided.

2. *Roasting of Concentrates.*—(*a*) The efficiency of the roast is not decreased by the presence of lumps of concentrate up to 8 mesh in size in the roaster feed, although these lumps do not disintegrate during roasting.

(*b*) Roasting proceeds in three stages:—

Stage 1.—From cold to 420° C. Up to 86% of the arsenic is oxidized and eliminated as arsenious oxide, As_2O_3, and partial oxidation of the pyrite takes place. There is no loss of gold during this stage.

Stage 2.—From 420° C. to 500° C. Completion of oxidation of pyrite. A loss of gold, up to 6%, occurs during this stage.

Stage 3.—From 500° C. to 800° C. Partial decomposition of calcium and magnesium carbonates, and sulphates. No further loss of gold takes place during this stage.

3. *Water Washing of Calcine.*—Stage 2 and Stage 3 (to 650° C.) Calcine.—Water washing produces no increase in extraction in the subsequent cyanidation, but reduces the consumption of cyanide and lime and the possibility of fouling the cyanide solution by dissolved salts.

Stage 3 (to 800° C.) Calcine.—Water washing is not necessary.

4. *Grinding of Calcine.*—Grinding of calcine is necessary as the hard grains formed during roasting do not break down when the calcine is mixed with water.

5. *Cyanidation of Calcine.*

Stage 1 Calcine.—The percentage of gold amenable to extraction by cyanide solution at this stage is very low.

Stage 2 Calcine.—Approximately 88% of the gold is soluble in cyanide solution at this stage, but an excessive amount of lime is required to obtain a minimum consumption of cyanide. The pulp filters very slowly and the filter cake retains a very high percentage of moisture.

Stage 3 (to 650° C.) Calcine.—The gold extraction is slightly higher than that obtained on Stage 2 calcine and the consumption of cyanide and lime considerably lower. The pulp filters readily and the filter cake does not retain an excessive amount of moisture.

Stage 3 (to 800° C.) Calcine.—There is a marked increase in gold extraction and the consumption of cyanide and lime is very low, while the product is ideal for filtering and washing.

Conclusions.—On the basis of the experimental data obtained in this investigation, the authors have arrived at the following conclusions regarding

the roasting and cyanidation of this sample of concentrates :—

1. Stages 1 and 2 of the roasting operation should be allowed to proceed slowly and at as low a temperature as possible. Stage 3 of the roasting operation should be carried to a finishing temperature of approximately 800° C.

2. There is a loss of gold up to 6% during Stage 2 of the roast, possibly due to the presence of chlorine in the concentrate.

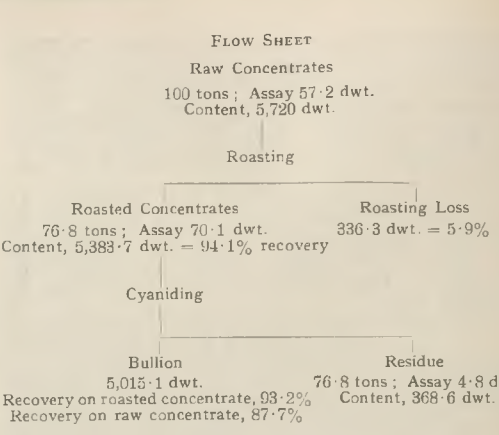
3. Washing of the calcine produced under the above conditions is not necessary.

4. The gold amenable to extraction by cyanide goes into solution during a short period of agitation with cyanide solution.

5. A comparatively weak cyanide solution—0·08% free KCN—is as efficient as a strong solution.

6. The consumption of chemicals during cyanidation of the calcine decreases as the finishing temperature of the roast is increased and, with a finishing temperature of approximately 800° C., the consumption should not exceed 0·5 lb. KCN and 5 lb. CaO per ton of calcine.

7. An extraction of 93% of the gold in the calcine is indicated, which, owing to the gold lost during roasting, is equivalent to 88% of the gold in the raw concentrate.



Calculated Head

	Tons.	Au. dwt.
Roasting loss	23·2	336·3
Cyanidation residue	76·8	368·6
Bullion recovery		5,015·1
Total	100·0	5,720·0

Head value, 57·2 dwt. Au. per ton.

ROCK-BURST EFFECTS IN SOUTH AFRICA

The *Journal* of the Chemical, Metallurgical, and Mining Society of South Africa for July last contains some notes by W. Allen which are the result of observations of the effects of certain rock-bursts and general hanging-wall behaviour on the Turf Shaft, Robinson Deep, Ltd. Experience on one mine is not sufficient to base theories on such an important subject, the ideas being given for discussion and further observation.

Conditions on the Turf Shaft are somewhat different from other mines. The ore comes from a depth varying from 6,400 ft. to 7,400 ft.—all stoping being below the next deepest mine. The average stoping width is 52 in. and the average dip 34°. The support consists of 8 ft. by 8 ft. filled pigstyes, in straight rows down the dip and staggered in the strike direction. They are spaced 4 ft. apart measured on the strike and 5 to 8 ft. apart measured on the dip. The faces are carried at an angle of about 25° to the dip direction. This is rather steeper than formerly, but is considered necessary so as to limit the number of chute lines which have to be kept open. The aim is to complete the work as quickly as possible so as to be clear before the stope is too narrow to work through.

It is possible that more favourable conditions are being reached regarding rock-bursts than those prevalent on the adjoining mines due to a sequence of hanging conditions from shallow workings to great depths which might be given thus :—

(1) *Shallow Workings.*—Hanging-wall held by pillars.

(2) *Medium Depths.*—Weight too heavy to be held by pillars, but not heavy enough to fracture hanging-wall frequently at the face and thus allow the hanging to move gradually down.

(3) *Great Depths.*—Weight sufficiently heavy to cause frequent fractures in hanging and/or foot-wall thus allowing hanging-wall to move gradually down (the speed increasing as depth increases) until it reaches the foot-wall and relieves the pressure on the face. This process would be the same as is artificially forced in some classes of mining by " breaking the back."

The effects of pressure on the workings can be dealt with under two heads :—

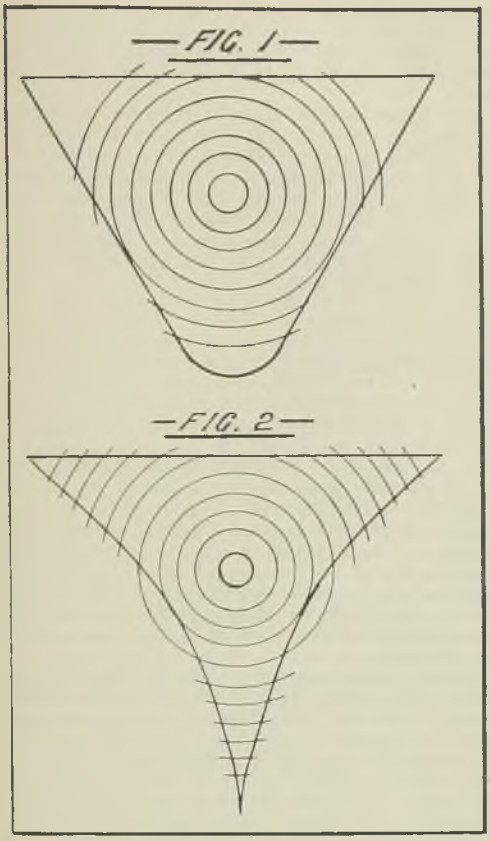
(*a*) Regular hanging-wall movement.

(*b*) Rock-bursts.

(*a*) Regular hanging-wall movement.—The first is the normal movement of the mass of rocks tending to close up the cavity made by removal of the reef. In deep mines it is a force which it is quite impossible to resist, it can only be retarded. As great depths are reached pressures become so enormous that this movement becomes evident even during the development period. When stoping has started supports show the movement when they are still quite close to the face. This movement can in places be seen by the numerous induced fracture planes which appear in the hanging and/or foot-wall. Close observation of these fractures has led to the conclusion that they become more or less frequent as the face is more or less strong. At the points of remnants the fractures are usually widely spaced owing, it is suggested, to the face not being sufficiently strong to induce them. Moving towards the centre of the face they gradually become more dense until the middle point of the face is reached where they become most dense.

(*b*) *Rock-bursts.*—The control, as far as it allows, of the regular hanging-wall movement is a comparatively simple and safe operation were it not for the second effect of pressure—" Rock-bursts." When two stope faces approach one another to form a remnant, the resultant shape of the remnant is normally that of an inverted isosceles triangle. The north face of the remnant is always covered by a row of south side packs and is never worked, so it is not necessary to consider the effects on that side.

In certain rock-bursts, the effects of which have been observed, it was noticed that the greatest



—FIG. 1—

—FIG. 2—

burst was usually placed somewhere in the middle of the East and West faces. Looking closer into the position of these bursts it was found that they were usually about half way up from the point or slightly above half way. That this has been usually the case has been verified by inquiry from other observers. On considering the possible reasons for this the conclusion was arrived at that it was because it was the strongest section of the remnant. If the conditions inside a remnant of ground be considered it is thought that there would be a central core which would be practically undisturbed and that the conditions as one moved from the core outwards towards the faces would alter in concentric circles as shown in Fig. 1. At each successive ring from the centre out the ground will be more and more affected by the pressure.

It seemed therefore that in order to have a burst, the face, hanging or foot-wall must be of such a strength as to be capable of resisting the pressure and storing it up until bursting point is reached. If the face, hanging or foot-wall were weak the pressure would cause the weakest of the three to fracture more frequently and more lightly before the pressure had built up to such an extent as to cause a severe burst.

To summarize the conclusions :—

1. To have a rock-burst one must have strength.
2. If the remnant at any point is weak it will not burst there.

Application to practice.—It was then considered how to apply this in the working of remnants so as to minimize the effect of rock-bursts. In order to avoid strength one must avoid the circular shape, *i.e.* convex faces. The effect of hollowing out the centre of the faces as shown in Fig. 2 to make them concave was considered. It seemed that carrying faces in this manner would :—

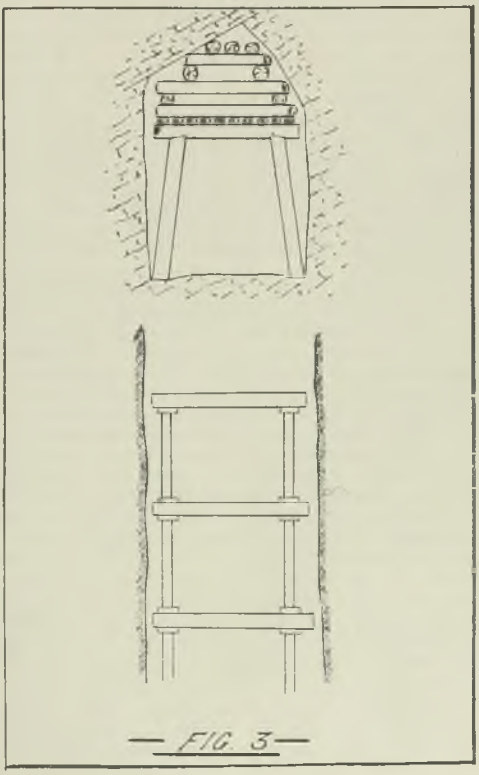
(1) Weaken the core of the remnant more quickly.

(2) Confine the potential bursting section of the face to smaller limits.

(3) Hasten the removal of the remnant by easing the breaking on the projecting points which would require very little drilling and blasting.

The suggested method of obtaining this shape is the following :—When two faces meet one another two machines on each face are made to commence drilling each morning at the centre of the face, the top machines working upwards and the bottom machines working downwards. This ensures the centre of the face moving more rapidly than the extremities. All work, drilling, lashing, and timbering in the early part of the shift would be concentrated on the centre of the face, completed as soon as possible, and the remainder of the shift spent in work between the packs and the extremities of the faces remote from the danger zone.

Some examples of recent experiences are given in the paper to illustrate the theories advanced. Most of the remnants shown are affected by dykes or faults and are therefore not such good examples as one could have wished for, but the large number of dykes and faults traversing the working area of the Turf Shaft make it difficult to find examples not complicated by these disturbances. The effect of dykes on the behaviour of remnants



—FIG. 3—

is very considerable, in some cases they are a protection and in others a danger.

Effect on Foot-Wall Drives.—Another very serious effect of rock-bursts in remnants is the effect on the foot-wall drives under them. The Rock-Burst Commission recommended that these sections of the drives should be setted. This is invariably done. From observation of the effects of bursts on the foot-wall drive the movement seems to be a very sharp compression and expansion on the hanging-wall and usually the walls of the drive. From the state of the timber in the cases which have been observed, it is thought that most of the setts have been shaken out and that the hanging-wall having naturally been shattered by the compression, has been free to fall. Very little broken timber has been found in falls of this nature except where the timber has been very lightly wedged against the rock.

As a result of these ideas it has been decided to timber such sections with setts, built as shown in Fig. 3. The idea is to make them so that they will stand up to the shake and still be in position when the hanging falls. If the drive is high, the setts are covered with a soft cushion of cribbing. As little blocking to the sides is done as possible, and when it is done it must be by soft wood blocks placed across the grain.

KALGOORLIE MINING PRACTICE

Improved methods of mining and advances in the metallurgical processes now in use at the Lake View and Star Mines in Western Australia are described by C. M. Harris in an article appearing in the *Chemical Engineering and Mining Review* of Melbourne for August 5. The writer says that as a first step towards the finding of new ore a system of diamond drilling was started and an economic geologist appointed to lay out the work. On every mine a model of the mine workings has been made to correlate the sections of the work done on at least four lodes. The cross sections were painted on sheets of glass and each section of the mine is built in one frame, which slides back, so that any part of the mine can be observed separately, while the various lodes can be seen as viewed from the south end. The slides and fault lines are shown. As a result it is so much easier to visualize the trend of the ore-bodies already worked and where to look for those lost or faulted. The discoveries of ore resulting therefrom are being developed as rapidly as possible and to increase the efficiency of the miners a number of alterations were made in the underground methods. In some cases at first the miners and the union leaders objected, but the increased footage and absence of dust and smoke, together with consequently bigger pays, have resulted in a willing co-operation to secure the desired improvement in work done.

The new 3-ft. wedge-cut introduced early this year has been the means of increasing the footage driven and cross-cut from less than 30 ft. to over 43 ft. for one man each on two shifts. Night shift has been cut out in nearly all work underground. In this standard cut, which must be bored by each man, the 18 to 21 holes are fired in one round and blasting is only permitted at crib and knock-off times. The fuses, with detonator already attached, are supplied to the miners, also clay tamping. This latter means the saving of about three-quarters of an hour on each firing out and the whole of the tamping for the four mines is made by one man with a machine similar to that used in making sausages. In order to fire out at one operation a measuring stick similar to that used by timbermen is used and has 22 holes bored in it; the fuses are inserted, starting from the bottom in the sequence the charges are to explode with the aid of a fuse lighter. Where the system is adhered to in the direction of the holes, now practically every case, there are no butts of holes left, and what is better, the boggers who come in to clean up the ore or mullock have not to eat smoke and dust. Each machine man is given two development faces to work, so that as soon as he fires out, the bogger comes in and cleans up the broken ore or mullock.

By the use of the Venturi system of ventilation a good current of air is maintained at the face of every drive and cross-cut. The Venturi pipe of a diameter of 5 in. is found to be most effective and economical, as three can be cut from one sheet of galvanized iron. The air jet is bored with an aperture of $\frac{1}{8}$ in. and delivers 300 to 370 c. ft. of free air per minute at the end of the pipe near the face. At the 3,300-ft. level it passes over ice held in a container.

The explosives used are 5 to 5½ plugs of 50% gelignite per hole. This has effected a considerable saving in the cost of explosives used and lessened the fumes greatly.

In order to speed up the trucking and obviate the strain of handling heavy trucks on flat sheets, rail points and curves are being put in throughout the mine. Three electric battery-driven locomotives have been in use for some months. They have a haulage capacity each of 150 tons per shift over a length of 2,000 ft. Two larger ones are on order. The reduction in cost and time saved in trucking is in keeping with that of the other portions of the delivery and making it possible.

Different types of rock drills, Leyner-Ingersoll drifters, Jackhamer and telescope drills, are used, and immediately a miner reports that his machine is out of order another is supplied, so that time lost in boring is reduced to a minimum. An expert is employed to keep the drills up to the best efficiency. Recently the steel and bits have been reduced in diameter, to ensure greater speed and economy. Each miner is supplied with at least 10 sets of sharp steel, which is carried in to him at the face, so that he has no cause for delay in looking for it. A rack containing spare steel of all lengths is put up at each plat.

An electric pump has been installed at the 3,300-ft. level, from where it lifts all the water to the 2,000-ft. level without any trouble. From thence the water gravitates to a water shaft from which it is at present being hauled to the surface by bailing tanks. Orders have been placed for two further electric pumps to be installed at the 2,000-ft. and 1,000-ft. levels, respectively, and when these are in place the whole of the water will be lifted by electric pumps in the three lifts. The pump at the 3,300-ft. level has been in operation for over three months and has given every satisfaction. It is to be duplicated at the station in order to guard against any possible breakdown.

A work necessary to the consummation of the full scheme of providing the tonnage required consists of the enlargement of Chaffers shaft from the surface to a depth of 2,800 ft., and this work is now well in hand. The new shaft will be of four compartments, two for ore haulage, one for men and supplies, and one for air and water service lines. It is being equipped with substantial poppet legs and a large steam-driven winding engine. It is hoped to have the first section of the shaft in full working order by the end of the current year.

The second stage of the programme has been the erection of a central crushing unit, which has replaced 12 ore-breakers at the various shafts and can crush twice the tonnage that they could. This is a 7½-in. Gates gyratory crusher housed in a special station below surface level with concrete foundations and walls. It is driven by a 35 h.p. motor. The ore is conveyed in trucks pulled by an engine, tipped into bins, and fed on to the crusher, which has a capacity of 60 to 100 tons per hour. From thence it is conveyed on a 24-in. belt to the Symons crusher which has a capacity of 100 tons per hour to ½-in. size and is driven by a 100-h.p. motor. Thence, in case of the tributers, the ore is elevated to bins quartered and broken down and sampled automatically. The company's ore is elevated to the main ore bins and fed into the Allis Chalmers type of ball-mill, two units of which are now in commission. Each has a rating of 10 tons per hour. The advantage of these is that the ore is wet crushed, giving greater tonnage capacity and the absence of dust, both very important factors. The pulp then passes over corduroy tables to collect the coarse free gold and is then elevated into Dorr classifiers. The overflow from these is gravitated to a sump and pumped by a Wilfley pump into a thickener direct, while the oversize goes to the two tube-mills 5 ft. 6 in. diameter and 22 ft. in length. Prior to this either thiocarbanilid or xanthate as a conditioner is added and experiments are being carried out at present to see which is the more satisfactory. The oversize from the tube-mill is returned, while the pulp is pumped up to the thickener; thence it flows into the surge tanks after which the frothing agent is added, pine oil or aerofloat. The product contains 90% minus 200 and 9% minus 150 and passes into the M.S.-type pilot flotation unit, which is handling 18 tons per hour.

In the new plant two Fahrenwald flotation machines with a rated capacity of 25 tons per hour have been erected. In the former machine the air is supplied by a Roots-type blower, while in the new machines it is inducted from the atmosphere. The float from the first three sections of the machine goes direct to the concentrate thickener, while the remaining five or the seconds are returned to the circuit to be further conditioned. The residues are pumped away to a slime dam. The concentrate from the thickener passes into a tank which feeds the Oliver filter. The present one has a capacity of two tons per hour, but those now being erected will be rated at four tons per hour each.

The concentrate passes over a Lowden drier and into Edwards duplex roasters, of which three will be in operation when the full tonnage of concentrate from 1,000 tons per day of raw ore is treated, in place of six roasters which now are needed for 450 tons per day of raw ore. The roasted ore is agitated with cyanide solution passed over Oliver filters and the gold precipitated by the Merrill Crowe zinc dust method and smelted as usual.

THALLIUM

Information Circular 6453 of the United States Bureau of Mines, by A. V. Petar, deals with thallium, one of the rare metals that has come into commercial use within recent years. The comparative scarcity of this metal, combined with a resemblance to the common metal lead, have retarded the development of its uses. Although production is still measured in pounds rather than in tons, it is now finding application in a number of fields. Its most important use is as a poison for rats and ants.

The physical and chemical properties of thallium are very similar to those of lead, the metal is white with a bluish-gray tinge, somewhat paler than lead. It has a bright metallic lustre when freshly cut, but dulls quickly when exposed to air. Thallium is softer than lead, it can be scratched by the finger-nail and is easily cut with a knife. It is malleable, but has little tenacity, and can be squeezed but not drawn, into wire.

There are no commercial ores of this metal, although it is present in small quantities in a great many minerals. The supply was formerly obtained solely from flue dusts that accumulated in sulphuric acid plants where pyrite is used. The thallium content of these flue dusts is small, usually about half of 1%, and the thallium is produced only by a by-product. At present most of the supply in the United States is a by-product of the purification of cadmium, itself a by-product of the smelting of zinc.

Four very rare minerals contain appreciable percentages of thallium. Crookesite, a thallium-copper-silver-selenide, which contains from 16 to 19%, is found in Skrikerum, Sweden. Lorandite, a sulphide of thallium and arsenic, contains from 59 to 60% of thallium and is found in Macedonia. Hutchinsonite, a sulpho-arsenide of thallium, lead, silver, and copper, has a thallium content of from 18 to 25%. This mineral occurs in white dolomite of the Legenbach Quarry in the Binnental, Switzerland. Vrbaite, found in Macedonia, is a sulphide of thallium, arsenic and antimony which contains 29 to 32% of thallium. Thallium is also present in small quantities in a great variety of rocks and minerals, such as pyrite, zinc blende, hematite, lepidolite, muscovite, orthoclase, pitchblende, berzelinite, frenzelite, pyrolusite, manganite, carnallite, etc. Owing to its occurrence in some of the common minerals, thallium is found in commercial products such as zinc, cadmium, platinum, bismuth, tellurium, and sulphuric acid. Copper pyrites and iron pyrites frequently contain thallium.

Alloys of lead and thallium are somewhat unusual in that they have higher melting points than either of the component metals; they are used in rather small quantities in special types of electrical fuses. An alloy containing 10% thallium, 20% tin, and 70% lead is resistant to the corrosive action of mixtures of sulphuric, nitric, and hydrochloric acids. This alloy has

been recommended for use as an anode for the electrolytic deposition of copper, since its corrosion is less than one-fifth that of lead alone. Experiments indicate that the addition of thallium to lead-base alloys markedly improves their resistance to deformation.

Many uses have been found for thallium compounds. By far the most important commercial outlet for the element is the utilization of thallium sulphate as a poison for rodents and as an insecticide for ants. The sulphate has the advantage of being tasteless and odourless. Because of their high refracting power, thallium compounds are used in the manufacture of certain kinds of optical glass in which a high refractive index is required. The oxysulphide of thallium is used in the "Thalofide" cell, which is more sensitive to light, especially that of low intensity and long wave length, than the selenium cell. Its electric resistance drops 50% on exposure to a quarter-foot candle.

The use of thallium and its compounds to prevent knocking in internal combustion engines has been patented. According to the patent specifications, thallium or thallium oxide may be vaporized outside the cylinder by an electric arc or a thallium compound may be mixed with the fuel or otherwise injected into the engine. The compounds which may be used include thallium ethyl, benzylate, phenylethylate, oleate, amylalcoholate, and acetoacetate.

A liquid amalgam containing 8.5% of thallium has been used in thermometers for recording temperatures as low as $-60°$.

Thallous chloride has found use as a "getter" in tungsten lamps to prolong the life of the filament. It is one of the few lower chlorides that is more stable than the compound of the higher state of oxidation.

In a study of heavy liquids for mineralogical analyses the United States Bureau of Mines found that the most suitable liquid for sink-and-float work on minerals of high specific gravity was a water solution of the double thallous formate-malonate. Thallium acetate has been used for the treatment of certain kinds of tuberculosis and ringworm. At one time it was used as a depilatory.

The demand for thallium and its salts is not large. The only compound of thallium that has attained any marked commercial development is the sulphate and it is understood that this demand is being taken care of largely by imports from Germany. No figures covering imports are available. Early in 1931 thallium metal was quoted at from $12·50 to $15 per lb. and the sulphate was selling at prices ranging from $10 to $15 per lb.

The discovery of thallium dates back to the early part of 1861, when W. Crookes noted a bright green line in the spectrum of the selenium residues from a sulphuric acid factory in the Harz Mountains; he was looking for tellurium, but spectroscopic examination revealed the presence of an unknown element, to which he gave the name "thallium"—"from the Latin thallus, a budding twig—a word frequently employed to express the beautiful green tint of young vegetation in spring."

Lead-Zinc Flotation at Midvale, Utah.—Concentrating practice at the Midvale Plant of the United States Smelting, Refining and Mining Company is described in Information Circular 6492 of the United States Bureau of Mines, by R. A. Pallanch. At this custom mill, which has a capacity of about 1,000 tons per day, all concentrates are produced by flotation except that an insignificant amount of pyrite is recovered by tables from the final flotation tailings. Most of the ore treated comes from the U.S. and Lark mines of the Bingham district, which are company controlled and furnish about 750 tons of ore per day. In addition, considerable custom ore is received from other lead-zinc-pyrite mines of the Bingham district and small shipments from Park City and Tintic, and from the neighbouring states of Colorado, Idaho and Nevada.

The plant is unique in that it provides for storage of separate ore and mixing of ores without resorting to bedding. The ore is crushed to ¾-in. size by a 14-in. gyratory breaker set at about 2 in. and two sets of 55 by 16 in. rolls in series. The second set of rolls is in closed circuit with vibrating screens.

The concentrator has 3 units, each equipped with one 5 by 10 ft. primary rod-mill and one 5 by 10 ft. secondary ball-mill both operated in closed circuit with classifiers. The overflow pulp of the secondary classifier feeds the lead flotation circuit which is equipped with a 12-cell 24-in. machine of the sub-aeration type. The first 5 to 8 cells produce finished lead concentrates; the remaining cells produce lead middling products which are returned to the head of the lead circuit.

The tailings of the lead section comprise the feed to the zinc flotation circuit which is equipped with a 10-cell 24-in. primary machine and an 8-cell 24-in. secondary machine. The first 3 to 5 cells of the primary machine produce finished zinc concentrates. The remaining cells of the primary machine produce first zinc middling products which are returned to the head of the primary machine. The tailings of the primary machine after conditioning and thickening in a 50-ft. thickener are treated in the secondary flotation machine. The first 2 cells of the secondary machine produce additional first zinc middlings which are returned to the head of the zinc circuit. The remaining cells produce second zinc middlings which flow by gravity to the seventh cell of the primary machine. The tailings of the secondary zinc flotation machine are treated in an 8-cell 24-in. machine referred to as the "pyrite machine." At present this machine produces third zinc middling products from the first 4 cells and pyritic concentrates from the last 4 cells. The third zinc middlings join the primary machine tailings for additional conditioning in the thickener.

The final flotation tailings are treated on tables which operate primarily as pilot tables and incidentally recover small amounts of pyrite concentrates which are added to the flotation pyritic concentrates. Similar concentrates from the three mill units are mixed and after thickening are filtered by 10-sector disc filters.

During the fourth quarter of 1929 the concentrator treated 88,353 tons of ore and produced 16,287 tons of lead concentrates, 9,805 tons of zinc concentrates and 19,658 tons of pyritic concentrates.

Electrical Resistivity and Electrical Induction Measurements.—The results of electrical resistivity and electrical induction measurements at Abana Mine, Quebec, Canada, have been published by the United States Bureau of Mines as Technical Paper 501, by E. Vernon Potter. This paper forms the latest contribution to a series devoted to geophysical prospecting for minerals.

The ore-body studied is an intimate mixture of chalcopyrite, sphalerite, and pyrite, with fractional percentages of galena and tetrahedrite. The gold and silver are associated with copper, zinc, and lead minerals. The pyrite contains no precious metals. In making these tests, it was the aim of the geophysical section of the Bureau of Mines to determine experimentally to what extent the megger earth-resistance tester would be applicable in locating the mineralization in this district. The megger, which embodies a source of electrical energy in the form of a little hand generator as well as a direct method for measuring the resistance between any two potential differences, was selected for making field measurements because of its simplicity. There is a great advantage in the use of an instrument of this nature, since it combines reliability, lightness, and accuracy to a remarkable degree. In addition to this instrument, ground stakes or electrodes, good insulated wire, a plane table, a level, and several reels are required.

The two geophysical prospecting methods described in this paper are based on widely different principles, and each has its own special field of application. The resistivity method is necessarily slow, but very detailed results are obtainable from its correct use. The alternating-current method, however, is good for rapid work but does not reveal the details, such as depth, slope, etc., nearly so well. A combination of two such methods should be very useful in making a survey over new country, the alternating-current method being used for a preliminary survey and the resistivity method for a detailed survey at interesting points. Needless to say, both methods discriminate between bodies of differing conductivity which may or may not represent mineralization. These surveys are of value in districts in which, from a geological viewpoint, mineralizations are likely to occur. The paper also contains an " Explanation of some factors associated with the induction method," by F. W. Lee.

SHORT NOTICES

Caving Methods of Mining.—M. J. Elsing deals with caving methods of mining in *Engineering and Mining World* for September.

Roof Support.—The support of excavations on the Witwatersrand is described by A. G. Boyden in *Engineering and Mining World* for September.

Compressed Air.—M. M. Motreul contributes a study on the cost and use of compressed air to *Revue de l'Industrie Minerale* for September.

Complex Ores.—Technical Paper 499 of the United States Bureau of Mines by G. L. Oldright contains data from experimental work on ores in the Denver laboratories of the Complex Ores Recovery Co.

Milling at Broken Hill.—In the *Proceedings* of the Australasian Institute of Mining and Metallurgy (New Series) No. 82, K. W. P. Parsons describes the milling practice at the Central Mine, Broken Hill, N.S.W.

Production Costs.—S. D. Strauss discusses the costs of copper production in the Americas in *Engineering and Mining World* for September.

Gas Generators in Metallurgy.—At a meeting of the Institution of Chemical Engineers held on October 2, N. E. Rambush and F. F. Dixon presented a paper on " The Gas Generator as a Direct Producer of Metallurgical Products."

Lead Blast-Furnace Data.—In the *Proceedings* of the Australasian Institute of Mining and Metallurgy (New Series) No. 82, O. H. Woodward describes some features of lead blast-furnace operations at Port Pirie.

Faraday's Metallurgical Work.—In the *Philosopical Transactions* of the Royal Society, Series A, Vol. 230, pp. 221-292, Sir Robert Hadfield gives the results of a research on Faraday's " Steel and Alloys."

Metallographic Abrasives.—J. L. Rodda describes the preparation of graded abrasives for metallographic polishing in Technical Publication No. 438 of the American Institute of Mining and Metallurgical Engineers.

Chilean Nitrate.—The production and uses of Chilean Nitrate of Soda are described by G. M. Donald in the *Chemical Engineering and Mining Review* of Melbourne for August 5.

Gold Mining in Russia.—V. M. Karmashov deals with Gold mining in the U.S.S.R. in *Engineering and Mining World* for September.

South African Torbanite.—The Ermelo torbanite as a source of oils is discussed by W. Bleloch in the *Journal* of the Institution of Petroleum Technologists for September.

Gypsum in Manitoba.—G. M. Brownell describes the Amaranth Gypsum Deposit in the *Canadian Mining and Metallurgical Bulletin* for September.

Victorian Bauxite.—The South Gippsland bauxite deposits are described by D. Clark in the *Industrial Australian and Mining Standard* for August 20.

Chromite in Montana.—In *Economic Geology* for September–October, V. Jones describes the chromite deposits occurring near Sheridan, Montana.

Age Relations of Minerals.—Several well-known authorities contribute to an article on the criteria of age relations of minerals, with especial reference to polished sections of ores, appearing in *Economic Geology* for September–October.

Gold in Quebec.—L. V. Bell describes the occurrences of gold in Cadillac, Quebec, in *Economic Geology* for September–October.

Waite Mine, Quebec.—The geology of the Waite-Ackerman-Montgomery ore-deposit is described by R. Peale in the *Canadian Mining and Metallurgical Bulletin* for September.

Coal Preparation.—T. W. Guy deals with the growth of coal preparation in the smokeless fields of West Virginia in Technical Publication No. 437 of the American Institute of Mining and Metallurgical Engineers.

RECENT PATENTS PUBLISHED

☛ *A copy of the specification of any of the patents mentioned in this column can be obtained by sending* 1s. *to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C.* 2, *with a note of the number and year of the patent.*

32,318 of 1929 (354,395). E. J. Lawrence and J. A. Daniel, London. Zinc alloyed with a small proportion of tin is used with hydrochloric acid

for producing hydrogen in a cassiterite ore pulp in order that the ore particles may be metallized and subsequently recovered by flotation.

3,094 of 1930 (353,891). S. JUNGHANS, Villingen, Germany. Alloys of aluminium, having the property of being "self-improving" with respect to hardness, are made containing 5-20% copper, 1-3% each of chromium, manganese, and tungsten, 0·1-3% nickel, and 0·1-2% of alkali or alkaline earth metals.

11,759 of 1930 (353,415). H. SUTTON and L. F. LE BROCQ, South Farnborough. The treatment of magnesium rich alloys in hot solutions of chromates or dichromates of alkali or alkaline earth metals is found to produce coatings of ornamental colour which are protective against corrosion.

14,727 of 1930 (354,816). A. GILDEMEISTER and E. CAMPAGNE, Paris. Vanadium, as vanadium sesquioxide, is recovered from heavy-metal vanadium ores by reducing in the presence of a flux consisting of one or more of the alkaline or alkaline earth chlorides or cyanides, the sesquioxide being almost infusible and quite insoluble in water.

14,872 of 1930 (354,794). I. G. FARBENINDUSTRIE A.-G., Frankfort-on-Main, Germany. Zinc oxide precipitated from zinc lyes by adding an alkali metal or alkaline earth metal hydroxide in such an excess that the liquid above the precipitate exhibits a pH value between 12·0 and 12·8, is found to make a pure white pigment of satisfactory covering power.

25,373 of 1930 (354,565). E. ROENNE, Copenhagen. Slurry for calcination is treated in a rotary kiln divided into two parts, the first for drying purposes being rotated at a higher speed than the second in which burning is carried out.

28,692 of 1930 (355,078). UNITED VERDE COPPER COMPANY, Clarkdale, Arizona. The iron sulphides contained in unreactive copper mattes are utilized for the production of hydrogen sulphide, resulting in a concentration of metallic copper.

37,833 of 1930 (353,815). I. G. FARBENINDUSTRIE A.-G., Frankfort-on-Main, Germany. Tungsten ores, wolframite, for example, are treated with a mixture of hydrogen and chlorine, in such proportions that the volume of hydrogen is a multiple of that of the chlorine, at a temperature of about 850-900° C., foreign substances in the mineral being chlorinated and volatilized.

NEW BOOKS, PAMPHLETS, Etc.

☛ Copies of the books, etc., mentioned below can be obtained through the Technical Bookshop of *The Mining Magazine*, 724, Salisbury House, London, E.C.2.

Simple Determinative Mineralogy. By H. R. Beringer. Cloth, octavo, 239 pages, illustrated. Price 10s. 6d. London: Mining Publications, Ltd.

Handbuch der Geophysik: Vol. II, Part I. GUTENBERG, Abkühlung und Temperatur der Erde; BERG, Chemie der Erde; BORN, Alter der Erde und geologische Zeitalter; GUTENBERG, Der physikalische Aufbau der Erde. Paper covers, 564 pages, illustrated. Subscription price, 68 RM. Vol. VI, Part I. REICH, Eigenschaften der Gesteine; HUNKEL, Die elektrischen Aufschlussmethoden; ANSEL, Theorie der gravimetrischen Aufschlussmethoden; MEISSER, Instrumente der gravimetrischen Aufschlussmethoden: (Part I). Paper covers, 312 pages, illustrated. Subscription price 42 RM. Berlin: Gebrüder Borntraeger.

Colloids. By E. S. HEDGES. Cloth, octavo, 272 pages. Price 12s. 6d. London: Edward Arnold.

Mathematics of Mine Surveying. By J. M. WATSON. Cloth, octavo, 112 pages, illustrated. Price 6s. London: Edward Arnold.

Principles of Structural Geology. By Dr. C. M. NEVIN. Cloth, octavo, 303 pages, illustrated. Price 17s. 6d. London: Chapman and Hall.

Prospecting for Gold. By ION L. IDRIESS. Cloth, octavo, 204 pages, illustrated. Price 5s. London: The Australian Book Company.

Deep Well Drilling. By WALTER H. JEFFERY. Third edition, 1931. Cloth, octavo, 816 pages, illustrated. Price $6. Texas: The Gulf Publishing Co.

Electricity for Coal-Mining Students. By J. STEVENSON and W. MILLER. Cloth, octavo, 250 pages, illustrated. Price 7s. 6d. London: Crosby Lockwood and Son.

Die Entwicklung der Blei- und Zinkerzeugung der Welt von 1907 bis 1928. By F. SCHULTZ. Paper covers, 80 pages. Halle (Saale): Otto Heudel Druckerei.

Tests on Timber Pit Props. By S. M. DIXON and M. A. HOGAN. Safety in Mines Research Board Paper No. 72. Paper covers, 82 pages, illustrated. Price 2s. London: H.M. Stationery Office.

Quebec: Annual Report of Bureau of Mines, 1930, Part A. Mining Operations and Statistics. Paper covers, 138 pages, illustrated. Quebec: Bureau of Mines.

Alberta: Annual Report of the Research Council, 1930. Paper covers, 76 pages, illustrated. Edmonton: University of Alberta.

Mineral Resources of the United States, 1930. Part II, pp. 15-44, Fluorspar and Cryolite, by H. W. DAVIS; pp. 59-67, Potash, by A. T. COONS. Washington: Superintendent of Documents.

Carte Géologique du Katanga. By M. ROBERT. Scale 1 : 1,000,000. Paper covers, Royal quarto. Brussels: Office de Publicité, 36, Rue Neuve.

Price Equivalent Tables: Per cwt. and 100 kilo. at stabilized exchanges. Price 2s. London: Kingston's Translations Institute.

Something in the City. By COLLIN BROOKS. Cloth, octavo, 266 pages. Price 8s. 6d. London: Country Life.

DIVIDENDS DECLARED

Central Provinces Manganese.—4%, less tax, payable October 1.

Changkat Tin.—6d., less tax, payable September 30.

El Oro.—7d., less tax.

Globe and Phœnix.—1s., free of tax, payable October 27.

Gopeng Consolidated.—4d., less tax, payable September 30.

Kampar Malaya.—4½d., less tax, payable October 24.

Minerals Separation.—1s., less tax, payable October 22.

Renong Tin.—1s., less tax, payable October 12.

Tekka.—3d., less tax, payable October 7.

Temoh.—9d., less tax, payable October 24.

Waihi Gold.—1s., free of tax, payable November 4.